Combining Speech Intervention and Cooperative Game Design for Children with ASD

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ABSTRACT

The design of the digital game *Feeling Factory* explores how to combine systematic Autism intervention structures with play-centric game design in the area of prosodic speech therapy. The goal of the game is to improve emotional and grammatical, productive and receptive prosody in high-functioning children with ASD. *Feeling Factory* uses a two-player cooperative game that allows children with ASD to practice prosody with another person mediated by a game. This structure motivates practice of speech skills within the context of a live conversation partner, a key challenge for Autism intervention, and combines interventionist exercise with digitally mediated gameplay. A user study was conducted consisting of semi-structured interviews with a panel of seven experts and five children with ASD to help determine the potential benefits of this design model. The study resulted in a high recommendation from both groups, especially regarding the two-player cooperative game mechanics.

Keywords

Cooperative Games; Autism; Prosody; Interventions; Case study

INTRODUCTION

The rates of Autism Spectrum Disorder (ASD) diagnosis in children have risen dramatically in recent years (Sansosti and Powell-Smith 2008). Abnormalities in communication are a defining feature of ASD, and problems with prosodic features are among the most common of these abnormalities likely to contribute to lesser social and communicative competence in high functioning children with ASD (Ploog et al. 2009). However, treatment of prosody for children with ASD is a particularly difficult area. Prosody is defined as the patterns of stress and intonation in language, contributing to intonation, tone, stress, and rhythm. It is how we speak, rather than the content and how words are put together via grammar. Prosody conveys information such as affective state, grammatical content (such as whether

an utterance is a question or statement), and other nuanced information, such as irony, sarcasm, emphasis, contrast, and focus. Prosody exists in both the domains of expressive and receptive language, or aspects of speaking and listening, respectively. Despite a call from the National Institutes of Health (NIH) indicating the importance of this area (Diehl and Paul 2009), very few interventions current exist for prosody treatment.

Although our target users' affinity to video games indicate that they can potentially improve the patients' motivation to participate in prosodic intervention, incorporating game mechanics with established intervention models poses considerable challenges. This is because the former emphasizes factors such as "fun," engagement, and flow (Csikszentmihalyi and Csikzentmihaly 1991) whereas the latter prioritizes structured repetition. As designers of *Feeling Factory*, we have to constantly balance these sometimes conflicting two design criteria. This paper reports our approach to address this key open question for educational games and other serious games at large.

Our solution is *Feeling Factory*, a two-player cooperative game that integrates narrative into the experience of practicing speech skills with another person. It is designed to increase motivation through gameplay and narrative, by using game mechanics that provide a sense of achievement and reward through player feedback (Ryan and Deci 2000). Most notably, our design encourages children with ASD to practice communicating with another person with a digital game as a mediator, which is used to encourage engagement with the conversation practice.

Our design is evaluated through a user study consisting of an expert panel and case studies with five children with ASD. Our study yielded positive results, with all participants able to play through the game and also giving it a recommendation, especially the two-player cooperative game mechanics. We believe the core mechanics of two-player cooperation has the potential of being useful for a wider range of games designed for players with ASD.

BACKGROUND
Here we discuss the current state of ASD interventions especially for prosody and existing digital games for speech.

ASD and Prosody Interventions
The most widely used treatment method used for ASD intervention today is Applied Behavior Analysis (ABA). A wide array of studies suggests it is the only currently known effective method of treatment (Foxx 2008). We designed the game *Feeling Factory* using ABA guidelines for design methodology including focusing on generalization and social and communication skills. We include systematic, tailored objectives, as well as instruction to be conducted in frequent, brief instructional sessions. We also include specialized interventions, with emphasis on development of spontaneous social communication skills. ABA is partially based on operant and respondent conditioning, so the use of exercise repetition for target skills and the use of external rewards for correct use of target behaviors are important (Cooper et al. 2007), and are reflected in the structure of *Feeling Factory*.

