Toward the Design of Enjoyable Games for Children with Fetal Alcohol Spectrum Disorder

Adrian L. Jessup Schneider[1], Kathy Keiver[2], Alison Pritchard Orr[2], James N. Reynolds[1], Neven Golubovich[1], T.C. Nicholas Graham[1]
[1]Queen's University, Kingston, ON, Canada, {adrian.schneider, jnr, 12ng2, nicholas.graham}@queensu.ca
[2]University of the Fraser Valley, Chilliwack & Abbotsford, BC, Canada, {alison.pritchardorr, kathy.keiver}@ufv.ca

ABSTRACT
Fetal Alcohol Spectrum Disorder (FASD) is a heterogeneous and complex set of disorders caused by prenatal alcohol exposure, estimated to affect 2-5% of the North American population. Deficits associated with FASD affect social skill development and executive function, including emotional regulation and impulse control. These deficits can increase the difficulty of playing digital games. While considerable research has been performed in understanding how to design games for people with neurodevelopmental disorders in general, there is little data on how to design engaging games for children with FASD. We conducted a ten-week in-school gaming trial with eleven elementary-aged children with diagnosed or suspected FASD. Participants enjoyed playing together and responded well to the in-game reward system, while some game elements caused unexpected frustration. Based on our observations, we advise that games for FASD be designed to have low cost of failure, avoid retracting options, account for taking breaks when needed, show progression in rewards, and enable cooperative play.

CCS CONCEPTS
• **Human-centered computing~Empirical studies in accessibility** • **Applied computing~Computer games**

Author Keywords
Fetal Alcohol Spectrum Disorder; FASD; Executive Function; Game Design; Social Play

INTRODUCTION
Fetal Alcohol Spectrum Disorder (FASD), caused by prenatal alcohol exposure, is a heterogeneous and complex set of disorders affecting an estimated 2-5% of the North American population [8]. Deficits associated with FASD affect social skill development and executive functions such as emotional regulation and impulse control [22], [23], [28].

These deficits can make many activities of daily living more difficult, including the play of digital games. However, there have been few studies concerned with how to design a game so it can be played and enjoyed by players with FASD. Games are an important pastime and cultural touchstone, and difficulty participating can exacerbate social isolation. Therefore, social equity demands that children with FASD be considered in the design of games.

CHI '20, April 25–30, 2020, Honolulu, HI, USA

ACM 978-1-4503-6708-0/20/04…$15.00
https://doi.org/10.1145/3313831.3376480

Additionally, games have been used in interventions intended to improve the symptoms of FASD. It is thus important to make them as fun and playable as possible, not only for equity's sake, but also to improve the effectiveness of game-based interventions for children with FASD.

To investigate, we observed the play of 11 children aged 7-11 years, either diagnosed with or suspected of having FASD, of the Liberi suite of seven multiplayer games [12]. The study involved 10 weeks of play in an elementary school setting. The children played together to allow for social interaction. Our research team included computer scientists, game designers, a neuroscientist specializing in FASD, and kinesiologists with extensive background in delivery of programming for children with FASD.

Our central research question is whether cognitive deficits associated with FASD negatively impact play of digital games, and if so, what lessons can be learned for the design of games for people with FASD and similar neurodevelopmental disorders. To this end, we performed thematic analysis of observations collected during the study, seeking aspects of the Liberi play sessions that were conspicuously positive, or negative, for our players.

Analysis gave rise to three themes: *frustration*, *rewards*, and *social interaction*. Our findings include that perceived unfairness in the games was a major trigger of emotional dysregulation; that standard gamification techniques were effective, despite difficulties experienced by children with FASD in planning and deferred gratification; and that children enthusiastically embraced collaborative group play, enabling the game to be a positive social experience.

In this paper, we review literature on FASD, and on game design for players with FASD and other cognitive disabilities. We then provide an overview of our research goals, describe the games study, explain the design of the study itself, and present the analysis and findings of our observations. Finally, we provide recommendations for the design of digital games for children with FASD.

BACKGROUND

Given the significant population of people with FASD, the fact that games are often used for interventions for FASD, and the social equity of games being available to all people with and without disabilities, it is important to understand how games can be effectively designed for play by people with FASD. However, there has been next to nothing published on designing fun games for children with FASD.

The following section is structured as follows: first, an introduction to FASD itself. Second, we describe four games designed for children with FASD, whose papers at least mention effective design. Third, we review game design guidelines for people with neurodevelopmental disorders in general; while these do not address FASD specifically, some aspects of these guidelines might be applicable to designing games for people with FASD.

Fetal Alcohol Spectrum Disorder (FASD)

FASD is the umbrella term for conditions caused by prenatal alcohol exposure [10], [28]. FASD is associated with a range of behavioural, cognitive, and physical deficits, impacting visual-spatial processing, attention, and fine and gross motor function [22]. FASD is also associated with social skill deficits, particularly social adjustment, appropriateness, and consideration of others [23], which Kodituwakku collectively terms *social adaptation* [19].

Another major impairment in FASD is executive function [20], [29]. Executive functions are cognitive abilities related to controlling and regulating other cognitive functions [7]. Deficits in executive function can cause problems with working memory, planning, impulse control and deferred gratification, and emotional regulation [28].

Deficits in executive function may also lead to children with FASD having difficulty recognizing consequences [23]. This can manifest in serious ways, including difficulties in the school system [23], high representation in the justice system [2], and poor eating behaviours [3].

To date, there has been limited study of how these deficits might impact the ability to play digital games. Deficits in visual-spatial processing can impact the ability to interpret complex visual displays [35]. Fine motor function is key to manipulating game controllers in fast-paced games [33]. Deficits in social adaptation can impact successful play of multiplayer games where cooperation is required [6]. Poor emotional regulation may lead to excessive frustration in response to set-backs in gameplay [37].

Games Designed for Children with FASD

To our knowledge, we are the first to investigate game design for people with FASD specifically for the sake of making better games. Most publications regarding games designed for people with neurodevelopmental disorders are concerned with the clinical effectiveness of game-based interventions, rather than how to design good games for their own sake. We now review examples of such games developed to improve capabilities of people with FASD.

Cognitive Carnival

Cognitive Carnival was designed to improve attention and working memory for children with FASD [26], [4]. The game presents challenges requiring sustained attention or working memory to play, allowing those abilities to be trained. The game was successful in engaging players, and showed positive clinical efficacy [26], [16]. The authors suggest three principles for designing games for people with FASD [4]:

- <u>Favour positive feedback over negative feedback</u> to minimize discouragement.
- <u>Increase engagement using intrinsic motivators</u>, such as in-game trophies.
- <u>Accommodate for physical limitations</u> with a simple control scheme.

The first two of these recommendations are targeted toward executive function deficits, particularly in emotional regulation and attention, while the third is intended to compensate for motor deficits.

Virtual Reality Fire Safety Training Game

This game was designed to teach young children with FASD about fire safety [25]. Players learn steps to take in the event of a home fire, by receiving instructions while navigating a virtual house. To adapt the game for players with FASD, the authors added more verbal instructions, and placed more visual cues in the virtual house to help offset the visual-spatial deficits associated with FASD.

