Incloodle: Evaluating an Interactive Application for Young Children with Mixed Abilities

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ABSTRACT
Every child should have an equal opportunity to learn, play, and participate in his or her life. In this work, we investigate how interactive technology design features support children with and without disabilities with inclusion during play. We developed four versions of Incloodle, a two-player picture-taking tablet application, designed to be inclusive of children with different abilities and needs. Each version of the application varied in (1) whether or not it enforced cooperation between children; and in (2) whether it prompted interactions through in-app characters or more basic instructions. A laboratory study revealed technology-enforced cooperation was helpful for child pairs who needed scaffolding, but character-based prompting had little effect on children's experiences. We provide an empirical evaluation of interactive technology for inclusive play and offer guidance for designing technology that facilitates inclusive play between young neurotypical and neurodiverse children.

Author Keywords
Inclusive play; play; inclusion; children; neurodiversity; child-computer interaction; universal design; inclusive design.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Play is a critical and beneficial part of children's lives. Through play, children develop physical, cognitive, creative, social, and emotional skills [17]. They also build and foster relationships as they engage and interact with the world and their peers during play [17]. Every child has a right to play [27]. However, not every child has the chance to participate equally in play because of how our environment, systems, and society are often structured in ways that are inaccessible and non-inclusive to those who do not fit into what our society defines as "normal." A non-inclusive play environment can ostracize children with disabilities.

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In the HCI community, there has been a crucial movement toward using a social model of disability and trying to increase the accessibility of technology using a Disability Studies perspective (e.g., [15,28]). Along the same lines, in our work we aim to understand how play technologies for young children can be *inclusive*. That is, how can we design interactive play technology to support children with differing abilities and needs? How can these technologies be designed to scaffold interactions, increase understanding between playmates, and attend to the needs of children with and without disabilities?

In this research, we empirically examined the ability of interactive design features to facilitate inclusive play between children with differing abilities and needs. We focused on *neurodiversity* in particular. Neurodiversity refers to neurological diversity, often associated with cognitive, developmental, learning, social, emotional, behavioral, or other similar disabilities or disorders [2]. In contrast to neurodiverse individuals, neurotypical individuals are neurologically typical and have not been diagnosed with said disabilities or disorders.

Based on formative work, we designed and developed four versions of Incloodle, a picture-taking iPad application designed for children to play together in pairs. Each version varied in whether it technologically enforced cooperation between children and in how it prompted children (i.e., through basic vs. character-based prompts).

We carried out a within-subjects lab study with pairs of neurodiverse and neurotypical children who played with all four versions of the application. We analyzed their play and interactions with the application using both qualitative and quantitative measures. Our results showed that technology-enforced cooperation helped pairs who had trouble cooperating to play together, though child dyads who did not need the scaffolding were limited creatively. Overall, children expressed significantly more positive affect when Incloodle did not enforce cooperation. In addition, character-based prompts had no meaningful effects on play. Finally, embedded turn-taking and picture-taking were beneficial tools for inclusive play.

We contribute an empirical understanding and evaluation of young children's interactive technology for inclusion during play. Our discussion surrounding the design features that facilitate inclusive play between young neurotypical and neurodiverse children can guide the design of technology in this space.

RELATED WORK

There is ample notable research in designing for and with neurodiverse children [36], particularly those with autism spectrum disorders [22]. Although there have been some initial explorations, there has been less research on designing technology for inclusive play among children with mixed abilities [36]. Holt et al. [19] explored ways to facilitate meaningful play among children with and without motor impairments. Though our work is similar in the goals of Holt et al. [19], we focus on neurodiversity. Brederode et al. [8] designed and evaluated a game for children ages 8 to 14 with differing cognitive abilities. Again, our work is similar, but we focus on a younger, preschool and kindergarten-aged population and more unstructured play.

Touchscreen Games & Tech-Enforced Collaboration

HCI research in collaborative games for children has shown the positive effects that using technology to enforce collaboration has on social interactions. Hourcade et al. [21] studied how two-player tablet apps can encourage social interactions between 10 to 14 year olds with autism. One of the applications they studied, called Untangle, requires children to cooperate to untangle a visual puzzle with multiple fingers so it cannot be used alone. They found this app led to significantly more supportive comments between children compared to other activities. Likewise, Boyd et al. [7] examined how Zody, a collaborative iPad game, facilitated social skill development among 8 to 11 year olds with autism. Zody uses various in-game elements to support collaboration. The researchers show that the app's various cooperative gestures align with the development of turn taking, compromise, empathy, joint attention, communication, and shared joy.

Piper et al. [32] found computer-enforced rules in SIDES, a cooperative tabletop game they designed to help adolescents with autism practice their group work skills, has the potential to encourage positive behaviors. Similarly, Battocchi et al. [4] showed that enforcing collaboration in their tabletop game called the Collaborative Puzzle Game led to positive effects on collaboration in pairs of typically developing boys and in pairs of boys with autism, all approximately 9 years old.

These projects inspired us to investigate whether technological enforcement would have similar successes among children with differing needs. Yet, unlike these works, rather than investigating cooperative gestures, we examined joint picture-taking.

Interactive Apps & Character-Based Prompting

The involvement of characters to prompt interactions and promote social skill development within interactive technology has also been explored within the HCI community. Family Story Play is a system that promotes dialogic reading activities for very young children and their families across long distances. The system supports child engagement with remote grandparents during reading, using help from Elmo (a popular character from *Sesame Street*) [34]. Elmo provides questions and prompts to support family communication and dialogic reading goals. In a study that compared Family Story Play to book reading over Skype, children enjoyed Family Story Play overwhelmingly more because of Elmo, as they were interested and engaged with the character. His involvement also helped the grandparents focus the children's attention on the story.

