Running Head: DIGITAL GAMES, COGNITIVE DEVELOPMENT, SCAFFOLDING

Playing digital games as scaffolding:

How cognitive developmental level interacts with digital games' formal features

CarrieLynn Reinhard

The Ohio State University

Abstract

Being the newest medium, and one with which children are engaging at a consistently increasing amount of time and energy, digital games have received scrutiny for both its possible negative effects and its possible positive effects. Studies in television effects have investigated how attention and comprehension towards the medium and its content are a necessary component for any effects to occur, and this attention/comprehension cycle can itself be impacted by the child's cognitive abilities. In the study of digital games, these components have not received sufficient examination. This study proposes to investigate how young children attend to digital games and how a child's pre-existing cognitive skills can affect their interaction with the game as well as be impacted by this interaction.

Literature Review

> "Learning to deal with multiple interacting variables is a significant accomplishment because the world is not a simple system, but rather many complex systems of multiple interacting factors. But how much transfer can we expect from video games to other domains of knowledge and life?"
>
> - Patricia Greenfield, 1984, p. 114

Introduction

The history of the mass media has born witness to a chief concern: how will interacting with this or that medium and/or its content impact our children? So it was with film, comic books, television, the Internet, and now digital games. The term digital games is used to refer to any form of interactive gameplay that requires a level of computer technology in order to operate, and thus subsumes games that could be found on computers (i.e. computer games), consoles or even handheld devices (the latter two are referred to as videogames). Regardless of the actual device one uses to play the game, the games all share the characteristics of visual stimuli that are responsive to the input of the player due to the processing capabilities of the game's programming.

It is this responsiveness aspect of digital games that has worried society and set it apart from television or any other visually-based medium. Researchers who study television have repeatedly used social learning theory's proposition of observational learning to explain how television could teach aggressive or other bad habits to the child viewer. In digital games, the ability for the child to virtually perform aggressive behavior allows for a different type of learning through direct modeling, and such modeling may increase the possibility of the child engaging in the negative behavior after playing the game. At the same time, this interactive feature, along with other aspects of digital games, has been studied as providing greater cognitive abilities due to the requirements of the gameplay.

As it applies to other media, whether or not playing digital games can have an effect may hinge upon the ability of the child to attend to and comprehend the game with which they are engaging. This supposition arises out of research in education and media studies regarding the link between attending to some stimuli, the ability to attend the stimuli, and thus the capacity for learning from that stimuli. Being able to perceive and comprehend a stimulus can result in higher attention, which can lead to greater comprehension and then more learning. This attention/comprehension (A/C) cycle is also dependent upon the cognitive capabilities of the child, as some children may be more or less able to attend to and/or comprehend the content of a stimuli based on their cognitive developmental age.

While digital games do share some formal features with television and film, the level of active participation required to engage with the games sets them apart. While some of the research then on attention/comprehension of television content may be applicable to digital games, this added dimension to the games requires approaching this medium as a unique entity. This entails conducting research as to how well children at different cognitive development levels can interact with digital games.

Rideout, Vandewater and Wartella (2003) found that 48% of children 6 years old and younger have used a computer at some point. Of these, 27% use a computer daily, and 56% can use the computer alone. Along with computers, 10% have a game console in their bedrooms, although playing digital games is less common in this age range, accounting for just an average 5 minutes of media use a day. However, 30% of this age range have played digital games at some point in their life, with 4 to 6 year olds averaging a little over an hour when they play. All these statistics fall below the gameplay averages for older children, and it may be that younger children do not play digital games because cognitively they cannot. Thus, the first part of this study was designed to understand how well a young child can interact with this active medium:

> RQ1: How does the cognitive developmental level of a child interact with the specific formal features of digital games to impact the child's gameplay experience?

As a means of understanding the comprehension aspect of the A/C cycle, as well as exploring a basic level effect possible from gameplay, this study also explored how engaging with a specific digital game may impact the child's cognitive abilities. In this case, the cognitive ability of interest was spatial reasoning:

> RQ2: Does engaging with a digital game that is based on spatial reasoning skills provide scaffolding for children of less developed spatial reasoning skills?

If it can be found that younger children can learn new cognitive skills by engaging with digital games, and yet they are limited in doing so due to the cognitive requirements of current games, then hopefully the end result of this research would allow game designers and educators to take the next step to developing games for younger audiences.

