DOWN SYNDROME VIDEO GAME PREFERENCES

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ABSTRACT

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Playing video games, particularly of the action genre, may facilitate learning in people with Down syndrome by improving cognitive processing. In order to examine this effect the kinds of video games these children prefer to play must be determined. Favorite video games and gaming systems were collected via survey of parents of children with Down syndrome. Most frequently played games and gaming systems were coded for genre and coordination requirements, respectively. The children did not prefer other video game genres over action video games, but did prefer gaming systems that primarily require unimanual coordination to gaming systems that primarily require bimanual coordination. The results suggest that children with Down syndrome are playing action games. In order to design more effective games for learning for this audience how they play the games is an important next step.

Keywords: Down syndrome, cognitive processing, action video games, coordination requirements

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Video games may have the potential to reduce some neurological deficits that inhibit learning in people with Down syndrome (DS); a chromosomal disorder that causes mental retardation (Morrison, 2006). DS influences brain plasticity in a way that makes it difficult to process new information (Chakrabarti et al., 2010). Video games can increase brain plasticity in people without DS (Kühn, Gleich, Lorenz, Lindenberger, & Gallinat, 2013), and it is possible that this phenomenon can occur in people with DS as well. Not much is known about DS and video gaming (Brandao et al., 2010). To develop video games that increase brain plasticity and enhance learning, DS video game preferences must be identified. A game cannot make an impact if the target audience is not playing it.

Uses and gratifications is a mass media theory used to understand what kinds of media people prefer based on perceived needs of cognition and feeling (Katz, Blumler, & Gurevitch, 1974; Rosengren, 1974). The current study explores video game preference and cognitive demands taking into account the assumptions of the uses and gratifications theory. Using a survey, a list of the most frequently played video games, genres, and gaming systems was compiled. It is hypothesized that people with DS will have lower preference for the genres that are the most effective at improving plasticity and gaming systems that are too cognitively demanding.

Literature Review

Down Syndrome Prevalence and Characteristics

Approximately one in every 800 children is born with DS (Morrison, 2006). DS occurs at the very beginning of a pregnancy due to the existence of an extra chromosome in the fetus. There are over 25 different phenotypes that result from the genes affected by the extra chromosome (Lyle et al., 2008). Some genes are more expressive than others resulting in wide variations of symptoms and deficits within each of the three areas effected (Mao, Zielke, Zielke, & Pevsner, 2003). Children with DS exhibit a unique array of physical characteristics including: slanted eyes (epicanthic fold), flat face, enlarged tongue, small hands, hypotonia (poor muscle tone), heart issues, and other characteristics (Down, 1866; Lee & Jackson, 1972). Deficits in mental functioning include mental retardation, attention deficits, poor short-term memory, social immaturity, and trouble with strategy development (Reed et al., 1980; Spanó et al, 1999; Vicari, Carlesimo, & Caltagirone, 1995). Due to physical differences and mental functioning deficits, children with DS display greater than normal difficulty in a set of physical functions including coordination, visuomotor skills, and balance (Spanó et al., 1999).

There are three types of DS; trisomy 21, translocation, and mosaicism (Aula, Leisti, & von Koskull, 1973). Trisomy 21 is the most common cause of DS, accounting for around 90 percent of all cases (Mikkelson, Fischer, Stene, Stene, & Peterson, 1976). It is caused by the existence of an extra chromosome on Chromosome Pair 21 of the fetus (Aula et al., 1973). Translocation and mosaicism account for fewer cases of DS; about six percent and two percent respectively (Mikkelson et al., 1976). Translocation occurs when the extra chromosome detaches from Chromosome Pair 21 and reattaches on another chromosome pair (Aula et al., 1973). Finally, mosaicism occurs when trisomy 21 exists in only some of the cells of the body while other cells remain normal.

Physical characteristics. Lee and Jackson (1972) developed a list of 25 of the most common physical characteristics of people with DS by examining 150 subjects. Flat face, slanted eyes, and small hands were some of the more common features. The wide array of features can be explained by variance in gene expression (Mao et al., 2003). Aula, Leisti, and

Von Koskull (1973) evaluated cases of trisomy 21, translocation, and mosaicism using this 25 item list. The two trisomy 21 cases included within the study demonstrated 7 and 13 features on the list. The translocation case demonstrated 16 characteristics, and the mosaic case demonstrated 11. Although the amount of differences in physical features is minimal and can be explained by variation in gene expression, the researchers observed that the mosaic case demonstrated greater mental capability than the other cases. This is consistent with Fishler, Koch, and Donnel's (1976) observations where they reviewed 25 trisomy 21 cases and 25 mosaic cases, to determine that mosaic cases demonstrate higher intellectual potential.

Mental function deficits. DS influences intellectual ability; it is the most common cause of mental retardation (Morrison, 2006). Learning capabilities vary due to the over- and under-expression of certain genes (Mao et al., 2003). For example, while some children can accomplish 12th grade reading levels others cannot surpass kindergarten reading levels (Fowler, Doherty, & Boynton, 1995). On average, children with DS achieve a reading level similar to that of an eight year old, and they can learn how to execute only simple mathematic equations.

Physical function deficits. The combination of physical differences and mental functioning deficits cause physical function deficits including coordination, visuomotor skills, and balance. Spanó et al. (1999) conducted a cross-sectional study of motor skills in children with DS ages four to fourteen and determined that all areas of motor functioning (gross motor skills and fine motor skills) are affected by DS. Gross motor skills include balance, walking, and throwing a ball. Fine motor skills include unimanual (single-handed) coordination such as putting pegs into a peg board and bimanual coordination (both hands) such as threading beads through a string. Gross motor skills showed the greatest improvement with age while fine motor skills showed little to no improvement over time. Gross motor skill deficits have greater variability and generally show more improvement with age than fine motor skills. Out of all of the tests conducted by Spanó et al. (1999) the subjects demonstrated the greatest impairments with bimanual coordination. Impairments in this skill were more obvious in the older subjects because they were not as similar to their same-age peers as younger children. All but one of the children over the age of 11 scored below that of a normal seven year old.

The researchers also conducted the Developmental Test of Visual-Motor Integration to assess visuomotor skills (Spanó et al, 1999). Using this assessment, the researchers observed the difficulties people with DS have in understanding three-dimensional figures and completing cognitive tasks. The subjects demonstrated poor understanding of where intersections exist in three-dimensional shapes and they lack the ability to develop and maintain strategy for planning and performing motor output.

Cause of Mental Function Deficits in Children with DS

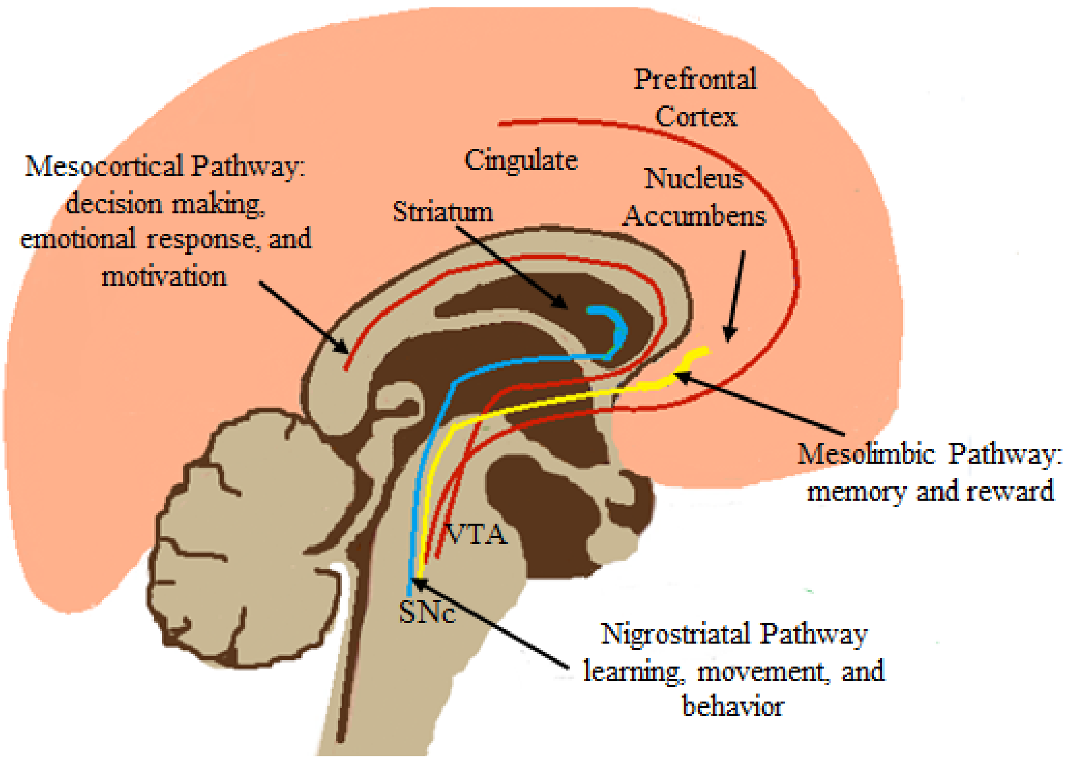
Neural processing results from synaptic connections among neurons and is facilitated and influenced by chemicals called neurotransmitters (Purves et al., 2004). The number of various neurotransmitters present (or absent) at synaptic connections influence a wide variety of human experience including pain, emotions, and memories. Neural response to neurotransmitter uptake can be inhibitory or excitatory. Inhibitory neurons are important in regulating and preserving connections and systems, allowing for stability in neural networks (see Bavelier, Levi, Li, Dan, & Hensch, 2010; Fagiolini & Hensch, 2000). Inhibitory neurons work more efficiently in established neural processing. Excitatory neurons are vital in establishing new neural connections. When the brain is high in excitatory neurons and can process new information rapidly, it has high plasticity (Fagiolini & Hensch, 2000). This is particularly important at birth and when people are adapting to new surroundings because they promote firing of other neurons in the brain. Although brain plasticity normally decreases with age, this process is expedited in people with DS who have an excess of inhibitory neurons which prevent the release of excitatory neurotransmitters (Chakrabarti et al., 2010). This makes it much more difficult for people with DS to learn new concepts.

