"I'm in his belly!": Children's Responses to Different Types of Characters in Virtual Reality

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ABSTRACT

Immersive technology, such as virtual reality (VR), has become more integrated in children's lives transforming how they experience education, medical treatment, and entertainment. In VR, children are likely to engage with interactive and socially real characters. To examine children's experience of virtual characters in VR, we studied 5-to 9-year old's (N= 25) spontaneous reactions towards three virtual character types (human, anthropomorphized fictional Muppet, animal). Results showed children engaged in four major behavioral interactions: they tried to touch the characters, embodied the characters, talked directly to the characters, and referred to themselves in regard to the virtual environment. These results suggest that children test concepts of realism through touch and verbalizations and physically examine social boundaries. Additionally, children consider self-representation while in a virtual environment. We discuss the implications of these results for future work and provide design considerations when creating VR content with and for children.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction paradigms; Virtual reality; Human computer interaction (HCI); HCI design and evaluation methods; User studies; • **Social and professional topics** → User characteristics; Age; Children.

KEYWORDS

Interactive Technology, Virtual Reality, Child Development

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1 INTRODUCTION

Through its increased immersive capabilities, virtual reality (VR) can make content and the characters in it perceptually real influencing how children think, feel, and behave. VR applications have transformed children's education [9, 17], reduced their physical and emotional pain during medical procedures [20], and reduced their anxiety [15]. Furthermore, fully embodied VR experiences provide children with the ability to express themselves with rich non-verbal behaviors that mirror their offline lives, increasing a sense of connection and intimacy with virtual others [16]. However, there still is a need to develop more child-centric VR environments that create safe spaces for children, taking into account their maturity levels [16]. Research also suggests that immersive VR technology can heighten children's social reactions to characters. For example, a study by Bailey and colleagues [1], revealed that children were more likely to comply with a social request and share more stickers with a character in VR compared to seeing the same character on a 2D TV screen. While this research illustrates differences in children's reactions to different technologies, the type of characters in VR could influence the types of social reactions children experience. More specifically, children may have a variety of behavioral responses to VR characters beyond compliance and sharing. We conducted an observational study examining children's spontaneous and automatic reactions to characters within a VR environment. We present findings of 5- to 9-year old's' reactions to three different character types (i.e., human, animal, anthropomorphized creature), and discuss implications for future research and design.

2 RELATED WORK

An immersive VR system, such as a head-mounted display (HMD), can block out the sensory information of the physical world and replace it with virtual stimuli, creating the illusion of being present in the content. These VR systems typically include several technological features that can enhance the perception that the virtual environment is real: (a) visual displays with a wide field of view, high resolution, and high frame rate, (b) trackers which measure body movements accurately, with a high update rate and (c) movement data sent to the system with low latency. VR systems with increased levels of technological immersion will increases users' experience of content as real (i.e., presence) [3, 8].

Stories and media content for children often employ a wide range of characters; whether educational TV programming such as Sesame Street and the Magic School Bus, or fictional story books such as Mother Goose's Nursery Rhythms. Children's characters can be anthropomorphic creatures (e.g., Muppets), human (e.g., other children), or animals (e.g., seen at the zoo). Because of VR's ability to create perceptually real and interactive content, the type of VR characters could affect children's social and emotional responses. Often, the measurement of a successful interaction between an agent and a human, such as a robot or virtual agent, is if users'

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Table 1: Demographic Information of Participants

Participant	Age	Gender	Race	Frequency using VR
P1	5	Boy	White	Never
P2	5	Girl	White	Less than once a month
P3	5	Girl	White	Never
P4	6	Boy	White	Several times a month
P5	6	Boy	White	Never
P6	6	Boy	East Asian/Asian American, White	Less than once a month
P7	6	Boy	White	Less than once a month
P8	6	Girl	White	Never
P9	6	Girl	White	Never
P10	7	Boy	White	Less than once a month
P11	7	Boy	Latinx, East Asian/American, White	Never
P12	7	Boy	White	Never
P13	7	Girl	White	Never
P14	8	Boy	Latinx, White, Filipinx	Never
P15	8	Boy	Latinx, White, Filipinx	Never
P16	8	Girl	White	Never
P17	9	Boy	Latinx	Less than once a month
P18	9	Boy	Black, Latinx, Native American/First Nation	Less than once a month
P19	9	Boy	White	Never
P20	9	Boy	White	Less than once a month
P21	9	Boy	White	Less than once a month
P22	9	Boy	Black, White	Less than once a month
P23	9	Boy	Asian/Asian American	Never
P24	9	Girl	Latinx, White	Never
P25	9	Girl	White	Less than once a month

treat it as they would another human in both verbal and non-verbal behaviors [7].