Another intervention model for ASD is Developmental, Individual-difference, Relationship-based (DIR) Floortime. The core tenants of DIR Floortime aim to build foundations for development (Pajareya and Nopmaneejumruslers 2011), as opposed to focusing on resultant

behaviors as with ABA. The interventions are child-focused, and centralize play to tailor interventions to children and promote positive interactions. DIR is used in our design focusing on play, promoting positive interaction with the co-player, and building foundational speech skills.

Despite widely observed difficulties children with ASD tend to face with prosodic skills, prosodic ability and the source of the difficulties remain severely under-researched areas. Among the few existing interventions, they tend to focus primarily on the expressive (Peppé 2009). A treatment program such as the one designed by Bouglé may often involve explicit instruction exercise repetition (Bouglé et al. 1995). These exercises are sometimes accompanied by some kind of visual feedback such as the *IBM SpeechViewer*, as is used by Bouglé in some trials. In other interventions no visual feedback is given, instead using verbal feedback to tell the child when they have taken a correct action (Bouglé et al. 1995). While our design also includes visual feedback and exercise repetition, these strategies are incorporated in a structure that lets the child practice these with another person with the mediating encouragement of a digital game.

Overall findings on the ability of existing interventions to maintain skills over time are even more limited, and results have been mixed (Hargrove 2013). A further analysis of the literature by Hargrove suggests that naturalistic/holistic methods (such as DIR Floortime) have not yet been investigated sufficiently to be deemed viable or not viable. All of the studies in the literature and meta-analysis are explicit, discrete, and are based on repetitive exercises. The core action of *Feeling Factory* seeks to adopt a similar strategy of exercise repetition.

Existing Speech Games

Very few games have been developed for prosodic speech skills, but there are a few programs in current development. A recent computer program called Vocsyl is currently in development to help children visualize speech in order to facilitate combining syllables (Hailpern et al. 2010). Although Vocsyl has shown initial success in testing, it must be noted that as of yet, a pilot study has been published testing only two children with ASD, who were qualitatively evaluated to successfully use Vocsyl to successfully practice combining syllables within the program (Hailpern et al. 2012).

Similar to *Feeling Factory*, Vocsyl uses ABA techniques as a model, using systems like prompting children for attempts at answers and rewarding correct responses. However, Vocsyl is not currently complete as a game, and as such, the rewards are completely separate, such as handing the child food when correct responses are given. Also in contrast to our work with *Feeling Factory*, Vocsyl focuses on the mechanical aspects of speech and feedback rather than the context of conversation, which may be of particular importance for prosody disorders in ASD (McCann and Peppé 2003).

A few abstract visualizations of speech have been developed for speech and language pathology. Notable examples include the IBM SpeechViewer (Bernard-Opitz et al. 1999), the Conversation Clock (Bergstrom and Karahalios 2007), and the preliminary research into *sPeAK-MAN* (Tan et al. 2013). SpeechViewer uses speech recognition software to encourage vocalizations of target sounds such as difficult vowels or consonant clusters, and rep-

resents successes in an abstract manner by rewarding the player with simple animations. These animations are not realistically related to the sounds themselves (for instance, a snail climbing a slope a little more each time a correct sound is voiced) is not a representation of that sound. Other games developed using the SpeechViewer include the *Stepping Stones Game*, a program designed to help modify speaking rate by providing visual and auditory feedback on the user's speaking rate, articulation, and pause time (Thomas-Stonell and Dolman 1991).

The Conversation Clock represents the speech of a group in a very abstract way by assigning each participant a color and marking down vocalizations of each member of the group by color in lines that form a spiral. More recent vocalizations are shown on the outside of the spiral and louder vocalizations are longer lines. The Conversation Clock has been well received as an interesting and potentially useful tool for self-awareness based on study participant feedback, but also has the notable drawback of being distracting of the conversation at hand to some users.