Suppression of excitatory neurotransmitters in people with DS is thought to be due to gamma-amino butyric acid (GABA), an inhibitory neurotransmitter that is overproduced in the brains of DS patients (Chakrabarti et al., 2010). Abundance of GABA accelerates the decline of plasticity by suppressing the release of dopamine, a neurotransmitter primarily associated with learning, pleasure, and reward (Brown, Bullock, & Grossberg, 1999; Di Cristo et al., 2007). Fried et al. (2001) conducted an experiment using microdialisis to sample dopamine release during cognitive tasks, and found that as dopamine is released it allows the subject to enter into periods of high learning. Based on this, they determined that dopamine is essential during the learning process and the suppression of it in the brain prevents connections from developing between old and new information (Fried et al., 2001).

High dopamine activity is an indication of higher plasticity in areas of the brain where dopamine is transported to (Arias-Carrión, Stamelou, Murillo-Rodríguez, Menéndez-González, & Pöppel, 2010). In a series of dopaminergic pathways (see Figure 1) dopamine is delivered from the midbrain to reward, decision making, and motor control centers. There are three main pathways by which dopamine is distributed. First, the nigrostriatal pathway transports dopamine from the SNc to the striatum, a part of the brain associated with learning (Erickson et al., 2010; Koepp et al., 1998), voluntary movement, and routine behaviors (Arias-Carrion et al., 2010). Secondly, the mesolimbic pathway sends dopamine from the VTA to the nucleus accumbens and hippocampus, parts of the brain that control reward and memory consolidation, respectively.

Finally, the mesocortical pathway sends dopamine produced in the VTA to both the prefrontal cortex (decision making), and the cingulate (emotional response and motivation). The mesolimbic and mesocortical pathways intertwine are often referred to as the mesocorticolimbic dopamine system.

Figure 1. Dopaminergic Pathways and Their Uses



The nigrostriatal pathway transports dopamine from the substantia nigra (SNc) to the striatum for learning, movement, and behavior. The mesolimbic pathway runs from the ventral tegmental area (VTA) to the nucleus accumbens and hippocampus for memory and reward, and the mesocortical pathway runs from the VTA to the prefrontal cortex and cingulate for decision making, emotional response, and motivation.

The dopaminergic connect reward, memory, decision making, and emotional response (Arias-Carrion et al., 2010; Purves et al., 2004). Action and reward become predictable through repetition. This process has allowed humans to evolve a system for learning basic movements such as walking or throwing, to more complicated processes such as hunting or building.

Learning to play a video game works similarly; prediction-reward decisions drive motor control processing and long term storage of game patterns.

Video Games and Brain Plasticity

Video games have been shown to increase dopamine release and improve plasticity. In 1998, Koepp et al. demonstrated that video game play increases dopamine levels in the brain. The researchers used emission tomography to measure the changes in neurotransmitters in the striatum while the subjects (eight healthy middle-aged men) played the video game. In the game the players were presented with the challenge of collecting flags on a battlefield without getting destroyed by enemy tanks. If they were able to collect all of the flags, they were rewarded with seven points and then moved up to a more difficult level. The researchers found that during game play the amount of extracellular dopamine more than doubled in the striatum (Koepp et al., 1998). Dopamine levels increase as players learn how to manipulate motor functioning in order to complete the task.

Researchers have found that the size of a key area of the dopaminergic pathways, the striatum, is a predictor of learning from video games. Following up on the Koepp et al., 1998 study, Erikson et al. (2010) set out to better understand the link between learning during video game play and dopamine by investigating the volume of the striatum and hippocampus prior to learning to play the video game *Space Fortress*. *Space Fortress* is a game designed by cognitive psychologists at the University of Illinois to study the process of learning how to play a video game. Striatal and hippocampal volume of subjects was measured using fMRI scanning prior to 20 hours of training on the game. Striatal and hippocampal volume were then correlated with the increase in game scores from initial game playing to game play after 20 hours of training. They found that the volume of the striatum can predict greater amounts of learning during cognitively demanding video game training, though hippocampal volume was not a significant predictor (Erikson et al., 2010).

Building upon these findings, Kühn et al. (2011) performed fMRI scans of 154 healthy 14-year-old adolescents to determine whether frequent video game players had greater striatal volume. Consistent with predictions, frequent gamers had significantly higher ventral striatal volume. In addition, subjects with greater striatal volume performed significantly faster in decision-making tasks and showed greater activity during the task. Similarly, in an fMRI study of 62 healthy adults, Kühn and Gallinat (2013) found that greater lifelong game play was associated with greater volume in the enthorinal cortex, a brain area that interfaces with the hippocampus and is active during spatial memory formation. In particular, greater volume was found to be positively correlated with logic/puzzle game play and platform-game play, and negatively associated with action-based role playing game play. To determine whether game play was causing observed differences in hippocampal volume of brain areas or if individuals with larger hippocampal regions were more likely to engage in game play, Kühn, Gleich, Lorenz, Lindenberger, and Gallinat (2013) conducted a study in which they measured volume in critical areas before and after two months of an action-platform game (*Super Mario 64*). Players in the treatment condition played the video game for 30 minutes every day for two months and demonstrated a significantly greater increase in right hippocampal volume than subjects in the non-video game playing condition. The researchers observed video game play provoking greater brain plasticity in the hippocampus and prefrontal cortex: parts of the brain that control decision making, motivation, emotional response, memory, and reward (see Figure 1; Purves et al., 2004). The changes observed improved navigation, memory, and spatial processing in players (Kühn et al., 2013, p. 4). In addition, subjects in the training condition also showed a positive correlation between hippocampal growth and subsequent desire to play the game. This suggests greater activation of reward due to increased dopamine.

During the past decade, evidence has continued to mount supporting the idea that action video game play causes greater perceptual and cognitive abilities (see Green, 2014; Green & Bavelier, 2012). This is particularly the case for action video games, which includes adventure games (games that take the player on a journey), fighter games (games where the player fights other characters), and shooter games (Green et al., 2012; Lucas & Sherry, 2004). Action video games present more challenges (or enemies) at a higher frequency than other types of games (Green, Sugarman, Medford, Klobusicky, & Bavelier, 2012). The challenges originate from all different directions so players experience a higher degree of uncertainty as to where and how the next challenge will present itself. There are also more possible actions the player can engage in action games than other video game genres. There are also more possible actions the player can engage in to respond to the challenges presented. Because players have to observe, process, and react to the challenges very quickly, action video games place a high demand on sensory, cognitive, and motor performances.

Feng, Spence, and Pratt (2007) conducted two experiments to compare spatial attention capabilities of action video game players to non-action video game players. Using the useful-field-of-view test (UFOV), they measured spatial attention scores of action video game players to non-gamers and found that action video game players scored significantly higher. Then, they assigned new participants to play ten hours of an action video game (Medal of Honor: Pacific Assault) or a puzzle game (Ballance). They collected pretest and posttest (after the 10 hours of game play) scores for the UFOV and the mental rotation test (MRT) and found that those assigned to action video game experienced greater improvements in both tests than those assigned to the puzzle game.

Video Games for Learning in DS Populations

People with DS show limits in brain plasticity because they typically have high levels of GABA suppress dopamine, while action video game play has been shown to increase production of dopamine and volume of brain areas in the dopaminergic pathways. It is possible that game play can trigger greater dopamine release in people with DS, potentially switching inhibitory neurons to an excitatory state which increases brain plasticity. There is some evidence of this. Bernath and Zigmond (1989) conducted a study examining the effects of added dopamine on GABA in the striatum of rats with a genetic disorder equivalent to that of DS in humans. They found that when dopamine is added it has an excitatory influence on GABA. This improves brain plasticity and facilitates learning.

If people with DS can play action video games that trigger dopamine release, it is possible that gaming can reduce the effects of the high levels of GABA and promote learning, but will we be able to get people with DS to play video games? There is limited scientific evidence that speaks to the questions of whether or how people with DS are playing video games. Wuang and Su (2012) asked 997 students with DS at 55 different elementary and high schools in Taiwan what free time activities they partake in. A total of 851 participants (93.9%) said they play video games. Brandao et al. (2010) developed a video game for learning with the specific goal of enhancing cognitive development in pre-school age children with DS. Games for learning are games with purposes other than just entertainment, such as improving cognitive processing, physical functioning, memory, or understanding of concepts (see Green & Bavelier, 2012; Kim, Park, & Baek, 2009). They tested various aspects of the game for usability by observing a child with DS playing it and found that the player understood how a mouse works and knew how to apply its functions to game play. They also found that the use of the mouse encouraged interaction between the player and the game (Brandao et al., 2010).

In another project, a group called A.K.A. New Media Inc. was created by the National DS Society to construct a series of online games that teach people with DS ages 14 to 20 how to use the internet (Kirijian, Meyers, & Charland, 2007). Through a series of usability tests, it was determined that font size must be big and easy to read, characters must be animated and the same age as the players or older, and the player's actions in the game must be clearly defined in order for the players to focus on the game. They suggest modifying or developing games to have "auditory reinforcement, animation, immediate positive feedback and support" (Kirijian et al., 2007, p. 36) to encourage people with DS to play them, and maximize learning during game play. Genres such as action, adventure, and sports games tend to have many of these characteristics whereas genres such as role-play, simulation, and strategy tend to not have them. Unfortunately they did not conduct studies after the release of the games to see if players were actually learning, so their study cannot speak to whether games are effective at teaching players with DS.