Tartaro and Cassell [38] developed an intervention for children with social and communication disorders in which the children interacted with a virtual peer in a collaborative narrative task. Their study showed that virtual peers engage children with autism in social interactions and facilitate contingent discourse, which is important for any social communication. There have been other studies that show the positive effects of virtual characters on supporting children with autism with their social communication skills as well [1,29].

There are also many commercial interactive "feelings" games that involve popular characters (e.g., Daniel Tiger, Arthur, Cleo, Buster, Clifford, Elmo) [30]. Led by the characters, these games allow children to interactively play to learn about and develop social and emotional skills. Our research builds on this previous work by examining the use of characters in interactive "feelings" technology targeted toward pairs of neurodiverse and neurotypical children.

Successful Inclusive Play

For this research, we needed to create a definition of successful inclusive play with Incloodle. We adapted Cross et al.'s definition of successful inclusion in the early childhood classroom [13] to our short-term lab investigation. In our adapted definition, inclusive play is successful when: (1) the technology supports the children in the **development of play skills anticipated for all children;** (2) the technology **fosters acceptance and positive attitudes between children; and** (3) **parents are pleased** with their children's play experience and participation and believe their **children appeared comfortable and happy in the play setting.**

RESEARCH QUESTIONS & HYPOTHESES

In this work, we asked specific research questions regarding the effectiveness of particular design features to support children with inclusive play.

Based on the findings in the aforementioned related work that technology-enforced rules for cooperation often lead to positive behaviors and collaboration among children with autism, we were interested in examining whether such rule enforcement would help children with differing needs to play together cooperatively. Specifically, does technology-enforced cooperation lead to more successful inclusive play compared to no technological enforcement (RQ1)?

We hypothesized that technology-enforced cooperation is more supportive of inclusive play than no technology-enforcement (H1). We postulated that the notion that technology can successfully provide structure to scaffold play and social interactions for homogenous groups may likely generalize to children with more heterogeneous needs.

Next, following the related work, we wanted to examine whether carefully designed content with characters would have an effect on inclusive play or if simple content would be enough to support children. We asked, does character-based prompting lead to more successful inclusive play than more basic prompting techniques (RQ2)? Similar to the related work, we hypothesized that character-based prompting is more supportive of inclusive play (H2).

INCLOODLE SYSTEM

We designed and developed four versions of Incloodle, a picture-taking iPad application for two children to play together on a single device. The goal of this application is to facilitate and lower barriers to inclusive play.

We programmed the app in Swift 1.2 within Xcode 6.4. We implemented real-time face recognition in Incloodle using Apple's AV Foundation Framework, which interprets face metadata captured from video input. The application was deployed on an iPad Air 1 running iOS 8.3.

Foremost, we were driven to design an interactive application because of how it can provide structure via predictability, rules, and stability, especially for children with autism [16]. We chose to design for a touchscreen tablet specifically because of its popularity, portability, accessibility, and usability among children [9,14] and because of its camera feature. We focused on using the camera for picture-taking because photography provides triggers for conversation, contextualizes experiences, and can empower users [10,12]. Photography is also a learning tool for young children in social and emotional development [10]. Photographing their own faces encourages children to focus on faces and emotions in relation to themselves and to others, which is important for developing theory of mind, perspective taking skills, and empathy [10]. These social and emotional skills can support both neurotypical children and neurodiverse children in understanding each other.

In line with this idea, we designed Incloodle to concentrate on social and emotional learning. Incloodle introduces different social and emotional learning topics through character anecdotes, questions about the children, and prompts for the children to take pictures together that correspond to each topic. The topics include happiness, sadness, anger, embarrassment, cheering up others, frustration, grumpiness, calming down, discomfort, being scared, silliness, worry, what you are working on, favorite shapes, favorite colors, and favorite toys. We developed and curated the topics and the wording of the written and spoken questions and prompts based on our formative work about inclusive play [36] and on children's literature that focuses on social and emotional learning and teaching about disability [5]. After generating a first draft of this content, we had an early childhood education teacher review and edit the content. We engaged in a discussion about each topic and edited the final content together. (Please see the supplementary table for a full list of Incloodle's content.)

	No technology enforcement	Technology enforcement
Basic prompting	Condition 1	Condition 2
Character-based prompting	Condition 3	Condition 4