CPAT Gamification

The Computerized Progressive Attentional Training (CPAT) is a set of four tasks for training attention [34]. Kerns *et al.* used gamification techniques to turn the CPAT into an attentional training game for children with FASD [15]. The system awards points to players who perform training tasks quickly or accurately. Points grant the player a real-world prize, such as a gift card. The authors report that the children enjoyed playing the game, and showed improvements in function.

Biofeedback Games for Children with FASD

Mandryk *et al.* used visual overlays to convert popular commercial games into biofeedback games for children with FASD [21]. The overlays obscure the players' display in response to emotional dysregulation. The use of this overlay technique allows a broad catalogue of commercial games to be easily adapted for biofeedback training.

Game Design for Other Neurodevelopmental Disorders

More design advice can be found by consulting the literature on design of games for cognitive disabilities in general. In this section, we include academic and industry sources that provide advice for game design for players with neurodevelopmental disorders, and that are wide in scope to provide a broad foundation. Such design literature is sparse: as Westin *et al.* note, "Unfortunately, the research literature on games and approaches for those with cognitive disabilities remains lacking." [39]

In their meta-review of design principles for games for people with cognitive disabilities [36], Tomé *et al.* suggest designing to reduce frustration for people with deficits in executive function affecting emotional regulation. For example, they recommend that designers avoid negative feedback to reduce frustration from mistakes being penalized, and emphasize positive feedback to increase motivation and satisfaction.

In their survey of game accessibility, Yuan *et al.* argue that cognitive disabilities primarily affect the players' ability to determine a response to the game's actions [41], and recommend games be designed accordingly to compensate. In particular, they advise reducing time constraints to give players more time to think, and reducing the range of stimuli and possible inputs to help players focus on choosing a course of action. These recommendations apply primarily to executive function deficits in attention and working memory, reducing cognitive load on players.

Similarly to FASD, Autism Spectrum Disorder (ASD) is associated with social, attentional, and working memory deficits [16]. In a review of serious game interventions for people with ASD, Whyte *et al.* [40] emphasize the value of social interaction in games, especially cooperatively, even for players with social deficits. They suggest imbuing long-term goals with social contexts—either through in-game storylines, or goals achievable by cooperating with peers—to increase engagement and encourage cooperative play.

In addition to these academic sources, there exist guidelines from industry sources for accessible game design, such as Includification [1] and the Game Accessibility Guidelines (GAG) [9]. Both these sources list design elements for accessibility, divided by disability category and by complexity of implementation. For example, the GAG provides "use simple clear language" as a basic cognitive guideline, while "avoid any sudden unexpected movement or events" is considered an advanced cognitive guideline.

Combined, these guidelines suggest ways to improve game accessibility for players with cognitive deficits. The studies examined cover a wide range of cognitive and intellectual disabilities, providing no guarantee that particular design guidelines are relevant to FASD in particular. These design guidelines also do not address all deficits associated with FASD, for example deficits in deferring gratification or planning, and there are few guidelines from a non-deficit-oriented paradigm. This highlights the importance of examining the play of games by people with FASD in hopes of better understanding how games should be designed for this specific population.

LIBERI

The game chosen for this study was Liberi, a suite of seven multiplayer games originally designed for children with Cerebral Palsy (CP) [12], but also extensively trialed with typically-developing children [13], [14], [30]. Liberi's design includes considerations for deficits common to both CP and FASD, including motor disabilities and visual-spatial deficits, allowing the game to already address some of the needs of this new population.

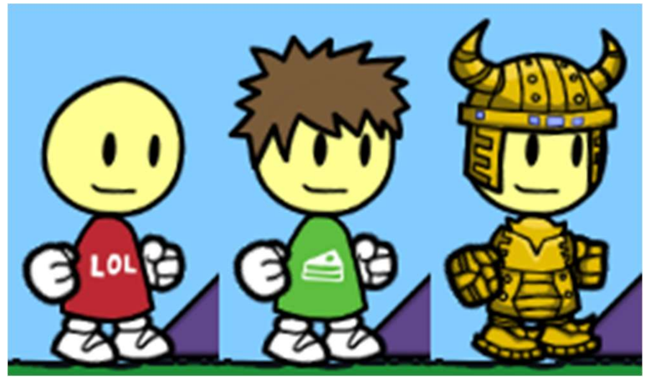

Figure 1: A player avatar wearing three different outfits, combined from items purchased in in-game stores using virtual coins earned through play of games. Left: default outfit. Centre: Hair and a new shirt. Right: A full set of golden armour.

For this study, Liberi offers the advantages not only of having been designed for players with neurodevelopmental disorders, but of being designed specifically to be fun to play. Liberi has been tested and found enjoyable by children across a range of populations, including typically-developing [13], CP [18], and now FASD. Despite being a "serious game," Liberi is fast-paced and action-oriented, and its focus on high-quality gameplay allows it to serve foremost as a game, not just as an exergame.

Liberi uses a stationary recumbent exercise bicycle and a standard wireless game controller for input. Players must pedal for their game avatar to move and to charge up their in-game abilities. The game controller is used for all other inputs, including selecting movement direction and activating game actions.

Liberi includes, as a motivation system, the ability to earn coins from games that can be spent on items at in-game shops. These include cosmetic items to alter the appearance of a player's avatar (Figure 1), as well as power-up items to give the player extra powers. Additionally, items have varying prices, with some "deluxe" items costing over ten times as much as cheaper items. This shopping system has, in previous studies, contributed to Liberi's success in motivating players [18], [13].

Liberi Minigames

The play of Liberi is structured as a set of seven minigames that can be entered from a central island area (Figure 2). The island contains the shops at which the game coins can be spent, and portals that lead to the individual minigames.

Four of the minigames are competitive, and three are cooperative. For example, *Gekku Race* is a racing game in which players play as "gekku" lizards, racing up a wall to be the first to the finish line. *Dino Dash* is a fast-paced collecting game, where players compete as dinosaurs taking eggs from a central nest to feed to their hatchlings. And in *Wiskin Defense,* players cooperate to defeat waves of approaching monsters, defending cute "wiskin" creatures.

Minigames are played in small groups. If fewer than four players join a game, then AI-controlled bots are used to make up the numbers.

STUDY CONTEXT AND DESIGN

We performed a 10-week study at an elementary school in which children with diagnosed or suspected FASD participated in a social exercise activity during school hours, using the existing Liberi exergame [12]. While Liberi is not representative of all possible styles of game, it does provide examples of several types of action games, including platformer, racing, fighting, sports, and defence styles of game, among others. Our focus is on how game mechanics and design elements can be affected by cognitive deficits, rather than on the specific interactions with Liberi's design alone. These observations are thus applicable to other games that employ the same or similar gameplay elements.