There have also been studies of the effects of video games on physical functioning, particularly using the game console Nintendo Wii for players with DS. These studies have tested the ability for Wii games to improve sensorimotor skills (Wuang, Chiang, Su, & Wu, 2011), balance (Rahman, 2010), and coordination (Berg, Becker, Martlan, Primrose, & Wingen, 2012). Rahman (2010) analyzed the effects playing Wii-Fit, a video game that encourages natural movement of the body as a source of interaction within the game. Significant improvements to balance and agility were demonstrated in the subjects assigned to play the game, while smaller improvements were demonstrated by those assigned to the traditional therapy group. Berg, Becker, Martlan, Primrose and Wingen (2012) observed a single child with DS play on Nintendo Wii for eight weeks. Over the course of play, the improvements were demonstrated in the child's unimanual coordination, balance, and speed. No improvements were observed in bimanual coordination. This is consistent with the observations of Spanó et al. (1999); children with DS experience the greatest motor functioning impairments with bimanual coordination, and bimanual coordination improves minimally with age. Wuang, Chiang, Su, & Wu (2011) also investigated the use of Nintendo Wii games to improve motor skills in people with DS. Interestingly, they observed that as the game grew more difficult, the player was motivated to keep playing in order to learn how to overcome the challenges. This may be an indication that dopamine is being released (reward), which is driving the child to continue playing. The researchers conclude that improvements in sensorimotor skills were due to increases in brain plasticity during video game play (Wuang et al., 2011). Although this conclusion makes sense, they did not conduct any research on whether or not video games actually increase brain plasticity in DS players.

Still, challenges remain in DS video game play, especially of the types of games that have been shown to increase dopamine levels; action games. Spence and Feng (2010) argue that action games are the most cognitively demanding genre. Players must be skilled in all six of the cognitive components: sensory (detection), attention, visuomotor (coordination), speed, memory, and cognition. Research conducted by Spanó et al. (1999) suggests that people with DS struggle with these cognitive requirements. They have severe deficits in coordination, speed, and the cognition. Because of the physical functioning deficits that people with DS experience and the cognitive capabilities action video games require, playing action video games can be challenging for people with DS. Although action video games are highly successful at improving dopamine in the brain and facilitating learning (Erickson et al., 2010; Kühn et al., 2013), a possible impediment is that people with DS do not have preference for this genre because it is too cognitively demanding.

The Dilemma of Game Play for Neural Plasticity

Action games can provide important benefits for people with DS. This is the dilemma. Is it possible to modify action games to make them accessible without compromising the characteristics that make them beneficial? Are there other genres that might have the same effect? Are these types of games more frequently played by individuals with DS? What are the features of games that people with DS enjoy playing? Answers to these questions are necessary in order to further promote and test the efficacy of games for learning in individuals with DS. This is an area where communication research can be of considerable insight. This section will explore what we know about why people play video games from a communication perspective.

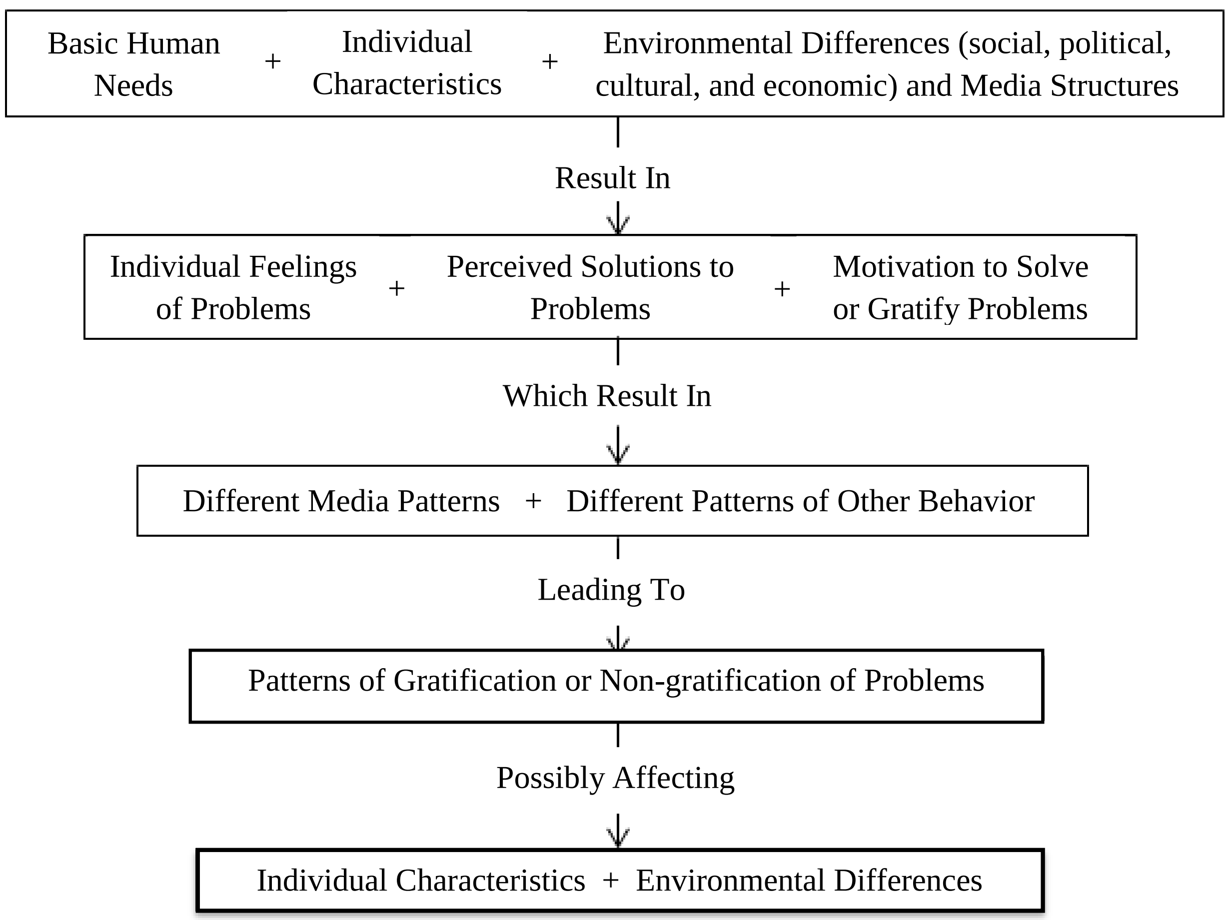
Why do people play video games? Sherry (2004) has argued that people are motivated to play various kinds of games because of differences in perceptions and cognitive processing capabilities. Employing a uses and gratifications perspective Sherry (2014) argues that game play is an on-going dialogue between player and media which the player controls for his or her own purposes. As such, game play is a function of the needs that the learner hopes to satisfy by engaging in the game-playing experience. When needs are not satisfied, engagement is thwarted.

Interest in uses and gratifications began in the 1930s and 40s with the idea that the media audiences actively select what media content to consume (Herzog, 1944). It has been applied to many forms of media including video games; first by Selnow (1989), but by many others since then (see Ruggiero, 2000; Swanson, 1991).

Katz, Blumler, and Gurevitch (1974) published one of the first elaborate definitions of the theory and identified five key elements of uses and gratifications. The first element identified is that of an active audience, explaining the idea that people develop expectations from content consumption overtime and actively choose media based on those expectations. The second element suggests that the expectations people create come from associations made between perceived needs and media content that has gratified those needs in the past. Third, the researchers acknowledge the existence of sources other than media that also gratify needs, and all sources compete for audience use. The fourth element claims that audience members can adequately report the motivations that drive them to consume different media. This suggests that people know their needs and select media usage or other activities accordingly. The fifth and final element of uses and gratifications identified by Katz et al. (1974) is that cultural importance of media and individual motivations for consumption contradict each other and therefore cultural importance of media should not be considered when evaluating motivations.

Rosengren (1974) developed a model for uses and gratifications that identifies human needs as the driving force for media selection. In this model, it is proposed that individual and societal differences result in an assortment of problems and needs (see Figure 2). An individual interprets problems and needs and determines possible solutions to gratify them. When use of a source consistently succeeds at gratifying perceived needs, associations between the source and gratified need develop and the individual is likely to return to that source again. Uses and gratifications explains the repeated use of similar media and overall appeal for one source over another, making it ideal for understanding video game preferences in people with DS.

Figure 2: Flow Chart of the Uses and Gratifications Model



Preference for media is developed through patterns of media us that lead to the gratification of perceived needs (adapted from Rosengren, 1974).

Sherry, Lucas, Greenberg, and Lachlan (2006) identify video game uses and gratifications in fifth-grade, eighth-grade, 11th-grade, and college students. They establish six motivations for video game play. Children play video games because of the challenge, competition amongst others, arousal, escape from the real world, social interactions, and fantasy that video games can provide. All fifth-grade, 11th-grade, and college students, as well as eighth-grade female students agreed that the greatest motivation to play video games is the challenge that video games present. Eighth-grade male students chose social interaction as the greatest motivation.

Sherry (2004) suggests that challenge is the greatest appeal of video games. Video games have the potential to assess the player's abilities and present appropriate challenges accordingly. This ability is due to the interactivity between the player and the game (Ritterfeld & Weber, 2006). When skill and challenge are evenly matched, the player experiences immersion into the world that the game creates (Sherry, 2004). Players report loss of awareness to the real world and intense concentration within the game. When skill and challenge are not equivalent, the player will grow bored by the lack of challenge or frustrated by too much challenge. Both result in termination of game play and a preference for that game will not develop.

Physical Function Requirements of Video Games

Certain capabilities are required in order to respond well to the challenges video games pose. The player must be able to notice and respond to the challenge a game presents. Spence and Feng (2010) composed a list of general cognitive requirements for video game play. Components of the list include sensory (detection), attention, visuomotor (coordination), speed, memory, and cognition. Some games require all of these components to be at a very high skill levels while others require only some of the components to be strong. If a player struggles to perform and utilize the cognitive requirements of any game, uses and gratifications suggests that preference for that game will not be developed.