Highlighting the attention/comprehension cycle

Learning either bad behaviors or good cognitions from the content of a mass medium is dependent on whether or not the content is even being attended to and comprehended (Lorch, Anderson & Levin, 1979). Fundamental to the definition of digital games, visual attention has been shown to be important in attracting young children's attention to the screen (Greenfield, 1984). Anderson and Lorch (1983) theorize that attention to a medium is an active cognitive transaction between the viewer, the medium and the viewing environment. "Visual attention is actively under the control of the viewer, even the young viewer, and is in the service of the viewer's efforts to understand the television program and to deploy attention efficiently between the television and other aspects of the viewing environment." (Anderson & Lorch, 1983, p. 2). Visual attention can be cued into being active due to features of the content and/or medium (to be discussed shortly), and it is the very nature of digital games that creates a need for active visual attention.

Not only are digital games potentially more attractive and thus more likely to garner more attention due to the visual action inherent in them, but the nature of active participation, or interaction, necessary to further the game's content also attracts children. There is a predictable pattern that children are attracted to activities that allow them to have involvement or control over the content. (Greenfield, 1984). In researching attention and interaction with computers, Calvert, Strong and Gallagher (2005) found that preschoolers' attention declined when they were not to some degree in control of their interaction with the computer program. Preference for active participation can begin at a very early age, as studies have shown children are attracted towards programs that are animated involve the viewer in problem-solving (Wartella & Jennings, 2000). In the case of digital games, it is likely a child will be very active in attending to the game not only because the interaction requires it to further the content but also because they are interested in having a measure of control as allowed by the medium.

The link of attention to learning also requires consideration of comprehension. A child cannot simply look at a page to learn about what Jane and Dick are doing. The child needs to be able to comprehend that the words and pictures refer to Jane and Dick doing something. Thus, in the model from attention to learning, comprehension plays a significant role. However, the relationship of attention and comprehension resulted in somewhat of a chicken-and-egg dilemma: is comprehension necessary for a child to attend to something; does a child need to attend to something first to comprehend it; or is there an interactive nature to the relationship? (Lorch, Anderson & Levin, 1979; Lorch, 1994).

While researchers have come down on either side of this A/C cycle, Huston and Wright (1983) maintain that attention and comprehension reside not in a linear relationship but in a cyclical loop; "…attention at the moment information is presented is a necessary, but not sufficient, condition for comprehension, and some level of comprehension is a necessary, but probably not sufficient, condition for attention to continue." (p. 58). Anderson and Lorch (1983) believe that visual attention is maintained by the viewer's ability to comprehend the content and the need to answer questions posed by comprehensibility of the content. When content is harder to comprehend, then attention to it may be higher, but learning from it may be lower than if the reverse was true (Crawley, Anderson, Santomero, Wilder, Williams, Evans & Bryant, 2002).

As digital games have such a high level of active participation required, this interaction would engender continuous attention to the visual stimuli; thus, there is a cycle between the interaction and visual aspects of digital games to assure that the player's attention is on the game, what Anderson and Lorch (1983) called "attentional inertia" in reference to television. This assurance should hold at all levels of comprehensibility, and possibly at low levels on incomprehensibility, where the player may remain motivated to overcome an obstacle. However, at higher levels of incomprehensibility, frustration may mount to the point that the game is discarded, thereby breaking the A/C cycle. The perception of incomprehensibility may vary depending on the player's cognitive ability level as it impacts their ability to process the information of the game and interact with the game (Roedder, 1981).

Anderson and Lorch (1983) indicate that the control of viewing a medium is with the viewer, based on experience with the medium, familiarity with the specific program, level of cognitive development, and general world knowledge (p. 9). In specific to viewing television, they promote the idea that children have a schemata for how to comprehend television content, and that children without this schemata will not attend to the television should some alternative activity be provided. Thus, a child's age, which relates both to cognitive ability and overall experience with a medium, would impact the A/C cycle, and this interaction would then become dependent on the features found in either the content and/or the medium as to how well the resulting attention, comprehension and learning would be.

Formal features and attention/comprehension cycle

While sharing characteristics with other media, television is studied separately for its immediacy and interwoven nature in everyday life. Besides this medium specific characteristic, there are other attributes of the medium that can be found across its content, and these characteristics can become perceptually salient features in that they elicit attention from the viewer, such as action, pace, visual techniques, verbal and nonverbal auditory events (Huston & Wright, 1983). These features of television can serve to cue in the viewer when to attend to the content as well as guide how to interpret it. Alwitt, Anderson, Lorch and Levin (1980) found that preschool children visually attended to television based a variety of content features, such as certain voices, and medium features, such as movement. These characteristics can also be found in most digital games as content features, but it is mostly the difference in medium features this study proposes to explore.

Television and digital games differ along the dimension of active participation (Greenfield, 1984; Calvert, Strong & Gallagher, 2005). While there are television shows designed to elicit participation from the audience (ex. *Blue's Clues*, Crawley et al, 2002), these programs do not allow moment-to-moment manipulation of content, an interaction possible in digital games due to the processing capacity of the computer and possibly artificial intelligence programming. Interactivity as a feature places a demand for certain levels of biological and cognitive development from the player.

