

CHILDREN'S COGNITIVE PROCESSING
OF EDUCATIONAL TELEVISION
MESSAGES

by

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A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts in the
Department of Telecommunication and Film
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2010

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ABSTRACT

This study used the Limited Capacity Model of Information Processing to provide more understanding about how children process information in a television program by looking at the effects of information density and structural complexity on attention and memory in children. Video clips from an episode of the show *Little Bill* selected according to levels of information density and structural complexity. Four video clips were selected for each of four categories. 58 children were recruited from a local pre-school and a local elementary school. Each child was shown video clips from one of the four categories. Attention, recognition memory, and recall memory were measured. This study found that the interaction between information density and structural complexity in video messages had significant effect on children's storage and retrieval memory processes in general. This study also found differences in information processing between pre-schoolers and 2nd graders.

DEDICATION

This thesis is dedicated to my wife Lauren and my step-daughter Rylie who have tolerated me and helped me through this process. I also dedicate this thesis to my dad for showing me the value in hard work and dedication, and to my mom who always told that if you can read you can do anything. Finally, I dedicate this thesis to the rest of my family and friends who have helped and supported me through this, whether it was helping me enter data or just telling me that things would be alright.

LIST OF ABBREVIATIONS AND SYMBOLS

d'	Sensitivity of the observer, d prime
df	Degrees of freedom
ϵ^2	Effect Size
F	Function
M	Mean
p	Probability
SD	Standard deviation
=	Equal to

ACKNOWLEDGMENTS

I would like to thank my committee members Dr. Shuhua Zhou, Dr. Erin Ryan, and Dr. Jason Scofield for helping me mold this thesis into what it is now. I would especially like to thank Dr. Zhou for helping clean up the mess that it was, and for turning the light at the end of the tunnel from an oncoming train to the actual end of the tunnel. I would also like to thank our department chair, Dr. Gary Copeland for putting up with me for so long. I would also like to thank Joey Goodsell for seeing my potential and offering the opportunity to get a master's degree.

Special thanks to Robin Hollingsworth and the teachers at the Children's Program at the University of Alabama, and to Lucy Sellers and the teachers at Northport Elementary. You made data collection the easiest and most enjoyable part of my thesis.

I must also thank Diane Shaddix for making sure I had an assistantship and helping me keep track of paperwork and deadlines, and Mary-Lou Cox for giving me a summer job, and just listening to me, a lot. Thanks also to my office mate, Mary Katherine, and the workers in the TCF office: Courtney, Laura, Heather, and Anna, who have supported and encouraged me. Finally, thanks to the workers in the equipment room, especially Heath and Matthew, for helping me get what I needed to get the job done.

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CHAPTER 1: INTRODUCTION

Past research has shown that the structural features of television have an effect on how we pay attention to television and process the information we get from it. Research on cognitive processing has shown that adults have a limited capacity to process information. While many studies have looked at information processing in children, few have looked at it in the context of television. The purpose of this thesis is to show how formal features of television programs affect information processing in children.

Research has shown that two aspects of television programs affect information processing: formal features and content. The formal features of a television program include the audio effects, visual effects, music, camera motion, and character action found within that program (Calvert et al., 1982; Gunter, Furnham & Griffiths, 2000; McCollum & Bryant, 2003; Pezdek & Hartman, 1983; Salomon, 1981; Shastri, 1993). These features have different effects on attention and memory, first by demanding either more or less attention, and second by requiring more or less memory space (Lang, 2000, 2006; Lang & Basil, 1998; Lang et al., 2000). As early as 12 to 48 months (1 to 2 years), the formal features of a television program tend to guide children's attention and memory; but, as the child develops, the content of the program begins to have more influence on processing (Anderson & Pempek, 1981; Lorch, et al., 2006).

So, given the evidence thus far, how do formal features of television programs affect attention and memory in children? What effects do those features have on children's processing of the information in those programs? Do those formal features have more of an effect on

younger children than they do on older children? This thesis addresses these research questions using the Limited Capacity Model of Information Processing. The Limited Capacity Model presents the idea that people are information processors with a limited amount of capacity to process information (Lang, 2000, 2006). While this model has been applied mostly to adults, it provides a framework for measuring the formal features of television messages, offering a way to look at how children process information.

The first aspect of information processing to examine is attention. Research has demonstrated that children begin displaying attentional behaviors, such as orienting themselves toward television sets and maintaining visual attention to the set, even in infancy, (Gilmore & Johnson, 1995; Goswami, 1998; Gunter & McAleer, 1990; Wartella, 1981). Studies have shown that not only does the *amount* of attention children pay to programs change with age, but the *content* they pay attention to changes as well, gradually shifting from formal features of television programs, such as music and movement, to content features such as plot elements (Anderson & Pempek, 1981; Lorch, et al., 2006; Van Evra, 2004). This thesis examines how formal features of television programs affect children's attention.