In addition, children can develop emotional bonds, sometimes called parasocial relationships, with media characters [2, 6, 13, 14]. Developing parasocial relationships with characters can increase children's academic and social learning [6, 18]. To develop emotional bonds, children need to feel safe and comforted by the characters [5]. The levels of attachment children feel relies heavily on the perceptual appearance of the characters [2, 5]. Through their research Freeman and Maloney [10] argue that "while visually pleasant and cute appearance may likely encourage social interactions, digital representations with less pleasant aesthetics works in an opposite way." Our study expands on prior research to understand children's verbal and non-verbal social responses to different types of characters in VR. This research will provide greater understanding for developing effective and enjoyable immersive experiences for children.

3 STUDY OVERVIEW

We conducted a within-participants study to examine children's automatic and spontaneous behaviors to different types of VR characters. Each child interacted with three different character types in VR: a human (i.e., child), an animal (i.e., giraffe), and an anthropomorphized creature (i.e., Grover™, a blue Muppet). Upon entering the virtual environment, children were prompted to approach each character in whatever order they preferred. Researchers recorded and observed children's automatic and spontaneous reactions to the different characters. In addition, data was collected on children's background (i.e., age, race/ethnicity, gender identity, and previous VR experience). We opted to use a commercially available HMD to consider children's responses to a fully immersive and widely accessible VR technology.

4 METHOD

4.1 Participants

Children ages 5-to 9-years old, were recruited from a medium sized city in Central Texas (N = 28). Children were excluded if they had a seizure disorder, epilepsy, or any condition that would make them susceptible to dizziness, disorientation, or nausea (no parents/caretakers reported any of these issues). Three children were excluded from the sample due to wanting to stop, or for removing the virtual reality headset multiple times during the experiment. Participants provided informed consent and assent and received $20 for their participation. The Institutional Review Board approved all aspects of the study. Parents/caretakers reported their child's age, race/ethnicity, gender identity, and previous VR experience (Table 1). Children reported their recognition of the different types of characters, with 100% recognizing the giraffe, 80% recognizing the child character, and 84% recognizing Grover.

The final sample consisted of 25 children (M = 7.4 years, SD = 1.5 years; 8 girls and 17 boys,).

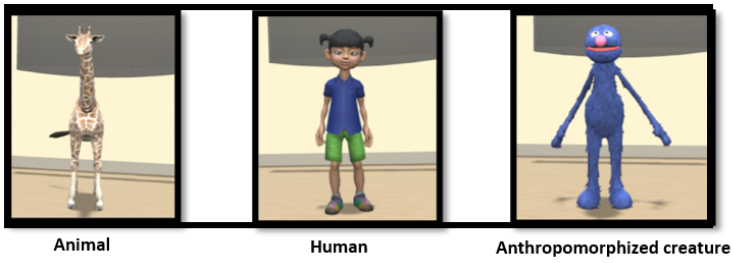

Figure 1: The three types of VR characters children experienced

4.2 Procedure

As part of a larger study, children completed a pre-test questionnaire (these results are reported elsewhere). During this time, parents/caretakers completed a demographic questionnaire about their children. When setting up the virtual environment, a researcher selected a human child character (out of 13 options) that most closely resembled the child's appearance (see example in Figure 1). A researcher showed the child pictures of each virtual character one-at-a-time and told them that these would be the characters they would be meeting in VR. The child was asked, "Do you know what this is?" for the giraffe and the child character pictures, and "Do you know who this is?" for the Grover picture. If the child responded with an affirmative the researcher asked them "What or who is it?"

After the pre-test, the researcher introduced each child to the HMD, an Oculus Rift CV1 (Panel Type: Dual OLED 1080x1200; Tracking: Outside in –6DOF; Audio: Integrated over-ear headphones and microphone; Lens Distance: Adjustable). The researcher helped adjust the HMD so it was comfortable for the child. Once the child was wearing the HMD, a researcher turned on a Samsung TV (Screen Size 52 inches, PC Resolution 1920 x 1080 @ 60 Hz) that was connected to a laptop showing the first person view of the child during the experience.

