RedCapes: the Design and Evaluation of a Game Towards Improving Autistic Children's Privacy Awareness

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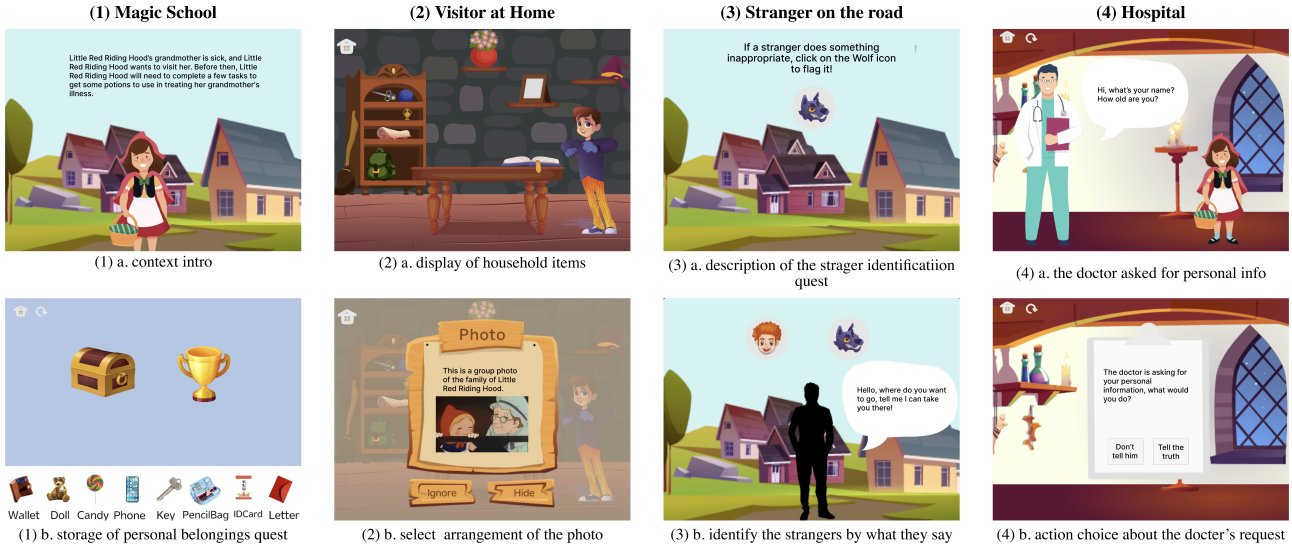

Figure 1: The screenshot of the *RedCapes*. The game consists of four scenarios: (1) Magic school. (a) shows the context of the game, (b) is the game quest for the first level, players are supposed to drag the items into an appropriate container; (2) Visitor at Home. The task of the second scenario is to rearrange the items displayed inside the house when a stranger arrives. (2) a. shows the layout of all elements and (2) b. is the description of a photo, players need to decide whether to ignore it or hide it; (3) Strangers on the Road: Players need to identify strangers based on what they say; (4) Hospital: The last scenario is in a hospital, the doctor requests personal information and physical contact, players need to respond to the doctors' request.

ABSTRACT

Autistic children have differences in social communication, making them vulnerable to privacy risks in social contexts. Research on typical development (TD) children's privacy learning often neglects autistic children's unique needs. Therefore, our study aims to understand their challenges in learning privacy and design an effective privacy education game for them. We designed a serious game, *RedCapes*, and recruited 9 autistic children and 6 TD children to evaluate the game. Our findings suggested that *RedCapes* improved autistic children's privacy awareness. Compared to TD children, autistic children have more difficulty identifying relevant privacy risk factors and understanding the full consequences of privacy violations. We propose three design implications for future privacy education games for autistic children. Our work contributes: insights into autistic children's challenges in learning privacy, a

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serious game prototype for privacy education, and design recommendations for future privacy education games focused on autistic children.

CCS CONCEPTS

• **Human-centered computing → User studies**.

KEYWORDS

autism spectrum disorder (ASD), privacy education, serious game, cognitive learning approach

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1 INTRODUCTION

Autistic children are characterized by differences in social communication and interaction and the presence of restricted, repetitive behaviors [10]. Compared to typical development (TD) children, autistic children sometimes struggle with bodily self-consciousness [60], interpreting social signals [10], and understanding abstract concepts [36]. In addition, many autistic children have differences in theory of mind [31] and perception of emotional states in others [21]. Since privacy depends on social interactions [42], autistic children may face more challenges in privacy protection due to the above differences. Insufficient privacy protection courses are provided to children in schools, posing a challenge in educating them about the complex nature of privacy [29]. Moreover, children with autism face particular difficulty in grasping abstract concepts [29].

Prior research has explored the potential of privacy education tools to teach digital privacy, which includes serious games (digital games with a primary aim to teach specific predefined skills or knowledge other than pure entertainment) [51, 71], interactive E-books [88, 89], and social media simulations [11, 25]. These interventions are designed for TD children and primarily focus on digital privacy risks, such as data security and online safety [90]. However, many of these interventions might not be effective enough for autistic children due to their developmental impairments for several reasons. For example, many autistic children display hyper- and hypo-sensitivities in multiple domains [8], correlated to repetitive behaviors, anxiety, and attention difficulties [17, 35]. Thus, the visual elements in the mentioned interventions may cause sensory overload and correlated processing problems in autistic children. In addition, many autistic children have auditory-language processing dysfunctions and social communication deficits [87]. Therefore, autistic children have unique challenges in attending to and understanding the existing interventions for TD children. Also, the existing interventions prioritize digital privacy risks over privacy risks in other domains, such as privacy concerns in interpersonal and institutional contexts [79]. While online digital privacy is essential to children's privacy literacy, little research has focused on understanding and improving the awareness and literacy of autistic children's digital privacy. Therefore, inspired by findings from literature and our prior work, we aim to design and develop a serious game to enhance autistic children's privacy awareness and literacy. More specifically, our research questions (RQs) include:

(1) RQ1: To what extent can autistic children enhance their privacy awareness and literacy through an educational game, and how do these outcomes compare to those of TD children when they engage with the game?
(2) RQ2: What opportunities and challenges do autistic children face in learning privacy through an education game like *RedCapes*?

To answer these RQs, we designed a serious game, *RedCapes*, which consisted of four scenarios—a school setting, a home setting, a public space, and a hospital setting. The game prompts the children to consider which personal property and personal information may be leaked to the public. It also encourages children to practice the correct reactions to potential privacy threats in a social context. We tested and iterated the game after a pilot test with autistic children with few cognitive impairments and relatively high cognitive abilities. Afterward, we conducted a study with 9 autistic children and 6 TD children. We tested their privacy awareness before and after the game, observed their game experience, and interviewed their parents. We found that autistic children's privacy awareness improved after the game, while TD children's awareness remained roughly the same. In addition, we found that autistic children faced unique challenges in answering privacy-related questions, identifying relevant risk factors, and generalizing privacy norms. Based on the findings, we identified design opportunities and proposed design implications of a serious game that enhance autistic children's privacy awareness. The contributions of our work are:

(1) We designed and developed a research prototype, *RedCapes*, and evaluated the opportunities and challenges that autistic children faced in learning privacy through this game.
(2) We presented design implications for future privacy education games for autistic children.
(3) We proposed insights for evaluating privacy awareness and literacy in future study measurements for autistic children.

2 RELATED WORK

In this section, we present background and related literature on children's privacy risks and education, focusing on challenges for autistic children. We also discuss current serious games designed for privacy education and analyze their content and strategies.

2.1 Privacy Risks and Education for Children

Privacy is a complex, multi-faceted, and context-dependent concept [42] and has also been empirically identified in six facets: solitude, isolation, anonymity, reserve, intimacy with friends, and intimacy with family [66]. According to Nissenbaum's theory of Contextual Integrity (CI), one's willingness to share information with others depends on attributes (the type of information), actors (parties involved in the information flow), contexts, and transmission principles (a constraint on the information flow) [9]. Since the definition of privacy has not achieved an agreement yet [2], in this study, we focus on autistic children and the privacy type

of anonymity, reserve, and intimacy with their families within the contexts of home, school, and other public spaces (e.g., hospital).