A primary skill in being able to engage in this interaction is the ability to coordinate what one sees with the movements of one's hands in order to properly interact with the stimuli. According to Piaget, such hand-eye coordination, a sensorimotor skill, can provide the foundation for later cognitive abilities, which is why the attainment of this skill is located within the first few years of life (Greenfield, 1984). This is a skill attainable via non-mediated experience, like all the skills related to television and digital game features.

Another feature and skill is divided attention. Divided visual attention is the need for dealing with simultaneous events at several locations on the screen. While it may be useful in television viewing to pick up incidental or peripheral information, divided attention is imperative in digital games where any part of the screen may require the player's attention at any time or else the game is over. In fact, those with more experience playing digital games do indeed show better ability at being able to spread their attention around the screen, an ability that has useful real-world applications, such as driving any vehicle (Greenfield, deWinstanley, Kilpatrick & Kaye, 1996). This divided attention informs another cognitive requirement, parallel processing, which refers to taking in information from various sources simultaneously and incorporating this information into a coherent whole (Greenfield, 1984).

The ability to coalesce information from across the screen leads to another aspect of gameplay. The rules are not all spelled out and often times the fun of the game, that which draws players to it, lies in the challenge of determining the way to succeed (Newman, 2004).

Not only does the player need to understand the content patterns, but the player must be able to understand how to coordinate the interactivity skills as well as how to attend to the variety of visual information being supplied. Inductive comprehension then occurs in regards to both content and medium features. Digital games are thus a confluence of numerous elements that demand and facilitate different forms of participation and activity.

But like television attention and comprehension, the chicken-and-egg scenario again arises. Are these skills necessary for engaging successfully with the game, or can they be manifested by interacting with the game? Or could it be that some necessary level of skills is required to even begin to engage with the game, but then through engagement these skills can be heightened? As Beentjes, deKoning and Huysmans (2001) indicate, younger children do not have enough real-world perceptual experience to properly comprehend formal features as representing certain types of information. As discussed in the A/C cycle, that could then mean the player would be less likely to attend to this content, which would further weaken their comprehension and their capacity to learn from the game.

While engaging with computers and digital games may increase cognitive skills, the content may be too abstract or too symbolic for preschoolers and young children to be able to cognitively handle, let alone master (Li & Atkins, 2004). Digital games also require active participation, and television researchers acknowledge that while children can and do engage in active viewing of television, this is a strategy that develops across time through experience (Meadowcroft & Reeves, 1989). If the game features elements based on cognitive skills the child as not yet mastered, then their attention will be diminished by the lack of comprehensibility they find within the game. Thus, the features of the game's content as well as those of the medium itself may prevent younger children from successfully engaging with the game.

Hypothesis 1a: Less cognitively developed children are expected to perform worse and like the game less than more cognitively developed children when playing the chosen game, *Tetris*®.

Hypothesis 1b: Children who have more digital games and overall computer experience should perform and like the game best.

As mentioned above, a fundamental feature of gameplay is the need for divided attention to be able to monitor all parts of the screen. However, children may also be likely to engage in selective attention, wherein a certain aspect is focused on while other information is filtered out as irrelevant. Research has typically shown that younger children are less able to selectively attend than older children (Blumberg, 1998), but this does not mean the child will be able to effectively divide attention either. While the younger child may look all over the screen, it is unclear whether or not this would improve their gameplay. A younger child may randomly look at one spot at a time when they should be looking somewhere else.

Hypothesis 2: Younger children will spend more time looking at various random locations on the screen than older children.

Research Question 3: How will differences in using selective attention versus divided attention impact gameplay outcomes and evaluations?

<u>Learning from digital games</u>

Social learning theory predicts that children can learn behaviors and cognitions if they observe said activity being positively modeled (Bandura, 1963). This theory has long been applied to mediums that allow only observation; however, digital games are not one of these media. Greenfield suggested there were three types of learning: enactive, done through use of the body; iconic, done through use of a visual system; and symbolic, done through the use of words (Calvert & Tan, 1996). All three types of learning are possible from digital games, coinciding with social learning theory, but it is the enactive possibility that contains both concern and promise. Digital games could be a tool for socialization, based on the theorizing of Vygotsky about the possible use of cultural artifacts and tools to be used to improve cognitive abilities in children, or how society can teach their youth by example rather than rote instruction (Subrahmanyam & Greenfield, 1996). "The anthropological study of games has demonstrated that a culture's games socialize children in accord with the needs and adaptational requirements of a particular society." (Greenfield, Brannon & Lohr, 1996, p. 172). Being interactive could allow digital games to be a source of enhanced learning, but virtually embodying the cognitions and behaviors of some game characters could also increase exposure to risky, inappropriate content (Wartella & Jennings, 2000; Subrahmanyam, Kraut, Greenfield & Gross, 2001).