H1: People with DS have lower preference for action games than other video game genres.

A particular cognitive requirement of video games identified by Spence and Feng (2010) is bimanual coordination, which DS players experience major deficits with (Berg, Becker, Martlan, Primrose and Wingen, 2012; Spanó et al., 1999). People with DS perform tasks that require bimanual coordination at a low skill level and demonstrate limited if any improvement with age. If the challenge of interacting with a game is too high because of this deficit, people with DS will not play them.

H2: People with DS will have lower preference for video games that require bimanual coordination than video games that only require unimanual coordination.

Finally, little is known about game genre preferences and how they align with functional deficits in children with DS. Therefore, this study will explore a set of research questions that will advance our knowledge of game preference:

RQ1: What genres are most and least preferred by children with DS?

RQ2: What gaming systems are most frequently used by children with DS?

RQ3: Are there relationships among DS diagnosis, symptomology, and game preference in children with DS?

Method

Overview

The goal of the study was to explore video game preference in children with DS. A 15-item online survey on video game preference (see Appendix A) was distributed to the parents of children with DS. The questions were divided into three categories: video game preference, demographics, and DS diagnosis. The survey items were intended to probe differences in video game preference due to age, gender, presence of siblings, and DS symptomology. The survey included both multiple choice and open-ended questions.

Survey Variables

Sets of questions about each of the following variables were presented in the following order on an online survey.

Video game preference. Eight items were included to determine type of video game the child most prefers playing, as well as the game system that the child prefers. Responding parents were asked whether or not their child plays video games, why they think their child does or does not enjoy playing video games and when the last time was that their child played video games, to understand the child's interest in gaming.

Preference of video game. Video game preference was identified through two survey items asking the responding parent to list up to five games that his/her child has played most frequently in the past six month and indicate which game was most frequently played. The games were subsequently coded for genre using Lucas and Sherry's (2010) list of popular video game genres: action/adventure, arcade, classic board games, fantasy/role-play, fighter, puzzle, racing/speed, shooter, simulation, sports, and strategy (see Table 1), and industry reports (e.g., game packaging, game maker websites, game review websites, etc.). Action/adventure, fighter, and shooter games all fit the definition that action games are games that present more challenges (or enemies) at a higher frequency coming from all directions, and were all considered part of the action game genre (Green et al., 2012). After data collection, exergames and educational genres were added to the list to better specify game types. The exergame genre is defined as games that use body motions other than pressing buttons on a controller to interact within the game. The educational game genre is defined as games used specifically for teaching academic concepts to players and cannot be categorized as any of the genres indicated previously.

Table 1

Coding for Video Game Genre

Genre	Description	Example
Action/Adventure	Player goes on an adventure within the games	Super Mario Bros.
Arcade	Games adapted from classic arcade games	Pac Man
Classic Board Game	Games adapted from classic board games	Checkers
Educational	Concepts are taught within the games	Montessori Math
Exergames	Game play requires motion of body parts	Just Dance
Fantasy/Role-Play	Player takes on a character role	Pokémon
Fighter	Game play focuses on combat between characters	Wrestlemania
Puzzle	Challenges are solved without element of chance	Angry Birds
Racing/Speed	Speed is the central goal of game play	Mario Kart
Shooter	Players shoot at other characters or targets	Deer Hunter
Simulation	Game play involves simulation development	Minecraft
Sports	Games involve an athletic event requiring controller	John Madden NFL
Strategy	Strategic planning is required for game play	Tetris

Note. (Adapted from Lucas & Sherry, 2004).

Preference for unimanual coordination. Preference for games that require unimanual or bimanual coordination was operationalized as the typical/dominant manual demands of the child's most frequently used gaming system (e.g., predominant use of Nintendo Wii, phone, tablet, computer, internet, iPad, or iPod/iPhone games would indicate unimanual coordination while predominant use of Xbox, Playstation, or Nintendo DS (or Gameboy) would indicate bimanual coordination preference).

Although preference for video games and gaming systems are operationalized by what the participants say is most frequently used by their children, reasons other than the child's preference could contribute to the games and systems identified. Children's game options are affected by parental mediation and sibling influence. For instance, a child might only have an iPad at home to play games on, but prefers playing Nintendo Wii at a friend's house. The child's parents would indicate iPad as most frequently played gaming system even though the child prefers playing games on Nintendo Wii.

DS symptomology. Children with DS are categorized according to the cause of the genetic abnormality leading to DS (trisomy 21, translocation, mosaicism). The first survey question simply asked the responding parent to identify his/her child's primary Down's diagnosis (trisomy 21, translocation, mosaicism). Parents were also asked to indicate whether their child received one of the following secondary diagnoses: apraxia, autism, attention deficit hyperactivity disorder (ADHD), or other secondary diagnoses.

Next, parents were asked for more specific diagnoses that may be important in video game play. Each individual child with DS has a unique array of phenotype characteristics based on genetic coding abnormalities on chromosome 2l (Lott & Dierson, 2010); as many as 25 phenotypes-genotype correlations for DS have been mapped (Lyle et al., 2008). Therefore, it is not scientifically accurate to ask about severity of the syndrome as a whole, as a child may have a severe deficit in some areas, yet be mildly affected or not affected at all for the other areas. Phenotypes of specific interest for video game choice behavior include: gross motor skills, fine motor skills, processing delays, short term memory, language, and slow reaction time.

Because of the issue of child deficits is very sensitive for parents, questions about symptomology were framed with the following introductory statement:

> "Each child is unique and displays a different set of that therapists sometimes diagnose as 'high functioning,' 'mild/moderate functional deficit,' or 'low functioning.' A subset of these behaviors is of interest to us because they might directly impact the type of game that your child may enjoy playing. For each of these behaviors, please tell us if one of your child's therapists has commented on his/her level of functioning. Of course your child may have never received a diagnosis on that particular behavior, so please simply indicate 'no diagnosis.'"

Respondents were presented with the set of game-related phenotypes and given the option of responding "high functioning," "mild/moderate functional deficit," "low functioning," or "no diagnosis."

Demographics. Four survey items asked about general demographics: age, grade in school, gender, and number of siblings. Bryant, Akerman, and Drell (2010) identify that family features including siblings, gaming systems in the home, and age of the child influence which games a child plays and how a child plays those games. These items were included to assist in understanding game preference.

Subjects

The study was designed for parental response rather than response by the children with DS. It is expected that the children have difficulty understanding and accurately responding to the survey questions, and that parents' responses will be more accurate because parents provided access to games, are present during the child's recreation time, and observe the child in a natural setting. Subjects were asked to respond to the questions based only on their child who has been diagnosed with DS.

Purposive sampling was used with the intention of including as many parents of DS children as possible. Subjects were accessed via national (National Down Syndrome Congress, National Down Syndrome Society, and Down Syndrome Affiliates in Action), and local (Down Syndrome Guild of Southeast Michigan, Kansas City Down Syndrome Guild, SMILE on Down Syndrome – Southwest Indiana) databases of parents of children with DS. To increase response and assure parents of the educational benefits of the survey, an email was sent out one week prior to distribution of the survey detailing the purpose of the study, who was conducting the research, and what the survey will be asking (see Appendix B). One week later, an email was sent out to members of the mailing lists asking for their participation and pointing them to links explaining the study and actual survey.

The survey was conducted using Qualtrics Survey Software online, supplied by Michigan State University (MSU). The first page of the survey contained the MSU human subjects consent form describing the purpose of the study and providing contact information (see Appendix C). The subjects were not offered any incentives.

Results

Seven national and local groups were emailed. Of those groups, three of them agreed to participate. Down Syndrome Affiliates in Action sent emails to their 79 affiliate groups; each group with at least 50 families and some with over 500. They also posted it to their private and public Facebook pages and posted the link to the survey on Twitter and LinkedIn. Emails were sent to all 175 members of SMILE on Down Syndrome – Southwest Indiana. The Down Syndrome Guild of Greater Kansas City posted to their website that has 6000 members, and also posted to a private parent discussion forum of 400 parents. A total of 29 surveys were received, but only 21(n = 21) were completed. There were no duplicate surveys submitted. The eight incomplete surveys were dropped from the data. The data represents seven females with DS (36.84%) and 12 males with DS (63.16%). Out of the 21 surveys completed, 19 (90.5%) participants indicated that their child plays video games and 2 (9.5%) did not. The average age of the participants' children was 12.4 (range: 3-21). Both participants whose children did not play video games identified that the reason their child does not play video games is because the parents do not promote video game play.

Table 2 lists the games that participants identified as the game their child plays most frequently as well as what genre they were coded as, age of the child, gender of the child, and presence of siblings (including age and gender of siblings). Of the 19 participants whose children play video games, 6 (31.6%) prefer action/adventure games, 4 (21.0%) prefer educational games, 3 (15.8%) prefer exergames, 2 (10.5%) prefer puzzle games, 2 prefer sports games, 1 (5.3%) prefers fighter games, and 1 prefers simulation games. All of the children whose top preference is action/adventure games are male while all of the children who prefer puzzle games are female. Also, all of the action/adventure games are games that can accommodate a wide array of skill levels.

Table 2

Most Frequently Played Games, Genres, and Demographics

Game	Genre	Age	Gender	Siblings (Age Gender)
Temple Run	Action/Adventure	15	Male	11 Male
Amazing Spiderman	Action/Adventure	13	Male	15 Male
Toy Story 3	Action/Adventure	13	Male	-
Lego Batman 2	Action/Adventure	12	Male	19 Female, 21 Male
Skylanders SWAP	Action/Adventure	10	Male	4 Female, 8 Male
Subway Surfer	Action/Adventure	5	Male	-
Starfall	Educational	15	Male	12 Male, 14 Female, 26 Male
Dr. Panda	Educational	6	Female	3 Female, 8 Male
Kaleido	Educational	5	Female	-
Pet Pals	Educational	8	Female	6 Male
Wii Sports	Exergame	19	Male	-

Table 2 (cont'd)

Game	Genre	Age	Gender	Siblings (Age Gender)
Wii Sports	Exergame	8	Female	13 Female, 15 Male, 17 Female
Just Dance	Exergame	16	Female	18 Male, 20 Male
Candy Crush	Puzzle	21	Female	-
Maleficent Free Fall	Puzzle	19	Female	10 Male, 16 Female
John Madden NFL	Sports	21	Male	17 Female
Bowling (iPhone)	Sports	18	Male	14 Male
WWE	Fighter	18	Male	17 Female, 20 Male
Minecraft	Simulation	9	Male	8 Male

Note. Sample size (*n*) was 19.