The serious game *sPeaK-Man* is still in development and research and only includes a pilot study, but the concept is centrally based on the same premises being discussed here. The structure is a modification of *PAC-MAN* that converts the mechanic of finding power-ups to make the ghosts vulnerable instead of threats into a mechanic that has the player speak a word displayed over the ghost's head. The speech is processed through the Xbox Kinect microphone and Microsoft's speech recognition software (Tan et al. 2013). There is little data available for the game at present, but it adheres to the concept that the core mechanics of a serious game ought to be fun to provide internal motivation to the participants, and that the educational material should be centrally involved in the mechanics. All of these digital tools hold in common abstract visualizations of the user's speech that also encourage self-motivated behavior modification of the target type of speech. Each one is entertaining enough to encourage participants to continue to use the tool, and the use of the tools themselves involve building on speech skills by using visual media to increase the user's awareness of their own speech. We intend to develop a similarly effective game for the purpose of prosody training for children with ASD.

DESIGNING *FEELING FACTORY*

Built on guidelines from the Autism intervention models of ABA, DIR-Floortime and educational game design theories such as the ones developed by Gee (Gee 2007), we designed and developed *Feeling Factory*, a two-player game for iPad. Our goal is to create a product that is effective in teaching the target prosodic speech skills through engagement and generalizability, by combining traditional ASD intervention techniques with educational digital game design techniques. Since learning language skills in implicit ways may be impaired for children with ASD due to deficits that hinder engagement and generalization, focusing on maximizing engagement and generalization could be a key factor to making an effective teaching tool. *Feeling Factory* aims to balance the learning aspects of intervention with the "fun" of gameplay.

Its main feature is that it provides a mediated channel for children with Autism to practice the perception and production of prosody with another person in a narrative context. When one player takes the role of speaking with different emotions (e.g. happy, sad, surprised),

the other player takes the role listening and interpreting those emotions. Players trade roles throughout the game. This format means that while the interface for the game is digital, the main action of the game is speaking and listening with another person in a mediated way. Drawing inspiration from the successful multi-player game Space Team, *Feeling Factory* integrates the former's core mechanics with ABA and DIR-Floortime. It is designed to be played by a child with ASD ages 10 to 14 with difficulties with prosody, and a therapist or parent who can help facilitate meaningful gameplay.

Narrative Design

Studies have shown narrative context is important for increasing immersiveness and engagement in games, which in turn can lead to increased learning (Gee 2007). This is particularly true for speech, which is intrinsically contextual (Obleser 2014). As argued above, however, most of the games and interventions for speech do not provide this context, which leads to difficulty generalizing learned skills to real world use. In *Feeling Factory*, we designed a background story not only for engagement, but also to provide an additional external context for speaking and listening closely to expressive prosody.

The main narrative in our game is that the elves in the factory have spilled the emotion potions, making them express an extreme, single emotion. To help them, the inventor of these potions must figure out which emotion potion each of the elves is affected by. The story creates an external reason for speaking with expressive prosody and listening carefully to expressive prosody. This adds an overarching narrative motivation on top of typically occurring real-world conversational motivations.

Core Mechanics

To play *Feeling Factory*, the two players sit back to back, with separate iPads running two networked versions of the game. They cannot see each other's screen and can communicate primarily through voice. At a given time, one person plays the elf player character who speaks with an assigned emotion and the other the inventor player character, who tries to identify the elf character's emotional tone through listening carefully to her speech. The two players switch their roles after each level and need to collaborate in order to win the game. The game begins with a tutorial and is followed by a series of levels, comprised of 1) an emotional prosody puzzle section, 2) a grammatical prosody puzzle section, and 3) a prompt for semi-structured discussion time, in which players are encouraged to discuss difficulties encountered or skills learned.

Emotion Prosody Puzzles

In the *emotion prosody puzzle section*, the player in the role of the elf says target sentences with specified prosodic cues. This allows the elf player to practice expressive language, which is how to output language. The only way for the inventor player to figure out the right emotion or grammatical content to pick is to listen to the prosodic cues. On the screen, the character which the player is currently playing is shown in fully saturated colors whereas the other character is greyed out. Fig. 1 left displays the various ways the elf player is cued to say the target sentence ("I like making potions!") in a happy tone of voice: an emoticon, the expression on the elf's face, and the content of a thought bubble all cue the player that

Figure 1: Left: the players' screen in the role of the elf in an emotion prosody puzzle. Right: The players' screen in the role of the inventor.

the character is currently happy. These levels become increasingly difficult. As players progress, the game shows less and less explicit emotion cues in the semantic content of the sentences.