Children are vulnerable when confronted with privacy risks, with their increased use of technologies nowadays [37, 46, 91], they face more privacy risks than ever before [91], such as disclosure of children's image, physical locations [61], which may cause identity theft, fraud, and child trafficking. Kumar et al. [43] suggested that TD children understood that certain information types could be sensitive but still had trouble understanding transmission principles and contexts. Previous researchers found that TD children under 11 have a basic understanding of privacy, perceiving privacy as a secret. Still, they do not yet understand their data has an inherent value and what data should be protected [65]. And Oates et al. [65] found that TD children under 10 focused on physical privacy but seldom addressed data privacy [64]. Thus, it is important to enhance their privacy protection awareness and help them understand how to protect both their physical and digital privacy in diverse contexts [22, 77].

Privacy education has been extensively studied, with many online courses designed to raise awareness of privacy among TD children and young adults. For example, the Virtual Privacy Lab [1] of the San Jose Public Library, a project that provides resources related to online privacy issues, allows users to create a customized privacy toolkit (links, tips, and resources that empower users to customize their online identity). Although the privacy-related content provided in this curriculum is very informative and practical for parents and educators, it falls short in missing features intended explicitly for autistic children's learning behaviors. Another project, Common-Sense Media's Digital Citizenship Curriculum [84], is designed for elementary, middle, and high school students. It introduces how online privacy education works technically and socially and the potential negative consequences of oversharing. But it is also curriculum-based and lacks customization and entertainment. Other solutions are more interactive and more appealing to students because they introduce the concept of gamification and collaborative learning. For example, Teens-Online [86] is a platform equipped with a partner-matching mechanism, allowing students to engage more in learning activities by pairing with their optimal partners. While this project positively raises learning interest, its effects on individual learning outcomes are unknown.

Thus, we discovered a space for designing an educational tool to enhance autistic children's perception and understanding of privacy in diverse scenarios [19]. By integrating theories of privacy and learning, researchers developed an educational framework known as the 5Ds of privacy literacy, which comprises Design, Describe, Discern, Determine, and Decide [45]. This comprehensive framework served as a valuable guide and inspiration for our design process in creating educational tools to teach autistic children privacy literacy, specifically focusing on understanding autistic children's attitudes toward their privacy. We drew upon the 5D framework to inform the game design, incorporating elements that promote autistic children's ability to understand privacy concepts (Describe), analyze potential risks and benefits (Discern), make informed decisions (Determine), and take appropriate actions (Decide), while considering the unique perspectives and needs of autistic children regarding their privacy. Through this framework, we ensured that the privacy educational game not only aligns with evidence-based practices but also addresses the specific concerns and attitudes of autistic children, fostering a better understanding and empowerment regarding their privacy.

2.2 Privacy Education Challenges for Autistic Children

Autism Spectrum Disorders (ASD) is a group of complex developmental diversities characterized by differences in social interaction and communication, repetitive behaviors, and limited interests [26]. It is a diverse neurodevelopmental condition characterized by various strengths and challenges. Intelligence alone is an imprecise predictor of functional abilities, highlighting the need for a nuanced understanding of autism that considers individual differences and personalized support [3].

Autistic children share the same privacy risks as TD children, such as disclosing basic personal information [81]. Still, they face more challenges because of communication differences and repetitive and stereotyped behavior patterns or interests [27]. They also have a weaker sense of privacy leakage awareness since they have difficulty considering other people's perspectives [70]. They show a myriad of other misconceptions and confusions as well, including difficulty in separating appearance and reality and problems in tracking the relation between experience and belief formation [57]. And they are more vulnerable to cyberbullying and discrimination if their ASD diagnosis is disclosed [15]. Moreover, autistic children face significant learning obstacles caused by their differences in language skills, social interaction skills, executive functions, and motor control [28]. For example, a previous study compared autistic individuals with a separate learning disorder and found that the autistic group "showed similar impaired performance on the working memory and planning tests." [48] Further, autistic children also have challenges in recognizing and decoding textual information [49] due to their hyper- or hypo-sensitivity. Hence, considering autistic children's learning challenges and the lack of appropriate private learning methods, helping autistic children recognize privacy risks and teaching them how to protect their privacy are urgently needed.

2.3 Serious Games for Privacy Education

Upon reviewing various educational tools for autistic children, it has been observed that computer-assisted instruction has proven effective in enhancing social communication and reducing inappropriate behaviors [82]. Moreover, when it comes to vocabulary learning, children with autism have shown increased attentiveness, motivation, and vocabulary acquisition when utilizing computer-based programs instead of traditional behavioral programs [59]. Additionally, humanoid robots have exhibited valuable advantages for children with autism, facilitating spontaneous tactile interactions and evoking notable responsiveness to the robot's behaviors during tactile interactions [73]. Serious games also effectively manage and ameliorate autistic children's symptoms. However, to our knowledge, little research has been done on the effect of serious games on teaching abstract concepts such as privacy to autistic children [54].

A few serious games have been designed to enhance players' awareness of privacy protections. For example, Escaping the Privacy Paradox [78] is a mobile game that asks users to solve multiple

puzzles to escape from a laboratory. Specifically, the user needs to discover lost parts of the data set and learn about privacy practices such as data collection, processing, and transfer. Their findings show early evidence that a serious game can be used as a medium to convey privacy policy information. Friend Inspector [18], is a browser-based serious game that enhances players' understanding of privacy settings on social networks. Another web-based digital literacy game is designed for tweens (avid users of digital media aged 11 to 13 years), which addresses the topics of cyberbullying, data privacy, and online reputation. [51].

Serious games have a meaningful role in privacy education. However, these serious games are tailored to TD children and often pose challenges to autistic children. For example, they may contain too many texts and visual decorations, causing sensory and cognitive overload for autistic children. They also make it difficult for autistic children to internalize the knowledge and transfer it to daily contexts [55]. In addition, most serious games on the market target digital privacy. There's a lack of serious games that teach fundamental privacy concepts such as physical privacy, personal information, belongings, and so on. Thus, we decided to address the gap and create a game that teaches autistic children to recognize potential privacy threats and practice them in daily activities. We aim to study how our game affects autistic children's understanding of privacy literacy and what design implications we can conclude from the user study.

In conclusion, we reviewed the related literature on children's privacy risks and education, with a focus on the challenges faced by autistic children. Existing serious games for privacy education often lack customization for autistic children and fail to address their unique needs. By incorporating the 5Ds of the privacy literacy framework, we developed a game to enhance autistic children's understanding of privacy concepts and empower them to protect their physical and digital privacy. We considered sensory sensitivities by carefully selecting colors and adopting a minimalist visual style, while also using clear and concise language. Autistic children without cognitive impairments or with high cognitive abilities face additional challenges in communication and information processing, highlighting the need for tailored privacy education methods. Through user studies, we will assess the effectiveness of our game in enhancing privacy literacy and derive design implications for future privacy education tools, ensuring the specific needs of autistic children are addressed.

3 DESIGN OF REDCAPS

In this section, we present the game's objectives, scientific principles, and design guidelines we have applied in implementing these objectives. The game's ultimate goal is to enhance autistic children's privacy awareness in different contexts. The objectives will be explained in detail later. *RedCapes* design process iterated after a pilot test with two autistic children. From the pilot test, we realized that the game content was too limited, the privacy vocabulary used was too vague, and the pre/post-game tests were too long and complicated. After the test, we added more scenes, such as interacting with a doctor in a hospital and meeting strangers in public. We also changed the vocabulary used in the game and the tests.

3.1 Game Objectives

We had three objectives in designing this privacy education game.

3.1.1 Objective 1: Identify the privacy concepts and practices that are least familiar to autistic children. Privacy education plays a pivotal role in children's development, equipping them with the knowledge and skills necessary to protect their privacy, a fundamental right that deserves protection and respec [47]. Central to this endeavor is the need to address two critical facets: personal information protection and safe social interactions. To instill privacy awareness among children, it is essential to educate them about safeguarding their personal information, including their full name, address, phone number, and social security number, to prevent identity theft and unauthorized access. Furthermore, emphasis should be placed on safe social interactions in both online and offline contexts. This involves guiding children on exercising caution when communicating with strangers and understanding the potential risks associated with sharing personal information with unfamiliar individuals. While Montgomery's study [58] makes a valuable contribution to privacy education, it predominantly addresses physical and personal information privacy, highlighting the need for a more comprehensive approach.