Table 9 (Appendix D) has a complete list of all of the games mentioned by participants, genres, frequencies, average age of the children who play each game, and percent male who play each game. In all, 71 games were mentioned by the 19 participants whose children with DS play video games. Of those 71 games, 19 (26.76%) were coded as action/adventure games, 18 (25.35%) were coded as exergames, 11 (15.49%) were coded as educational games, nine (12.68%) were coded as puzzle games, four (5.63) were coded as racing/speed games, three (4.23%) were coded as fighter games, three were coded as sports games, two (2.82%) were coded as simulation games, one (1.41%) was coded as classic board games, and one was coded as shooter games. There were no arcade, fantasy/role-play, or strategy games mentioned. The average ages of action/adventure games (10.84) and educational games (10.36) were much lower than the mean age of the sample (12.4), while the average ages of puzzle (17.11), sports (20), and fighting (16.33) were higher than the sample mean. Action/adventure games were predominately played by males (78.95%) as were racing/speed (75%), sports (100%), and fighting (100%). Puzzle games were predominately played by female (22.22% male). Exergames games (50%) and educational games (45.45%) were split more evenly by gender.

H1. The first hypothesis that people with DS will have lower preference for action video games than other video games was not supported. To determine action video game frequency, the game that participants determined as the game their child plays most often was categorized as "action" (action/adventure, fighter, and shooter games), or "not action". Only participants who indicated that their child does play video games were included in this analysis (n = 19). A one-tailed binomial exact test revealed that the number of participants whose children do not play action games most frequently, n = 12 (63.16%), p>.05, CI (41.47%, 84.85%) was not significantly greater than those whose children do, n = 7 (36.84%), p>.05, CI (15.15%, 58.53%).

H2. The second hypothesis that people with DS will have lower preference for video games that require bimanual coordination than video games that only require unimanual coordination was supported. The child's most frequently used gaming system was operationalized as the typical manual demands of the child's most frequently used gaming device; primarily bimanual or primarily unimanual (for distribution of systems see Table 3). Nintendo Wii, phone, tablet, computer, internet, iPad, and iPod/iPhone were categorized as unimanual coordination. Xbox, PlayStation, and Nintendo DS were categorized as bimanual coordination. When asked what systems their children play on most frequently, multiple participants combined iPhone, iPad, and iPod in their responses. When they combined these systems, it could not be identified which system the game was played on most frequently. For this analysis iPhone, iPad, and iPod were combined because game play is almost identical on all three of these systems and a single favorite could not be identified in the responses. One participant indicated that their child most frequently plays games on a Kindle which was categorized as unimanual because it has tablet-like characteristics. Two subjects indicated that their child plays games most frequently on both unimanual and bimanual systems. These two were dropped from this analysis because unimanual or bimanual preference could not be determined. A one-tailed binomial exact test was used to determine the differences between percentages. The number of participants whose children play on games primarily demanding unimanual coordination, $n = 16$ (94.1%), $p<.05$, CI (82.9%, 100%) is significantly greater than those whose children play on games primarily demanding bimanual coordination, $n = 1$ (5.9%), $p<.05$, CI (0%, 17.1%).

Table 3

Most Frequently Played Systems and Coordination Requirements

Most Frequent System	Frequency	%	Coordination
Wii	8	47.06	Unimanual
iPhone/iPad/iPod	5	29.41	Unimanual
Phone	2	11.76	Unimanual
Kindle (Tablet)	1	5.88	Unimanual
Xbox	1	5.88	Bimanual

Note. The sample size (*n*) was 17.

RQ1: RQ1 asked what genres are most and least preferred by children with DS. The games that were identified as most frequently played were coded for genres: action/adventure, arcade, classical board games, educational, exergames, fantasy/role-play, fighter, puzzle, racing/speed, shooter, simulation, sports, and strategy (see Table 1). Table 2 displays the distribution of game genre preference. Action/adventure genre games were most frequently the game identified as most preferred by the participants' children (31.6%), while arcade, classic board games, fantasy/role-play, racing/speed, shooter, and strategy genre games were not a favorite among the participants' children (0%). To better understand video game preference, all of the games listed by each participant were coded for genre (see Table 9, n=71). Action/adventure was still identified as the most frequently played genre (26.76%), but arcade, fantasy/role-play, and strategy were identified as the least played genres. Although games of the action/adventure genre were most frequently mentioned by participants, the most frequently mentioned game was Wii Sports of the exergame genre, mentioned six times (8.45%)

RQ2: RQ2 asked what gaming systems are most frequently used by children with DS. Frequencies were calculated for which systems are used most frequently. iPad was the gaming system most frequently used (84.21%), and PlayStation was the gaming system least frequently used (15.79%; see Table 4). Under the "Other" option Kinect was listed twice and Leap Pad and VTech Smile were each listed once.

Table 4

Frequency Distribution of all Gaming Systems Used

System		Frequency	%
iPad		16	84.21
Nintendo Wii		15	78.95
iPod/iPhone		10	52.63
Computer		7	36.84
Nintendo DS (or Gameboy)		6	31.58
Phone		5	26.32
Xbox		5	26.32
Internet		5	26.32
Tablet		4	21.05
PlayStation		3	15.79
Other			(21.05)
	Kinect	2	10.53
	Leap Pad	1	5.26
	Vtech Smile	1	5.26

Note. The sample size (*n*) was 19.

RQ3: RQ3 asked if there are any relationships among DS diagnosis, symptomology, and game preference in children with DS. Due to the lack of responses, there was not variation in primary diagnosis. All subjects indicated that their children were diagnosed with Trisomy 21. Secondary diagnoses were only identified in seven cases; three cases of apraxia, two ADHD, one was autism, and one identified ADHD, autism, and poor vision as secondary diagnoses (see Table 5).

Table 5

Secondary Diagnosis, Most Frequently Played Game Systems, Games, and Genres

Secondary Diagnosis	Game System	Game	Genre
Apraxia	iPad	Candy Crush	Puzzle
Apraxia	Wii	Just Dance	Exergames
Apraxia	Xbox	Amazing Spiderman	Action/adventure
ADHD	Wii	Skylanders SWAP	Action/adventure
ADHD	Wii & DS	Lego Batman 2	Action/adventure
ADHD, Autism, & Poor Vision	Wii	Wii Sports	Exergames
Autism	Wii	Toy Story 3	Action/adventure

Goodman-Kruskal's index of relationship (gamma, ϒ) was performed to assess association between symptomology independent variables (gross motor skills, fine motor skills, processing delays, short term memory, long term memory, language, and slow reaction time) and the dependent variable manual dexterity. Gamma was used for this analysis because the independent variable could take on three ordinal values (low functioning = 1, mild/moderate functional deficit = 2, high functioning = 3) and the dependent variable was dichotomous (primarily unimanual coordination systems = 1, primarily bimanual coordination systems = 2). In this analysis "no diagnosis" was represented as n/a. The unimanual/bimanual categorizations of the games indicated as most frequently played by the participants were used for this analysis. Values for gamma range negative one to one (-1 to 1). A positive gamma means that preference for primarily unimanual coordination systems is associated with lower functioning, and bimanual coordination systems is associated with higher functioning. The farther away from zero a gamma value is indicates a stronger association. For this analysis, the two subjects who indicated that their child plays games most frequently on both unimanual and bimanual systems were coded as having bimanual preference to observe more variation in the data. All of the associations listed in Table 6 were weak and were not significant. Sample size (*n*) varied because of “no diagnosis” answers.

Table 6

Goodman-Kruskal’s Index of Relationship for Symptomology as a Predictor of Game System Coordination Demands

Variable	*n*	Gamma (ϒ)	Assymp. Std. Error[a]	Approx T[b]	Approx. Sig.
Gross Motor Skills	19	-0.20	0.47	-0.41	0.68
Fine Motor Skills	19	-0.07	0.44	-0.17	0.86
Processing Delays	18	-0.45	0.52	-0.76	0.45
Short Term Memory	18	-0.32	0.40	-0.75	0.46
Long Term Memory	17	0.12	0.45	0.27	0.79
Language	19	0.25	0.39	0.62	0.53
Slow Reaction Time	17	0.14	0.44	0.31	0.76

Note. The independent variables had four conditions: high functioning, mild/moderate functional deficit, low functioning, and no diagnosis.

[a]Not assuming null hypothesis.

[b]Using the asymptotic standard error equals zero.

To analyze the association between symptomology and video game genre preference, Goodman-Kruskal’s measure of predictability (lambda, λ) was performed because the independent variable can take on three ordinal values and the dependent variable (genre) is nominal and not dichotomous. Values of lambda range from zero to one (0 to 1). The closer a lambda value is to one the greater the association is between the independent and dependent variables. All associations listed in Table 4 were weak and not significant. There was no association found between severity of any of the symptoms and genre choice. Sample size (*n*) varied because of “no diagnosis” responses.

Table 7

Goodman-Kruskal's Measure of Predictablity for Symptomology as a Predictor of Video Game Genre Preference

Variable	*n*	Lambda (λ)	Assymp. Std. Error[a]	Approx T[b]	Approx. Sig.
Gross Motor Skills	19	0.29	0.34	0.72	0.47
Fine Motor Skills	19	0.17	0.34	0.45	0.63
Processing Delays	18	0.00	0.00	-	-
Short Term Memory	18	0.30	0.19	1.41	0.16
Long Term Memory	17	0.44	0.20	1.78	0.08
Language	19	0.13	0.31	0.38	0.70
Slow Reaction Time	17	0.29	0.38	0.64	0.52

Note. The independent variables had four conditions: high functioning, mild/moderate functional deficit, low functioning, and no diagnosis.