There have been numerous studies exploring the link between violent video games and aggression in the player. Both correlational and causal research has found a link between playing violent games and either acting, thinking or feeling aggressive (Dill & Dill, 1998; Anderson & Dill, 2000; Anderson, 2004). The main concern lies in the active participation aspect of video games, which is said to lead to increased learning due to rehearsal and repetition (Anderson, 2004). "Interactions with an aggressive virtual reality game may well cultivate enactive, bodily representations (e.g., firing a gun) that may then be easily recoded into subsequent aggressive behavior in future situations." (Calvert & Tan, 1996, p. 68). Calvert and Tan found that immersion in a virtual reality game lead to higher levels of aggressive thoughts as well as physiological arousal. But immersion and interaction are two related but distinct forms of cognitive engagement with a digital game.

Other studies, looking specifically at interaction, have compared playing a digital game to watching someone else play the game. If a child's ability to interact with a violent game would be more likely to increase aggression, then there should be a difference between these two children. However, this has not been observed to be the case (Cooper & Mackie, 1996; Silvern & Williamson, 1987). This difference between interaction and observation was also found in the context of more positive results. Calvert, Strong and Gallagher (2005) found that irregardless of whether or not the child was in control of a computer program, they still learned the same from the content.

While perhaps just a stepping stone between exposure and negative effects, another branch of digital games research has looked at how the use of such technology can foster cognitive skills like visual and verbal intelligence (Subrahmanyam, Kraut, Greenfield & Gross, 2001; Subrahmanyam, Greenfield, Kraut & Gross, 2001). Use of computers and digital games have been found to improve children's ability to comprehend spatial relations, fine motor skills, premathematical knowledge and even self-concept (Li & Atkins, 2005).

McClurg and Chaillé (1987) found that playing computer games enhanced 5th-9th graders ability to mentally rotate 3D objects. Subrahmanyam and Greenfield (1996) found that after having 10-11 year old children play the game *Marble Madness*, those that were low in spatial skills during the pre-test improved their skills for the post-test, but they did not catch up with those already high on the skills during the pre-test. The researchers concluded that while some initial level of spatial skills improved mastery of the game, that repeated exposure to the game did increase a less skilled player's spatial abilities. Okagaki and Frensch (1996) found similar results after having adolescents play the game *Tetris* over a period of time. These findings relate to the notion of scaffolding as a theory to explain how an interactive digital game could have an instructional impact through enactive learning.

Scaffolding was a concept derived from the work of Vygotsky to describe how a more cognitively advanced tutor could instruct and aid in the development of certain skills for a learner (Luckin, Connolly, Plowman & Airey, 2003). As long as the learner is within a proper zone of proximal development, which would be a cognitive developmental level advanced enough that the new task is not completely impossible, then this gradual instruction process should allow the child to further their development, possibly even reaching new abilities faster than would have occurred without the scaffolding (Puntambekar & Hübscher, 2005). "The expert not only helps motivate the learner by providing just enough support to enable him or her to accomplish the goal, but also provides support in the form of modeling, highlighting the critical features of the task, and providing hints and questions that might help the learner to reflect." (p. 2). The concept, applied to the education field since the 1980s, has been studied most recently with the possibility that computer technology could provide similar results in classrooms where the teacher may not be able to interact with each child individually.

As a computer technology, digital games may provide this same scaffolding in the context of informal learning and entertainment. Digital games can model behavior needed to overcome an obstacle, such as learning how to manipulate shapes to fit with other shapes or where to point a gun to kill a bad guy. Not only does the game allow the player to enact these behaviors and abilities under a reward-punishment framework, but often this modeling occurs over numerous attempts, and it is this repetition that can ingrain these behaviors and abilities in the player. Thus, in order to successfully interact with a digital game, a player must be able to model the encouraged behavior or ability, which may require numerous repetitions in which the behavior or ability is refined.

For this particular study, the debate between good and bad effects is set aside to focus on spatial abilities and attention. "Skill in spatial representation is one example of everyday cognitive skills utilized and developed by video games and other computer applications." (Subrahmanyam & Greenfield, 1996, p. 96). Three important factors to spatial representation: spatial relations ability, capacity to rapidly mentally transform objects; spatial visualization; ability to deal with complex visual problems which require imagining the inner movements of objects; and perceptual speed, ability to rapidly encode and compare visual forms.