Children stood on a set of footprints on the floor that acted as the starting and reset point. First, children completed an orientation phase where they identified three different colored orbs in the virtual space. The researcher then let them know that the characters were going to come out to play and pushed a keyboard button. Three different virtual character types grew out of each of the orb's placements and expanded in size until they were approximately equivalent to the height of the child. The characters' heights were calculated using position of the HMD along the y-axis at the start. The three different characters were randomly placed at one of three different locations in the environment (all within view the participant's view).

Then children were prompted to choose one character to walk up to and asked a series of questions about their views of each character as part of a larger study. After children answered the questions, the researchers navigated them back to the starting point and repeated the same exercise for the remaining two characters. Once the experience was completed, the characters shrunk back down into the three colored orbs. Children were then removed from the VR experience and completed a post-test questionnaire (administered by a researcher). Once the session was completed two researchers created a joined memo of field notes after each child. With permission from parents and guardians, the sessions were video recorded for coding purposes.

4.3 Coding Techniques

Thematic analysis [4] techniques were used to code and analyze the children's behaviors. Two researchers started the analysis process by randomly selecting three videos, coding each one separately and referring to the field notes from the experiment. The individual notes reported observable behaviors of children's responses to the virtual characters and the virtual environment. The researchers then compared observation notes to develop (a) a coding scheme and (b) consistency and agreement on the observed behaviors. Finally, they coded an additional video separately, compared notes and reconciled any differences in opinions by reviewing the video footage together. Once agreement was met on identifying children's behaviors, the researchers coded both verbal and non-verbal behavior in all videos. The behavior codes were clustered into four agreed upon themes of repeated social behaviors the children were exhibiting: (1) physically attempting to touch a virtual character, (2) physically attempting to get inside a virtual character, (3) addressing a virtual character, and (4) commenting on the self. Coding for the video footage started when the HMD was placed on the child and stopped when the HMD was removed. Researchers coded four videos individually at a time, compared their codes, and then reconciled differences by reviewing the video footage together. A third rater was available to address any unresolved issues.

4.4 Coding Schemes

We identified four behavioral themes from the children: (a) physically attempting to touch the character, (b) attempting to get inside the character, (c) speaking to the character, and (d) commenting on their own self placed in the virtual environment. Children were coded as physically attempting to touch the virtual character if they (a) extended a hand out as if to pet or pat the virtual character (b) clasped their hands together in the air in front of them, (c) clapped their hands together in the air in front of them, (d) padded their hands at the air in front of them, (e) brought their hands upwards with arms extended in an arc towards the HMD, (f) brought their hands downwards with arms extended in an arc away from the HMD, (g) kicked a foot out towards a character, (h) stepped a foot out towards a character, (i) waved arm/s back and forth in the air in front of them where the character would be in the virtual world.

Children were coded as attempting to get inside a virtual character if they entered the space where the virtual character was placed,

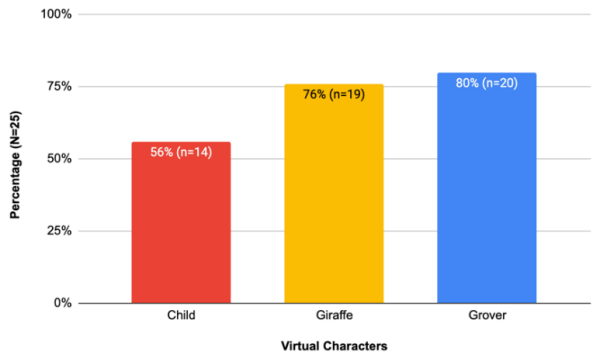

Figure 2: Percentage of children attempting to touch a virtual character by character type

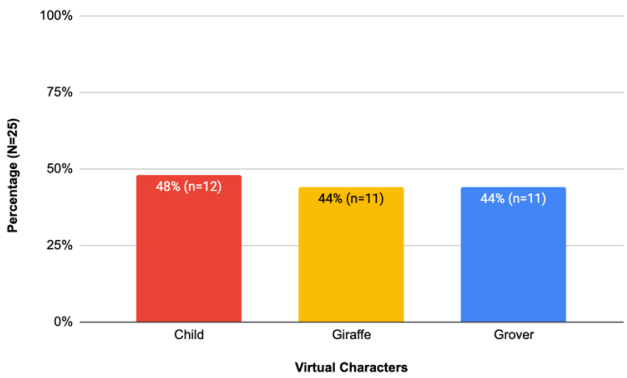

Figure 3: Percentage of children attempting to get inside a virtual character by character type

breaking into the clipping plane of the character (i.e., being inside the 3D model), as viewed by the TV mirroring the child's viewpoint. Children that used any words or phrases aimed directly at one of the characters (e.g., "Hello!") were coded as verbally addressing the virtual character. Finally, children were coded as commenting on themselves if they remarked on how they were represented in the virtual environment.