[a]Not assuming null hypothesis.

[b]Using the asymptotic standard error equals zero.

Included in the survey was an open-ended response to the question "why do you think your child enjoys these games?" Themes in the responses were identified and coded as five different categories. Responses that mention that their child enjoys interaction with the game, or finds the game fun were coded as "enjoyment of interaction." Any responses that claim the child likes the challenge or finds the games rewarding were coded as "challenge/reward." The responses that mentioned that the child likes games because of they recognize the characters or events that take place were coded as "familiar characters or events." Responses that stated that the child finds the game easy or that the game is user-friendly were coded as "ease of play." Finally, responses explaining that the child likes playing the games with friends and family were coded as "friends and family." Table 8 displays the frequency of each type of response. Many of the responses collected included two or more types of responses. Participants most often indicated that their child enjoys video games because interacting with them is fun (52.63%).

Table 8

Frequency of Types of Responses to Question "Why Does Your Child Enjoy These Games?"

Type of Response	Frequency	%
Enjoyment of Interaction	10	52.63
Challenge/Reward	7	36.84
Familiar Characters or Events	7	36.84
Ease of Play	4	21.05
Friends and Family	4	21.05

Note. The sample size *(n)* is 19.

Discussion

The purpose of this project was to explore video game preference in players with DS. The results suggest that this audience plays many different genres, including action video games. Unfortunately, because of the low amount of responses, there is inadequate data to draw generalizations to the larger population based on inferential statistics.

We predicted that people with DS would not be playing action games, but 36.84% of participants indicated that their children are playing action games. Still, the sample plays less action games than that of the population of the United States (62.7%; 31.9% action, 6.9% adventure, 3.9% fighter, and 20.0% shooter) (Entertainment Software Association, 2013). All of the action games mentioned by participants are games that can be played by people of all skill levels. For instance, the most frequently mentioned action/adventure game, Super Mario Bros. is recommended for everyone six and older. Although the game does get more complicated as the player advances, it can be enjoyed by children with beginner skill levels (unlike the action/adventure game Call of Duty which requires high skill levels from the beginning).

The responses to "Why do you think your child enjoys these games" suggest that children with DS have several motives driving game play (see Table 8). Although over half of the participants indicate that their child simply has fun interacting with the games (53.63%), 36.84%

discuss feelings of success that their child has during game play. This can be interpreted through uses and gratifications as overcoming the challenges video games present are associated with feelings of success and reward. If these associations can be achieved, then dopamine may be influencing the reward process and possibly improving brain plasticity during game play. These are not the only reasons given for why children with DS enjoy video games. Participants also explained that familiar characters and events (36.84%), the ease of the game play (21.05%), and playing with friends and family (21.05%) were reasons their child enjoys video games; all of which may have impacted the child's video game genre preference. For instance, one participant said that her daughter "enjoys being able to 'participate' in various games that she sees her family & friends involved in," and another said her daughter "enjoys the movie/character/music. Familiarity." Age and gender also influenced gender choice (see Table 9).

The game that participants identified most frequently as played by their children with DS was Wii Sports, and exergames was the most frequently mentioned genre aside from action/adventure games. This observation makes sense because exergames primarily require gross motor skills (such as balance and jumping) rather than fine motor skills (coordination). Consistent with the literature, participants indicated that their children have higher functioning gross motor skills (high functioning = 12, mild/moderate functional deficit = 9, low functioning = 0, no diagnosis = 1) than fine motor skills (high functioning = 2, mild/moderate functional deficit = 14, low functioning = 4, no diagnosis = 1). In a response to "Why does your child enjoy these games?" one participant wrote, "Wii games are games he can play independently, user friendly. We have an Xbox, but it is too difficult to use... My sons motions are too clumsy to match the dexterity to operate it. Wii is easy for him." Uses and gratifications interprets this as frustration during game resulted in lack of preference for Xbox play. This may explain why the child with a secondary diagnosis of ADHD, autism, and poor vision liked Wii Sports; the game is easy to play and does not have a lot of cognitive requirements. Although exergames require gross motor skills instead of other cognitive requirements that improve brain plasticity and fine motor skills (like action games), it is still physically beneficial for children with DS to be playing these games.

In these data, children without siblings are more likely to play games that do not have complex interaction requirements than children who have siblings. Candy Crush, Wii Sports, Kaleido, and Subway Surfer are all games that can be played simply by waving a hand or swiping a finger. Toy Story 3 requires more complex actions, but it is still played unimanually (using the Wii controller as a wand). This may be due to siblings encouraging complex game play directly or by example. This is a ready-made avenue for getting children with DS to play games that have been directly linked with increased dopamine.

Recruitment of families went much poorer than anticipated. One issue with recruitment was that although emails were sent to each of the national and local groups, some of the groups only posted a survey link instead of sending direct messages to each of their members. This may have resulted in less people learning about the project. In the future, it may prove important to make more direct contacts instead of relying on anonymous requests. One option is to attend events hosted by DS groups and making personal connections with families. Also, personally handing out survey links to members instead of relying on group presidents should be utilized.

Future research should explore how children with DS are playing video games. Results suggest that they are playing action video games, but what features they are playing remains unknown. Are these players able to immerse themselves into the game play, or are they playing in short, sporadic segments? No assumptions can be made about whether changes in brain plasticity are occurring and in order to determine if video games can promote learning in DS players, knowing how they play video games is the next step.

APPENDICES

APPENDIX A

Down Syndrome Video Game Preferences Survey

Please answer all questions about your child with Down syndrome.

Item 1: Does your child play video games?
- Yes
- No

If the answer to this question was "no," the participant was directed to Item 2. If the answer was "yes," the participant was directed to Item 3.

Item 2: Why do you think your child does not play video games?

Item 3: Please check all gaming systems on your child plays on:
- Nintendo Wii
- Phone
- Xbox
- Tablet
- PlayStation
- Nintendo DS (or Gameboy)
- Computer
- Internet
- iPad
- iPod/iPhone
- Other (please specify)

Item 4: Which of the gaming systems identified does your child play on most often?

Item 5: Over the past six months what game did your child play most frequently and on what gaming system (up to five)? Please follow this format: Game, Game System.
- Game 1
- Game 2
- Game 3
- Game 4
- Game 5

Item 6: Of the games identified in the previous question, which game does your child play most often?

Item 7: When was the last time your child played video games?
- -Today
- -Yesterday
- -Last Week
- -Last Month

Item 8: Why do you think your child enjoys these games?

All participants were asked the following questions regardless of their answers to Item 1.

Now we are going to ask about your child's individual diagnosis so we can see how it relates to his/her game play.

Item 9: Has your child been diagnosed with trisomy 21, mosaicism, or translocation?
- -Trisomy 21
- -Mosaicism
- -Translocation
- -Other (please specify)

Item 10: Has your child been given any secondary diagnoses?
- -Apraxia
- -Autism
- -Attention Deficit Hyperactivity Disorder
- -Other (please specify)

Item 11: Each child is unique and displays a different set of behaviors that therapists sometimes diagnose as "high functioning," "mild/moderate functional deficit," or "low functioning." A subset of these behaviors are of interest to us because they might directly impact the type of game that your child may enjoy playing. For each of these behaviors, please tell us if one of your child's therapists has commented on his/her level of functioning. Of course your child may have never received a diagnosis on that particular behavior, so please simply indicate "no diagnosis."
- -Gross motor skills
- -Fine motor skills
- -Processing delays
- -Short term memory
- -Long term memory
- -Language
- -Slow reaction time

You're almost done, just a couple questions left to help us understand game choices.

Item 12: What's your child's date of birth? (MM/DD/YYYY)

Item 13: What grade is your child in?

Item 14: What is your child’s gender?

-Male

-Female

Item 15: If your child has any siblings, what are their ages and genders? Please follow this format: age, gender; age, gender…

APPENDIX B

Email Prior to Survey Email

Dear Parent of a Child with Down Syndrome

I am Kelsey Prena, a graduate student at Michigan State University who is researching how children with Down syndrome use communication technology, with hopes that we might be able to design better educational software for your child. I know several Down's children who love playing video games on iPhones, iPads, computers, etc. and I am hoping that their passion might present an opportunity to improve education for children with Down syndrome.

As a member of ______ , we are hoping you might help us by partaking in a brief survey about your child's video game use.

The survey will ask whether or not your child plays video game. We encourage you to participate even if your child does not play video games because we expect that the answers will be informative and contribute to a better understanding of video game play. If your child does play video games, we will ask you for your child's most frequently played video games, including those played on tablets, gaming consoles, phones, computers, and the internet. The survey will also include questions about your child's symptomology and basic demographics (age, gender). All answers will be kept anonymous and will only be used to further our understanding of video game preferences of children with Down syndrome.

One week from today we will send out an email using this address with information on how to participate in the study. Participation is completely voluntary and should take no more than 20 minutes of your time. We hope that you will choose to participate in our survey!

Thank you,

Kelsey Prena- (248) 303-0561- Graduate Student of Communication, Michigan State University, 473 Communication Arts and Sciences, East Lansing, MI 48824 kelsprena@gmail.com

APPENDIX C

Research Participant Information and Consent Form

Dear Parent of a Child with Down Syndrome,

You are being asked to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you have.

Study Title: Down Syndrome Video Game Preferences
Researcher and Title: Kelsey Prena, Graduate Student
Department and Institution: Communication Arts and Sciences, Michigan State University
Address: 473 Communication Arts and Sciences, East Lansing, MI 48824

Purpose of Research

You are being asked to participate in a research study of video game preference of children with Down syndrome. You have been selected as a possible participant in this study because of your online membership with a local or national Down syndrome group. From this study, the researchers hope to learn how to attract people with Down syndrome to video games that promote learning. They also hope to learn how Down syndrome symptomology influences video game preferences. You must be over 18 to participate in this study.