3.1.2 Objective 2: Explore inclusive game elements and interaction schemes for privacy education games tailored to autistic children. To foster inclusivity in privacy education for autistic children, the design of educational games must carefully consider their unique cognitive and sensory characteristics. In *RedCapes*, a game designed to enhance privacy awareness, specific features were incorporated to cater to the needs of children with autism. One key observation in our design was the increased vulnerability of autistic children in social interactions [5]. They often face challenges related to social cues, understanding social norms, and maintaining personal boundaries, making them susceptible to exploitation or manipulation by individuals seeking personal information [34]. Consequently, we devised interactive scenes where autistic children can simulate appropriate responses to strangers' inappropriate questions. Moreover, considering the sensitivity around disclosing diagnoses among autistic children [5], we included items in the game, such as a medical record, to underscore the importance of medical information to privacy. We chose very specific items to represent privacy concepts to make the game easily understandable.

The design of interaction schemes is crucial in addressing the cognitive strengths of autistic children. Leveraging their visual and spatial processing abilities, *Redcapes* incorporates drag-and-drop interactions, alongside tapping, to provide an accessible and engaging interface for children with autism. This design not only caters to their cognitive strengths but also promotes fine motor skill development [30]. Moreover, the game acknowledges potential sensory sensitivities in autistic children and takes deliberate steps to address them. The minimalist visual style with a clear hierarchy of elements [14] is aimed at mitigating sensory sensitivities. To further ensure comfort, the choice of colors and textures is based on research indicating that autistic children prefer blue and brown colors over yellow [76]. Thus, the game avoids overstimulating or overwhelming hues, opting for smooth and non-distracting textures in two-dimensional designs, thereby preventing discomfort.

3.1.3 Objective 3: Compare the game experience and performance between autistic children and TD children. In the pursuit of fostering privacy awareness, it is imperative to gauge the effectiveness of educational games, especially when targeting specific populations like autistic children. *Redcapes* takes a multi-faceted approach by not only focusing on the developmental differences of autistic children but also considering their cognitive strengths. To evaluate the impact of the game, a comparison between the game experience and performance of autistic children and TD children is conducted. The aim is to discern whether the game's design and elements effectively bridge the gap in privacy awareness between these two groups, contributing to a more inclusive privacy education.

The design principles in *Redcapes* go beyond addressing cognitive and sensory considerations; they also incorporate key learning theories into the gameplay experience. Building on social constructivism, the game embeds privacy concepts in various social contexts, fostering meaningful interactions and learning experiences. This approach aligns with research on privacy literacy education, emphasizing the importance of situating learning in meaningful social interactions. In addition, the game design adheres to recommendations for serious games for autistic children, ensuring a coherent storyline, game levels of varying difficulty, and a system of constant feedback and rewards [54, 63, 83]

Furthermore, the design takes into account specific instructional design principles, such as providing immediate feedback on errors, using visual aids to enhance textual or verbal descriptions, and offering multiple and varied examples to teach abstract concepts [40]. By meticulously considering these principles and conducting a comparative analysis of the game experience and performance, *Redcapes* strives to offer a comprehensive and inclusive approach to privacy education, addressing the distinct needs of autistic children while fostering their privacy awareness.

3.2 Game Design and Implementation

RedCapes is a single-player mobile game and is designed to be played on phones and pads. All the game interactions will be done through a touch screen.

3.2.1 Narratives. Our game's narrative is adapted from the story Little Red Riding Hood. At the beginning of the game, the player is told that Little Red Riding Hood's grandmother is sick and that she needs to go through different game levels to earn magic pills to save her grandmother. Although the game is based on a fictional story, it incorporates elements related to daily life and privacy-related scenarios that have both negative and positive consequences. The player needs to protect their private information, respect other people's personal items, and disclose information when needed.

3.2.2 Mechanics. In the game mechanics of *Redcapes* players engage in a dynamic learning experience that combines puzzle-solving, quizzes, and role-play within a privacy-oriented context. The game is structured around scenarios of increasing difficulty, with each level designed to provide clear takeaways on privacy concepts and practices. With this progression dynamics, players receive valuable incentives in the form of magic pills as rewards for successfully completing each level. These rewards form a feedback loop, giving players a sense of achievement and motivating them to actively participate and learn. Figure. A.2.4 illustrates the game's flow, showcasing the player's journey through these engaging scenarios. Interactions with the game are made intuitive and accessible for all, including children with autism. Players use tapping and dragging gestures on the touchscreen, making the game interface responsive to their actions and preferences. Importantly, there are no time limits imposed on players, ensuring a stress-free experience and preventing any unnecessary pressure on children with ASD. This design choice prioritizes a supportive and accommodating environment, allowing players to focus on their learning journey while engaging with the game at their own pace.

3.2.3 Game Implementation. We implemented this 2D mobile game in Unity, with Mandarin as our primary language. We added audio narration for all texts. The game was run on a Windows 11 laptop during our study.

Magic School. The first scene is set at a magic school where Little Red Riding Hood interacts with the school administrator. This level aims to teach players the concept of personally identifiable information. The player will be presented with eight objects, some of which expose their personal information while others don't. The player needs to recognize which objects are risky and put them away. If the players successfully pass this level, they receive a magic pill. If they fail, there is no punishment and they will be asked to try again. As illustrated by Fig.1.(1) b, there are eight different objects that need to be put in a safe or a cup, the former stands for risky objects, and the latter stands for neutral objects.

A visitor at your home. The second scene is set in Little Red Riding Hood's home. The concept of personally identifiable information is reiterated but framed in a family setting. This game level aims to teach players which objects in the house will expose private information regarding the family to guests. The player must identify at least three objects that may expose sensitive information.

Strangers on the road The third level is set on the road to the grandmother's house. The player will determine if the questions or requests made by the stranger are appropriate. This level teaches the concept of privacy in social contexts. Players must choose the right responses for every question or request.

Hospital The next level is set at the hospital. The player will choose how to respond to a doctor's requests. This level teaches privacy norms in medical settings. It mentions multiple privacy concepts, including information privacy, body privacy, and personal safety. The player will learn when they should disclose their personal information.

4 METHODOLOGY

We conducted a mixed-method study to investigate the usability and effectiveness of our game. The game's usability was evaluated through observations of children playing the game and interviews with their parents. The game's effectiveness was determined by children's improvements in privacy awareness tests before and after the game. To understand the unique privacy learning challenges autistic children without cognitive impairments or with high cognitive abilities face, we conducted the study with autistic children and TD children.