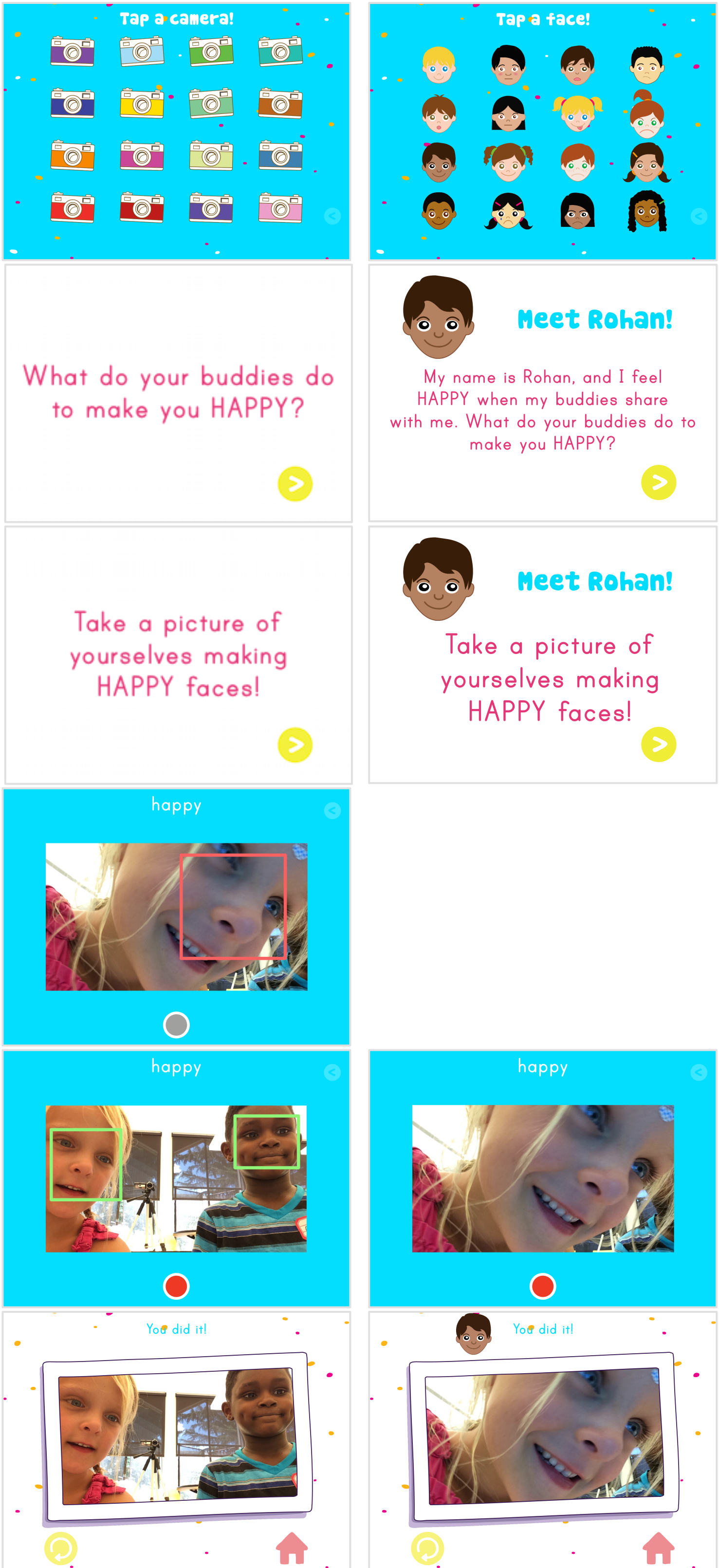
Table 1. Four study conditions for Incloodle.

Overall, the theoretical motivations for our design were grounded in research on the importance of social interactions and collaborative play for learning [39], the prosocial benefits of cooperative gaming [18], constructivist learning [31] (i.e., meaning making through "creating" photographs), and the positive effects of social relevancy (social contingency and social meaningfulness) in media on learning [11,20,25,26] (i.e., in our case, characters were socially relevant to the children).

Design

Prior research on facilitators and barriers of inclusive play [36] informed the design of Incloodle, shown in Figure 1. Incloodle can *facilitate* inclusive play by providing direct support for play interactions, increasing transparency, and focusing on child interests and strengths by explicitly referencing personal social and emotional content. The fact that the application asks the children to talk about their wants, needs, and interests while taking pictures of themselves allows the children to demonstrate their understanding of different emotions and also share a silly, face-making experience. The open-endedness of the questions and prompts allows it to be adjusted to any pair that plays with the application. Incloodle also provides embedded support (i.e., ways for children to learn through experience as opposed to being taught concepts explicitly) for turn-taking and cooperation in gameplay and in picture-taking.

Incloodle can *lower barriers* to inclusive play by enabling playmates and their caregivers to learn about the children's wants and needs through the questions and prompts. For example, by hearing the children discuss what they might want when they are upset (as prompted by Incloodle), caregivers may better know how to support a child in times of need, away from our application. This allows the children and adults to be more familiar with each other. When the children learn about each other's similarities and differences during gameplay, it provides an opportunity for them to increase positive attitudes about each other and for people who are different than themselves. Finally, Incloodle is not a solitary application. Instead, it is cooperative and social. The questions can generate discussion; the picture-taking is a shared experience, and the ability to immediately view the pictures taken allows for discussion and reflection.



Start screen: The children choose a topic from the start screen via a picture of a camera or a character's face, which are randomly ordered in a matrix in each launch. The application says, "Tap a camera," or "Tap a face."

Topic introduction & question prompt: The children are introduced to a topic about themselves or about social and emotional learning. They are asked a question about this topic.

Picture prompt: The children are prompted to take a picture that relates to the topic introduced previously. This involves making certain faces in the picture or taking a picture with specific objects.

Picture-taking/disabled shutter button: The children take a picture together using the iPad's front-facing camera. Here the shutter button is disabled because both children's faces are not recognized by the application.

Picture-taking/Enabled shutter button: The children take a picture together. Here the shutter button is enabled; on the left, this is because both faces are recognized by the application. On the right, there is no enforcement, so the shutter button is always enabled.

Review of picture: The application says, "You did it!" and shows the picture taken. Children can then choose to retake the picture or go back to the start screen. The completed topic no longer appears on the start screen.