5 RESULTS

The majority of children socially reacted to the virtual characters, with 88% of children (n = 22) engaging in at least one of the themes. We report the overall number of children's responses according to each theme as well as children's responses according to their previous VR experience (none versus any). Among our participant sample, 12 children had used VR at least once and 13 had never used VR. Due to children's high and similar recognition rate of each character we do not report the themes according to this variable.

5.1 Physically Attempting to Touch a Virtual Character

As the most prevalent behavior, 88% of participants (n = 22) attempted to touch at least one of the virtual characters at least once. A greater percentage of children tried to touch the giraffe (76%) and Grover (80%) than those attempting to touch the child character (56%; Figure 2). Among children who never used VR, 92% (n = 12) attempted to touch at least one virtual character, while 83% of children that had previous experience with VR attempted to touch at least one virtual character (n = 10).

5.2 Attempting to Get Inside a Virtual Character

Overall, 64% (n =16) of participants attempted to enter the virtual body of at least one character. Children attempted to enter the different character types at similar rates (Figure 3). Among children that had no prior experience with VR, 69% (n = 9) attempted to get inside at least one virtual character, and 58% of children with prior VR experience attempted to enter at least one virtual character (n = 7).

Global observations showed that children were more likely to try to get inside a character when they first attempted to touch the character. Many children provided verbal responses when they walked inside the character. Children giggled, laughed, and yelped with sounds of surprise. One child remarked that they *were* the character. Children would often remark on their location within the virtual character: "I'm in his belly!" (referencing Grover) and "I'm inside the nose" (referencing the giraffe). In addition, children commonly commented on seeing the inside parts of a character. For example, the giraffe character had teeth and a tongue inside its mouth. The children who went inside the giraffe would spend time remarking on them, going in and out of the mouth. One child acted as if they were brushing the giraffe's teeth and role-played being a dentist and the giraffe their patient.

5.3 Directly Addressing the Virtual Character

Children that addressed the characters would most commonly greet them with "Hello" or "Hi." Observations showed that 32% (n = 8) of participants verbally addressed a virtual character at least once. Children typically greeted the character as they were approaching it (i.e., "Hi Grover™" or "Hi Giraffe"). Some children would make an audible exclamation when the virtual characters first appeared, and others would wave and greet the characters before they walked up to any of them. Among children without previous VR experience, 31% (n = 4) addressed at least one of the characters, and 33% of children with previous VR experience addressed a character (n = 4).

5.4 Commenting on Self

The results showed that 12% of children (n = 3) commented on themselves in some regard at least once. The children would attempt to see their hands by holding them up in front of the HMD. Their comments were "I'm invisible," "Whoa, I can't see myself!" and "I'm a ghost." Of the three children that commented on themselves, two had no previous VR experience, and one had previous VR experience.

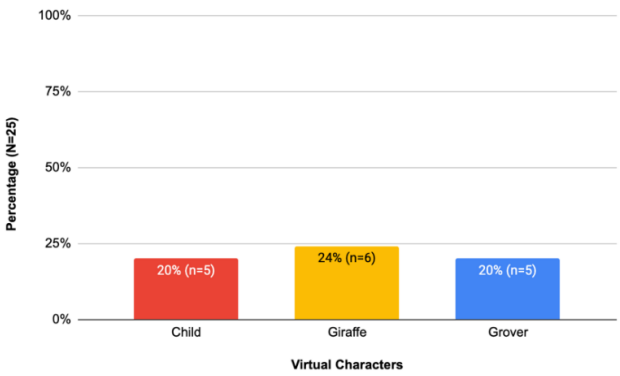

Figure 4: Percentage of children directly addressing a virtual character by character type

6 DISCUSSION

Our study explored children's spontaneous reactions to VR characters. Overall, children automatically responded to the characters with curiosity and engagement regardless of type. Developmental psychologist, Alison Gopnik [12] posits that children are "little scientists" and learn about the physical world by "testing hypotheses and assessing the data in the light of those hypotheses." Our study results give evidence that children employ this same approach when interacting with a virtual world. Children used touch to explore the characters, examined social boundaries by embodying the characters, and tested concepts of realism and self-representation in VR. We provide future design and research directions based on our findings.