Digital games may aid in the formation of these skills through repetition and trial-and-error experience, which is a part of scaffolding. This has been found, but among older children who theoretically would have already acquired an understanding of these spatial abilities. Indeed, Li and Atkins (2004) found that if preschoolers had a continual access to computers at home, then the child was more advanced in their cognitive abilities; however, as this study relied on a survey measure, any exact causality cannot be determined, even if the researchers controlled for various environmental influences. Children in Piaget's preoperational stage have difficulty with spatial problems and may be less likely to be able to engage with a digital game for which this ability is necessary (Hypotheses 1); that is, the game may be less comprehensible, requiring more attention and resulting in less learning. However, children at a later period of preoperational may be able to further their spatial abilities by engaging in such a game, and thus the game would serve as a scaffolding device.

Hypothesis 2a: Repeated exposure to the digital game should improve the child's spatial abilities when compared to control group of same level, but the child would not increase to meet with different level.

Hypothesis 2b: Children at the end of preoperational should show the most improvement in their spatial abilities after playing the game.

Methods

Participants

Numerous studies have explored the cognitive benefits of engaging with digital games in older populations, given the prevalence of game play in their everyday lives. However, if there is the possibility that engaging with these games can scaffold younger children by aiding such cognitive skills as spatial reasoning, then a sample of younger children, who may not be active players, should be explored.

Thus, for the purpose of this study, three age groups were selected to explore the range of a specific Piagetian cognitive development stage not yet fully explored. The Preoperational stage is characterized by a deficiency in mentally and logically reasoning issues of spatial relations, such as conservation and transformation of objects (Piaget & Inhelder, 1969). The first group chosen would be 30 3 year olds (± 3 months). This group is chosen to be the youngest as they are moving from sensorimotor to preoperational thinking, and as such should have already mastered some level of hand-eye coordination necessary for a degree of interaction with the game. The second group chosen would be 30 5 year olds (± 3 months), as they are theoretically in the middle of the preoperational stage, and would thus have developed some of the spatial reasoning skills but not all that would move them to the next stage. The third group would be 30

7 year olds (± 3 months), as they are moving from preoperational to concrete operational; if they have not yet mastered conservation and/or transformation, then theoretically they soon will.

The sample will not be furthered subdivided for ethnicity or gender, and will most likely be drawn from convenience samples at local daycares, preschools and kindergartens.

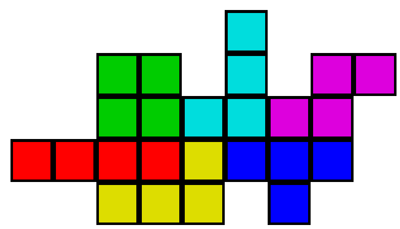
Design

The design of the study, matching the complexity of the concepts under review, combines both between and within analyses over a series of repeated trials with a pre-test/post-test measure. A 3x2 between groups design is translated into the three age groups being tested along with their participation in either a gameplay condition or no-play condition. To understand the effect of playing the game on spatial reasoning abilities, both the gameplay and no-play condition will be pre- and post-tested (respectively Time 1 and Time 2), which will serve as the main MANOVA comparison between these groups to test H2a and H2b. In addition to this between-group comparison, in order to understand differences in digital game experience, attention, and evaluation and gameplay performance, the three age groups will be compared with ANOVA to test RQ3, H1a and H1b. Finally, to understand how playing the game might impact the different age groups, a final MANOVA will be used to explore the within age group differences across the gameplay and no-play conditions to also test H2a and H2b..

Measures

Spatial ability scores: A child's cognitive level will be measured using the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R) at Time 1 and Time 2. The WPPSI-R is chosen due to its tested reliability in measuring a child's spatial reasoning skills with the Performance Scale. The Performance Scale contains six subtests: Object Assembly, Geometric Design, Block Design, Mazes and Picture Completion. Each of these subtests is designed to measure either an aspect or the aggregate spatial reasoning ability of the child. While the test can be used to obtain an overall IQ score (as done by Li & Atkins, 2004), the focus here is to use it for generating standardized scores on which to compare the children's spatial abilities (as done by Subrahmanyam & Greenfield, 1996). The test will be administered at Time 1, and then two weeks later at Time 2. In this two week span, those children in the gameplay condition will have undergone three 20 minute sessions of playing the digital game, *Tetris*.

Tetris: Tetris first appeared in 1989 for the Nintendo game console and handheld GameBoy, and soon became one of the industry's most popular games, spawning both spin-offs and rip-offs. *Tetris* was chosen for this study for a number of reasons. First, *Tetris* contains visual and abstract icons as the principal stimuli. The purpose of *Tetris* is to manipulate a series of different shaped blocks so that they fit into holes created by other blocks already at the bottom of the screen. The goal is to manipulate the blocks by turning them on their side to get the best fit possible before the block reaches the bottom (see Figure 1). The game begins with the blocks slowly falling from the top, but each new level hastens this descent. When a horizontal line of blocks is created without any holes, that line is taken away, the overall height of the blocks is diminished, and the player is rewarded with a score determined by how many lines were destroyed. The goal is to never allow any of the blocks to reach the top. Based on the puzzle-solving, non-violent nature of the game, the ratings board for digital games has deemed it appropriate for all ages.