Our goal was to understand how children with FASD play digital games, and how this experience can inform the design of digital games for people with FASD and related neurodevelopmental disorders. To our knowledge, this is the first study to apply observational techniques to improve understanding of how to design games for children with FASD. The 10-week duration of the study also provides a richness of data, allowing any novelty effect to dissipate, and permitting players enough time to form social bonds and a comprehensive understanding of Liberi.

Participants

11 children were recruited from an elementary school (nine male, two female), ages 7-11 years. All the children were identified as having, or suspected of having, FASD. FASD is frequently not formally diagnosed, due to the need for proof of prenatal alcohol exposure, and the potential stigma associated with FASD [27]. Those children without a diagnosis had been noted on their official record as having behavioural or other issues consistent with FASD. The Resource Room teacher and principal of the elementary school have extensive experience working with children with FASD, and assisted with recruitment.

The participants were divided into two cohorts of five and six players, split evenly for demographic factors such as age and gender. Members of each cohort played together in a room provided by the school. Each player used a stationary recumbent exercise bicycle to provide the cycling input to the game, and a wireless game controller for other inputs (Figure 3). The game ran on a tablet computer mounted to a stand in front of the bike.

Session Structure

Sessions were conducted for ten weeks on Wednesday and Friday mornings, selected to cause minimum disruption to normal school activities. The school was closed on two

Figure 2: A player avatar in the Liberi island. On the right is a portal to the Wiskin Defense minigame. On the left is a weapon shop. In the centre is an upgrade shop.

Fridays, giving a total of 18 game sessions. Participants spent an average of 41 minutes per session playing Liberi.

Each week, the list of available minigames was changed, with four of the seven being available in any given week. This was intended to keep interest up by regularly providing new games and by creating anticipation when a game returned. Similarly, the in-game shops had new items added every one to two weeks.

Personnel and Reporting

Each participant was assigned a "buddy", a kinesiology student from a local university who helped the participants individually when needed. To ensure that buddies could fully focus their attention, each buddy was responsible for a single player, and buddies were not responsible for moderating the sessions overall. Buddy duties included answering questions from their participants, encouraging players to keep pedaling if motivation was flagging, being the first to offer help in case of emotional upset, and otherwise managing participant behaviour. Buddies also gathered data about their participant's experiences, using a standardized "passport" checklist. The passport questions were divided into two sections.

Figure 3: A participant playing Liberi on a tablet, on a stand in front of the player. The player is using a stationary exercise bike and handheld video game controller.

The first section of questions was posed, at the end of every game session, to the participants by the buddies:

- What was your favourite game? Why?
- What did you like?
- What didn't you like?

The second section was for buddies to note sentiments that the participants expressed spontaneously, as well as the buddies' own observations:

- What went well in today's session?
- Note any struggles that were experienced
- Other comments

Buddies were trained before the study on how to fill out passports, as well as given standardized examples of what to note. To ensure sufficient detail, the passports were examined by the researchers after each session, and any unclear notes were sent back to the buddies for clarification.

Finally, players answered the Self-reported Experiences of Activity Settings (SEAS) questionnaire [17], mid- and post-study, to assess enjoyment of the game. SEAS is a validated instrument designed for children with neurodevelopmental disorders, including FASD. Similarly to the Fun Toolkit [31], SEAS uses pictographs to convey concepts.

Method

The passports were analyzed using Braun and Clarke's reflexive thematic analysis process [5]. We employed an inductive approach, using the passports to direct our understanding of the buddies' observations and, therefore, the course of the sessions.

The reflexive thematic analysis process is innately constructivist, meaning that it acknowledges that the outcomes are inescapably influenced by the understanding and experiences of the analysts. The same data may provoke non-identical conclusions if analyzed by other researchers, but the conclusions we present reflect our goals and understanding regarding accessible game design.

The first three steps in the process—Familiarization with the Data, Coding, and Generating Initial Themes—were initially performed by one researcher. An open coding process was used, with numerous iterations. A second researcher collaborated in the refinement of codes, and in the Reviewing Themes and Defining and Naming Themes steps. Themes were created by observing which codes appeared to us to form intuitive groups of related ideas.

Some parts of the thematic analysis are supplemented by additional sources, for particular questions that could be addressed quantitatively. These sources are the aforementioned SEAS questionnaire, as well as data logs created by Liberi. For example, to better understand in-game shopping behaviour, we examined the logs that recorded actual purchases made. Similarly, we counted instances of each code across the study, to better understand what behaviours were more or less common.

ANALYSIS AND FINDINGS

This study was designed to observe the impact that the cognitive deficits associated with FASD had on playing a multiplayer game, and to infer from those observations what game design aspects were or were not suitable to this population. We interpreted these observations in the context of prior experience with Liberi in non-FASD populations.

In this section, we present the findings of our thematic analysis. For each theme, we describe the theme and its component codes, followed by the findings obtained through comparison to previous trials of Liberi.

Theme One: Frustration

The most negative theme we found during analysis was *frustration*. By frustration, we mean a statement or behaviour indicating distress or annoyance during the game session. On average, we noted frustration between five and six times per day, divided across the eleven players.

A player being frustrated by something in a game is not particularly surprising on its own. However, some instances of frustration were severe enough to cause disruptions to the game session. For example, in an early session, a player who was unhappy at losing a game shouted loudly for a prolonged time, ultimately leading to intervention by the school principal. On that occasion, and others, the upset player's buddy brought them out of the room to calm down, such as by going for a walk or simply sitting quietly. These instances of severe frustration we call <u>emotional outbursts</u>. The remaining incidents, ranging from passing frustration to just short of an emotional outburst, are <u>non-outbursts</u>.

This intensity of frustration was not seen in other populations playing Liberi, implying that it is related to FASD. We observed six distinct causes of frustration, which can be broadly divided between two subthemes: *design elements*, in which the design of Liberi or the study were problematic for our players; and *non-design causes* that are not part of the design and thus cannot be solved merely by redesign (Figure 4).

Design Elements

Several sources of frustration were related to the design of the Liberi games. The most common was <u>conflict with bots</u>, where players felt targeted by the bots used to fill out games with fewer than four human players. (Bots did not, in fact, target particular players.) One player, for example, left the room and "claimed that the Bots were cheating and only targeting her," as noted by her buddy.

Players were on occasion upset by the weekly rotation of available minigames, leading to <u>restricted availability</u> of games they wanted to play. For example, one player was "really frustrated that she could not play Gekku Race," after the game had rotated out.

Players at times expressed visible frustration, or specifically stated they were upset, due to <u>losing</u> a game. An example is when a player "had an outburst due to losing to [opponent] in Gekku Race (claimed [opponent] was cheating)." In practice, this only occurred in competitive games, never cooperative games.

The final source of frustration from design elements was accidental purchases, caused by the lack of a refund option for shop purchases. This led to problems when players bought unwanted items accidentally, such as when one player "got upset when he accidentally bought Brawler's mitts and could not get a refund."

Non-design causes
Two other causes of frustration, glitches and external factors, were not attributable to the design of the game. Glitches were second only to bots in causing frustration. One glitch that caused an emotional outburst had a player losing health to enemies that were, due to a bug, invisible. Not understanding what was happening, the player felt that she "took damage and moved for no reason."