A second important aspect of information processing to examine is memory. Children's memory goes through a series of developmental stages (Goswami, 1998; Halford, 1982; Schneider, 2004; Smith, 2004), each having an effect on how they process information. The limited capacity model of information processing suggests that the amount of memory space, as well as memory type, influence information processing (Goswami, 1998; Halford, 1982; Lang, 2000, 2006). Research shows that, in adults, certain features of messages require more cognitive resources for encoding into memory than others (Goswami, 1998; Halford, 1982; Lang, 2000,

2006; Lang & Basil, 1998; Lang, et al., 2000). This thesis examines how such features of television programs affect children's encoding and memory.

This study aims to provide more understanding about how children process information in a television program by looking at the effects of information density (the amount of information introduced in a camera change), and structural complexity (the frequency of camera changes in a television message) on attention and memory in children.

CHAPTER 2: REVIEW OF LITERATURE

The guiding theoretical perspective of this thesis is the Limited Capacity Model of Information Processing. Information density and structural complexity are two aspects of television messages that affect attention and memory aspects information processing. Two aspects of information processing affected by information density and structural complexity are attention and memory. This chapter explains the limited capacity model, as well as the roles of attention and memory in information processing and how information density and structural complexity affect information processing.

Information Processing: The Limited Capacity Model

The Limited Capacity Model of Information Processing operates on two major assumptions related to this study; first, that people are information processors, and second that a person's ability to process information is limited (Lang, 2000; 2006). Individuals have a cognitive system with a limited and fixed pool of cognitive resources for processing information. This thesis focuses on the automatic allocation of cognitive resources by children for attention to a message, and to the encoding of information during television viewing, where encoding involves getting a bit of information out of the environment and into the brain (Lang, 2000).

Cognitive resources are allocated from the limited and fixed pool to a given processing task (Lang & Basil, 1998). Structural features of media messages elicit automatic allocation of cognitive resources (the "resources allocated" piece of the pie) to encoding (Lang, 2006). Lang and Basil (1998) used a money analogy, comparing total cognitive resources in the pool to the

amount of money in your wallet when you go shopping. In the money analogy, structural features draw dollars from your wallet in anticipation of the cognitive cost of a stimulus (Lang & Basil, 1998). The brain automatically responds to structural features that introduce new information. As the frequency of structural features increase, the brain increases the allocation of resources to process the new information and promote survival. To extend the money analogy, consider six items of comparable value. Perception of greater cost for items would draw more money from the wallet and on to the counter in preparation for the purchase of five of the items, when compared with an expected purchase of one of the items. Resources allocated similarly increase with the frequency of structural features.

Resources required are the amount of capacity required to process a primary task, or the attention required to encode a bit of information. Resources required are like the actual price of the item in the analogy. The price increases with the information introduced by a structural feature. If resources allocated are like the amount of money that you have set on the counter to pay a cashier for your items, resources required is the actual (cognitive) cost of buying (i.e., processing the information introduced by the structural feature) the item (Lang & Basil, 1998).

Resources available, then, are the difference between resources allocated and resources required (Lang & Basil, 1998). In the shopping analogy, resources available represent what is left on the counter after the transaction. If the difference is positive, resources available are positive and in surplus (i.e., there is change on the table). If there is no difference in *resources* allocated and resources required, your resources available will be zero (i.e., no change) and the system is said to be operating at capacity. If resources available are negative, there are not enough resources to cover the cognitive cost of the transaction and the system is in overload (Lang & Basil, 1998).

Thus, when resources allocated are high, and resources required are low, resources available are positive and encoding should be very thorough. When resources allocated are high and resources required are medium, resources available should be about even and encoding should be thorough. However, when resources allocated and resources required are both high (and encoding is poor, indicative of cognitive overload), resources available should be in deficit. In the shopping example, the cart of groceries has a certain price (resources required). You have set aside a certain amount of money for the cart of groceries (resources allocated), but have some money set aside for a candy bar at the checkout line. The amount of money set aside for the groceries and the extra money for the candy bar are the total resources available. If the groceries you plan to buy end up costing more than you have set aside, you may have to borrow from the extra resources that were set aside for the candy bar. If the groceries cost more than the money you set aside for them (resources allocated) and the extra money for the candy bar (resources remaining), you will have to put some groceries back, which would be equivalent to non-thorough processing of the message. If the groceries cost less than expected, you would then have enough resources left for a candy bar *and* a soda.