Figure 1. Incloodle system screenshots. *Left column:* Condition 2: technology-enforced cooperation + basic prompting. *Right column:* Condition 3: no technology-enforced cooperation + character-based prompting. Please see the video figure to view the interaction flow for Conditions 2 and 3. (Artwork created and edited by Lucas Colusso. Original character images from sweetclipart.com.)

Figure 1 shows the basic design of Incloodle. (See video figure to view the interaction flow.) Audio accompanies all text in the app to remove the need for reading literacy. Additionally, the audio prompts repeat if there is no app activity for 30 seconds. Buttons wiggle if they are not tapped to provide clues about interaction capabilities. The four versions of Incloodle vary in terms of technology-enforced cooperation and type of prompting (Table 1).

Tech-Enforced vs. No Tech-Enforced Cooperation

Children are prompted to take a picture together by making certain faces or with a particular object. In the version with technology-enforced cooperation, the application performs face recognition. When zero or one face is recognized, the camera shutter button is disabled. When one face is recognized, a red box is shown around the face. If a child taps the disabled shutter button, the application says, “Make sure both buddies are in the picture.” When two faces are recognized, there are green boxes around each face and the shutter button is enabled. When there is no technology-enforced cooperation, the shutter button is always enabled, and there are no boxes around the players’ faces.

Prompting: Basic vs. Character-Based

How the topics are presented to the children depends on whether or not there is character-based prompting. During the basic prompting condition, the children choose from a matrix of cameras, and the topics are presented through text and audio with a female voice. The children are asked a question and prompted to take a picture, either making a certain face or with specific objects (e.g., a block, a picture of a circle). For example, “What makes you feel frustrated? Take a picture of yourselves making frustrated faces!” After the children take the picture, the picture is shown; the voice says, “You did it!” and gives directions on how to retake the picture or move on. With character-based prompting, the children choose from a matrix of character faces. They meet a character who tells the children an anecdote about himself or herself that relates to the picture-taking prompt via text and audio. For example, character Mia says, “My name is Mia, and I’m working on using my words instead of hitting or biting. When I have a hard time using my words, I feel frustrated.” The remainder of the application is the same as with basic prompting; however, the audio is spoken in the voice of the character; the character’s face is on all of the screens; and the character says, “Thanks for sharing with me,” after he or she announces, “You did it!”

METHODS

We carried out a mixed-methods 2x2 within-subjects study. The four conditions varied in whether there was technology-enforced cooperation (i.e., requiring that both children’s faces must be in the picture) and in the type of prompting the app provided (basic vs. character-based) (Table 1). We used a 4x4 Latin Square design to counterbalance the order of the conditions for the eight study sessions. We randomly assigned each condition order to two study sessions. However, due to cancellations (covered in the section below), we did not have a perfectly balanced Latin Square.

Pair	Diagnosis	Gender	Age	Rising grade*
1	Sensory perception disorder	Male	5y0m	K
	Neurotypical	Male	4y11m	K
2	High-functioning autism	Male	6y8m	1
	Neurotypical	Male	7y0m	1
3	High-functioning autism	Female	7y4m	2
	Neurotypical	Female	6y10m	2
4	Anxiety	Female	7y5m	2
	Neurotypical	Female	6y3m	1
5	Developmental disability	Male	6y1m	1
	Neurotypical	Female	6y0m	K
6	Anxiety	Male	6y0m	1
	Neurotypical	Female	5y8m	K
7	Sensory perception disorder	Male	5y5m	K
	Neurotypical	Female	5y6m	K
8	Developmental disability	Male	5y4m	K
	Neurotypical	Male	6y0m	1

Table 2. Participant pair information. *Rising grade indicates at what grade the child starts school in the following year.

Participants

We recruited a total of 20 unacquainted children, 10 of whom were neurodiverse and 10 of whom were neurotypical, using the University of Washington Communication Studies Participant Pool, which is a list of people in the community interested in participating in research studies. Our inclusion/exclusion criteria were verbal children between the ages of 4.5 and 7 years who were either neurodiverse or neurotypical, as reported by their parents. We also recruited one parent per child. For the study, we attempted to pair one neurodiverse child and one neurotypical child by closest age/rising grade, by gender, and by study time availability. However, time availability limited our ability to match all dyads by age/rising grade and gender.

Children were not only diverse within a pair but they were also diverse across pairs; not all neurotypical children were or are the same and not all neurodiverse children were or are the same. For our sample, being neurotypical did not necessarily imply that the child did not have his or her own social or emotional skills to work on. A child being diagnosed with a disability or disorder did not imply he or she had to work on social or emotional skills. Due to one cancellation and one mismatch where both children were neurodiverse, we had a total of 16 child participants (9 male, 7 female; mean age = 6 years, 1 month; SD = 9.4 months)

Figure 2. Experimental setup. We held study sessions in a design studio-based classroom at the University of Washington.

and 16 parent participants (all female). See Table 2 for the final information for the child pairings. All children had prior experience using touchscreen tablet or iPad applications. We compensated adult participants by giving them a US$25 Amazon gift card. We also gave the children the option to choose up to two small toys from a toy bin.

Setting

The children played in the middle of a classroom at a small table (Figure 2) while the parents sat and watched from the side of the room. One researcher sat in a chair next to the small table, and another researcher sat closer to the parents. There were tables set up in the corners of the room for between-condition child questions, and snacks and water were at the front of the room for whenever the participants needed them. Children used one iPad to play Incloodle and used a different iPad to take normal pictures before and after playing with Incloodle. Both iPads had large foam child-friendly cases with handles, and when in use, the iPad rested against a stand on the table (Figure 2). We video recorded the sessions with two cameras, in front and behind the children, and audiotaped the child interviews.