Fig. 1 right shows the inventor character's screen. Note that there are no emotional cues shown on the screen, so the prosody in the other player's voice is the only way to determine which is the correct answer. Optionally, the player in the elf role may complete an accompanying action with her iPad that helps enhance role-playing the emotion: shaking the iPad excitedly for happy, turning the iPad upside down for sadly, and holding the iPad still for surprised. Players switch roles between the elf speaker and the inventor listener each time after they succeed in their joint challenge of prosody communication.

The levels become increasingly difficult as players progress through the game. In the first level, the sentences the elf player uses explicitly say which emotion he should role-play. In the second, the semantic content is tied to the emotion, but not by saying the explicit name of the emotion. By the third level, the semantic content of the sentences is neutral, removing the extra content so that players can only correctly identify an answer by the way the sentence is said. For example, at first, the sentences the players are directed to say semantically cue the information as well (i.e. a happy emotion is cued explicitly by the sentence being, "I am happy I made this potion" and in the next level the sentence would become slightly more ambiguous as, "I like making potions" before progressing to a completely semantically neutral sentence such as, "I made this potion"). The first sets of levels offer only three choices of emotions: happy, sad, and surprised. With a level of increased difficulty, other emotions are added. A playthrough of the game may end at a different level, depending on the level of skill the child has acquired already, with the hope that practice will allow for progressing further into the game on replay.

Grammar Prosody Puzzles

In the grammar prosody puzzle section, players have to distinguish between question and statement prosody through a similar speech-and-listening mechanic. The player currently assigned the role of the elf (Fig. 2 right) is shown the word "ready" with either a question mark or a period, indicating that he or she should say the word "ready" with the indicated intonation of question or statement ("ready?" versus "ready."). The player currently as-
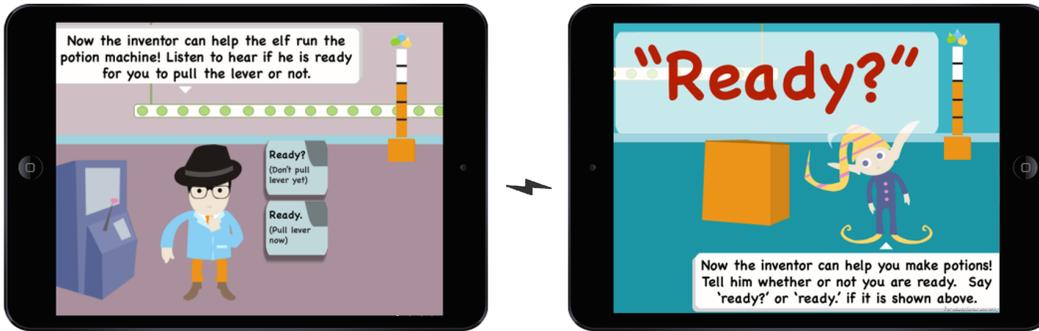
Figure 2: Left: The players' screen in the role of the inventor in a grammar prosody puzzle. Right: the players' screen in the role of the elf.

signed the role of the inventor (Fig. 2 left) then chooses between a button that matches the intonation spoken by the other player. As in the emotion prosody puzzle section, the two players switch roles after the completion of each puzzle.

At the conclusion of each section, the players are prompted for semi-structured discussion time to discuss together what they have just practiced and any difficulties that emerged with their care-givers.

Multisensory Stimuli: Visual and Sound Design

The visual design of *Feeling Factory* uses a 2D flat-design style. The objects are relatively large and there are few extraneous elements on the screen, making the images relatively simple to interpret. Visual focus is additionally directed to the elements the player should be focusing on the most through bright colors and arrow cues that point to the character being played. Other, more hand drawn styles were also developed for the game, but it was determined that the combination of flat-design style, colors, and large elements in the final design were the easiest to follow visually, to avoid any problems with visual perception that a child with ASD might experience (Moore and Taylor 2000).