The limited capacity model of information processing takes attention and memory into account when trying to predict processing of information. The limited capacity model was “specifically developed to investigate how people process television messages” (Lang, 2000, p. 47). The limited capacity model explains that attention occurs when processing resources are allocated to a task (Lang & Basil, 1998) and that information processing is also influenced by the amount of memory available (Halford, 1982). Media messages vary in the cognitive demands they place on the human cognitive system. Media messages may demand only part of an individual’s cognitive resource pool or more resources than the pool has for processing. When a

media message requires more resources than are available, cognitive overload occurs (Lang, 2006). Lang & Basil (1998) described cognitive resources as a pie consisting of four pieces: resources required, resources allocated, resources remaining, and available resources. When the system operates within capacity, resources are available for processing information. Processing efficiency improves with available resources (Lang, 2000).

Information Density and Structural Complexity

Two aspects of a television message that influence information processing are information density and structural complexity. Information density and structural complexity are both related to cuts and edits within the message. Lang (2000) defines cuts as changes from one visual scene to a different visual scene, and edits as a change from one camera to another in the same visual scene (p. 59). It has been shown that people experience orienting responses to the information introduced when a cut or edit occurs (Lang, 2000; Lang et al., 2006), and that resources allocated associated with an orienting response vary depending on the “strength and vigor” of that orienting response (Lang, 2006). Lang et al. (2006) classifies both cuts and edits as camera changes, thus they are termed as such.

Information density refers to the amount of information introduced after a camera change in a video message. Structural complexity refers to the amount of camera changes in a television message, or the frequency of camera changes. In this thesis, the formal features of a television program are measured by determining information density and structural complexity.

Attention

Attention occurs when processing resources are allocated to a task (Lang & Basil, 1998). The limited capacity models of attention suggest that if attention does not occur, processing does not happen. Many studies about children's attention to television have involved measuring frequency and duration of visual contact, or "look time," with the television set. These studies have provided some important clues as to what causes children to look at the television, and what keeps them looking. It has been demonstrated that babies are able to control attentional activity by 3 ½ months, and that by 6 months, they can control attention span up to 5 seconds (Goswami, 1998, p. 11-12). Around 2 or 2 ½ years, children show a shift in the amount of looking at television, and eventually begin to position themselves to face the TV. At this age, children also display longer and more frequent looks at the television, making it the central activity even with the presence of toys and other activities (Gunter & McAleer, 1990, p. 28-29), in spite of the fact that toys serve as distractions (Wartella, 1981, p. 30). Several studies also show that children as early as preschool develop "adult-like TV 'watching' patterns" that include orienting themselves toward the TV screen for viewing (Wartella, 1981, p. 30).

Children progress through stages of viewing TV, first taking attention cues from formal features, progressing to where attention is drawn and maintained by aspects of the storyline (Gunter & McAleer, 1990). Huston and Wright (1983) suggested that younger children are better able to comprehend television messages when they were accompanied by formal features, where "comprehension was less closely associated" with those features in older children (p. 44).

Formal features of a television program are the first things to attract a child's attention. Younger children's attention depends more on these features than older children's attention, as older children use learned signals to direct their attention more selectively (Calvert, et al., 1982).

Calvert added that “they [formal features] may attract and maintain attention as a consequence of their salient perceptual qualities” and that “they may guide a child’s attention by their association with comprehensible, interesting, informative, or otherwise attention-worthy content” (p. 602). Salomon (1981) also stated that “children are attentive to aspects of programs they understand (dialogue for example) and inattentive to those they cannot understand” (p. 80). Van Evra (2004) put the same ideas in the context of advertising, stating that advertisers know that certain features are especially appealing to children, and that these features appear in commercials geared toward children. She explained that features such as fast cutting visual techniques and music are designed to create “moods, images, and impressions” instead of being used to provide the information (p. 123). Although it is believed that dependency on formal features diminishes over time, “it is quite likely that even children as old as seven or eight still have very rudimentary understanding of the various audio-visual techniques employed in television, such as zooms, pans, slow motion and other audiovisual symbols” (Wartella, 1981, p. 31).

While comprehensibility is a factor for attention to a television program in children as young as 24 months (Anderson & Pempek, 2005), children still rely on formal features of television programs for attentional cues until about 8 years old (Wartella, 1981). As children grow older, they gradually depend less on the formal features of a program to guide their attention and more on content features. Anderson et al. (1986) found that children 2, 3 1/2, and 5 years old looked less at a program when the material was less comprehensible to them. Van Evra (2004) also found that children over 5 years old were able to increase their attention during less comprehensible or more challenging programs, concluding that older children actively guide their attention according to the comprehensibility of the program’s content. Considering these findings, it seems there is a transitional period between children’s reliance on the formal features

of a television program and their shift to reliance on content features that takes place between 2 years old (Anderson et al., 1986) and 8 years old (Wartella, 1981). Visual orientation, or the amount of time a person is looking at the television screen, is the most common measure of visual attention, and produces “highly reliable data” (Lorch, 1994, p. 214).