Procedure

The study took approximately one hour per session. Two researchers facilitated the session. One researcher briefed and debriefed the parents while the other researcher ran the study with the children. Both researchers asked the children questions following each condition.

At the beginning of the session, the children went to the center of the room to meet each other and play with blocks for about five minutes while their parents signed consent forms and were briefed on the study. After the children played with the blocks, the researcher explained to them what they would be doing. The children practiced using the iPad's front-facing camera to ensure that they understood how to take pictures. Before each condition, the researcher explained to the children that they needed to listen to the directions and take pictures together, and that their faces either did or did not have to be in the picture. While their parents observed, the children played with the iPad in a condition for between three and eight minutes. A prior power analysis revealed we could limit the sessions to three minutes each, which was ideal for our young participants. However, some children asked to play longer. After each condition, the two researchers asked the children a few questions, and they received a sticker. The parents also filled out short questionnaires about the play condition during this time. After all of the conditions were completed, the children were allowed to play with the iPad camera however they liked for five minutes.

Parent and Child Questions

On paper-based questionnaires, parents answered 5-point Likert-scale questions with optional explanations regarding their children's happiness and comfort and how pleased they were with their children's experiences during each condition. Because the majority of parents' qualitative answers only discussed how their children felt being with new people in a new environment, instead of their children's experiences playing a particular version of the application with their playmate like we intended, we did not include the quantitative responses in our discussion.

We also asked children a series of quantitative and qualitative questions about how much they enjoyed the game [35], how easy they thought the game was to play, if they would like to play the game at home/school, and how close they felt to their playmate [33]. However, there was significant acquiescence bias from the children, as they generally misunderstood the meaning of closeness in a relationship (i.e., believed it meant physical distance). Therefore, we only examined the limited qualitative responses from children.

Quantitative Coding and Analysis

Related to our adapted definition of inclusive play success, our two main quantitative dependent variables were child *affect* and *synchronous reciprocal interactions*. Koegel et al. [24] developed these measures for their study on play date interactions between children with autism and typically developing peers. *Affect* assesses children's comfort and happiness on a 6-point Likert scale (0-1 being negative, 2-3 being neutral, and 4-5 being positive). *Synchronous reciprocal interactions* addresses positive attitudes between children and development of play skills. These interactions occur when both children engage in social communicative behaviors (verbal initiations and responses, eye contact, facial expressions, and/or gestures) at the same time. Successfully taking a picture together did not count as a synchronous reciprocal interaction. The lead researcher divided the video recordings of each condition into 30 second intervals. Then, two coders rated the affect of each child during each interval. If a child pair was engaged in synchronous reciprocal interactions for the majority of the 30 seconds, the coder also marked the interval as "yes" (1) for synchronous reciprocal interactions; otherwise, the coder marked the interval as "no" (0).

The two coders independently coded 20% of the recorded data. For affect, Cohen's κ was 0.819. For synchronous reciprocal interactions, Cohen's κ was 0.890. Afterward, they discussed their disagreements, adjusted their mismatched codes, and then coded the remaining data separately, which was split evenly between them.

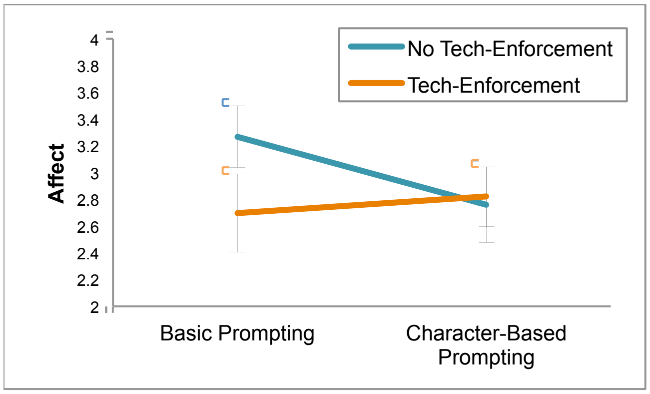


Figure 3. Average affect scores across participants over time. (0-1: negative, 2-3: neutral, and 4-5: positive).

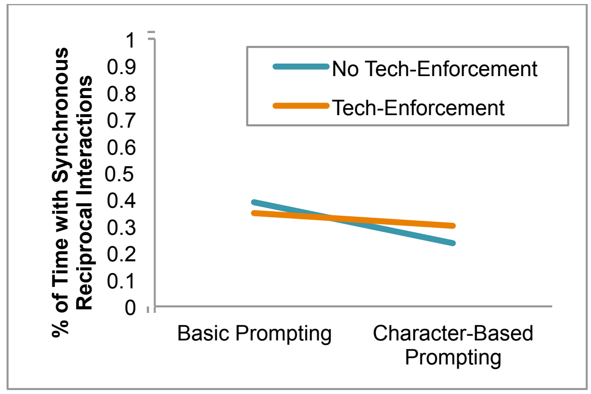


Figure 4. Percent of session time with synchronous reciprocal interactions across dyads. Higher value indicates more synchronous reciprocal interactions during play.