Both sound and animated visuals are used as rewards. When players get answers right, progress bars fill and they are also rewarded with a star animation at the end of levels and an animation of the characters dancing at the end of the game. These animations are accompanied by simple sound cues. Contrastingly, incorrect answers show an image that simply explains in text what must be tried again, without as much visual or audio feedback. This design choice is meant to prevent children from purposefully making wrong choices if audio/visual feedback was interpreted as more rewarding than intended, following the findings of (Hiniker et al. 2013).

An Integrated Picture

Overall, the design of *Feeling Factory* combines elements of ABA interventions (Foxx 2008), DIR-Floortime (Pajareya and Nopmaneejumruslers 2011), and digital games in an attempt to maximize the engagement the player feels with the core mechanic of listening to and speaking with expressive prosody. The combination of techniques also centralizes the goal of generalization amongst different exemplars and ideally to the context of novel real

world scenarios as well. The following outlines how specific strategies are used from each of ABA, DIR-Floortime, and digital game design, largely following the theories of James Paul Gee (Gee 2008).

USER STUDY

A user study was designed to evaluate the potential use and implications of *Feeling Factory*. The study consists of qualitative evaluation by a panel of experts as well as case study testing with five children with ASD and difficulties with prosody.

Expert Panel

The expert panel consists of seven speech pathology experts in the greater Philadelphia area who all have experience in practice with clients with ASD and prosodic disorders.

Expert Panel Procedure

Expert panel members participated in a semi-structured interview with the researcher. The goal was to cover similar significant areas of evaluation with each panel member but also allow for variations in particular areas of response and interest. Panel members were given about 15 minutes to examine *Feeling Factory* on two iPads provided by the researcher, with the researcher present to answer questions. Then the interview was conducted for about 30 minutes with the game still accessible. The list of questions, listed in the Appendix below, includes questions encouraging discussion of the game's overall strengths and weaknesses, potential as a teaching tool, and specific questions about different aspects of the game, such as the story and artwork and the two player structure.

Expert Panel Results

Expert panel responses in semi-structured interviews about the feasibility of *Feeling Factory* were very positive. All of the panel members indicated interest in trying the game with students/clients and said they would recommend it to others. Panel members thought that *Feeling Factory* may be able to help children with ASD engage with the game enough to learn the target prosody content and practice enough to generalize the prosody skills to novel sentences and use in real world conversation.

Two-player Cooperative Structure

In particular, all panel members indicated very high interest in the two-player game structure. Many noted that their clients usually have a high interest in computers and games, but they sometimes get too focused on computers when they use them, isolating themselves. However, the panel members noted that with *Feeling Factory* being for two players, they would not face this problem, and could probably greatly increase client interest in speaking with another live person for practicing prosody.

Many noted the importance of practicing speech with another actual person rather than a computer program. They also noted that they do not know of much, if any, materials for practicing prosody that currently exist. The interest in games that the panel mentioned is reflective of the importance of including the elements of child-direction and play using a

"train and hope" generalization strategy, which are elements of DIR-Floortime that aid in motivation and generalization to context. The additional comment of the added benefit of the two-player in person speech system points to successful integration with an element of situated meaning from game design to additionally support generalization to context.

Core Mechanics and Training Modules

The panel members liked the overall structure and content of the gameplay. The core mechanics and training modules are reflective of the inclusion of the exercise repetition technique from ABA and the automation and repetition technique for ongoing learning from game design. These elements are meant to aid in generalization of the core activity to new exemplars (in this case, practicing speaking and listening to emotional and grammatical prosody). The panel's answers indicate that they believe the core mechanics of *Feeling Factory* may form successful exercises. Additionally, the semi-structured discussion section is designed to help boost players' ability to form relationships across the game system by critically discussing with their partner, helping to form an active, critical learning environment. All of the panel members indicated that they liked the inclusion of this element, and one suggested that this section could be improved by adding variations with different, very specific discussion suggestions (i.e., "Discuss together how you say something with a happy tone of voice").

All of the panel members liked the inclusion of the emotional prosody and grammatical question versus statement prosody levels. They all expressed liking the inclusion of practicing speaking and listening as well.