The second reason for choosing Tetris as the experimental stimuli is found in the mechanics of the gameplay. While the explanation of what the player needs to do appear simple, it is deceptively so. "Tetris is a game that requires the rapid rotation and placement of two-dimensional stimuli… players must not only mentally represent the shapes in different orientations (mental rotation skill), but must also mentally visualize what would happen if the shapes were dropped into a particular opening in the wall (spatial visualization skill)." (Okagaki & Frensch, 1996, p. 120-122). The player must be able in their hand-eye coordination to manipulate the game pieces in time, as one slip can prove disastrous at higher levels and faster speeds. Thus the game necessitates a certain level of sensorimotor skills as well as high active participation, as the player is required to constantly manipulate the game pieces with the only reprieve coming if the gameplay is paused. Along with knowing how to make the controls twist the blocks, the player needs to know how a twisted block can best fit into a given hole, and this requirement is a classic display of spatial reasoning ability.

The game demands that the player be aware of what are the conditions in several sections of the screen. The player needs to be aware of where the holes are in the bottom, what types of holes they are, how high the blocks have gotten, what is the current block falling, how that block can be manipulated, how to follow straight lines from top to bottom, and even what is the next block about to be dropped. With all of these questions, add the last most strategic of all, how to place the blocks so as to destroy the most lines at once and thus gain the most points. All of these questions point to the other two formal features of digital games: divided attention and inductive comprehension. To be able to successfully navigate the game, the player needs to be able to attend to the bottom of the screen, the top of the screen and the middle of the screen, at various times and even simultaneously when the game reaches higher levels. To be able to score the most points, and to prevent losing, the player needs to determine what are the most efficient ways to make lines; while this is the given objective, there is no rulebook as to how to make the lines, especially as the blocks drop at random. This inductive reasoning is an ongoing and constantly changing requirement for mastery of the game.

Attention: Visual orientation is a common way for measuring attention to visual stimuli in that it measures how often a child's eyes are directed towards a stimulus. For the purposes of this study, visual attention will be measured by visual fixation, or the precise location on the screen the eyes are directed at (Anderson & Lorch, 1983). While the child is playing Tetris, two unobtrusive cameras will record (a) the child's face, focusing on their eyes, and (b) the screen on which the game is shown. The child's line of sight focus will be matched with the reciprocal location on the game screen so as to determine what location the child was looking at and what was the action going on during that moment. This match will then be coded for the following: (a) the location of their focus, be it the top, bottom or middle of the screen; and, (b) the amount of time the player attends to any one location on the screen. These two measures taken together will provide a composite score to separate players as either engaging in selective or divided attention. A child engaging in selective attention will spend the most of their time focusing on a specific area of the screen. A child engaging in divided attention will spend most of their time looking at various parts of the screen with no one location receiving more viewing time than any other.

Game performance and evaluation: After each gameplay session, the child's performance will be collected by recording the level and score attained. Additionally, the player will be interviewed about their experience, with particular focuses on how much the player enjoyed the game and how frustrated they felt with the game. The player will be asked to use pictures of children, ranging from very happy to very sad, to answer these questions.

Experience: As digital games and computer use may be present in their everyday lives, measures of how often they engage with these devices are necessary to determine if such experience may be already present in how it influences the player's interactions with the game. Parents and children alike will be asked to give an average time spent with both digital games (which will be broken down to computer, game console and handheld) and other computer programs (including the Internet). Should the parent-child answers be discrepant by more than 5 hours, an average of the two estimates will be calculated.

Procedure

Regardless of their assigned condition, all the children will be tested with the WPPSI-R as a pre-test in a controlled setting (preference would be at the child's school or daycare facility). After this pre-test, 45 children (15 from each age group) will three days later be brought to a laboratory setting by their caregiver where they will play the game on a Nintendo game console. At the first session, the child will be given a brief tutorial on how to use the controller. The child will also be told that they can stop playing at any time, and that the researcher will ask them to stop playing after twenty minutes. The child will be allowed a minute of practice to familiarize themselves with the gameplay. After this minute has passed, without interrupting the child, the cameras will start recording.

After the allotted time has expired, the research will ask the child to put down the controller so that the research can record the game score and level attained. The child will be sent to their caregiver, where another researcher is waiting to ask the evaluation and media use questions after a few minutes of allowing the child to interact with the caregiver. These few minutes should act as a buffer, should the child feel frustrated from being forced away from the game.