The information introduced by camera changes elicits orienting responses, which require cognitive resources for processing. As stated previously, according to the limited capacity model, attention occurs when cognitive resources are allocated to a task. Since different levels of information density and structural complexity require different amounts of cognitive resources for processing,

Hypothesis 1a) Messages that are high in information density will require more cognitive resources, eliciting more attention than those that are low in information density.

Hypothesis 1b) Messages that are high in structural complexity will require more cognitive resources, eliciting more attention than those that are low in structural complexity.

Research Question 1) How do information density and structural complexity interact to affect attention?

Since younger children’s attention is driven more by formal features of television programs,

Hypothesis 1c) Messages that are high in structural complexity will elicit more attention in younger children than in older children.

Memory

There are two types of memory involved in information processing: storage and retrieval. Goswami (1998) suggested that different *types* of memory influence each other as they develop, concluding that memory systems do not develop independently, but that “the memory systems that *develop* are thus characterized by the fact that they benefit from the increasing sophistication of other cognitive processes” (p. 197), leading to “improvements and developments in working

memory” (p. 186). Storage memory is indicated by recognition, or the “ability to recognize that something is familiar and has been experienced before” (Goswami, 1998, p. 167). In other words, when a bit of information is taken from the environment and stored in the brain, it can be recognized later. Retrieval is indicated by recall, or “the retrieval of a conscious memory of what has been experienced in the past” (Goswami, 1998, p. 167); in other words, when information is encoded after storage, that information can be recalled later. This thesis measures memory using recognition and recall tests.

One way to measure recognition is through signal detection where the “task is usually to discriminate material a subject saw in some experimental stimulus from similar material he or she did not see,” typically through true-false type questions (Shapiro, 1994, p. 134). Signal detection is considered the best way to analyze recognition memory data, and has become a common method for measuring recognition memory (Shapiro, 1994, p. 135). Signal detection can show a person’s “ability to discriminate old and new items” (p. 135), and judgment effects as well (Shapiro, 1994). In other words, through signal detection measures, we can see not only what people recognize from a message, but also how confident they are in their assertion that they have or have not seen that piece of information.

Shapiro (1994) explained that “because recognition for visual items is so good, it is hard to make visual recognition items difficult enough,” suggesting including very brief exposures or using only a small part of the image as remedies (p. 142). Shapiro also suggested that “recognition tests are most sensitive if investigators use a large number of items and if items are equally divided between old material and new material” (p.142). In Fox’s (2007) study, the participant presented items they had seen before (targets) and items they had not seen before (foils), if they have previously seen the stimulus. The participant was instructed to respond with,

“yes” if the stimulus was old and with “no” if the stimulus was new. When a target was correctly identified as old, the response was considered a hit. When a target was incorrectly identified as new, the response was considered a miss. When a foil was correctly identified as new, the response was considered a correct rejection. When a foil was incorrectly identified as old, the response was considered a false alarm.

In signal detection, the ratio of hits and false alarms are first used to calculate sensitivity (denoted by d'), which indicates a viewer's ability to recognize something they have seen before, (Shapiro, 1994). The ratio of hits and false alarms is also used to determine criterion bias, which measures how liberal or conservative a viewer is in deciding whether they have seen a target or foil, (Shapiro, 1994). Greater sensitivity indicates higher accuracy of memory, where greater criterion bias indicates the confidence a viewer needs to feel about having seen an item before they are willing to say whether the item has been seen before (Lang, et al., 2000).

In order to store information, attention must be paid to that information at some level. Encoding information for later recognition requires cognitive resources as well, leaving fewer resources available. Since greater amounts of information require greater amounts of cognitive resources for encoding,

Hypothesis 2a) Messages that are high in information density will require more cognitive resources than messages that are low in information density, and result in low recognition memory.

Hypothesis 2b) Messages that are high in structural complexity will require more cognitive resources than messages that are low in structural complexity, and result in low recognition memory.

Research Question 2) How do information density and structural complexity interact to affect recognition memory?

Since younger children's attention is driven more by formal features,

Hypothesis 2c) Messages that are high in information density will result in better recognition in younger children.