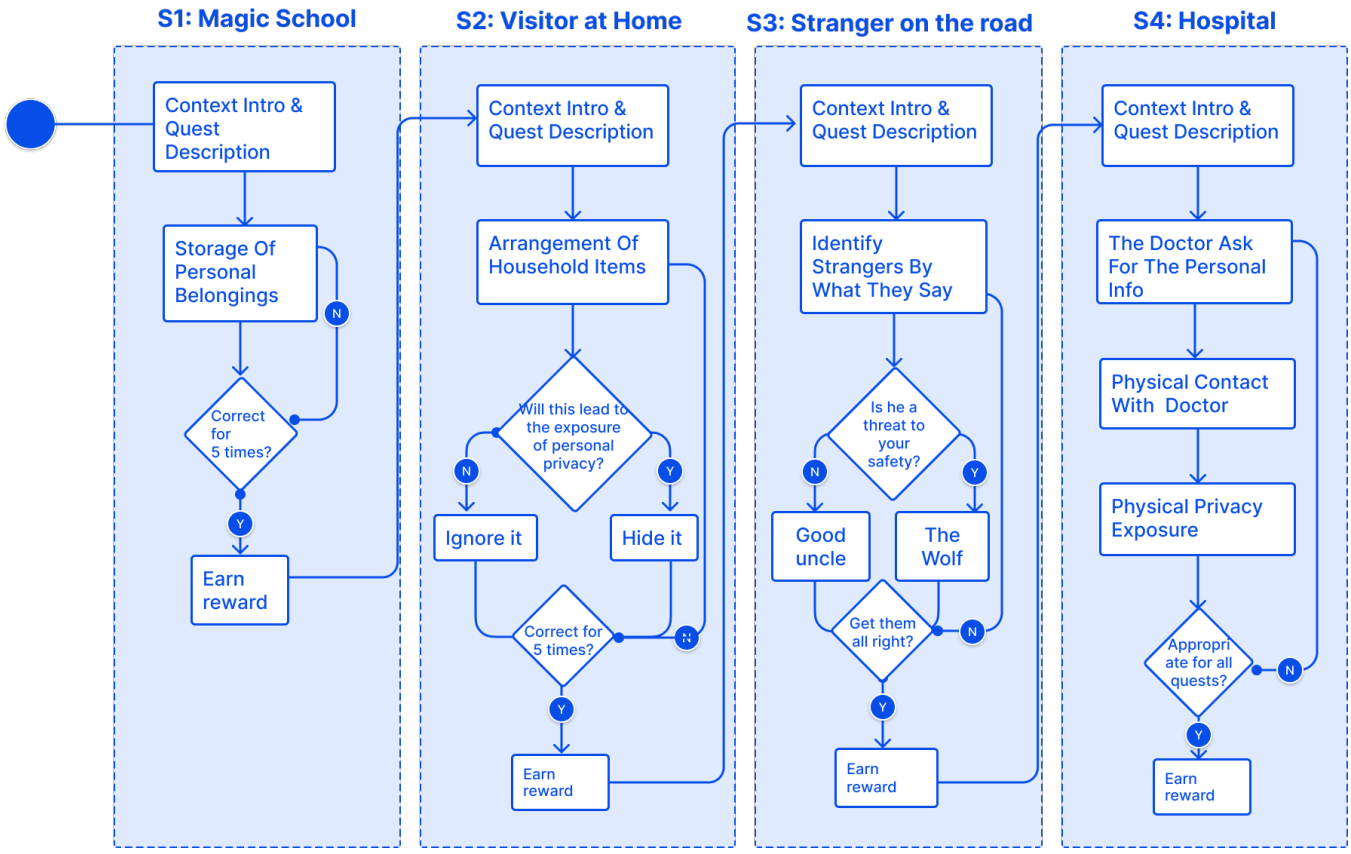

Figure 2: Game flow of the game: From left to right, there are 4 scenes, (1) magic school; (2) visitor at home; (3) stranger on the road; (4) hospital. The players need to follow the quest description shown at the beginning of each scene.

Demographics of Children (TD)			
No.	Age	Sex	Group
P1	5	Male	TD
P2	6	Male	TD
P3	5	Male	TD
P4	6	Male	TD
P5	10	Male	TD
P6	5	Male	TD

4.1 Participants

A total of 15 participants were recruited, with 9 participants assigned to the ASD group and 6 to the typically developing (TD) group. Including TD children served two purposes: (1) to explore variations in privacy understanding between ASD and TD children and (2) to explore design elements that facilitate accessibility for children with ASD and TD children. Specifically, autistic children with few cognitive impairments and relatively high cognitive abilities were recruited from a specific educational institution, while TD children were randomly recruited through our lab's social media platforms.

Table. 1 listed the demographics of participants. We selected the participants with different Autism Spectrum Quotients (AQ) (max = 103, min = 64), Social Responsiveness Scale 2 (SRS) (max = 136, min = 38), and Autism Treatment Evaluation Checklist scores (ATEC) (max = 55, min = 24). AQ quantitatively measures traits associated with the autistic spectrum in adults of normal intelligence [6]. SRS identifies the presence and severity of social impairment within the autism spectrum [20]. ATEC covers 77 items in the areas of communication, sociability, sensory and cognitive awareness, and health and physical behavior [50]. The scores in these three tests are associated with different degrees of behavioral problems, language and cognitive skills, and social and communication skills [6, 39]. Although the participants vary in their tests, their cognitive abilities are relatively high. Incorporating participants with different abilities helped us examine whether the idiosyncrasies of ASD children will influence their understanding of the game and privacy concepts.

Demographics of Children (ASD)						
No.	Age	Sex	Group	AQ	SRS	ATEC
P7	N/A	Male	ASD	74	53	25
P8	N/A	Male	ASD	N/A	N/A	N/A
P9	8	Female	ASD	N/A	N/A	N/A
P10	7	Male	ASD	N/A	N/A	N/A
P11	9	Male	ASD	103	136	46
P12	5	Male	ASD	N/A	N/A	N/A
P13	12	Female	ASD	64	53	24
P14	8	Male	ASD	N/A	N/A	55
P15	N/A	Male	ASD	94	91	32

Table 1: Demographics of participants: There are 15 participants in total, nine of them are children with ASD with ages ranging from 5 to 10 (mean:8.17, SD:2.32), and six of them are TD children, with ages ranging from 5 to 12 (mean: 6.17, SD: 1.94).

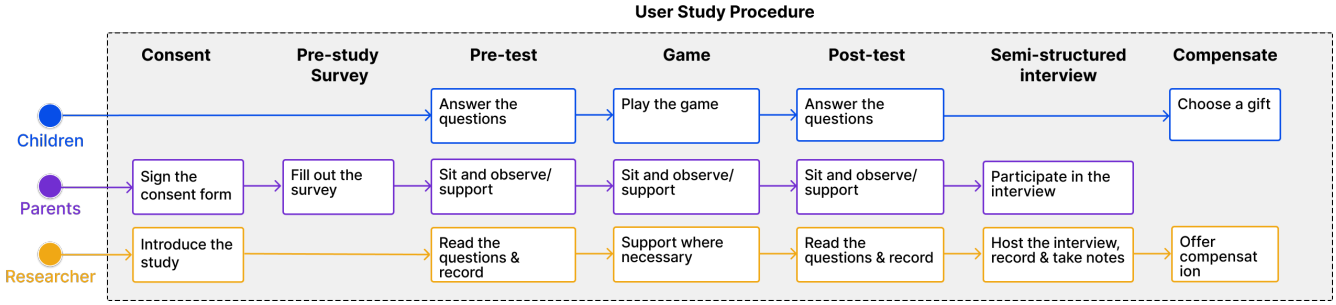

Figure 3: User study procedure follows seven stages in total: (1) consent; (2) pre-study survey; (3)pre-test; (4) game; (5)post-test; (6) semi-structured interview; (7) Compensation. The involved parties include children, their parents, and one of the authors.

In addition to the scores, our demographics survey showed that five autistic children had behavioral and emotional problems; five autistic children have been taught privacy; only one parent believed that her child had a strong privacy awareness. We obtained informed consent from guardians, secured ethical approval from Duke Kunshan University's IRB, and implemented structured and flexible procedures to conduct a sensitive and ethical study involving children with ASD.

4.2 Procedure

Once a parent signed up, we invited them to sign the consent form and introduce them to our pre-study survey, which includes basic demographic information. We guided the participants to answer the pre-game tests. The audio of their answers was recorded. Then, participants played the game under the researchers' and parents' supervision. Children read the game content, listened to audio narration, and navigated the game on a Windows laptop. Our researcher facilitated their transition to new game levels as necessary, while the guardians provided assistance to enhance the children's comprehension of the game. We recorded the game logs and screen recordings while the children were playing. Participants were asked to complete a post-game test after the game. Afterward, researchers conducted a semi-structured interview with parents to understand their children's experience and performance during the game. See Fig. 4 for the flow chart of our study procedure.

4.3 Instrument

4.3.1 Pre/Post-Game Test. To evaluate learning outcomes, we conducted privacy awareness tests with the participants before and after the game. We used the evaluation methods proposed by Maqsood and Chiasson and used interviews to evaluate whether children will apply privacy knowledge to new situations [52]. In addition to asking about children's decisions and the effects of their decisions, we added some questions inspired by Nissenbaum's [62] conception of privacy as contextual integrity. The Contextual Integrity (CI) framework posits that privacy is provided when the information flow aligns with the norms of given contexts and spheres. There are three parameters involved when defining the norms: the type of information involved, the concerned parties (i.e., who discloses the information, and who receives the information), and the transmission principles (i.e., constraints on the information flow). The CI framework provides a theoretical framework to measure whether children fully understand a privacy problem. We created the content of our pre-game/post-game tests based on the three parameters above. We sourced images of different scenarios and devised a set of questions for each image, asking children to identify the information type, involved subjects, the appropriateness of subjects' behaviors in the image, and to explain their reasoning. Participants' responses were recorded and analyzed. By asking these specific questions, we prompted the children to explain their thinking process when applying privacy knowledge to new situations. This resembles the concurrent think-aloud method which is commonly

used for user testing and is considered efficient and easy to relate to.