After this first session, the child will return in three days for the second session, where they are again given the one-minute practice before the cameras begin recording. The gameplay will end just as before, with the same buffer and questions. For the third session, three days after the second session, there will be no practice minute, while all other aspects remain the same. Three days later, or what equals to be two weeks after Time 1, the children will again be tested with the WPPSI-R and thanked for their overall participation.

References

Alwitt, L. F., Anderson, D. R., Lorch, E. P. & Levin, S. R. (1980). Preschool children's visual attention to attributes of television. Communication Research, 7(1), p. 52-67.

Anderson, C. A. (2004). An update on the effects of playing violent video games. Journal of Adolescence, 27, p. 113-122.

Anderson, C. A. & Dill, K. E. (2000). Video games and aggressive thoughts, feelings and behaviors in the laboratory and in life. Journal of Personality and Social Psychology, 78(4), p. 772-790.

Anderson, D. R. & Lorch, E. P. (1983). "Looking at television: Action or reaction?" In J. Bryant & D. Anderson (Eds.) Children's Understanding of Television: Research on attention and comprehension. (pp. 1-33). New York, NY: Academic Press.

Bandura, A. (1963). Influence of models' reinforcement contingencies on the acquisition of imitative responses. Journal of Personality and Social Psychology, 1, p. 589-595.

Beentjes, J., deKoning, E. & Huysmans, F. (2001). Children's comprehension of visual formal features in television programs. Journal of Applied Developmental Psychology, 22, p. 623-638.

Blumberg, F. C. (1998). Developmental differences at play: Children's selective attention and performance in video games. Journal of Applied Developmental Psychology, 19(4), p. 615-624.

Calvert, S. L. & Tan, S. L. (1996). "Impact of virtual reality on young adults' physiological arousal and aggressive thoughts: Interaction versus observation." In P. Greenfield & R. Cocking (Eds.) Interacting With Video (pp. 67-82), Norwood, NJ: Ablex Publishing Group.

Calvert, S., Strong, B. & Gallagher, L. (2005). Control as an engagement feature for young children's attention to and learning of computer content. American Behavioral Scientist, 48(5), p. 578-589.

Cooper, J. & Mackie, D. (1986). Video games and aggression in children. Journal of Applied Social Psychology, 16(8), p. 726-744.

Crawley, A., Anderson, D., Santomero, A., Wilder, A., Williams, M., Evans, M. & Bryant, J. (2002). Do children learn how to watch television? The impact of extensive experience with *Blue's Clues* on preschool children's television viewing behavior. Journal of Communication, 52(2), p. 264-280.

Dill, K. E. & Dill, J. C. (1998). Video game violence: A review of the empirical literature. Aggression and Violent Behavior, 3(4), p. 407-428.

Greenfield, P. (1984). Mind and Media: The effects of television, videogames and computers. Cambridge, MA: Harvard University Press.

Greenfield, P., Brannon, C. & Lohr, D. (1996). "Two-dimensional representations of movement through three-dimensional space: The role of videogame expertise." In P. Greenfield & R. Cocking (Eds.) Interacting With Video (pp. 169-186), Norwood, NJ: Ablex Publishing Group.

Greenfield, P., deWinstanley, P., Kilpatrick, H. & Kaye, D. (1996). "Action video games and informal education: Effects on strategies for dividing visual attention." In P. Greenfield & R. Cocking (Eds.) Interacting With Video (pp. 187-205), Norwood, NJ: Ablex Publishing Group.

Huston, A. C. & Wright, J. C. (1983). "Children's processing of television: The informative functions of formal features." In J. Bryant & D. Anderson (Eds.) Children's Understanding of Television: Research on attention and comprehension. (pp. 35-68). New York, NY: Academic Press.

Li, X. & Atkins, M. (2004). Early childhood computer experience and cognitive and motor development. Pediatrics, 113(6), p. 1715-1722.

Lorch, E. P. (1994). Measuring children's cognitive processing of television. In A. Lang (Ed.) Measuring Psychological Responses to Media. (pp. 209-226). Hillsdale, NJ: Erlbaum.

Lorch, E. P., Anderson, D. R., & Levin, S. R. (1979). The relationship of visual attention to children's comprehension of television. Child Development, 50, p. 722-727.

Luckin, R., Connolly, D., Plowman, L. & Airey, S. (2003). Children's interactions with interactive toy technology. Journal of Computer Assisted Learning, 19, p. 165-176.

McClurg, P. & Chaillé, C. (1987). Computer games: Environments for developing spatial cognition? Journal of Educational Computing Research, 3, p. 95-111.

Meadowcroft, J. & Reeves, B. (1989). Influence of story schema development on children's attention to television. Communication Research, 16(3), p. 352-374.

Newman, J. (2004). Videogames. New York, NY: Routledge.