Other Elements

All panel members liked the aesthetics and story. Three panel members mentioned liking the simplicity of the graphics overall, and the large, easy to read font and icons as well. Four of the panel members liked that the story externalized the reason for needing to identify and express prosody, adding extra incentive to use prosody. The panel feedback suggests that the narrative design, visual and sound design were addressed successfully.

Expansion Suggestions

Several panel members had additional suggestions for expanding the game in the future. All of the panel members noted that they could use the game with clients with prosody difficulty besides those with high functioning ASD, including low-functioning ASD (as long as there was a basic ability to read), those with other developmental disorders, cerebral palsy, traumatic brain injury, Parkinson, strokes, stutter disorders, and more. To expand the game for a wider audience, in addition to the earlier suggestion about narration for the tutorial to lower the reading demand, one panel member suggested that by swapping out the artwork and story, she would be very interested in using it with her adult clients. One panel member also suggested adding female characters to extend the audience appeal more to female clients. Additionally, three of the panel members indicated an interest in trying out the game in a group setting, letting two clients try the game together. However, two of the other panel members said this would most likely be frustrating for clients, since they both need to use prosody correctly at the same time to advance (one speaking, and one listening),

and that the second player may need to facilitate the gameplay too much for that to work.

Additional suggestions for expanding the game included the possibility of adding more emotions, particularly anger. Many of the panel members noted that their clients with ASD often express anger inappropriately and do not use their voices to do so, and one mentioned that being able to receptively identify anger is very important. None of these panel members thought that using anger in the role-playing setting of the game would be upsetting for their clients. When the researcher additionally mentioned the possibility of expanding the emotion section by using degrees of emotions (very happy versus slightly happy), six of the panel members thought this would be too difficult while one said she would like to try it. Another panel member suggested the possibility of expanding the game to include sarcasm, pausing, and other grammatical intonation patterns.

Case Studies

Case studies were conducted with five students with ASD in the Philadelphia Area, all of them were identified with ASD and prosodic speech difficulties. The participants were recruited through their speech and language pathologists, providing a recruitment flyer to their parents.

Case Study Procedure

The study was conducted at participants' schools in each participant's speech classroom. All participants were students in public schools with mixed typical classroom settings and ASD support classrooms. Additionally, all students received speech and language pathology pull-out classes, and had been previously identified with prosodic speech difficulties by their speech and language pathology instructors. Background information on each participant was gathered from existing test scores and Individualized Education Plan files from the participants' schools.

Testing sessions were conducted with each student individually. Each student's speech and language pathology instructor was present for the testing sessions. Each testing session consisted of the student playing through *Feeling Factory* with the researcher on two iPads. Playthrough time lasted approximately 20-30 minutes. Following playthrough sessions, the researcher interviewed each student for approximately 20 minutes.

Case Study Results

Below we report results from the researcher's observation of how the participants interact with *Feeling Factory* and from post-interview about their experience.

Participant Observations

All participants were able to complete a playthrough of the entire game of *Feeling Factory* within the allotted 30 minutes, without additional help from the researcher. Overall results were very encouraging, with high levels of interest in the game expressed by all participants. Furthermore, the participants all seemed to improve in the target skills of the game over time.

For example, Participant "Cole" (male, age 12, 6th grade) was identified with ASD and prosodic speech difficulties. He speaks with "sing-song" voice, a typical prosody symptom

in which the patient repeats the same intonation pattern in every sentence and the pattern includes that each utterance ends in rising intonation. His speech and language pathologist noted that he has a high level of interest in computers and electronics. Cole's IEP lists his cognitive functioning as low/average and his reading comprehension as low/average. Listening comprehension of questions is listed as one of his primary learning goals in the IEP, making Cole a particularly good candidate for trying the receptive grammatical question versus statement section of *Feeling Factory*.