We ran a Repeated-Measures ANCOVA with neurodiversity (specified as yes/no) as a covariate to analyze the main effects of tech-enforcement and prompting on child affect. Because we used a Latin Square design, we could not analyze the interaction effect. Next, since the synchronous reciprocal interactions measure is categorical (yes/no), we could not analyze these results using a general linear model. However, compressing the data into a frequency (the percentage of time synchronous reciprocal interactions occurred in each condition) leads to eight data points per condition (i.e., one frequency per pair), which we analyzed using an ANOVA. Again, we could not analyze the interaction effect due to the Latin Square design.

Qualitative Coding and Analysis

We also aimed to understand qualitative differences in play based on the varying conditions and/or themes regarding play based on other static design features. Two researchers annotated all the videos with descriptive notes. We took a joint inductive/deductive approach to coding and performed open coding on annotations, iterating on loose codes with more specific codes as we iterated through data.

RESULTS

Effects of Tech-Enforcement on Inclusive Play

Technologically enforcing joint picture-taking changed play between the children in meaningful ways. There was a significant main effect of enforcement type on affect, $F(3, 12) = 5.85$, $p = 0.012$, $\eta^2 = 0.84$, $1- \beta = 0.91$, such that the children had more positive affect when there was no technology-enforcement compared to when there was technology-enforcement (Figure 3). There was not a significant main effect of enforcement type on the frequency of synchronous reciprocal interactions between conditions, $F(3, 4) = 0.047$, $p = 0.83$, $\eta^2 = 0.007$, $1- \beta = 0.054$. There were not major differences in the percentage of time with synchronous reciprocal interactions between the tech-enforcement (M = 32.6%; SD = 27.1%) and no tech-enforcement conditions (M = 31.2%; SD = 27.1%), but there was extremely high variation among the dyads in both cases. Figure 4 shows the average percentage of 30-second intervals with synchronous reciprocal interactions.

By design, technology-enforcement via face recognition ensured both children's faces were in the picture, so most cooperated with picture-taking in this condition. However, being coerced to take the picture together when they may not have wanted to, either because they would have rather played separately or because they would have rather explored taking pictures of other things, may have led to these differences in affect.

The fact that some pairs needed enforcement to cooperate became most evident when they were using Incloodle without enforcement. In these cases, the children used the iPad totally separately when there was no tech-enforced cooperation. Either each child took turns holding the iPad to himself or herself, or one child dominated picture-taking until the other child disengaged. For Pair 1, each child held the iPad in his lap at different times and played completely separately. When the neurodiverse child in this pair did not get a turn, he asked the researcher for help. In Pair 5, the neurotypical child dominated picture-taking by only including her own face in the pictures until the neurodiverse child asked the researcher for help as well.

Not having tech-enforcement caused a significant problem in Pair 3 when the neurotypical child took a picture of herself with a block while her neurodiverse playmate was still searching for one. After being left out, the child cried and hid under a table. Although the researchers and parents intervened and restored the game to allow the girls to retake the same picture together, it was not enough to improve this child's experience. She explained later she hated this version of Incloodle because she "missed the picture." Thus, tech-enforcement largely helped pairs who had trouble cooperating and being patient with each other. For instance, when Incloodle had tech-enforcement, rather than leaving her playmate out, the neurotypical child of Pair 3 helped the neurodiverse child move her face into the frame so that it could be recognized.

However, there were some instances in which tech-enforcement hindered the children's experiences, especially for the pairs who did not need face recognition to ensure cooperation. For these pairs, enforcement limited their exploration. We did not initially expect children would have so much fun purposefully not following the prompts of the application, but it later became clear how silly and fun it was to break the rules by disregarding the prompts. Without face recognition, some children realized they could take pictures without their bodies or faces. Pair 2 negotiated these plans: "No bodies this time, okay?" said the neurodiverse child to his playmate. The playmates in Pair 2 also worked together to position objects and their bodies in front of the camera without their faces. The neurotypical child brought his shirt close to the camera and said "Now," and the neurodiverse child tapped the shutter button. For Pair 7, the neurotypical child verbally and physically helped the neurodiverse child position his block in front of the camera while he stood behind the iPad. The children laughed and smiled in these instances.

Finally, technologically enforcing cooperation caused issues for one dyad, Pair 1, in another way we did not expect. The neurotypical child of Pair 1 realized he could trick his playmate by keeping his face within the frame to keep the camera shutter button enabled; then, right before his playmate tapped the button, he would move his face out of the view, disabling the shutter button. While the neurotypical child was having fun breaking the rules and teasing his playmate, the neurodiverse child understandably became incredibly frustrated. This child's mother mentioned, "[My child] is very interested in rule following and being fair/sharing. He liked [this version] because there were clearer rules…but was frustrated that his buddy [was not] following them." Later on she said, "He's irritated. He would really enjoy this game if his buddy cooperated," and, "I'm getting irritated too."

Effect of Prompting on Inclusive Play

The involvement of a character in the prompts did not considerably change children's experiences with the application. There was no significant main effect of prompt type on affect, $F(3, 12) = 0.202$, $p = 0.98$, $\eta^2 = 0.15$, $1- \beta = 0.078$ (Figure 3). There was also no main effect of prompting type on the frequency of synchronous reciprocal interactions between conditions, $F(3, 4) = 2.36$, $p = 0.170$, $\eta^2 = 0.250$, $1- \beta = 0.263$. However, there was a larger difference in the percentages of time with synchronous reciprocal interactions between prompting conditions than there was between enforcement conditions (Figure 4). Dyads were engaged in synchronous reciprocal interactions for 36.9% of the time on average during basic prompting conditions (SD = 28.1%) compared to 26.9% of the time on average during character-prompting conditions (SD = 25.1%). However, again, there was extreme variation across the pairs. Additionally, the children had to listen, and thus *not* interact with each other, for longer amounts of time during the character-based prompting conditions, since there was more text/audio for the character to say. This could have skewed the results to be biased toward basic prompting in this case.