The other sources of frustration unrelated to design were external factors that were not part of the game at all. This includes one day where a player "had a rough time (multiple, major meltdowns) deciding between attending [the gaming session] or going on a class field trip."

Analysis (Frustration)
FASD is associated with difficulty regulating emotion, which can lead to difficulty coping with frustration [37]. While emotional outbursts only happened around once per day on average, the impact when they did occur was substantial. Such frustration leading to emotional outbursts was not seen in previous Liberi trials, implying the deficits in emotional regulation associated with FASD negatively affected players' ability to cope with challenging events.

Despite the presence of disruptive emotional outbursts, most frustrations (roughly five-sixths) did not lead to an outburst, suggesting the players successfully practiced emotional regulation on those occasions. Nevertheless, given the impact that outbursts had on gameplay, it is clearly important to reduce sources of frustration in designing games for children with FASD.

Common between the four causes in the *design elements* subtheme is a sense of unfairness, or of being punished for unavoidable mistakes. If a player feels bullied by aggressive bots, permanently loses coins by accident, loses a competition despite their best efforts, or is unable to play a particular game, then that player is not only having a negative experience, but one they feel could not have been avoided. All three of these game elements were present in previous trials of Liberi [11], [12], [13], [18], without producing this sort of negative response. This suggests that avoiding perceived unfairness is particularly important for designing games for children with FASD.

Of particular note is losing. This code only ever occurred in competitive games, and only at the end of a game. Seeing players ahead on the in-game leaderboard, or losing at the

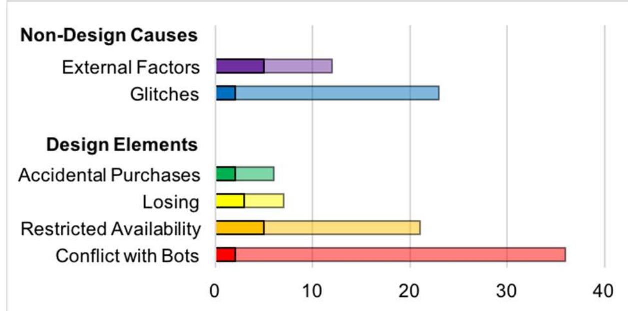

Figure 4: Number of instances of each code under the *frustration* theme, divided by sub-theme. Solid bars indicate an emotional outburst, while shaded bars are non-outburst instances. X-axis is number of incidents of each code. If an observation fits multiple codes, it is included in both.

cooperative Wiskin Defense, did not cause notable frustration. In principle, one could remove competitive games entirely, and no player would ever need to see another player reach the finish first. However, players also enjoyed those competitive games. Indeed, restricted availability of competitive games was itself a cause of frustration. Simply denying competitive gameplay to players with FASD may therefore be an overly simplistic solution to frustration around losing.

Non-design causes are unrelated to the design of Liberi or of the study, and accordingly cannot simply be avoided. All complex computer games involve glitches, due for example to programming errors or bad network conditions; similarly, external factors, by definition, cannot be eliminated in game design. While it may be possible to reduce the impact that either of these factors can cause, the prevalence of this sub-theme suggests that games designed for children with FASD must be able to account and compensate for players sometimes becoming upset, despite the designer's best efforts. In our sessions, for example, the presence of a buddy to help participants regulate their emotions (or to leave the room) was important to mitigating frustration and reducing the disruption caused by outbursts.

Theme Two: Rewards
Players commented frequently on Liberi's in-game rewards, almost always positively. This theme references two types of rewards: the virtual coins earned through playing minigames; and the costume pieces and gameplay upgrades that can be purchased with coins at the in-game shops.

In addition to gameplay itself, this coin-and-shop reward system is one of the core motivators in Liberi. Players are expected to feel drawn to accumulate coins over time, so that they can afford to buy items later (Figure 1). Learning how players responded to these long-term rewards is important for understanding how well Liberi's design suits the needs of children with FASD.

Codes belonging to the theme of rewards are split into two sub-themes, according to which type of reward they address: *coins* themselves, and *shops* (Figure 5).

Coins

Players were interested in obtaining coins, either for specific reasons (saving up or collecting coins) or else a general interest in coins. When a player gave a specific reason for wanting coins, it was usually that they were saving up to buy a particular item, for example when a player "was excited about saving up for the new Minecraft outfit." Alternatively, some players enjoyed collecting coins for the sake of having a large number of them, such as when one player "made a coin goal of 1,000 just for fun (not even to buy anything)."

Even when they did not specify why they wanted them, the players overall displayed a strong general interest in coins. Sometimes, players would even play a particular minigame because it provided a lot of coins. For example, a player described Wiskin Defense as "basically coin farming."

On the negative side, players occasionally expressed unhappiness that they didn't have enough coins to buy something (can't afford). For example, one player's buddy noted that she "wants to shop and gets upset when she does not have enough money to buy things."

Shops

Players expressed interest in the shops in two ways: interest in purchasing specific items, and in the act of shopping. When a player went to the shops, it was often because they were interested in purchasing specific items. Especially popular were the "deluxe" costume items ("[player] was excited about purchasing all the gold skins") and the weapon upgrades ("[player] really enjoyed the new upgrades in Wiskin Defense.")

Sometimes players visited the shops to enjoy the act of shopping, whether or not they bought anything. Indeed, on one occasion a player "spent a lot of time shopping today even though she did not have enough to buy anything."

Rarely, a player would instead show distinct disinterest in any of the items currently available for purchase. For example, one player "does not like to shop because she likes the original 'LOL' shirt."

Analysis (Rewards)

FASD is strongly associated with impairment of executive function, including planning, impulse control, and deferred gratification [20], [28], [29]. Reward systems underlying many games also rely on these abilities, for example, to save for items the player wants to purchase in the future.

Liberi's shopping system tested participants' ability to defer gratification, since purchasing any of the "deluxe" costume pieces (Figure 1) required at least 1,000 coins, taking an average one week of play to obtain.

Players did indeed demonstrate that they were able to plan ahead and defer spending to obtain the expensive "deluxe" items. In addition to those times a player expressly stated that they were saving up to purchase one of these expensive items, analysis of the game logs shows that players spent

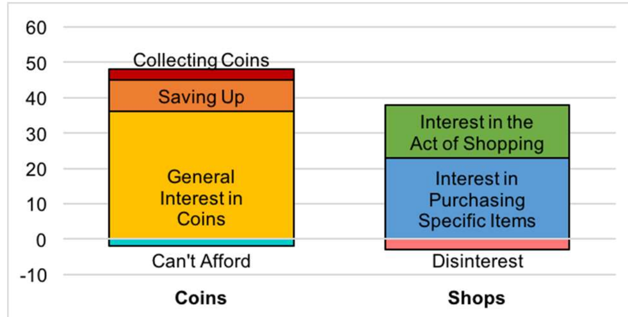

Figure 5: Number of instances of each code under the *rewards* theme, divided by sub-theme. Y-axis is number of incidents of each code. Positive numbers indicate positive interactions, negative numbers indicate negative interactions.