Okagaki, L. & Frensch, P. (1996). "Effects of video game playing on measures of spatial performance: Gender effects in late adolescence." In P. Greenfield & R. Cocking (Eds.) Interacting With Video (pp. 115-140), Norwood, NJ: Ablex Publishing Group.

Piaget, J. & Inhelder, B. (1969). The Psychology of the Child. New York, NY: Basic Books

Puntambekar, S. & Hübscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? Educational Psychologist, 40(1), p. 1-12.

Rideout, V., Vandewater, E. & Wartella, E. (2003). Zero to six: Electronic media in the lives of infants, toddlers and preschoolers. Henry J, Kaiser Family Foundation, Menlo Park, CA.

Roedder, D. L. (1981). Age differences in children's responses to television advertising: An information-processing approach. Journal of Consumer Research, 8(Sept.), p. 144-153.

Silvern, S. & Williamson, P. (1987). The effects of video game play on young children's aggression, fantasy and prosocial behavior. Journal of Applied Developmental Psychology, 8, p. 453-462.

Subrahmanyam, D. & Greenfield, P. (1996). "Effects of videogame practice on spatial skills in girls and boys." In P. Greenfield & R. Cocking (Eds.) Interacting With Video (pp. 95-114), Norwood, NJ: Ablex Publishing Group.

Subrahmanyam, D., Greenfield, P., Kraut, R. & Gross, E. (2001). The impact of computer use on children's and adolescents' development. Applied Developmental Psychology, 22, p. 7-30.

Subrahmanyam, D., Kraut, R., Greenfield, P., & Gross, E. (2001). "New forms of electronic media: The impact of interactive games and the Internet on cognition, socialization, and behavior." In D. G. Singer & J. L. Singer (Eds.). Handbook of Children and the Media. (pp. 73-93.) Thousand Oaks, CA: Sage.

Wartella, E. & Jennings, N. (2000). Children and computers: New technology - old concerns. Children and Computer Technology, 10(2), p. 31-43.

Appendix

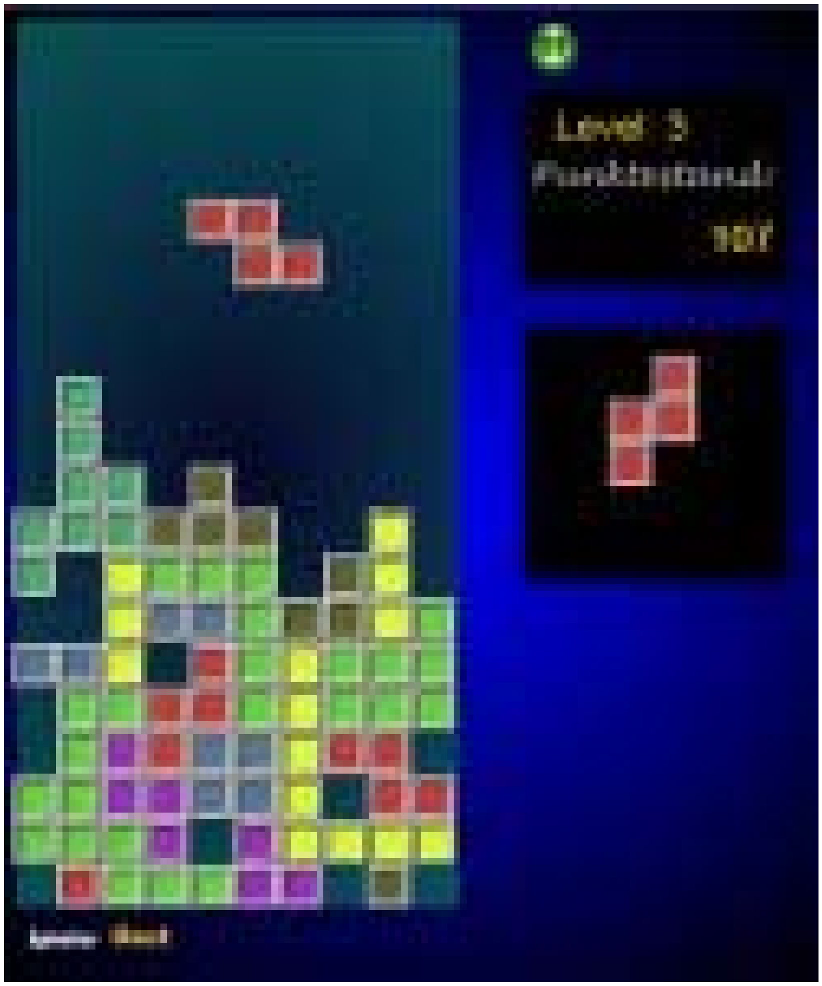


Figure 1 - Tetris gameplay screenshot