6.1 Using VR to Enhance Children's Exploration

The results of our study suggest that VR acts as a place for children's discovery: regardless of previous VR experience children showed active engagement with the characters. Children did not show fearful behaviors but instead acts of curiosity. Despite being told that the characters were virtual, the two most common spontaneous behaviors children engaged in were attempting to touch the characters and trying to look inside them.

Children, starting from infancy, use their hands to explore the world [19], and the perceptual realism of the characters may have encouraged children to use touch for exploration. Interestingly, more children attempted to touch the giraffe and Grover, compared to the child character, but children tried to enter all three characters at similar rates. Novel or unusual characters may promote more initial discovery than typical representations.

Based on these findings, future VR designs could utilize characters to promote discovery and exploration. For example, education content could incorporate "what is it made of" lessons (such as for anatomy) where educators could use atomically correct virtual characters to encourage science learning. Another possible area for future work could be the children embodying a virtual character; where a child walks into the body of a virtual character they want to become and then can control it as if it were their own. Our results suggest that children are willing to embody a diverse set of character types.

6.2 Children's Social Boundaries and Self Representation in VR

Our results suggest that children use VR to test social boundaries and consider how they are presented in a virtual environment. Children would begin the VR experience by saying hello to a character, potentially testing the social realism and interactivity of the character. Even though our age group has an understanding of the fantasy-reality distinction in media [21], 32% of children spoke out to the characters. Furthermore, children greeted each of the different characters at roughly the same rate. In contrast, children were less likely to try to touch the child compared to the giraffe and Grover. Future designs may need to consider character type in regard to the social practices they would like children to engage in.

During our VR experience, children interacted with the environment from a first-person point of view, but without a virtual body. Children would typically remark on this observation when they tried to touch one of the characters. For example, one child said: "I can't touch it, I also can't see my hands." While only 12% of participants said something related to the self, more children in our study could have made these same observations but didn't remark on them. For example, children would sometimes bring their hands up in front of the HMD or look down at themselves but keep silent. Without verbal confirmation, we didn't code children as commenting on themselves in the virtual environment (as not to speculate on their intentions). Our findings connect with previous research showing that adult users feel the avatars they control with their bodies are "a more engaging an embodied approach to explore their own identity" [11]. Future designs may benefit from incorporating self-identity in social VR experiences, even among elementary aged children (as demonstrated from our results) by providing children with an avatar they can control and see from the first person.

6.3 Limitations

One limitation of this study is that novelty may have driven children's reactions. However, regardless of their previous VR experience, children participated in many of the observed social behaviors. Future work could examine children's responses over repeated interactions. Another limitation is that we observed a relatively small number of children; including greater diversity in age and background could provide additional insights. For our study we chose to use computer animated graphics, and these results could vary with photorealistic images. In addition, future work could examine how the type of VR technology influences behaviors. For example, by using an HMD, children may have been more inclined to move their limbs as opposed to their heads as compared to using a Cave Automatic Virtual Environment (CAVE) or 3D projection screen. Additionally, because using an HMD blocks seeing the physical body, children may be primed to consider issues of embodiment.

Our preliminary work provides greater insights for researchers and designers on developing characters in VR that children find appealing and engaging. Children in our study reacted to the different types of characters through verbal and non-verbal actions

to discover and achieve various goals in the environment. In addition, the method employed in this study could act a potential tool to measure children's engagement with characters in other immersive technologies. By examining the effects of virtual reality environments and characters on children and youth, we may find new ways to provide children and youth with social connections in safe places during times when they need it the most. Finally, we did not include traditional self-report presence measures. Future work would benefit from developing and examining how validated self-report presence measures for children correspond with our results.

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SELECTION AND PARTICIPATION OF CHILDREN

Children ages 5-9-years old were recruited from posted and shared flyers in libraries, schools and communities. Prior to starting the study, the Institutional Review Board at The University of Texas at Austin reviewed and approved the study. Parents who contacted the research team about their children participating in the study were given a description of the study before being scheduled to come in. Children and parents were individually read the consent/assent form which included the intent of the research, description of the study procedure and any risk/discomfort/benefit that may be involved. Parents were given a copy of the consent/assent form and we obtained verbal permission from both parties. Parents filled out demographic and child temperament forms during the study session. Children were told that they could stop the study at any point, their participation was voluntary, and they could ask the researchers questions at any time. Parents were given the option to not have their children be included in audio and video recordings. The audio and video were used by the research team only for research purposes. Parents were given the option to stay in the lab room for the duration of the study session.

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