One way to measure retrieval is by free recall, a commonly used procedure that involves asking viewers to relate everything they can remember after viewing a television message (Lorch, 1994, p. 220). As stated previously, when information is encoded after storage, that information can be recalled later. Lorch (1994) explained that although the use of free recall has major disadvantages, such as "placing high demands on children's verbal abilities," and relying on children to "supply the organization for free recall," (p. 221), it is useful in detecting what children find "most salient and retrievable in a program," (p. 221). Lorch (1994) concluded that while free recall may be an appropriate technique to use in certain situations, such as focusing on what children spontaneously remember, "it should not be assumed to completely reflect children's level of comprehension," (p. 221). Because this study focuses on the way formal features and comprehensibility affect attention and memory in children of different age groups, and does not *solely* rely on free recall to measure memory, this method is appropriate.

According to the limited capacity model of information processing, there is a limited pool of cognitive resources from which to perform information processing tasks. As with recognition, attention is essential to the process of retrieval. In other words, a message cannot be encoded for retrieval if it was not seen. Encoding information for later recall requires cognitive resources leaving fewer resources available. Since greater amounts of information require greater amounts of cognitive resources for encoding,

Hypothesis 3a) Messages that are high in information density will require more cognitive resources than messages that are low in information density, and result in low recall memory.

Hypothesis 3b) Messages that are high in structural complexity will require more cognitive resources than messages that are low in structural complexity, and result in low recognition memory.

Research Question 3) How do information density and structural complexity interact to affect recall memory?

Since older children's attention is driven more by content than by formal features,

Hypothesis 3c) Older children will allocate more cognitive resources to the task of encoding messages for retrieval, resulting in better recall.

The limited capacity model explains that people have limited cognitive resources for processing television messages. Different levels of information density and structural complexity in television messages require different amounts of cognitive resources. When certain features of a message require more resources, more resources are allocated to those features, leaving fewer resources available for the viewer to process those messages. This thesis uses measures of attention and memory to see how the features of television messages affect information processing.

CHAPTER 3: METHODOLOGY

To see how children process television messages, we must look at the effects of information density and structural complexity in those messages on attention and memory. Information density and structural complexity were coded in a selected television show and segments of that show were selected according those aspects. Attention was measured using eye-on-screen time, and memory was measured using recognition and free recall tests.

Participants

Pre-school children and second-graders from classes at a local pre-school and a local public school were recruited with director consent, parental consent, and participant assent. All children individually completed the session near their classroom in a room designated by the school director or principal. Of the 58 participants, 22 were four years old, six were five years old, 15 were seven years old, 14 were eight years old, and one was nine years old.

Stimuli

The program chosen for analysis in this study is a representative episode of the Nickelodeon program *Little Bill*, entitled “Little Bill’s Adventure with Captain Brainstorm.” *Little Bill* is an educational program targeted toward preschool aged children. Nickelodeon’s web page *About Little Bill* describes the series as follows:

Little Bill is the latest character to sprout from the fertile mind of comedian Bill Cosby, and both the show and the character reflect the wisdom, outlook, and humor of their creator. The show is based on Cosby's popular book series and is developed through research and in consultation with a panel of educational consultants. The show is designed to help kids celebrate their everyday experiences and the people who share them. Little Bill shows kids that what they do makes a difference in the world. By dealing with conflicts encountered in everyday life, the program encourages children to value the love of their family, to increase self-esteem, and to develop social skills. (n.p.)

The structural features of this episode were rated and segments were selected based on those features, while the presence of a coherent plot element was also considered. Selected segments were kept at approximately one minute; duration was dependent on the plot element within the clip.

Design

The basic experimental design for this study is a 2 (High Information Density, Low Information Density) \times 2 (High Structural Complexity, Low Structural Complexity) between-subjects design. Four segments were used for each condition.

Procedure

Consent from program directors/principals was obtained from each facility where the students attended. After this, consent was obtained from each classroom teacher and caregiver. Parental consent forms were provided to the program director or teacher at each school. After obtaining signed parental consent, the participants' classrooms were visited, and children were taken one by one to participate. Experimental protocol was explained to each child in clearly understandable terms and assent was attained, after which the session proceeded.

Children were shown four segments from a certain category (High Information Density/High Structural Complexity, High Information Density/Low Structural Complexity, Low Information Density/High Structural Complexity, Low Information Density/Low Structural Complexity). Each participant was recorded on video to measure eye-on-screen attention time.

After viewing the video clips, the corresponding targets and foils were presented one-by-one to the child. Upon being presented with each target or foil, the participant was asked if they remembered seeing it in the video clips they watched.

To measure free recall, each participant was re-visited the day after viewing the video clips and asked to tell what they remembered happening in the videos they had seen the day before. Children were allowed to answer freely, the only prompting was being asked if that was all they remembered when they seemed to be finished talking.

Independent Variables

Two aspects of a television message that influence information processing are information density and structural complexity. Information density and structural complexity are both related to camera changes within the message. Although the television messages used in this study are from an animated program, the animation mimics the cuts and edits used in a live action production. Thus, the term camera change is still used, as it refers to an implied camera, not a physical camera. Information density and structural complexity are used to determine the amount of information presented by a television message, in turn providing a way of knowing which messages should require greater or fewer cognitive resources.