Qualitatively, our results reflected this lack of effect of prompting on the children's experiences. In a few cases, a child mentioned the name of a character. For example, the neurotypical child in Pair 6 repeated the name "Alexis" after meeting the Alexis character, and the neurotypical child in Pair 1 repeated the name "Tobin" (AKA Toby) after meeting the Toby character. This same child also asked, "[S]he bites? [S]he bites?" after character Mia said she was working on using her words instead of hitting or biting. Both children in Pair 6 made sounds (i.e., "Ooooh!") when hearing about this specific anecdote about Mia too.

Moreover, the faces on the main screen that demonstrated different emotions appeared to be more memorable than the cameras, as they enabled children to choose new topics that they remembered they had not completed in the prior character condition. Some children verbally associated the faces with the characters' names and the emotions, demonstrating both memory skills and social and emotional awareness. Nevertheless, the neurodiverse child in Pair 4 said she liked the fact that it was more of a surprise for which prompt they would get with the cameras on the main screen.

Other General Findings

In addition to the hypothesized features, Incloodle had other design features that supported children with inclusive play.

Overall, it appeared that the topic had a greater impact on whether or not the children answered the questions prompted by Incloodle. For instance, the majority of the children answered what their favorite colors were. This makes sense, considering answering a question about your favorite color or shape is easier and makes a person less vulnerable than answering questions like, "What makes you feel sad?"

An embedded support within the game was button tapping, which provided an opportunity for the children to practice turn-taking, although some pairs were more successful at this than others. In some cases, the more play-dominant child, who we determined through qualitative analysis as regulating, controlling, or directing the play (in 5/8 pairs, this was the neurotypical child), became impatient with his or her playmate and took complete control of tapping buttons. In Pair 7, the neurotypical child repeatedly tapped the redo button when the neurodiverse child wanted to move onto a new topic. The playmates in Pair 5 rushed their hands to the iPad screen to get to the buttons first, going as far as to hovering their hands over the screen so that they would be ready to tap first when buttons appeared. The neurotypical child's mother in Pair 5 mentioned, "[My child] wasn't sharing well… She kept pushing the picture button." She went on to ask, "[Is] a sharing component possible?"

However, with other dyads, the embedded support for turn-taking led to cooperation between the two playmates. The neurotypical playmate in Pair 3 regulated turn-taking by explaining when it was her turn ("my turn") and when it was her playmates ("your turn"). Moreover, the children in

Pair 8 did not have trouble sharing and also self-regulated without verbal interactions when tapping buttons.

Picture-taking also enabled cooperation between playmates and for the play-dominant child to be a peer support for his or her playmate. Prompting the children to take pictures with objects led to negotiation and cooperation. Children often shared blocks and other objects with each other. In some instances, holding an object made sure that both children had to cooperate to take a picture. For example, in Pair 6, the neurotypical child held a block in front of the camera while the neurodiverse child tapped the shutter button.

Prompting the children to make different faces for the pictures not only led them to consider and model what emotions look like, but it also allowed them to connect with their playmates and be peer models. The children often copied each other's positions and faces when taking the pictures (Figure 5). The children in Pair 4 both crossed their arms in most of the angry and frustrated pictures as initiated by the neurotypical playmate. Pair 4 laughed as they made silly faces and did not follow the directions by making funny and happy faces for the sad and embarrassed prompts.

The immediate review of pictures acted as a way to reflect, often with smiles and laughter, on the children's prior interaction with the game and each other. "It looks like I have a beard," said the neurodiverse child of Pair 4 while both children laughed. The neurodiverse child in Pair 2 said, "Look at us [and] our faces," and his playmate pointed at the picture and said, "That's mine." Pair 8 smiled at their pictures and each other after looking at their pictures too.

DISCUSSION

No Tech-Enforced vs. Tech-Enforced Cooperation

Our first research question (RQ1) asked: does technology-enforced cooperation lead to more successful inclusive play compared to no technological enforcement? While we posited that (H1) tech-enforcement would lead to more successful inclusive play, the answer is not a clear yes or no. Technology-enforced cooperation changed the ways in which children interacted with our application and with each other. Generally, we found that technology-enforcement helped children take pictures together when they had a difficult time cooperating without enforcement. Yet, for the times when pairs did not need enforcement to cooperate, they did not need the enforced rules too. In addition, there were tensions between these rules and free play. Both findings most likely explain why children had more positive affect in the no technology-enforcement conditions and no differences in synchronous reciprocal interactions. For instances in which the children did not need scaffolding, the enforcement limited their creativity and the non-enforcement version of Incloodle was more fun to play. For those who had trouble cooperating, the requirement that they had to cooperate, without explaining why it was important, made the experience less fun. Affect and engagement with the application may have directly influenced

Figure 5. Neurodiverse child copying her playmate's poses.

synchronous reciprocal interactions; when the children were not having as much fun or not using Incloodle together, they were not interacting with each other in the same way.