42% of their coins on these items, more than on either ordinary costume pieces or on game upgrades.

Given the importance of deferred gratification to the reward systems of many games, it is reassuring that this basic mechanic proved enjoyable, despite the deficits in executive function in the FASD population. Responses were overwhelmingly positive in both sub-themes, with less than eight percent of responses being negative regarding *shops*, and only four percent for *coins*. The positive reception in this study implies that gamification techniques like in-game rewards are useful for children with FASD, agreeing with findings from other researchers [4], [15], [25].

Unexpectedly, some players expressed pleasure in collecting coins, not to spend them on any particular item, but merely to enjoy having a large number. One player had collected over 7,000 coins at one point, requiring five weeks of play to collect. This suggests that the intermediary of coins may be a positive feature. In effect, the coins are able to function as an immediate reward, while also showing progression toward long-term rewards.

Sometimes players expressed frustration that they could not afford a desired item. However, this happened infrequently, suggesting that they otherwise did not have difficulty planning how to obtain the items they wanted. Overall, players actively engaged with the shopping system. Players were far more likely to be excited to buy particular items, or even just spend time shopping, than to feel unsatisfied by the rewards available.

Theme Three: Social Interaction

The final major theme from analyzing the passports is social interaction. This theme collects player comments and buddy observations regarding players interacting.

Social play can form a strong motivator in playing games [40]. Participants played the games while located in the same room, offering the opportunity to play socially. In this paper, instances of social play are defined as occasions when buddies noted that players expressed a desire or intention, or made a deliberate effort, to play alongside or interact with other players in-game.

This theme contains three sub-themes, defined by how the players interacted with others: *conflict with other players*, *independence*, and *engaging with other players* (Figure 6).

Conflict with Other Players

Conflict with other players was seen rarely, and was also far less common than conflict with bots (Theme 1). The worst such incident involved other players "ganging up on [one player] during Dino Dash because she was winning." This player ended the conflict herself, when she "maturely went and played Bobo Ranch by herself." The other occurrences were simply buddies noting that two players "had an unfriendly competition."

Independence

Independence refers to times when a player plays or expresses a preference to play alone, instead of playing with the others. While more common than conflict, independence was also infrequent (Figure 6). A typical example is when a buddy noted that a player was "very quiet today and not interested in talking."

Some players were more inclined to play independently than others, though even those players would at times want to play socially: "[player] started off saying he works alone in games, but later in game time he changed his mind and felt that everyone should work together."

Engaging with Other Players

Engaging with other players was far more common than either independence or conflict, with associated observations split across four codes: cooperativeness, competitiveness, general multiplayer interest, and improvised play.

The most common sentiment related to engaging with other players was a desire for cooperativeness. For example, one player liked playing Wiskin Defense because all players were on the same team, so "you don't have to play against friends."

Other times, players instead demonstrated competitiveness in their interactions, such as one player who "liked racing against other players." This friendly competition was more common than conflict, and cooperativeness was more common than competitiveness.

Not all expressions of interest in playing socially were explicitly cooperative or competitive. Examples of this sort of general multiplayer interest include one player who liked being able "to play with everyone at once," while another wished that "the entire lobby was players instead of Bots—makes it more fun."

The most surprising social behaviour we saw is what we call improvised play, where participants found ways of playing the game that were not intended or foreseen by the game's designers. This took two different forms: players improvising tag or hide and seek games in the island, and players playing cooperatively in competitive games by teaming up against the bots.

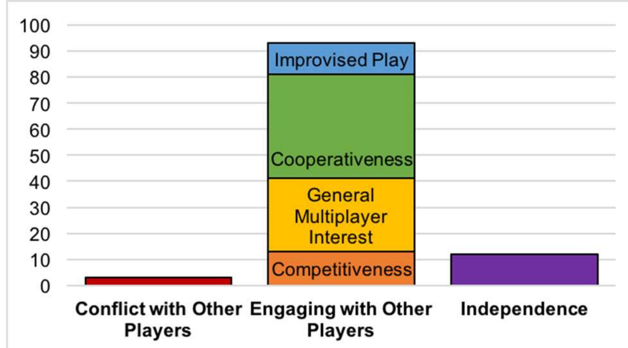

Figure 6: Number of instances of each code under the *social interaction* theme, divided by sub-theme. Y-axis is number of incidents of each code.

Analysis (Social Interaction)

FASD is associated with deficits in social adaptation (social adjustment, appropriateness, and consideration of others) [19], [23]. Given that starting point, we were unsure how well or quickly the players would be able to adapt to the social play intended by the design of both Liberi and the game sessions.

In fact, players quickly formed social connections, as shown by the *engaging with other players* sub-theme vastly outweighing both conflict and independence.

Supporting this conclusion are the SEAS results, graphed in Figure 7 as a diverging stacked bar chart [32]. In agreement with the passports, the SEAS responses are overwhelmingly positive, with only three negative responses out of 55. Of particular note are the subscales for Social Belonging and Meaningful Interactions, indicating that players felt social connection to the other members of their cohorts.

We also observed a strong 3-to-1 preference for playing cooperatively over competitively. Even when players did play competitively, it was more likely to be amicably social than involving interpersonal conflict. This strong inclination toward playing socially shows encouraging potential for the use of multiplayer games to help children with FASD to produce social bonds, employ social skills, and practice social adaptation.

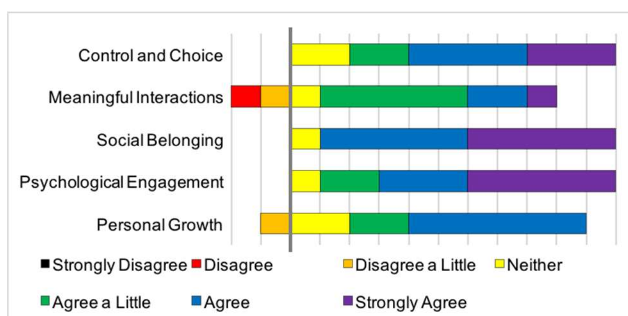

Figure 7: Post-study SEAS responses, by subscale, showing number of participants reporting each category. Negative responses left of vertical bar, neutral/positive right. Each segment represents one player's response.

Indeed, the players' desire to play together was strong enough that they chose to improvise their own social play even out of the contexts expected by Liberi. These instances took two forms.

First, while waiting in the central island for a session to start, players improvised simple playground games like tag and hide and seek. This was likely a contributor to the fact that the players seldom became impatient while waiting, since their connection to other members of their cohorts allowed them to make their own activities. Liberi's island likely helped keep our players from becoming frustrated, or taxing their ability to defer the gratification of starting play.

The second form of improvised play involved players working together cooperatively, even in games designed to be competitive. In even the first session, when one player "got very frustrated in Dino Dash because the Bots kept taking all his eggs," another player "teamed up with him in the game to keep the Bots away." This is another indication of players favouring cooperative play over competitive play, and forming social connections. Despite our concerns that the players might not want to interact socially, we instead found that players were so eager to play together that they would even create their own ways of playing socially. This indicates a strong desire to form a social group, even beyond the ways provided by the game.