4.3.2 Survey. The goal of the survey is to understand the backgrounds of participating parents and children. We created a survey in Qualtrics and the survey includes demographic questions(age, gender, occupation, and children's behavior characteristics). The next section is about children's previous experiences with privacy (e.g., children's privacy conception and parents' teaching approaches). The last section of the survey is about children's experience with games (e.g., frequency of playing games, favorite video games). See appendix A.1 for survey questions.

4.3.3 Semi-structured Interview. To further understand children's privacy learning outcomes and game experience, we conducted semi-structured interviews with their parents directly after the game. The interviews took 30-40 minutes and consisted of three sections: (1) Feedback on the Game's Privacy Content; (2) Children's Game Experience; and (3) Customization for Autistic Children. The complete set of questions is included in the appendix. We employed the open-coding analysis method described by Braun and Clarke [13] to analyze our qualitative data. Two researchers coded interview transcripts independently and applied Cohen's kappa to assess inter-rater reliability. The average Cohen's kappa score across all codes was 0.49, which suggested moderate agreement.

4.3.4 In-game Data. We collected in-game data to assess the game's usability, which consists of children's number of trials (how many times children attempted before they passed the game level) and completion times for each level. In addition, we recorded the game sessions to complement the in-game data. By evaluating the game's usability, we wanted to confirm that autistic children do not encounter difficulties understanding and learning from the game. It also helps us examine whether autistic children can improve their privacy awareness and what challenges they may face learning privacy from the game.

5 RESULTS

In the study, we collected qualitative data from interviews and observations and quantitative data from game logs and screen recordings. We used qualitative coding and data visualization to process the data. Our findings belong to three broad categories: game experience and usability, autistic children's improvements in privacy awareness tests, and their perceived challenges in learning privacy.

5.1 Game Usability

We first present our evaluation of the usability of the game. Our measurement of game usability shows to what extent TD and ASD children understood and enjoyed the game mechanism and privacy learning content. Evaluating the usability helps us identify potential points of confusion and challenges for TD and ASD children to play and learn from the game. We can also spot the differences in TD and ASD children's reactions to the game. These observations help us answer the research questions. In terms of overall interactions with the game, children in both groups understood the physical interaction schemes used in the game, including dragging, touching the buttons, and touching the objects. As shown in Figure 4, it took autistic children a long time to understand the text in the game (TD children game duration: mean: 313.5, SD: 119.2, ASD children game duration: mean: 365.1, SD: 91.9). But the narration of the text helped children comprehend the meaning of the text. No ASD children showed confusion about the game content or interaction schemes. The accuracy of choosing game moves in both groups is similar (TD children accuracy: mean: 0.69, SD: 0.20, ASD children accuracy: mean: 0.67, SD: 0.11). However, compared to TD children, autistic children showed confusion about the names of particular objects, such as "documents" and "medical records." Some of them reported that they had no previous exposure to these objects. The word "document" is also too generic, which confused two children. The choice of color and visual style helped minimize distractions and obstacles in navigating the game. No children fixated their attention on any graphics or content, and they all figured out how to transition from one scene to another.

5.1.1 Engagement of Game Story. From observations and game logs, we found that all children in both groups (n = 15) successfully completed the game without showing any signs of boredom. However, two autistic children's parents and one TD child's parent pointed out that their children were temporarily distracted during the game. One parent (P13's parent) suggested that we divide the game into smaller modules and ask fewer questions in each module. Another suggestion is to provide shorter texts containing more verbs to autistic children. In general, we found that parents and children hoped the game could reduce cognitive load and empower more game control. This approach is echoed by parents of TD and ASD children alike.

5.1.2 Clarity of Privacy Content . The majority of the parents believed their children understood and enjoyed the game. They believed that the story of Little Red Riding Hood and the illustrations helped their children immerse in the game. The texts and audio in the game didn't pose any challenges to TD and autistic children. However, we found that more connections can be established between certain items to privacy, such as the medical record and the wallet. Some items, in particular, may not be considered private in certain contexts. For example, some schools publish students' grade reports openly and thus they are not considered private. Autistic children were more confused when the connections were not that clear. However, explanations of these objects and their connections to privacy will greatly help children in both groups to understand the goal of the game.

5.1.3 In-Game Feedback for Game Move. Our game provided feedback for every move children took in the game. Overall, children in both groups understood and learned from the feedback. Most of them corrected their moves after the feedback. However, four autistic children's parents raised concerns about the feedback the game provides. They believed that if the game presented more hints and rewards, their children would find it more engaging and would have a greater sense of accomplishment. Parents of TD children didn't express such concerns. In addition, the parents of autistic children suggested that more customized feedback and rewards may be more engaging. As one parent proposed, we should let them choose whether they want cars or toys. The feedback should

be closely related to the game narrative and the privacy concepts taught.

5.2 Children's Improvements in Privacy Awareness Test Outcomes

Regarding TD and ASD children's performance in pre and post-tests, we used qualitative coding to evaluate their responses. Autistic children gave more correct answers in privacy awareness tests after playing the game. Children improved their answers the most in the first and fourth questions. For the first question, three children neglected risks related to strangers prying on personal information. After the game, all but one of the children successfully identified and explained this risk. Their answers were more convincing as well. For the last question, three children improved their understanding of privacy risks caused by one's own negligence. They failed to describe what privacy risks would be brought upon them if they were not careful with their personal items. After the game, they did a better job identifying and describing such privacy threats. The four scenes in the game only cover certain categories of privacy, thus we cannot conclude about the generalization of other privacy concepts, such as online privacy.

Compared to autistic children, TD children's answers to privacy awareness tests before and after the game didn't change substantially. TD children had a better understanding of privacy concerns in social contexts before. They had less difficulty understanding the presented questions and privacy metaphors before the game. They also showed less confusion connecting our questions to their personal experiences. However, they answered questions about appropriate information disclosure in medical settings better after the game. Overall, their improvement in privacy understanding is limited.

In addition to improvements in test outcomes, we observed that autistic children improved in the following aspects during the privacy awareness tests. They were less distracted by irrelevant information and had a better understanding of people involved in a privacy problem and when to disclose their information.

5.2.1 Autistic Group Improved their Ability to Filter Out Irrelevant Information. The autistic children group paid more attention to irrelevant information in the pre-game privacy literacy test. Five out of nine provided justifications for their decisions that are unrelated to privacy risks. For example, they made decisions based on personal preferences or the functionality of perceived objects. For example, in the scenario where children were asked for their personal information at a hospital. Four children (P7, P8, P10, P12) refused to disclose their information because they didn't want injections. Three children (P7, P10, P12) only mentioned objects' functionalities without referring to their relation to privacy. For example, they said that the key is used to open the door. However, they failed to identify that after opening the door, other people would enter their homes and gather their personal information. The key, from their perspective, is only used to unlock the door. In the post-game test, children paid more attention to privacy-relevant information. We observed fewer occurrences of irrelevant information and more mention of privacy-related concepts such as private property. However, the TD children group didn't display such problems before the game and thus didn't show noticeable improvement.

5.2.2 Autistic Group Improved their Ability to Identify Involved Parties in Privacy Problems. Before the game, many autistic children struggled to identify the people involved in a privacy challenge. Five of them failed to identify whose privacy is being violated and who is violating privacy. They had trouble imagining themselves in the given scenario. Whereas most TD children understood that it was a hypothetical question for them, autistic children showed more confusion. They would answer that the researcher's privacy is being violated or the hypothetical character's privacy is being violated. Furthermore, five of them failed to recognize privacy risks that were caused by one's own negligence. In the scenario where a child forgets to take his key home.

In the game, we prompted the children to think about the people involved in a privacy challenge. The game would explain these people's roles and responsibilities, such as pointing out that the gatekeeper at the school might be threatening Little Red Riding Hood's privacy. Also, the second scene in the game emphasizes how Little Red Riding Hood's oversight may put her grandmother's privacy at risk. After the game, autistic children displayed fewer problems discussed above.

5.2.3 Autistic Children Had Better Understanding About Appropriate Information Disclosure. Autistic children often need to trust their therapists and follow their instructions. However, our results showed that prior to the game, six of the autistic children failed to disclose private information when a doctor needed it for treatment. They also didn't allow doctors to get close to them for physical examination. In the game, we presented a hospital scene where children interact with a doctor and need to make decisions about their doctor's requests. Children tended to refuse the doctor's requests at first. However, we provided explanations and asked them to retry the game for reinforcement. Thus, after the game, except for two autistic children, the rest changed their decisions and provided clearer justifications. TD children also improved their understanding of appropriate information disclosure. Two children chose to provide relevant information to the medical professional when asked. The rest of them answered correctly before the game.