Information Density

Information density was determined by the amount of information introduced in each camera change in each segment. The selected segments during *Little Bill* were scored using a seven-point “information introduced” scale based on the amount of information introduced by a camera change using a dichotomous rating system developed by Lang (2006), (See APPENDIX A). The frame following each camera change was rated according to the seven dimensions of the seven-point scale: object change, novelty, relatedness, distance, perspective, emotion, and form change. A one (1) was scored when the dimension was present, and a zero (0) when the dimension was not present. The scores for each dimension were summed to determine total information density (i.e., seven is the highest possible information density score, one is the lowest and zero means there was no change). Higher scores indicate greater amounts of information introduced. Summing the scores for each camera change during the selected segments resulted in an “information introduced” score for the segment. The higher the information introduced score, the greater the information density associated with a given cut or edit. (See APPENDIX B).

Structural Complexity

Structural complexity scores were determined by adding the number of camera changes in each selected segment, then dividing that by the number of seconds in that segment. Of the clips that were selected, high information density scores averaged 3.33, low information introduced scores averaged 2.38. High structural complexity segments averaged 0.30 camera changes (per second). Low structural complexity segments averaged 0.20 camera changes (per second), (See APPENDIX C).

Sixteen segments from *Little Bill's Adventure with Captain Brainstorm* were identified and selected, each varying appropriately (according to the manipulation aims of this study) in structural complexity and information density. Four segments rated high in structural complexity and in high information density, four segments rated high in structural complexity and low in information density, four segments rated low in structural complexity and high in information density, and four segments rated low in structural complexity and low in information density.

Dependent Variables

Attention

Participants were video-recorded during their viewing session. The videos of the participants were viewed later so the eye-on-screen time of each participant could be measured and recorded. Eye-on-screen time was subtracted from the total duration of each clip to determine “missed attention” times. Because measuring eye-on-screen time is an objective measure, only one coder was used.

Recognition Sensitivity

In the current study, targets include screen captures of images that the participant has seen during the video clips shown in the experiment. Screen captures from the camera changes that rated highest and lowest in information density in each selected video clip were chosen as targets for their respective categories (see APPENDIX D). Foils were chosen from another episode of the same program, in order to be similar to and parallel given targets (see APPENDIX E). This study utilized twenty-four items consisting of twelve targets and twelve foils, each from

a single frame of video. Hits and misses, and correct rejections and false alarms were individually tallied, and the ratio of hits and misses, as well as the ratio of correct rejections and false alarms.

Free Recall

The day after viewing the video clips, each child was asked what they remembered happening in the video clips they had watched. The children's responses were recorded, and then transcribed later for accuracy. Each correctly remembered element was given a score of one (1), and incorrectly recalled elements were given a score of zero (0). The number of correctly recalled elements was then summed.

Pre-school aged children and second graders were asked to view four video clips that were selected from a television program according to levels of information density and structural complexity. After viewing the video segments, attention and memory were measured to see how they process television messages.

CHAPTER 4: RESULTS

Hypothesis 1a predicted that high information density messages would elicit more attention than low information density messages. Information density did not have a significant effect on viewer's attention, $F(1, 56) = 0.90, p = .35, \epsilon^2 = .02$. Children did not fixate on the screen longer for the high density condition than the low density condition, as the missed attention measure indicated that children missed an average of three seconds for the high density condition ($M = 3.37, SD = 7.04$) and six seconds for the low density condition ($M = 5.74, SD = 11.33$).

Hypothesis 1b predicted that high structural complexity messages would elicit more attention than those that were low in structural complexity. Information density did not have a significant effect on viewer's attention, $F(1, 56) = 0.02, p = .90, \epsilon^2 = .00$. Children did not fixate on the screen longer for the high complexity condition than the low complexity condition, as missed attention measure indicated that children missed an average of five seconds for the high density condition ($M = 4.75, SD = 7.83$) and four seconds for the low density condition ($M = 4.24, SD = 10.70$).

Research question 1 asked whether information density and structural complexity interacted to affect attention. Results indicated that the interaction between the two independent variables was not significant, $F(1, 56) = 3.50, p = .07, \epsilon^2 = .06$. Note, however, the interaction is approaching significance. It appeared that high information density and high structural complexity elicited the most attention, as indicated by an average of one second missed attention

($M = .93$, $SD = 1.53$). However, when information density was low and structural complexity was high, missed attention was more pronounced, as indicated by an average of 8 seconds missed attention ($M = 7.79$, $SD = 14.74$), (see APPENDIX E).