What You Will Do

If you choose to participate in this study, you will complete an online survey. The survey will ask you questions about your child with Down syndrome. Questions are about what video games and on which gaming systems your child plays most frequently, symptomology, and basic demographics. The survey should not take more than 20 minutes of your time. Findings can be provided upon request.

Potential Benefits

You will not directly benefit from your participation in this study. However, your participation in this study may contribute to the understanding of video game preferences in people with Down syndrome.

Potential Risks

There are no foreseeable risks associated with participation in this study.

Privacy and Confidentiality

The data for this project are being collected anonymously. Neither the researchers nor anyone else will be able to link data to you. Information about you will be kept confidential to the maximum extent allowable by law. Names will not be collected and there will be nothing linking you to your answers. Data will be collected into a database where only the researchers and Institutional Review Board (IRB) will have access to the data. Instructors/teachers cannot access identifiable data. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. Data will be anonymously collected using the internet, and IP addresses will not be collected.

Your Rights to Participate, Say No, or Withdraw

Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. You have the right to say no. You may change your mind at any time and withdraw. You may choose not to answer specific questions or to stop participating at any time.

Costs and Compensation for Being in the Study

You will not receive money or any other form of compensation for participating in this study.

Contact Information

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher (Kelsey Prena, 473 Communication Arts and Sciences, East Lansing, MI 48824, kelsprena@gmail.com, (248) 303-0561).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at (517) 355-2180, Fax (517) 423-4503, or email irb@msu.edu or regular mail at Olds Hall, 408 West Circle Drive #207, MSU, East Lansing, MI 48824.

You indicate your voluntarily agreement to participate in this research study by selecting "Agree" below and completing the survey. You may print this page to keep as a copy.

__Agree
__Disagree (You may exit survey window)

APPENDIX D

Complete List of Games Mentioned by Participants

Table 9

List of Games, Systems, Frequency, Average Age of Children Who Play Game, and Percent of Whom are Males

Genre and Game	System	Freq.	%	Avg. Age	% Male
Action		**19**	**26.76**	**10.84**	**78.95**
Super Mario Bros	Wii	3	4.23	10	66.66
Lego Star Wars	Wii	2	2.82	13.5	100
Lego Batman	Wii	1	1.41	12	100
Super Mario Galaxy	Wii	1	1.41	8	0
Spongebob	Wii	1	1.41	13	100
The Amazing Spider Man	Wii	1	1.41	13	100
Donkey Kong	Wii	1	1.41	10	100
Skylanders Swap	Wii	1	1.41	10	100
Disney Princesses	Wii	1	1.41	8	0
Disney Infinity	Wii	1	1.41	9	100
Toy Story 3	Wii	1	1.41	13	100
Fruit Ninja	iPhone/iPad/iPod	1	1.41	5	0
Temple Run	iPhone/iPad/iPod	1	1.41	15	100
Subway Surfer	iPhone/iPad/iPod	1	1.41	5	100
Sonic	Nintendo DS	1	1.41	10	100
Scooby Doo	Nintendo DS	1	1.41	18	100
Exergames		**18**	**25.35**	**14.88**	**50**
Wii Sports	Wii	6	8.45	16.5	66.66
Just Dance	Wii	5	7.04	14.6	60
Wii Sing	Wii	2	2.82	19	0
Just Dance 2	Wii	1	1.41	19	0
Michael Jackson Dance	Wii	1	1.41	21	100
Wii Play	Wii	1	1.41	8	0
Kinect Adventures	Xbox (Kinect)	1	1.41	8	0
Wipeout	Xbox (Kinect)	1	1.41	15	100
Educational		**11**	**15.49**	**10.36**	**45.45**
Kaleido	iPhone/iPad/iPod	1	1.41	5	0
Coloring Game	iPhone/iPad/iPod	1	1.41	5	0
Cooking Mama	iPhone/iPad/iPod	1	1.41	18	100
Count Money	iPhone/iPad/iPod	1	1.41	15	100

Table 9 (cont'd)

Genre and Game	System	Freq.	%	Avg. Age	% Male
Montesory Math	iPhone/iPad/iPod	1	1.41	5	100
SuccessMaker Educational Site	Computer	1	1.41	16	0
Starfall	Computer	1	1.41	15	100
1XL Math Games	Computer	1	1.41	16	0
Dr. Panda	Kindle	1	1.41	6	0
Pet Pals	Leap Pad	1	1.41	8	0
Educational Games		1	1.41	5	100
Puzzle		**9**	**12.68**	**17.11**	**22.22**
Angry Birds	iPhone/iPad/iPod	4	5.63	16.5	50
Where's My Water	iPhone/iPad/iPod	1	1.41	8	0
Candy Crush	iPhone/iPad/iPod	1	1.41	21	0
Maleficent	iPhone/iPad/iPod	1	1.41	19	0
Frozen	iPhone/iPad/iPod	1	1.41	19	0
Puzzles	iPhone/iPad/iPod	1	1.41	21	0
Racing/Speed		**4**	**5.63**	**13.35**	**75**
Mario Kart	Wii	2	2.82	13	50
Cars 2	Wii	1	1.41	12	100
Driving Games	Xbox	1	1.41	15	100
Sports		**3**	**4.23**	**20**	**100**
John Madden NFL	Wii	1	1.41	21	100
NBA	Wii	1	1.41	21	100
Baseball	PlayStation	1	1.41	18	100
Fighting		**3**	**4.23**	**16.33**	**100**
Wrestlemania	Xbox	1	1.41	13	100
WWE	Nintendo DS	1	1.41	18	100
Wrestling	PlayStation	1	1.41	18	100
Simulation		**2**	**2.82**	**7**	**50**
Minecraft	Xbox	1	1.41	9	100
Makeup Game		1	1.41	5	0
Classic Board Game		**1**	**1.41**	**15**	**100**
Checkers	iPhone/iPad/iPod	1	1.41	15	100
Shooter		**1**	**1.41**	**12**	**100**
Deer Hunter	iPhone/iPad/iPod	1	1.41	12	100

Note. Sample size (*n*) was 19. A total of 71 games were listed.

REFERENCES

REFERENCES

Arias-Carrión, O., Stamelou, M.., Murillo-Rodríguez, E., Menéndez-González, M., & Pöppel, E. (2010). Dopaminergic reward system: A short integrative review. *International Archives of Medicine*, 3, 24-29. doi:10.1186/1755-7682-3-24

Aula, P., Leisti, J., & Von Koskull (1973). Partial trisomy 21. *Clinical Genetics, 4*, 241-251. doi:10.1111/j.1391-0004.1973.tb01149.x

Bavelier, D., Levi, D. M., Li, R. W., Dan, Y., & Hensch, T. K. (2010). Removing brakes on adult brain plasticity: From molecular to behavioral Interventions. *The Journal of Neuroscience*, *30*, 14964-14971. doi:10.1523/JNEUROSCI.4812-10.2010

Berg, P., Becker, T., Martian, A., Danielle, P. K., & Wingen, J. (2012). Motor control outcomes following Nintendo Wii use by a child with Down syndrome. *Pediatric Physical Therapy, 24,* 78-84. doi:10.1097/PEP.0b013e31823e05e6

Bernath, S., & Zigmond, M. J. (1989). Dopamine may influence striatal GABA release via three separate mechanisms. *Brain Research*, *476*, 373-376. doi:10.1016/0006-8993(89)91262-6

Boyan, A., & Sherry, J. L. (2011). The challenge in creating games for education: Aligning mental models with game models. *Child Development Perspectives, 5*(2), 82-87. doi:10.1111/j.1750-8606.2011.00160.x

Brandao, A., Trevisan, D. G., Brandao, L., Moreira, B., Nascimento, G., Mourao, P. T.,…Clua, L. R. (2010). Proceedings from SBGames 2010: Semiotic inspection of a game for children with Down syndrome. Florianopolis, SC.

Brown, J., Bullock, D., & Grossberg, S. (1999). How the basal ganglia use parallel excitatory and inhibitory learning pathways to selectively respond to unexpected rewarding cues. *The Journal of Neuroscience, 19(23),* 10502-10511. Retrieved from http://www.jneurosci.org/content/19/23/10502.full

Bryant, J. A., Akerman, A., & Drell, J. (2010). Wee Wii: Preschoolers and motion-based game play. *International Journal of Gaming and Computer-Mediated Simulations,* 2(12), 1-17. doi:10.4018/jgcms.2010040101.\

Chakrabarti, L., Best, T. K., Cramer, N. P., Carney, R. S. E., Isaac, J. T. R., Galdzicki, Z, Haydar, T. F. (2010). Olig1 and olig2 triplication causes development brain defects in Down syndrome. *Nature Neuroscience*, *13*, 927-934. doi:10.1038/nn.2600

Deci, E. L., & Ryan, R. M. (2000). The “what” and “why” of goal pusuits: Human needs and the self-determination of behavior. Physiological Inquiry, 11, 227-268. doi:10.1207/S15327965PLI1104_1

Di Cristo, G., Chattopadhaya, B., Kuhlman, J. J., Fu, Y., Bélanger, M. C., Wu, C. Z.,…Huang, Z. J. (2007). Activity-dependent PSA expression regulates inhibitory maturation of critical period plasticity. *Nature Neuroscience, 10,* 1569-1577. doi:10.1038/nn2008.