5.3 Challenges Autistic Children Face in Learning Privacy

From researchers' observations, interviews with parents, and children's performance, we found two problems autistic children displayed in the study, which may affect their learning outcomes.

5.3.1 Autistic Children Paid Less Attention to Privacy Learning in Familiar Contexts. We observed that autistic children were more likely to detect privacy risks in unfamiliar situations than in familiar situations such as homes and schools. In both the privacy awareness tests and the game, when in a familiar context, autistic children took less time to make privacy decisions and provide explanations but their responses were often affected by privacy-unrelated factors. For example, four autistic children provided wrong reasons for what the child did wrong at school during the privacy awareness tests. The answers are often related to school rules, grades, and teachers. In the game, autistic children were also more likely to misclassify whether an object may bring potential privacy risks in family contexts. Some of them displayed a sense of possessiveness

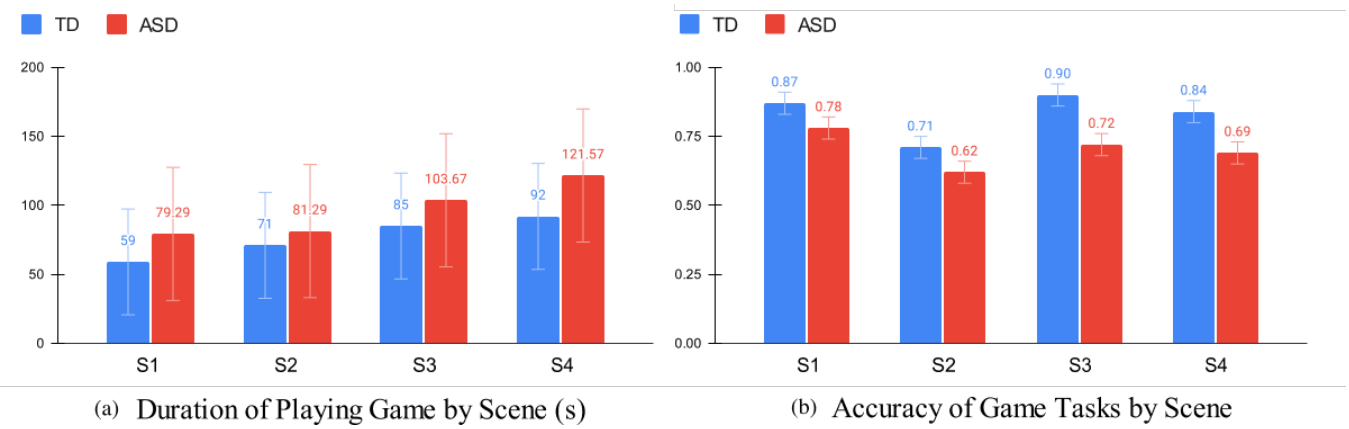

Figure 4: TD and ASD children's duration of play and accuracy of tasks in each game scene (S1, S2, S3, and S4).

when asked if they should put neutral objects like a vase, a ball, and a trophy away. For objects that will bring privacy concerns, such as the medical record, they didn't pay particular attention. Overall, autistic children seem to think less about privacy and do things as they used to in familiar contexts.

During the parent interview, one parent confirmed that their child may not realize that he's learning privacy if the scene is too familiar.

> *"He may think it's just a game — a simulation of real life. He doesn't know you're teaching him privacy if the game resembles reality too much. He may find the scene boring because the child thinks it's a simulation of real life. The child acted as he usually did at home or school and didn't consider privacy as prompted."* P8's parent

What's more, four parents of autistic children raised concerns that in familiar environments, such as schools and homes, their children are used to relying on their teachers and guardians. Thus, they are not used to making important privacy decisions on their own.

5.3.2 Autistic Children Struggled to Understand the Full Range of Privacy Risks. Privacy is involved in all aspects of our life. However, we found that many autistic children could only identify certain types of risks and their consequences. For example, they would know that they should not get into strangers' cars or follow strangers. But in terms of personal information like names, birthdays, and home addresses, many associated it only with personal safety. They failed to articulate the potential effects of privacy leakage on reputation and social relationships. Two children, on the other hand, didn't consider privacy norms but rather social norms. For example, P11 believed that one should be polite when visiting other people's houses. What's more, P14 rejected a stranger's request to send him snacks because he believed he could buy them himself. They made the right decisions but clearly didn't uncover privacy risks in the shown scenarios.

6 DISCUSSION

6.1 Summary of Research

In this study, we worked with nine autistic children with relatively high cognitive abilities and few impairments and six TD children to examine how autistic children learn privacy concepts from a serious game titled *RedCapes*. We evaluated whether autistic children encountered difficulties in learning abstract privacy concepts compared to TD children and also tested the effectiveness and engagement levels of *RedCapes* in teaching autistic children privacy knowledge. We discovered that in comparison with TD children, autistic children had greater improvement after playing *RedCapes*. They did better at avoiding distractions, and identifying people involved in privacy problems. However, they also faced some unique challenges in comprehending privacy concepts. Their lack of engagement in familiar scenes and failure to recognize all kinds of privacy risk factors hindered their learning. Therefore, we further discuss the opportunities and challenges in improving privacy-related serious games like *RedCapes* and provide design implications for future research and games, which are simulating and training privacy attitude and behavior gaps, incorporating and teaching privacy metaphors, and increasing awareness of other people's privacy.

6.2 Opportunities and Challenges for Designing Serious Games for Autistic Children

Our findings revealed several opportunities and challenges to improve a privacy game similar to *RedCapes* for autistic children. Here, we discuss some of the key opportunities we identified and challenges we encountered in *RedCapes* to provide more insights for future work, including creating games that simulate and train privacy behaviors, incorporating and teaching privacy metaphors, and teaching autistic children to consider and respect other people's privacy.

RedCapes created scenes that adopted imaginative elements, which were still grounded in real-world interactions, such as the scenario where players will need to clean their house for a guest's visit. Interview findings with parents revealed that autistic children

were more likely to neglect privacy risks in familiar game environments and setups because they lost interest, thus missing the privacy concepts and learning objectives of this game. Therefore, future research and games can consider implementing fantasy elements in attractive and novel settings that are tied to the game narratives. For instance, the game can incorporate an adventurous task where the player needs to escape from a prison cell by leaking some personal information. The player, however, could not leak vital information that would bring them harm. In this way, autistic children could be more engaged in the gameplay and pay more attention to the intended learning concepts. Meanwhile, our interviews with parents suggested that providing the opportunity to induce and train ASD children's natural responses to privacy risks will be helpful. Thus, balancing the imaginative elements and real-world interactions could significantly benefit the learning transfer from virtual games to real-life scenarios. Future research could consider adopting and evaluating more narratives and interactions related to autistic children's daily living conditions and social situations, online browsing social media interactions, and so on. This way, a balance of both cognitive stimulation and behavioral training is achieved since children can not only learn abstract privacy metaphors but also practice real-world responses.

Moreover, *RedCapes* provided immediate feedback on game moves. However, it didn't have multiple narratives with delayed feedback on children's in-game choices. While immediate feedback in serious games enhances children's motivation and learning outcomes, *RedCapes* can also provide different storylines based on children's choices. Since privacy has been considered to be a latent risk factor in many social situations [74], repeating the feedback in future scenes could potentially help autistic children understand medium- to long-term implications and potential consequences of their privacy choices. Increasing the game's length and complexity could also increase players' engagement and playful experiences.

Finally, some minor confusions shown by ASD children indicated that *RedCapes* could have been implemented with more instructions of relevant privacy knowledge through a scaffolding process. In the future, it could further elaborate on the privacy concepts and sources covered in the game, explain different privacy risks, and teach autistic children privacy vocabulary [69]. As revealed in the clarification of privacy content findings, we observed that some autistic children struggled to understand the learning goals in different scenes. A few autistic children encountered challenges in understanding how to utilize privacy knowledge to resolve the game tasks. For example, they didn't understand why they were asked to put away items in their grandmother's house when a guest came to visit. Parents reported that autistic children tend to pay more attention to details at the expense of the bigger picture, as also indicated in prior literature [32], thus struggling to connect each scene to privacy concepts. Therefore, clarifying teaching goals and learning objectives, and equipping autistic children with relevant vocabulary are essential for future work to consider, to shift autistic children's focus to abstract game concepts from detailed in-game information. For example, at the start of each scene, the game can explain each abstract privacy concept with familiar and concrete examples. Pop-up cards will also be helpful in testing autistic children's understanding of appropriate privacy behaviors, which could ensure the children understand the game objectives instead of coming across the right moves by chance.