Most importantly, understanding how children can use or misuse these mechanisms of enforcement can help designers create applications for inclusive play. Piper et al. [32] reported on the challenges that technologically enforcing turn-taking caused in one of the groups when a child consistently refused to cooperate with the enforced rules and delayed gameplay. On the other hand, Boyd et al. [7] described how one child in a dyad consistently dominated turn-taking when it was not enforced. Related to both of these issues, Boyd et al. [7] suggest that technology or a human facilitator must help enforce turn-taking, yet they highlight that it is still an open question for designers on how to facilitate cooperative interactions "without overly prescribing them." We also lean toward a middle ground.

Ultimately, technologically enforcing cooperation *alone* is not enough to wholly support young children with inclusive play. In our case, being more transparent throughout the play about why the enforcement is important, in both picture-taking and turn-taking, i.e., to help the playmates cooperate and play together, would likely help children collaborate and learn play skills. Instead of being dichotomous and either enforcing or not enforcing cooperation, the application could be more adaptive. It should explain why cooperation is important to contextualize enforcement. For instance, when two faces are not recognized, the application could suggest the playmates work together in the next picture. Giving the ability of assisting adults to toggle on and off enforcement could also be more adaptive to the abilities and needs of pairs of children as well.

Basic vs. Character-Based Prompting

Our second research question (RQ2) asked: does character-based prompting lead to more successful inclusive play than more basic prompting techniques? The involvement of characters in the application did not have substantial quantitative or qualitative effects on inclusive play between the dyads of children in our study. While we expected (H2) that having a human character who explained some aspects of an emotion and his or her experience with that emotion through plain text, spoken words, and a static image would lead to more positive interactions (like talking, answering questions, play cooperation, or other connections between the children), this was not the case. It appears that there were slightly more synchronous reciprocal reactions for basic prompting; however, this may be due to the fact that children spent less time facing and listening to the characters in the basic prompting condition, so they had more opportunities to interact proportionally. In response, we recommend keeping character dialog shorter to increase opportunities for children to interact with each other.

Based on the related work, we still believe incorporating characters into interactive technology can support children with inclusive play, although it could be optional if resources are constrained. We posit more complex ways that characters could make a positive effect on children that might also overpower the particulars of social and emotional learning content (i.e., the fact that children answered less personal questions, as in what their favorite color was as opposed to what makes them feel scared). The inclusion of popular or familiar characters, deeper stories behind the characters' experiences, accompanying animated video, interactive story elements, and/or interactive characters will likely lead to more positive affect and stronger connections between children. Additionally, based on the fact that some children recognized the character faces or reacted to their stories, it is possible that longer-term usage with the application could lead to observable social and emotional learning, including an appreciation of the characters and their stories and a greater understanding of particular emotions.

Picture-Taking

Our study also revealed the potential for interactive picture-taking of objects and faces as a successful way to facilitate inclusive play. There are various social and emotional training applications that promote rote learning of what emotions look like (e.g., [3,6,37]). However, for inclusive play, we believe a system that is more interactive is appropriate. Byrnes and Wasik [10] explain it is helpful for young children to have "actual pictures of themselves demonstrating different emotions and feelings so that they can think and talk about feelings in relation to themselves and their own experiences." Thus, to be more interactive, inclusive social and emotional learning applications can have the option to use players' own faces. Doing this with a playmate effectively allows for collaboration and joint reflection too.

Limitations & Future Work

There are several limitations in this work. First, we had an uneven Latin Square, so the order of conditions was not perfectly balanced in our sample. Next, unfortunately we did not get reports on the neurotypical children's prior experiences with children with disabilities or any measure of their level of empathy or understanding of disability, which may have acted as a confound. Furthermore, although it allowed us to control for differences between the participant pairs, the limited adult intervention in the study and the fact that the children were complete strangers may not be as ecologically valid as having children who know each other play together in a natural setting. Finally, because the lab study session durations were short, we were not able to test longer-term impacts on children's behavior, social and emotional learning, and/or changes in children's acceptance of diverse individuals, including those with disabilities.

Future work entails examining our data in alternate ways to understand different social and emotional effects. For example, we could analyze the data for task completion, pairs' mimicry in the photos, and engagement in the task. Other future work involves iterating on the design of Incloodle based on our lab study results. We also plan to support parents and caregivers with Incloodle such that they can use the application to talk to their children about what they are learning in order to promote inclusion. Finally, we will run a long-term study where young neurotypical and neurodiverse children can play with Incloodle at home. This will allow us to analyze the children's learning, identification with characters, empathy development, and changes in opinions about their peers over time.

CONCLUSION

We aimed to understand the role of interactive technology in supporting children with mixed cognitive abilities. We asked specifically whether certain design features result in interactions between children that are indicative of successful inclusive play more than others. Our study revealed the ways that using technology to enforce cooperation changed the inclusive play experiences of children with differing needs. While we investigated enforcing joint picture-taking through face recognition, enforcing turn-taking or other modes of interaction on a small tablet may be more challenging. There is room for exploration to understand how different types of joint interactions might be mediated with enforcement, for instance turn-taking with face recognition (i.e., to determine who is holding the device) or joint audio recording (e.g., singing, answering questions) with speaker recognition [23], and how these different kinds of tech-enforcement affect inclusive play. While we did not find substantial effects of character-based prompts on children's experiences, we believe there is more work to do to understand how characters and narratives within technology can facilitate inclusive play. Based on this empirical evaluation, our future work involves iterating on Incloodle's design such that it can better adapt to the needs and abilities of all children. Incloodle can support children more inclusively with options to moderate enforcement, the involvement of more interactive story-elements, and more transparency regarding disability and the importance of cooperation.

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