Cole was particularly good at the emotional language levels, both receptive and expressive, and was able to identify the emotions from the other player easily and speak with emotions easily, using correct intonation and not his typical 'sing-song' intonation. However, he had more difficulty with the grammatical question versus statement levels of the game. He got several of the answers wrong in the first level when he was receptively listening for question statement intonation, but improved over time. For expressive question versus statement intonation (saying 'ready?' versus 'ready.'), he needed demonstration for how to raise his intonation for a question several times. At first, he said all of the prompts the same way, with flat intonation. However, by the end, he was able to say the statement 'ready.' with fairly correct and improved prosody fairly consistently, and could sometimes say the question 'ready?' with correct and improved prosody. Cole's struggle in this particular area is not surprising given the particular difficulties in his IEP regarding question intonation, and it was encouraging to see some improvement even in the short testing session. It must also be noted that this section seemed a little frustrating to Cole and was indicated to be his least favorite part of the game.

Another example is Participant "Brad" (male, age 13, 6th grade). According to researcher observation, Brad speaks with a monotone voice and slightly elevated volume. His IEP lists his overall cognitive ability as about two years below average and his reading level as below average. His IEP includes improving pragmatics and expressive receptive and productive language use as goals. This makes Brad a great candidate for the use of *Feeling Factory*, to try both the receptive and productive language aspects of the game.

Brad was able to play the game fairly easily. He required a little bit of prompting to speak expressively, but required less prompting by the end of the game. Brad was better at the emotional prosody sections than the question versus statement prosody sections, and particularly struggled with expressive prosody when saying 'ready?' as a question versus 'ready.' as a statement. He would say the word with a monotone voice at first. After the researcher demonstrated the correct prosody multiple times, he was able to improve enough that the researcher could correctly identify which he intonation he was using. The researcher had to continue to demonstrate the question and statement prosody throughout, but less often over time.

"Daniel" was able to play the game fairly easily (male, age 10, 4th grade). According to researcher and speech and language pathologist observation, Daniel speaks with exaggerated affect. Daniel's IEP lists his academic level as below average in all areas, and his cognition as low as well. His IEP lists receptive and expressive language skills as skills to be focused on through a speech and language therapy program, as well as grammatical skills necessary for following directions.

Daniel needed repeated help to read the word 'emotion' but was able to understand the story according to his interview. Daniel was the only test subject who used the motions that accompany the emotions for a significant portion of his playthrough (about the first third of his play time). Daniel was able to very easily interpret and correctly answer the receptive/listening parts of the game. He required some researcher prompting (about 5 times) to repeat his reading with emotion during his expressive/speaking turns. He also required researcher modeling of how to say the question 'ready?' versus the statement 'ready.' but was able to do so with better intonation after modeling. He required less prompting over time, improving his ability to play by the end of the playthrough.

Interviews with Participants

All of the participants were able to correctly summarize the content of the story during the interview, mentioning that it was about elves, a factory, and potions that give different emotions. The participants were also able to figure out how to play (correctly speaking and pressing the buttons on their turns) without outside intervention from the researcher. All participants answered that it was easy rather than hard to figure out how to play the game. These results are indicative that all participants were able to read and understand the story and instructions. This is an encouraging indication of the usability of the game, particularly given that all of the participants have difficulties with reading comprehension and the target skill of expressive and/or receptive prosody.

The participants all responded that they enjoyed playing the game with another person, and would recommend it to a friend to play. When Brad answered, "Yeah, I wanna try it with my friends," his speech pathologist noted after the conclusion of the testing that she was surprised by this response, given that Brad is generally only interested in interacting with adults, but indicated he would like to try playing the game with a friend. The willingness to play with another person was also particularly encouraging for Andy (male, age 14, 7th grade), as his speech pathologist noted after testing that he does not usually like interacting with others and avoids interaction. The core mechanic of emotional prosody role-playing may have been especially successful with Cole, who noted it as his favorite part of the game, indicating an elevated level of engagement. The core mechanic of grammatical prosody may have been especially successful with Ethan (male, age 12, 6th grade), who has improving question skills as a goal in his IEP. Ethan not only listed the grammatical section as his favorite (referring to it as the "ready? ready. part"), but also answered the question "What could make the game better?" with "More of the ready? ready. ready? ready.!"