The specific form this improvised play took also suggests a possible role served by cooperative play, in addition to the value of providing a venue for social interaction. The earliest observed instance of this improvised cooperation, for example, involved one player who had become frustrated with the bots, being helped deliberately by another player. The fact that players were able to team-up like this helped both reduce frustration and enhance the social experience of gameplay, suggesting it may be beneficial to ensure such activities are possible even in non-cooperative games.

IMPLICATIONS FOR DESIGN

Our analysis of the play sessions illustrates which game mechanics and design elements were especially successful for our players, and which did not work well. Drawing from these observations, we propose five guidelines for the design of games for children with FASD; these are intended to help lower frustration, inspire engagement in the game, and encourage social experiences. These guidelines seek to address the root neurobehavioural implications of observed problems, rather than individual design decisions. For instance, we use observations of Liberi's coin-and-shop system to inform design of reward systems in general. Designing fun games for players with FASD appears to require being thoughtful about some issues, but overall, children with FASD enjoy cooperative and competitive games, enjoy social play, and respond well to gamification strategies. Therefore, rather than thinking of designing games for people with FASD, we want to consider how relatively modest considerations could help make all games accessible to people with FASD. Our results might also aid in generating hypotheses around how to make games more accessible to other neurodivergent populations.

Ensure Low Cost of Failure

Failure is an important part of games. Without the chance of failure, there is little incentive to put effort into succeeding. Failure, however, can come at the cost of frustration, and sometimes in this study, this frustration was too high for children with difficulty in emotional regulation.

Two of the greatest frustrations experienced by our players could have been improved by a lower cost of failure. Existing literature already suggests that games emphasize positive over negative feedback [2], [36]; our observations suggest that the threshold for negative feedback may be very low indeed for players with FASD.

In the case of accidental purchases in Liberi, the cost was the loss of the game money spent on an unwanted item. The aggravation caused by bots can also be considered a case of excessive cost of failure. While the actual outcome is not particularly damaging—perhaps dropping an egg in Dino Dash, or just stopping for a moment in Gekku Race—a player stunned by a bot is unable to do anything until their avatar recovers. This "cost" of being temporarily unable to play the game appears to have been very frustrating.

We advise carefully examining any cost included in a game targeted toward children with FASD, as well as searching for effective costs where none were intended—such as the accidental purchases. Emotional regulation deficits mean that consequences that do not bother other players can detract from the game experience for children with FASD.

Avoid Retracting Options

Throughout the study, we changed which games were available to play during any given week. This was designed to keep players from becoming bored with the games that were available, by presenting a different set of options regularly. This technique had been standard in previous investigations with the Liberi exergames, with no ill effects.

However, restricting these play options, such that players knew what they were missing, proved to be a major source of frustration for this population.

In contrast, the items available in the shops were also changed over the course of the study. However, rather than a rotation, new items were simply added to the shops, with no items leaving circulation. No players objected to this method of keeping the available options from stagnating, strongly implying that it was the taking away of games that was to blame for players feeling frustrated by the rotation.

We therefore recommend that, when possible, games be designed to avoid taking away any options that players with FASD have become accustomed to having available. This might include game features such as seasonal or limited-time events, or promotional items that become inaccessible once the promotion is over.

Account for Breaks

While the prior two suggestions concern sources of frustration that should be reduced or eliminated directly, two common sources of frustration—glitches and external factors—are difficult or impossible to remove entirely from a game. In cases where a player was upset by one of these factors, especially in the case of an emotional outburst, a useful measure was for that player to be able to leave the room for a short break.

These breaks had the dual benefits of removing that player from the source of their frustration, and also allowing them to be upset without distracting the other players. Two aspects of the sessions permitted this to be done.

First, Liberi is highly interruptible. Playing Liberi involves playing multiple minigames serially, instead of a long uninterrupted game session. Most minigames are short, taking only one or two minutes to finish. A player taking a break therefore is minimally disruptive to the overall game experience, and we advise that games for an FASD population be made with interruptibility in mind.

Second, each player had their own buddy assigned to them to assist them and manage their behaviour. In the event that a player needed a break, the buddy was right there to help direct them out of the room to calm down. This personalized supervision meant players did not need to decide for themselves that they needed a break—a difficult decision to make while severely upset.

In our study, we had the buddies available to perform this role. In a home deployment of the game, this function would likely be fulfilled by a parent or guardian. In any case, play of games may require that someone be available to perform this buddy role for players, to help interrupt frustration with a well-timed break.

Show Progression in Rewards

We were initially uncertain how well Liberi's money system would work as a reward system for our players, given that the coins must be saved up to buy items. This turned out not to be a problem: the reward system worked well to motivate players, not just the purchasable items, but also the coins themselves.

We had, however, two players who became impatient with how long it took them to save up for items. To an extent, this is expected, given the existence of more expensive "deluxe" items. However, it is important that players feel that they are making progress toward their goals. An example is having an expensive item be built up from smaller "milestone" items, like a suit of armour built from individual matching pieces.

Favour Cooperation over Competition

In a multiplayer context, cooperation can be very powerful. If players are able to team up to defeat difficult enemies, then the game can become more enjoyable. This is not to say that competitive play should be abolished. Even in our group of players that favoured cooperative play over competitive play, there were still many instances of players expressing an interest in playing competitively. And, while losing a competition was a source of frustration (Figure 4), so too was the absence of a competitive game that players enjoyed.

However, we suggest that steps be taken to make it possible to team up even in non-team games, due to the benefits of players being able to help each other out in tough situations. We saw, for example, that players were able to gang up on the bots to beat them, because the games allowed them to simply avoid hitting each other and instead target only the bots.

Allowing this sort of cooperation can also help avoid unfriendly competitions from developing. We seldom saw instances of players feeling attacked by other players, while the bots—which could only be engaged competitively—were the most common source of frustration. If playing with other players could likewise only be done competitively, this would potentially lead to more conflict and emotional outbursts.

CONCLUSION

Our goal for this study was to use observational techniques to find ways to improve the design of games for players with FASD, not necessarily as part of an intervention or training program, but primarily for the sake of producing better games. Toward that end, we performed a 10-week study for 11 children with either diagnosed or suspected FASD, and observed how players responded to the game.

During the study we observed six common causes of frustration with the game, mostly related either to a loss of control or to factors outside of game design. We saw that the players enjoyed earning, saving, and spending the reward currency, and were able to play together socially and feel socially connected.

Based on our observations, we advise that games designed to be played by children with FASD have a low cost of failure to reduce frustration, avoid having previously-available options be made unavailable, and provide possibilities for taking breaks to calm down when players are upset for reasons outside the designer's control.

We also suggest that reward systems be employed, taking care that the rewards are appealing to the players and that even expensive items give a sense of progress.