Hypothesis 1c predicted that messages high in structural complexity and information density would elicit more attention in younger children than in older children. Information density and structural complexity did not significantly affect younger children's attention more than older children's attention, $F(1, 56) = 0.64$, $p = .43$, $\epsilon^2 = .01$. Younger children did not fixate on the screen longer than older children, as the missed attention measure indicated that younger children missed an average of six seconds for the high complexity condition ($M = 5.48$, $SD = 11.28$) and older children missed an average of four seconds for the high complexity condition ($M = 3.60$, $SD = 7.18$).

Hypothesis 2a predicted that recognition memory would be high when messages were high in information density. Information density did not have a significant effect on children's recognition memory, $F(1, 56) = .02$, $p = .90$, $\epsilon^2 = .00$. The high density condition did not appear to affect recognition memory more than the low density condition, as the recognition memory measure indicated that children correctly identified an average of twenty-one targets/foils for the high density condition ($M = 21.17$, $SD = 3.54$) and twenty-one targets/foils for the low density condition ($M = 21.04$, $SD = 3.13$).

Hypothesis 2b predicted that recognition memory would be high when messages were high in structural complexity. Structural complexity did not have a significant effect on children's recognition memory, $F(1, 56) = 0.02$, $p = .90$, $\epsilon^2 = .00$. The high complexity condition did not appear to affect recognition memory more than the low complexity condition, as the

recognition memory measure indicated that children correctly identified an average of twenty-one targets/foils for the high density condition ($M = 21.07$, $SD = 3.39$) and twenty-one targets/foils for the low density condition ($M = 21.14$, $SD = 3.32$).

Research question 2 asked whether information density and structural complexity interact to affect recognition memory. Results indicated that the interaction between the two independent variables was not significant, $F(1, 56) = 0.62$, $p = .44$, $\epsilon^2 = .01$. As indicated by signal detection measures, children correctly identified an average of twenty-one items when messages were high in information density and high in structural complexity ($M = 21.47$, $SD = 2.97$) and when information density was low and structural complexity was high ($M = 20.64$, $SD = 3.86$), (see APPENDIX F).

Hypothesis 2c predicted that recognition would be higher in younger children. Information density and structural complexity significantly affected younger children's recognition memory than older children's recognition memory, $F(1, 56) = 7.15$, $p = .01$, $\epsilon^2 = .13$, thus, this hypothesis was supported. As indicated by signal detection measures, younger children correctly identified an average of less than twenty items ($M = 19.56$, $SD = 4.04$), where older children correctly identified an average of more than twenty-two items ($M = 22.50$, $SD = 1.57$), (see APPENDIX F). Using d' as a sensitivity measure, it is apparent that the effects of information density and structural complexity affected younger children differently than older children, (see APPENDIX G). The graphs in Appendix G show the familiarity of old items (targets) and new items (foils). Familiarity is shown in the overlap of distributions, where less overlap indicates greater sensitivity of the observer (d'), (Shapiro, 1994). Shapiro (1994) explains that "in some situations the two distributions may not overlap at all" indicating that it is "so easy for the observer to distinguish between old and new item that he or she will never make

an error” (p. 139). This was the case for older children in the high information density/low structural complexity and low information density/high structural complexity conditions (see Figure G2). In the same conditions, younger children showed the greatest overlap (see Figure G3), indicating that they had greater difficulty distinguishing old items from new items.

Hypothesis 3a predicted that since messages that are high in information density require more cognitive resources, recall would be more difficult because children’s resources would be in overload and encoding would not be thorough. Information density did not have a significant effect on children’s recall memory, $F(1, 53) = 2.12, p = .15, \epsilon^2 = .04$. Children did not recall fewer items for the high density condition than the low density condition, as the recall memory measure indicated that children recalled an average of more than three items for the high density condition ($M = 3.44, SD = 2.15$) and less than three items for the low density condition ($M = 2.67, SD = 1.92$).

Hypothesis 3b predicted that since messages that are high in structural complexity require more cognitive resources, recall would be more difficult because children’s resources would be in overload and encoding would not be thorough. Structural complexity did not have a significant effect on children’s recall memory, $F(1, 53) = 0.28, p = .60, \epsilon^2 = .01$. Children did not recall fewer items for the high complexity condition than the low complexity condition, as the recall memory measure indicated that children recalled an average of three items for the high density condition ($M = 3.19, SD = 1.82$) and three items for the low density condition ($M = 2.93, SD = 2.30$).

Research question 3 asked whether information density and structural complexity interact to affect recall memory. Results indicated that the interaction between the two independent variables was significant, $F(1, 53) = 4.47, p = .04, \epsilon^2 = .08$. It appeared that when information

density was high and structural complexity was low encoding was thorough; as indicated by the recall memory measure, children recalled an average of four items ($M = 3.86$ $SD = 2.48$).