Similar to prior privacy serious games [53, 71] or most digital interventions and games designed for autistic children [4, 16, 83, 85], in this research, we did not measure how well the privacy knowledge autistic children gained from *RedCapes* could be transferred and generalized in the physical world. Measuring generalization can be a challenging procedure to carry out due to time and recruitment constraints and usually requires separate studies to investigate autistic children's real-life behavioral changes in longitudinal research [83]. For example, a study that evaluated computer-based social skills training programs conducted training sessions twice a week for six weeks [38]. However, we did incorporate design elements that prior work suggests to be effective for generalization: we had a coherent and engaging storyline, a goal-oriented narrative, and a mix of training and instruction in the game [83]. Other design elements are also carefully constructed but their use for learning transfer needs to be tested. Thus, future studies could do more training and testing sessions and evaluation on various design strategies used in *RedCapes*.

To conclude, our study showed that presenting clear privacy teaching goals, authoring coherent and creative narratives, and providing immediate feedback and rewards could engage autistic children's attention and learning interests. Compared to other privacy serious games [12, 33, 51] *RedCapes* focused on interactions in daily lives and considered autistic children's needs for privacy. However, some autistic children encountered challenges in understanding intended privacy metaphors and the learning objectives. Future research can further investigate the best approach to integrating realistic interactions and privacy metaphors into the game flow to reach optimal literacy teaching outcomes and game engagement.

6.3 Design Implications

Based on the merits and opportunities of the design of *RedCapes*, we present the following design implications for future privacy education games for autistic children.

6.3.1 Design implication 1: Simulate Privacy Attitude and Behavior Gaps through In-Game Multi-Agent Systems.

Our findings suggested that autistic children tended to neglect privacy risks in a familiar environment (section 5.3.1). Parent interviews revealed that autistic children often leaked their private information accidentally when conversing with their peers or even strangers. We also observed that autistic children sometimes answered a question about privacy risks right but when experiencing the situation themselves, they could not protect their privacy. Autistic children seem to demonstrate privacy attitude and behavior gaps as well, which is the dichotomy of information privacy attitude and actual behavior displayed [41]. Therefore, identifying moments of privacy violations and the behavior-attitude gaps and simulating the violation scenarios in games would make privacy education games more effective [24].

In other words, future serious games and research could consider eliciting autistic children's emergent privacy violation behaviors and teach them to avoid such behaviors. Our observations indicated that behavior-attitude gaps mostly occurred in familiar and social settings and when privacy implications were less obvious.

For example, when leaking information privacy does not harm the involved people directly and immediately, but in the long term, the violation can bring damage to reputation.

Thus, a multi-agent game could better simulate scenarios of privacy violations. The other agents apart from the autistic children can be human facilitators or AI-based virtual agents. Multi-agent systems could potentially elicit users to show spontaneous reactions to privacy violations, thus exposing users' potential privacy attitudes and behavior gaps [7]. Well-structured, goal-oriented tasks are still needed for teaching privacy concepts. Additionally, autistic children/players could interact with the multi-agent systems (human facilitator or game NPCs) through open-ended in-game prompted conversations and guidance, in which process the autistic children's privacy behaviors could be manifested and the potential gaps between their attitudes and behaviors can be identified. Once identified, the game could reinforce children's understanding through game tasks. Agents leveraging their zone of proximal development will help their children improve privacy literacy. [43, 44, 92].

6.3.2 Design Implication 2: Integrate Privacy Metaphors in Games for Teaching Abstract Privacy Concepts to Autistic Children.
Previously, metaphors were adopted to simplify complicated topics into comprehensible items and behaviors that help children understand privacy concepts [72]. Although research implied that autistic children met difficulties in metaphor comprehension and expressive language abilities, such as conceptualizing and formulating ideas [80], findings from this work suggested that autistic children could misunderstand privacy metaphors in *RedCapes*. For example, one scene in the post-game test was about "peeking at other people's files," inferring a violation scenario of informational privacy. A few autistic children failed to identify how the metaphorical behaviors demonstrated in *RedCapes* and the tests connected to abstract privacy, asking whether the document is a medical record or a piece of paper.

In addition, in *RedCapes*, most autistic children failed to associate the behavior of putting things in a safe place with protecting one's privacy. However, the effectiveness of various metaphor teaching techniques has been proved, such as the relational frame theory-based instruction [67], intraverbal training interventions [68], and thinking maps [67] has been used to establish metaphor understanding in autistic children and their findings showed that autistic children are able to acquire metaphorical comprehension and interpret metaphors accurately [56, 67]. Thus, future research and serious games could carefully construct privacy metaphors and design special instructions for autistic children to understand them with the support of the above-mentioned metaphor teaching techniques. For example, the game can teach children the risks of leaking passwords by explaining its similarity with leaking a house key. The game can identify the shared features between a password and a key —— they both can be used to access something valuable. Furthermore, metaphors should be concise and straightforward to avoid distraction and extra cognitive overload for autistic children [75]. Future work could consider adopting familiar items or objects related to privacy from real life, such as locks and safes; and then extend the concept to more abstract metaphors, such as medical records and passwords. Explaining the shared features between the real-life tangible objects and abstract metaphors and providing visual prompts are helpful for autistic children to better establish the metaphorical connections to privacy [67].

6.3.3 Design Implication 3: Increase Autistic Children's Perceptions and Awareness of Risks Invading Other People's Privacy.
Though autistic children improved their ability to identify privacy risks they might face, from the game and pre/post-game tests, we noticed they experienced more difficulties in being aware of others' privacy or reflecting on their inappropriate behaviors when they invade other people's privacy. For instance, in the second game scene (Figure 1 (2) a), a few autistic children failed to recognize that leaving their grandmother's personal objects unattended would bring privacy risks to their grandparents' living environment. Prior research also demonstrated that autistic children had more difficulty understanding and reasoning about other people's thoughts [23]. Therefore, future research and serious games could implement scenarios that teach autistic children to care for and recognize other people's private information and needs. Future games can adopt Nissenbaum's contextual integrity framework and implement scenes and tasks that present how other people's privacy risks can be violated or protected to increase autistic children's perceptions and awareness of others involved in a privacy situation and whose privacy would be at stake.

6.4 Limitations and Future Work

Our study has several limitations. We had a small sample size in this research, including nine autistic children and six TD children. Their demographics also showed that TD children's parents received higher education on average. Also, the ASD children also represented a diverse range of ages, which may undermine our findings. *RedCapes* has been designed for and evaluated with autistic children with relatively high cognitive abilities and few cognitive impairments. Although the autistic participants displayed developmental differences in their language and social skills, they do not represent all autistic children on the spectrum, especially autistic children with cognitive impairments. Thus, our findings and discussions may be not representative of all autistic children, but more specific to those without cognitive impairments. In addition, our game was tested on a laptop with a computer mouse and keyboard, instead of a mobile device, so researchers helped the children navigate the game. Therefore, children's interactions with the game may not accurately reflect their interactions in an uncontrolled setting. Moreover, the privacy concepts introduced in *RedCapes* were limited to personal information, physical privacy, and appropriate information disclosure, which the other aspects could also be included in future gameplay based on Nissenbaum's contextual integrity framework. Finally, our study was not a longitudinal study and the privacy awareness test could not be used to evaluate long-term generalization outcomes in the real world. Therefore, future work could consider conducting follow-up studies or testing autistic children's behaviors in the wild.

Given the findings from this research, we propose the following research directions and objectives to design privacy-related serious games for autistic children for future research. (1) Explore and enhance autistic children's digital privacy awareness. Since our study only examined their awareness of basic privacy concepts, such as personally identifiable information and personal belongings, future

work can design a series of other privacy concepts in new games that could facilitate autistic children's mental models of digital privacy. (2) Co-design with autistic children, their parents/caregivers, and teachers. Our findings uncovered a gap between researchers' understanding of privacy risks based on limited existing literature and the actual privacy risks autistic children face in real life. Since parents from our study were not familiar with abstract privacy concepts as well as game design terminologies, they had some trouble clearly articulating their concerns and suggestions. Future work could further equip parents and autistic children with basic privacy literacy and game design concepts to better engage them in the co-design or design evaluation processes. Finally, as a serious game and a research prototype, *RedCapes* had limited game content and the playtime could be short (5-10 minutes) since we focused on answering our major RQs. Thus, players may not be able to learn from a short time span. We would like to further extend the game content and privacy concepts to achieve a longer and more sustainable game where players will then be able to play the game in an uncontrolled environment.