Finally, we advise that it be possible to play cooperatively, even in competitive games, given the social and emotional benefits of players helping each other out.

ACKNOWLEDGEMENTS

This work was supported by the Kids Brain Health Network of Centres of Excellence, a program of the federal government to advance science and technology, and the NSERC READi CREATE program. We gratefully acknowledge the support of Central Elementary School.

REFERENCES

[1] The AbleGamers Foundation. 2012. *Includification: A Practical Guide to Game Accessibility*. Retrieved Aug. 18, 2019 from https://accessible.games/includification/

[2] Clare S. Allely and Piersanti Gebbia. 2016. Studies Investigating Fetal Alcohol Spectrum Disorders in the Criminal Justice System: A Systematic PRISMA Review. *SOJ Psychology* 3, 1 (Feb. 2016), 1-11. DOI: http://dx.doi.org/10.15226/2374-6874/3/1/00123

[3] Robyn M. Amos-Kroohs, Birgit A. Fink, Carol J. Smith, Lyanne Chin, Sandra C. Van Calcar, Jeffrey R. Wozniak, and Susan M. Smith. 2016. Abnormal Eating Behaviors Are Common in Children with Fetal Alcohol Spectrum Disorder. *The Journal of Pediatrics* 169 (Feb. 2016), 194-200. DOI: https://dx.doi.org/10.1016%2Fj.jpeds.2015.10.049

[4] David W. Bartle. 2012. *Development of Cognitive Video Games for Children with Attention and Memory Impairment*. Master's thesis. University of Victoria (UVic) Victoria, British Columbia, Canada.

[5] Virginia Braun and Victoria Clarke. 2006. *Qualitative Research in Psychology* 3, 2 (Jan. 2006), 77-101. DOI: http://dx.doi.org/10.1191/1478088706qp063oa

[6] Nicolas Ducheneaut and Robert J. Moore. 2005. More than just 'XP': learning social skills in massively multiplayer online games. *Interactive Technology and Smart Education* 2, 2, 89-100. DOI: https://doi.org/10.1108/17415650580000035

[7] Encyclopedia of Mental Disorders. 2019. *Executive function*. Retrieved Aug. 18, 2019 from http://www.minddisorders.com/Del-Fi/Executive-function.html

[8] Katherine Flannigan, Kathy Unsworth, and Kelly Harding. 2018. *The Prevalence of Fetal Alcohol Spectrum Disorder*. CanFASD Issue Paper. Canada FASD Research Network, Canada.

[9] Game Accessibility Guidelines. 2019. *Game Accessibility Guidelines*. Retrieved Aug. 18 from http://gameaccessibilityguidelines.com/

[10] Courtney R. Green, Jocelynn L. Cook, Jacqueline Pei. 2016. *Computer Game Interventions for Individuals with FASD*. CanFASD Issue Paper. Canada FASD Research Network, Canada.

[11] Hamilton A. Hernandez, T.C. Nicholas Graham, Darcy Fehlings, Lauren Switzer, Zi Ye, Quentin Bellay, Md Ameer Hamza, Cheryl Savery, and Tadeusz Stach. 2012. Design of an Exergaming Station for Children with Cerebral Palsy. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 2619-2628. DOI: https://doi.org/10.1145/2207676.2208652

[12] Hamilton A. Hernandez, Mallory Ketcheson, Adrian Schneider, Zi Ye, Darcy Fehlings, Lauren Switzer, Virginia Wright, Shelly K. Bursick, Chad Richards, and T.C. Nicholas Graham. 2014. Design and Evaluation of a Networked Game to Support Social Connection of Youth with Cerebral Palsy. In *Proceedings of the 16th international ACM SIGACCESS Conference on Computers & Accessibility (ASSETS '14)*. ACM, New York, NY, USA, 161-168. DOI: https://doi.org/10.1145/2661334.2661370

[13] Maximus D. Kaos, Mark R. Beauchamp, Shelly Bursick, Amy E. Latimer-Cheung, Hamilton Hernandez, Darren E.R. Warburton, Christopher Yao, Zi Ye, T.C. Nicholas Graham, and Ryan E. Rhodes. 2018. Efficacy of Online Multi-Player Versus Single-Player Exergames on Adherence Behaviors Among Children: A Nonrandomized Control Trial. *Annals of Behavioral Medicine* 52, 10 (Oct. 2018), 878–889. DOI: https://doi.org/10.1093/abm/kax061

[14] Maximus D. Kaos, Ryan E. Rhodes, Perttu Hämäläinen, T.C. Nicholas Graham. 2019. Social Play in an Exergame: How the Need to Belong Predicts Adherence. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. ACM, Glasgow, Scotland, UK, paper 430. DOI: https://doi.org/10.1145/3290605.3300660

[15] Kimberly A. Kerns, Jennifer MacSween, Shelly Vander Wekken, and Vincenza Gruppuso. 2010. Investigating the efficacy of an attention training programme in children with foetal alcohol spectrum disorder. *Developmental Neurorehabilitation* 13, 6 (Oct. 2010), 413-422. DOI: http://dx.doi.org/10.3109/17518423.2010.511421

[16] Kimberly A. Kerns, Sarah Macoun, Jenny MacSween, Jacqueline Pei, and Marnie Hutchison. 2016. Attention and working memory training: A feasibility study in children with neurodevelopmental disorders. *Applied Neuropsychology: Child* 6, 2 (Apr. 2016), 120-137. DOI: https://doi.org/10.1080/21622965.2015.1109513

[17] Gillian King, Beata Batorowicz, Patty Rigby, Margot McMain-Klein, Laura Thompson, and Madhu Pinto. 2014. Development of a Measure to Assess Youth Self-reported Experiences of Activity Settings (SEAS). *International Journal of Disability, Development and Education* 61, 1 (Mar. 2014), 44-66. DOI: https://doi.org/10.1080/1034912X.2014.878542

[18] Shannon Knights, Nicholas Graham, Lauren Switzer, Hamilton Hernandez, Zi Ye, Briar Findlay, Wen Yan Xie, Virginia Wright, and Darcy Fehlings. 2014. An innovative cycling exergame to promote cardiovascular fitness in youth with cerebral palsy: A brief report. *Developmental Neurorehabilitation* 16, 2 (Jun. 2014), 135-140. DOI: http://dx.doi.org/10.3109/17518423.2014.923056

[19] Piyadasa W. Kodituwakku. 2007. Defining the behavioral phenotype in children with fetal alcohol spectrum disorders: A review. *Neuroscience & Biobehavioral Reviews* 31, 2, 192-201. DOI: https://doi.org/10.1016/j.neubiorev.2006.06.020

[20] Piyadasa W. Kodituwakku. 2009. Neurocognitive profile in children with fetal alcohol spectrum disorders. *Developmental Disabilities Research Reviews* 15, 3 (Sep. 2009), 218-224. DOI: https://doi.org/10.1002/ddrr.73