Down, J. L. H. (1866). Observations on an ethnic classification of idiots. *London Hospital Reports, 3,* 259-262. Retrieved from th-hoffmann.eu/archive/down/down.1866b.pdf

Entertainment Software Association. (2013). *Best-selling video game super genres by units sold, 2013* [Image]. Retrieved from http://venturebeat.files.wordpress.com/2014/04/esa.jpg

Erikson, K. I., Boot, W. R., Basak, C., Neider, M. B., Prakash, R. S., Voss, M. W., …Kramer, A. F. (2010). Striatal volume predicts level of video game skill acquisition. *Cerebral Cortex, 20,* 2522-2530. doi:10.1093/cercor/bhp293

Fagiolini, M., & Hensch, T. K. (2000). Inhibitory threshold for critical-period activation in primary visual cortex. *Nature, 404,* 183-183. doi:10.1038/35004582

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science, 18,* 850-855. doi:10.1111/j.1467-9280.2007.01990.x

Fishler, K., Koch, R., & Donnell, G. N. (1976). Comparison of mental development in individuals with mosaic and trisomy 21 Down's syndrome. Pediatrics, 58, 744-748.

Fowler, A. E., Doherty, B. J., & Boynton, L. (1995). The basis of reading skill in young adults with Down syndrome. In L. Nadel & D. Rosenthal (Eds.), Down syndrome: Living and learning in the community (pp. 182-196). New York: NY: Wiley & Sons.

Fried, I., Wilson, C. L., Morrow, J. W., Cameron, K. A., Behnko, E. D., Ackerson, L. C., & Maidment, N. T. (2001). Increased dopamine release in the human amygdala during performance of cognitive tasks. *Nature Neuroscience, 4,* 201-206. doi:10.1038/84041

Green, C. S. (2014). The perceptual and cognitive effects of action video game experience. In F.C. Blumberg (Ed.), *Learning by Playing, Video gaming in education* (pp. 29-41). Cambridge, MA: MIT Press.

Green, C. S., & Bavelier, D. (2012). Learning, attentional control, and action video games. *Current Biology, 22*, R197-R206. doi:10.1016/j.cub.2012.12.012

Green, C. S., Sugarman, M. A., Medford, K., Klobusicky, E., & Bavelier, D. (2012). The effect of action video game experience on task-switching. *Computers in Human Behavior, 28,* 984-994. doi:10.1016/j.chb.2011.12.020

Herzog, H. (1944). What do we really know about daytime serial listeners? In P. F. Lazarsfeld &

F. N. Stanton (Eds.), *Radio research 1942-1943* (pp. 3-33). New York, NY: Duell, Sloan & Pearce.

Katz, E., Blumler, J. G., & Gurevitch, M. (1974). Utilization of mass communication by the individual. In J. G. Blumler & E. Katz (Eds.), *The uses of mass communications: Current perspectives of gratifications research* (pp. 19-32). Beverly Hills, CA: Sage.

Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education, 52,* 800-810. doi:10.1016/j.compedu.2008.12.004

Kirigian, A., Meyers, M., & Charland, C. (2007). Web Fun Central: Online learning tools for individuals with Down syndrome. In Sharp, Rogers, & Preece (Eds.), *Interaction Design: Beyond Human-Computer Interaction* (pp. 1-40). John Wiley & Sons Ltd.

Koepp, M. J., Gunn, R. N., Lawerence, A. D., Cunningham, V. J., Jones, T., Brooks, D. J., … Grasby, P. M. (1998). Evidence for striatal dopamine release during a video game. *Nature, 393,* 266-268. doi:10.1038/30498

Kühn, S., & Gallinat, J. (2013). Amount of lifetime video gaming is positively associated with entorhinal, hippocampal, and occipital volume. *Molecular Psychiatry, (*May), 1-6. doi:10.1038/mp.2013.100

Kühn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2013). Playing Super Mario induces structural brain plasticity: gray matter changes resulting from training with a commercial video game. *Molecular Psychiatry,* (October), 1-7. doi:10.1038/mp.2013.120

Kühn, S., Romanowski, A., Schilling, C., Lorenz, R., Mörsen, C., Seiferth, N.,…Gallinat, J. (2011). The neural basis of video gaming. *Translational Psychiatry, 1*(August), e53. doi:10.1038/tp.2011.53

Lee, L. G., & Jackson, J. F. (1972). Diagnosis of Down's syndrome: Clinical vs. laboratory. *Clinical Pediatrics, 11,* 353-356. doi:10.1177/000992287201100610.

Lott, I. T., & Dierssen, M. (2010). Cognitive deficits and associated neurological complications in individuals with Down's syndrome. The Lancet Neurology, 9(6), 623-633. doi:10.1016/S1474-4422(10)70112-5

Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research, 31,* 499-523. doi:10.1177/0093650204207930

Lyle, R., Bena, F., Gagos, S., Gehrig, C., Lopez, G., Schinzel, A., … Antonarakis, S. E. (2008). Genotype-phenotype correlations in Down syndrome identified by array CGH in 30 cases of partial trisomy and partial monosomy chromosome 21. *European Journal of Human Genetics, 17*(4), 454–466. doi:10.1038/ejhg.2008.214

Mao, R., Zielke, C. L., Zielke, H. R., & Pevsner, J. (2003). Global up-regulation of chromosome 21 gene expression in the developing Down syndrome brain. *Genomics, 81,* 457-467. doi:10.1016/S0888-7543(03)00035-1.

Mikkelson, M., Fischer, J. G., Stene, J., Stene, E., & Peterson, E. (1976). Incidence study of Down's syndrome in Copenhagen, 1960-1971: With chromosome investigation. Annals of Human Genetics, 40, 177-182. doi:10.111/j.1469-1809.1976.tb00177.x.

Morrison, J. (2006). *DSM-IV made easy: The clinician's guide to diagnosis*. New York, NY: The Guilford Press.

Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement. *Review of General Psychology, 14,* 154-166. doi:10.1037/a0019440

Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A. S., McNamara, J. O., & Williams, S. M. (Eds.). (2004). Neuroscience (3rd ed.). Sunderland, MA: Sinauer Associates, Inc.

Rahman, S. A. R. A. (2010). Efficacy of virtual reality-based therapy on balance in children with Down syndrome. *World Applied Sciences Journal, 10(3),* 254-261. Retrieved from http://www.idosi.org/wasj/wasj10(3)/1.pdf

Reed, R. B., Pueschel, S. M., Schnell, R. R., & Cronk, C. E. (1980). Interrelationships of biological, environmental, and competency variables in young children with Down syndrome. *Applied Research in Mental Retardation, 1,* 161-174. doi:10.1016/0270-3092(80)90002-8

Ritterfeld, U., & Weber, R. (2006). Video games for entertainment and education. In Vorderer, P., & Bryant, J. (Eds.), *Playing video games: Motives, responses, and consequences* (pp. 399-414). Mahwah, NJ: Lawrence Erlbaum.

Rosengren, K. E. (1974). Uses and gratifications: A paradigm outlined. In J. G. Blumler & E. Katz (Eds.), *The uses of mass communications: Current perspectives of gratifications research* (pp. 269-286). Beverly Hills, CA: Sage.

Ruggiero, T. E. (2000). Uses and gratifications theory in the 21st century. *Mass Communication & Society, 3,* 3-37. doi:10.1207/S15327825MCS0301_02

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25,* 54-67. doi:10.1006/ceps.1999.1020.

Selnow, G. W. (1989). Playing videogames: The electronic friend. *Journal of Communication, 34,* 148-156. doi:10.1111/j.1460-2466.1984.tb02166.x

Sherry, J. L. (2004). Flow and media enjoyment. *Communication Theory, 14,* 328-347. doi:

10.1111/j.1468-2885.2004.tb00318.x

Sherry, J. L. (2014). Media effects, communication and complexity science insights on games for learning. In F. C. Blumberg (Ed.), *Learning by Playing: Video gaming in education* (pp. 104-120). Cambridge, MA: MIT Press.

Sherry, J., Greenburg, B. S., Lucas, K., & Lachlan, K. (2006). Video game uses and gratifications as predictors of use and game preference. In P. Vorderer & J. Bryant (Eds.), *Playing computer games: Motives, responses, and consequences* (pp. 213-224). Mahwah, NJ: Laurence Erlbaum.

Spanó, M., Mercuri, E., Randó, T., Pantó, T., Gagliano, A., Hendreson, S., & Guzetta, F. (1999). Motor and perceptual-motor competence in children with Down syndrome: Variation in performance with age. *European Journal of Paediatric Neurologu, 3*, 7-14.

Spence, I., & Feng, J. (2010). Video games and spatial cognition. *Review of General Psychology*, *14*, 92-104. doi:10.1037/a0019491

Swanson, D. L. (1992). Understanding audiences: Continuing contributions of gratifications research. *Poetics, 21*, 305-328. doi:10.1016/0304-422X(92)90011-Q

Vicari, S., Carlesimo, A., & Caltagirone, C. (1995). Short-term memory in persons with intellectual disabilities and Down's syndrome. *Journal of Intellectual Disability Research, 6*, 532-537. doi:10.1111/j.1365-2788.1995.tb00574.x

Whalen, C., Liden, L., Ingersoll, B., Dallaire, E., & Liden, S. (2006). Behavioral improvements associated with computer-assisted instruction for children with developmental disabilities. *The Journal of Speech-Language Pathology and Applied Behavior Analysis*, 1(1), 11-26. Retrieved from http://www.baojournal.com/SLP-ABA/WEBSITE/Past-JournalIndexes.html

Wuang, Y., Chiang, C. S., Su, C. Y., & Wang, C. C. (2011). Effectiveness of virtual reality using Wii gaming technology in children with Downs syndrome. *Research in Developmental Disabilities, 32,* 312-321. doi:10.1016/j.ridd.2010.10.002

Wuang, Y., & Su, C. Y. (2012). Patterns of participation and enjoyment in adolescents with Downs syndrome. *Research in Developmental Disabilities, 33,* 841-848. doi:10.1016/j.ridd.2011.12.008

Yuan, B., Folmer, E., & Harris, F. C., Jr. (2011). Game accessibility: A survey. *Universal Access in the Information Society, 10,* 81-100. doi:10.1007/s10209-010-0189-5