Overall, the participants all indicated that they liked playing the game, which suggests good levels of engagement and motivation in their gameplay experiences. Cole's favorite part was role-playing the different emotions in the elf role. Cole mentioned, "talking like the elves was fun! I liked saying things in the different voices." As mentioned above, Ethan's favorite part was the grammatical levels, which he indicated by saying, "I liked the ready? ready. part!" This is a particularly encouraging response, as it emphasizes enjoyment of the main gameplay mechanic of role-playing, even over external reward content. When asked about dislikes and changes they would like to make to the game, Brad initially did not think of anything but eventually said he disliked the story a little. Cole disliked the pictures a little and did not enjoy the grammar levels identifying questions versus statements. Andy did not

have any dislikes. Concerning the story, Andy, Cole, Daniel, and Ethan enjoyed it, Brad less so. Daniel (male, age 10, 4th grade) mentioned "I liked saving the elves. They were funny!" Brad indicated that this was because he dislikes elves. It is difficult to conclude if any changes should be made to the story or not based on this result, given that individual difference in theme preference like this seem likely to occur for any story theme selected. The participants were able to correctly comprehend the narrative as well.

DISCUSSION AND CONCLUSION

We believe that *Feeling Factory* was a successful game from a feasibility standpoint based on expert panel and case study participant interview results. The study described above was able to provide qualitative data indicating that the target demographic is able and excited to use *Feeling Factory*. The interviews with the expert panel indicate that the integration of traditional intervention techniques with game design techniques successfully provided a tool that the experts believe could be generalizable and engaging enough for children with ASD to benefit.

In particular, the two-player digital game model seems to have successfully solved many of the problems typically found in either traditional interventions, which tend to lack enough incentive for engagement, and digital games, which tend to cause problems getting participants to generalize to real world interactions with other people. The two-player digital game model instead harnesses interest in digital interfaces shown by participants along with interest in the audio-visual and narrative context to enhance engagement, while still requiring the person-to-person interaction essential to traditional interventions. This structure may be able to be used in many other educational games for both speech pathology and autism intervention.

Combining the exercise repetition of intervention combined with game structures focused on "fun" can be at odds with each other. Along with the two-player structure, narrative seems to have been a key feature for our design in combining these elements, allowing for the structured, ordered exercises to be presented in the fun context of a silly narrative that grants additional rewards beyond those normally found in a conversation.

In summary, the design of the digital game *Feeling Factory* explores how to combine systematic Autism intervention structure with play-centric game design in the area of prosodic speech therapy. The goal of the game is to improve emotional and grammatical, productive and receptive prosody in high-functioning children with ASD. *Feeling Factory* uses a two-player cooperative game that allows children with ASD to practice prosody with another person mediated by game. This structure motivates practice of speech skills within the context of a live conversation partner, a key challenge for Autism intervention, and combines interventionist exercise with digitally mediated gameplay. A user study was conducted consisting of semi-structured interviews with a panel of seven experts and five children with ASD to help determine the potential benefits of this design model. The study resulted in a high recommendation from both groups, especially regarding the two-player cooperative game mechanics.

Given the success of the user study, continued work in this area would benefit from efficacy studies of *Feeling Factory*. The existing study could benefit from additional participants

beyond the five case studies, with potential integration of a quantitative intervention acceptability measure. Based on the expert panel feedback, these studies could also be expanded to include other demographics beyond those with high-functioning ASD to any person with prosodic speech difficulties and the ability to read. Expanding the research beyond prosody could also be used to explore the potential of the two-player digital game model and integration of traditional intervention methodologies with game design techniques. These models could be used for studying the design of tools for ASD education that extend to many other skills and behaviors.

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APPENDIX: Semi-structured Interview Questions

Semi-structured interview questions for children and speech therapists:

Was there anything you liked about the game?

Was there anything you disliked about the game?

Was there anything you would change about the game?

What did you think about playing with another person?

What did you think about playing on an iPad?

What did you think about the animations if you got the answers right?

What did you think about the hints if you got the answers wrong?

What did you think about moving the iPad while you talked?

Did you like the look of the game?

Would you recommend the game to a friend?

What could make the game better?

Was it easy or hard to figure out how to play the game?

What do you think the story was about?

What did you think about the story?

Did you learn anything from the game? If yes, what did you learn?