[21] Regan L. Mandryk, Shane Dielschneider, Michael R. Kalyn, Christopher P. Bertram, Michael Gaetz, Andre Doucette, Brett A. Taylor, Alison Pritchard Orr, and Kathy Keiver. 2013. Games as Neurofeedback Training for Kids with FASD. In *Proceedings of the 12th International Conference on Interaction Design and Children (IDC '13)*. ACM, New York, NY, USA, 165-172. DOI: https://doi.org/10.1145/2485760.2485762

[22] Sarah N. Mattson, Nicole Crocker, and Tanya T. Nguyen. 2011. Fetal Alcohol Spectrum Disorders: Neuropsychological and Behavioral Features. *Neuropsychology Review* 21, 2 (Apr. 2011), 81-101. DOI: https://doi.org/10.1007/s11065-011-9167-9

[23] Julie A. Millar, Janet Thompson, Dorothy Schwab, Ana Hanlon-Dearman, Deborah Goodman, Gal Koren, and Paul Masotti. 2017. Educating students with FASD: linking policy, research and practice. *Journal of Research in Special Educational Needs* 17 1 (Jan. 2017), 3-17. DOI: https://doi.org/10.1111/1471-3802.12090

[24] Mary J. O'Connor, Elizabeth A. Laugeson, Catherine Mogil, Evy Lowe, Kathleen Welch-Torres, Vivien Keil, and Blair Paley. 2011. Translation of an Evidence-Based Social Skills Intervention for Children with Prenatal Alcohol Exposure in a Community Mental Health Setting. *Alcoholism: Clinical and Experimental Research* 36, 1 (Jul. 2011), 141-152. DOI: https://doi.org/10.1111/j.1530-0277.2011.01591.x

[25] Lynne S. Padgett, Dorothy Strickland, and Claire D. Coles. 2006. Case Study: Using a Virtual Reality Computer Game to Teach Fire Safety Skills to Children Diagnosed with Fetal Alcohol Syndrome. *Journal of Pediatric Psychology* 31, 1, 65-70. DOI: https://doi.org/10.1093/jpepsy/jsj030

[26] Jacqueline Pei and Kimberly Kerns. 2012. Using Games to Improve Functioning in Children with Fetal Alcohol Spectrum Disorders. *Games for Health Journal* 1, 4 (Aug. 2012), 308-311. DOI: https://doi.org/10.1089/g4h.2012.0036

[27] Svetlana Popova, Shannon Lange, Larry Burd, Albert E. Chudley, Sterling K. Clarren, and Jürgen Rehm. 2013. Cost of Fetal Alcohol Spectrum Disorder Diagnosis in Canada. *PLoS One* 8, 4 (Apr. 2013). DOI: https://dx.doi.org/10.1371%2Fjournal.pone.0060434

[28] Carmen Rasmussen, Rosalyn McAuley, and Gail Andrew. 2007. Parental ratings of children with Fetal Alcohol Spectrum Disorder on the Behavior Rating Inventory of Executive Function (BRIEF). *Journal of FAS International* 5, 2 (Feb. 2007).

[29] Carmen Rasmussen. 2005. Executive Functioning and Working Memory in Fetal Alcohol Spectrum Disorder. *Alcoholism: Clinical and Experimental Research* 29, 8 (Aug. 2005), 1359-1367. DOI: http://dx.doi.org/10.1097/01.alc.0000175040.91007.d0

[30] R.E. Rhodes, M.D. Kaos, M.R. Beauchamp, S.K. Bursick, A.E. Latimer-Cheung, H. Hernandez, D.E.R. Warburton, Z. Ye, T.C. Nicholas Graham. 2018. Effects of home-based exergaming on child social cognition and subsequent prediction of behavior. *Scandinavian Journal of Medicine & Science in Sports* 28, 10 (Oct. 2018). DOI: https://doi.org/10.1111/sms.13225

[31] Janet C. Read, Stuart MacFarlane. 2006. Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction. In *Proceedings of the 2006 Conference on Interaction Design and Children (IDC '06)*. ACM, Tampere, Finland, 81-88. DOI: https://doi.org/10.1145/1139073.1139096

[32] Naomi B. Robbins, Richard M. Heiberger. 2011. Plotting Likert and Other Rating Scales. In *Proceedings of the 2011 Joint Statistical Meetings*. Miami Beach, FL, USA, 1058-1066.

[33] James C. Rosser Jr, Paul J. Lynch, Laurie Cuddihy, Douglas A. Gentile, Jonathan Klonsky, and Ronald Merrell. 2007. The Impact of Video Games on Training Surgeons in the 21st Century. *Archives of Surgery* 142, 2 (Feb. 2007), 181-186. DOI: https://doi.org/10.1001/archsurg.142.2.181

[34] Lilach Shalev, Yehoshua Tsal, and Carmel Mevorach. 2007. Computerized Progressive Attentional Training (CPAT) Program: Effective Direct Intervention for Children with ADHD. *Child Neuropsychology* 13, 4 (Jun. 2007), 382-388. DOI: https://doi.org/10.1080/09297040600770787

[35] Ian Spence and Jing Feng. 2010. Video games and spatial cognition. *Review of General Psychology* 14, 2, 92–104.

[36] Rita M. Tomé, João M. Pereira, and Manuel Oliveira. 2014. Using Serious Games for Cognitive Disabilities. In *Proceedings of the 5th International Conference of Serious Games Development and Applications (SGDA 2014)*. Berlin, Germany, 34-47. DOI: http://dx.doi.org/10.1007/978-3-319-11623-5_4

[37] Christy M. Walcott and Steven Landau. 2004. The Relation Between Disinhibition and Emotion Regulation in Boys With Attention Deficit Hyperactivity Disorder. *Journal of Clinical Child and Adolescent Psychology* 33, 4, 772-782. DOI: https://doi.org/10.1207/s15374424jccp3304_12

[38] Hao Wang and Chuen-Tsai Sun. 2012. Game Reward Systems: Gaming Experiences and Social Meanings. In *Proceedings of the 2011 DiGRA International Conference: Think Design Play (DiGRA '11)*. Springer, Hilversum, The Netherlands, 1-12.

[39] Thomas Westin, Kevin Bierre, Dimitris Gramenos, and Michelle Hinn. 2011. Advances in Game Accessibility from 2005 to 2010. In *Proceedings of the 6th International Conference on Universal Access in Human-Computer Interaction: Users Diversity (UAHCI '11)*. Springer, Orlando, FL, USA, 400-409. DOI: https://doi.org/10.1007/978-3-642-21663-3_43

[40] Elisabeth M. Whyte, Joshua M. Smyth, and K. Suzanne Scherf. 2014. Designing Serious Game Interventions for Individuals with Autism. *Journal of Autism and Developmental Disorders* 45, 12 (Dec. 2014), 3820-3831. DOI: https://doi.org/10.1007/s10803-014-2333-1

[41] Bei Yuan, Eelke Folmer, and Frederick C. Harris Jr.. 2011. Game accessibility: a survey. *Universal Access in the Information Society* 10, 1 (Mar. 2011), 81-100. DOI: https://doi.org/10.1007/s10209-010-0189-5