7 CONCLUSION

Research on prior literature and serious games exposed a lack of privacy education games for autistic children. In our study, we designed and evaluated a privacy education game for autistic children. We want to test the game's effectiveness and identify challenges autistic children face in learning about privacy. We observed nine autistic children and six TD children play the game, tested their privacy awareness before and after the game, and interviewed their parents. We found that autistic children improved a lot after the game while TD children did not improve much. However autistic children face more difficulties in articulating and internalizing privacy concepts, such as focusing on irrelevant details and neglecting others' privacy.

These findings present opportunities for future privacy education game design and research. We show the improvements needed for our serious game. We also provide design implications for a privacy learning game that addresses autistic children's perceptions of privacy risks and their differences in understanding metaphors. Also, we present design insights that can help autistic children gain privacy literacy and adapt to risks in real-world interactions. In addition, we make suggestions to create more usable and effective privacy awareness tests.

Our contributions include 1. Understanding autistic children's unique challenges in learning privacy through a privacy education game 2. Offering design insights on future privacy education games for autistic children 3. Providing recommendations on evaluating children's privacy awareness tests for future privacy education research. Our findings pave the way for a new paradigm of privacy education games that address the specific needs and opportunities of autistic children.

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A APPENDIX

A.1 Pre-study Survey Questions

The purpose of this study is to design a video game to help children improve their awareness of privacy protection. Your child will play a video game on a tablet, after which the child will take a quiz and you will participate in a semi-structured interview. During the interview, we will discuss the game experience, privacy-preserving topics, and the content of the game. Throughout the experiment, our conversations and on-screen behavior were recorded. This study will last 40 to 60 minutes. If you choose to participate, we will only use your name and email to contact you.

(1) What's your gender?
(2) What's your age?
(3) What's your education level?
(4) What is your current working status?
(5) What's the age of your children?
(6) What's the gender of your children?
(7) Has your child been educated about personal privacy (what is personal privacy information, how to protect personal privacy, etc.)?
(8) What are the methods of privacy education?
(9) What do you think of children's awareness of personal privacy protection?
(10) Have you ever encountered a situation in your life where your child's privacy has been leaked (such as being obtained by strangers for their child's name, home address, etc.)?
(11) What information was leaked?
(12) In what circumstances do you think it is possible to disclose the child's private information?
(13) Do you think there is a lack of privacy education for your children? Or does privacy education need to be improved?
(14) Does your child play games?
(15) Can you share with us the names of the games your children usually play? (If you do not play the game, please do not play this question.)
(16) Can you share the names of your children's video games? (Mobile, tablet and PC games are fine.)

A.2 Interview Script

Thank you for participating in this interview. We would like to briefly talk with you about your children's experience and privacy protection knowledge in this game. This interview is mainly divided into three parts, about 15-20 minutes, we will record and video the interview process. If you agree, let's continue.

A.2.1 Privacy Content.

(1) What is your child's previous understanding of privacy?
   - What kind of privacy is it? (such as body privacy, personal information, personal belongings, etc.).
   - Do you think he or she understands the privacy aspects of the game?
(2) Does your child have any privacy issues?
   - Has his or her privacy ever been violated? In what context?

- Does he or she intentionally invade other people's privacy? What kind of scenes?
- Do you worry about their privacy being invaded? Why is that?

(3) What privacy problems do you think children might encounter?
- For example, in what ways might your child's personality and habits be vulnerable to invasion of privacy?
- For example, in what ways might your child's personality and habits invade the privacy of others?

(4) Have you taught your children about privacy? What are you teaching them? How are they being taught?
- What tools do you use to teach, such as picture books, pictures, etc.
- How do you think the children's learning effect, how to teach them the most effective?

(5) Do you think children can learn something about personal privacy from games?
- If so, in which context and in which context can children learn about privacy?
- Do you think your child has learned anything about protecting their privacy? Which ones are they?
- Do you think children learn to respect other people's privacy?
- Can you comment on some of the aspects of privacy protection mentioned in the game? (This question can be skipped if it has been mentioned in detail.)

(6) If you were to design this game about privacy protection, what would you most want to teach your children about privacy protection?
- What kind of scenario do you think these knowledge should be put in? (in school classrooms, hospitals, etc.)
- How do you think this knowledge should be taught?
- Why do you want to teach your children this? Why do they matter?

A.2.2 Game Experience.

(1) What do you think of the game? What do you like about it? What do you like less?

(2) When playing games, what do you think of the children's game experience? Is the child interested in the game?

(3) Can they pay attention? If so, where exactly is the response (expression, language, movement, etc.)? Where do children focus most?
- If not, in what ways can it be seen? What might interfere with a child's ability to focus?
- Do they enjoy playing the game? What do they say about whether they like it or not? What is the most or least attractive place for him or her?

(4) Do you feel the purpose of each level in the game is clear? Will the child understand what we are trying to teach?
- Please give some explanation

(5) How difficult do you think this game is for children?
- If so, where exactly is it higher?
- If it's low, where exactly is it low?
- Will the child find the game challenging?
- Do you think the game is getting harder all the time? Does the child find it increasingly challenging?

(6) By observing the child playing the game, do you think he understands the story content in the game scene? What percentage do you understand?
- What parts of the game are easy to understand and what parts are not?
- Is there a barrier to reading text in the game? Do you know or understand all these words?
- What words or sentences do you find difficult for children to understand?
- Some of the images we use are cartoon (Little Red Riding Hood, Big Bad Wolf) and some are real (keys, passports). Which one do you think is easier for children to understand and enjoy?

(7) What do you think of the interaction (button clicking and dragging) in this game?
- Is the difficulty level appropriate for your child?
- If so, where exactly is this operation difficult? Why is that?
- If it is too simple, in which case is it too simple? Why is that?
- What about fun?
- What are the game interaction methods that appeal to your child?
- What are some ways that are less appealing to kids?

(8) What do you think of the help and instructions provided in this game? Are they too much?
- If not, where exactly do you need to add hints, and in what form?
- If so, where do you think the prompts should be reduced?
- How do these cues affect children's play?

(9) What do you think of the feedback in this game?
- Is there any timely feedback to the children?
- If so, what specific actions are the ones where the feedback is obvious or important to you?
- If not, where do you think more timely feedback is needed?
- W How does this feedback affect the child's learning process?

(10) What do you think of the story about Little Red Riding Hood in this game?
- Do children understand and like it?
- Do you think a child can fill the role of Little Red Riding Hood? Why or why not?
- Can you recommend some stories that your child likes?

A.2.3 Customization For TD children.

(1) Based on your understanding, does your child have any special preferences or habits?

(2) Would preferences or habits make your child more vulnerable to privacy attacks? Would these preferences or habits make your child learn and understand privacy concepts better?

(3) Does your child have any preferences for games, not only digital games?

(4) Based on your understanding, what is the best way for your child to abstract concepts, such as personal safety and the concept of money?

- What languages would help them understand and learn these concepts?
- What tools can help with that? For example, pictures?

A.2.4 Customization For ASD children.

(1) Based on your understanding, Based on what you know about your child, does he or she have any special hobbies or habits in life? (Here I want to ask about specific ASD topics, such as repetitive behaviors, cognitive development, social dysfunction, etc. This is relatively neutral, but try to smell some ASD features.)
   - Might these habits make it easier for children to invade or be invaded?
   - Might these habits help or affect children's ability to learn or understand the concept of privacy?
(2) Based on your understanding, do you think he or she will respond specifically to certain colors, sounds, or other sensory stimuli?
(3) Based on your understanding, do you think he or she likes games and has any preference for games (not just video games)?
(4) Based on your understanding, what do you think is the most effective way for him or her to learn abstract concepts, such as personal safety and money?
   - What language will help them understand and learn these concepts?
   - What tools can help? (such as pictures, don't tell the parents the answer, if the parents can not answer, then appropriate examples)