However, when information density was low and structural complexity was low, encoding was not as thorough; as indicated by the recall memory measure, children recalled an average of two items ($M = 1.92$, $SD = 1.66$).

Hypothesis 3c predicted that older children would recall more than younger children. This hypothesis was supported, as information density significantly affected younger children's recall memory more than older children's recall memory, $F(1, 53) = 24.21$, $p = .00$, $\epsilon^2 = .35$. As indicated by the free recall measure, younger children recalled an average of two items ($M = 1.88$, $SD = 1.62$), and older children recalled an average of four items ($M = 4.01$, $SD = 1.87$).

CHAPTER 5: CONCLUSION AND DISCUSSION

Using the Limited Capacity Model of Information Processing, this thesis observed attention and memory in pre-school and second-grade children to find out how formal features of television messages affect information processing in children, and the differences of those effects between younger and older children. The results of this study demonstrated that information density and structural complexity in television messages did not appear to independently affect attention and memory in children, but that the interaction between the two affected attention and memory in children. Furthermore, this study found that the interaction between information density and structural complexity varied by age.

Results for eye-on-screen attention measures demonstrated that different levels of information density or structural complexity did not significantly affect attention in children, and no significant difference was found in eye-on-screen attention between younger and older children. One reason for the lack of significance in this measure could be that eye-on-screen measure only showed when the children were *looking* at the screen, not if they were actually paying attention or allocating resources to the task of watching the video, such as when people have moments when we are talking to someone, or needing to pay attention to something, but we are thinking about something else and completely miss what is happening at the moment. This could be due to cognitive overload, where too many resources are required and the viewer begins to allocate resources to other tasks (Lang, 2006).

Despite the lack of significance in eye-on-screen attention time results for information density and structural complexity independently, the results for the interaction between information density and structural complexity approached significance, suggesting that messages rated high in information density and high in structural complexity elicited the most eye-on-screen attention time, and messages rated low in information density and high in structural complexity elicited the least eye-on-screen time. The limited capacity model suggests that when a message requires more resources, more resources will be allocated to the task of paying attention to that message (Lang, 2000; Lang & Basil, 1998; Lang et al., 2006). Messages with high information density and high structural complexity require more cognitive resources, so the children allocated more attentional resources to those video clips than to the others. Further explaining this result, previous studies have found that children's attention to television messages is first drawn by formal features (Gunter & McAleer, 1990; Huston and Wright, 1983), and that dependency on those features, although diminishing, lasts until seven or eight years of age (Wartella, 1981).

This study also found that the interaction between information density and structural complexity had a dramatic effect on children's recognition memory. Messages low in information density and low in structural complexity resulted in better recognition of targets and foils, where messages high in information density and high in structural complexity resulted in lower recognition. The limited capacity model can help to explain these results: low levels of information density and structural complexity require fewer cognitive resources, leaving enough resources available for encoding; high levels of information density and structural complexity require more cognitive resources, leaving fewer resources available for encoding (Lang, 2000; Lang & Basil, 1998; Lang et al., 2006). In this case, the messages that required fewer resources

left more resources available to be allocated to the task of encoding, resulting in better recognition. Messages that required more resources left fewer resources available for allocation to the task of encoding, possibly leaving resources in deficit, resulting in lower levels of recognition.

One of the most interesting observations in this study is the difference in performance on the recognition memory test between older and younger children because the results for second-graders were contradictory to the results of the pre-school children. Second-graders performed the best on recognition memory tests when information density was high and structural complexity was low, and when information density was low and structural complexity was high. Recognition was lower in second-graders when both information density and structural complexity were low. Using the limited capacity model, when information density is high and structural complexity is low, and when information density is low and structural complexity is high, cognitive resources are being used at an optimal level; there is neither a surplus nor deficit of cognitive resources. Regarding second-grader's performance in the low information density and low structural complexity condition can be explained by the idea that since the least amount of cognitive resources were being used and were possibly at a surplus, so the children allocated the extra resources to tasks other than encoding the video. A simple way to look at it is that since the selected program is aimed at preschool audiences, the second-grade children were bored and not paying as much attention to the videos.

Contrary to second-grader's results, pre-school children performed better on the recognition memory test when information density and structural complexity were both low and worse when information density was high and structural complexity was low, and when information density was low and structural complexity was high. These results are a little more

difficult to explain, and may be attributed to the idea that younger and older children are just simply different, and they process information differently. Schneider (1987) explains that “getting solid research information from children” presents unique problems, simply because “children do not perceive information like adults; they don’t think like adults; and they don’t express themselves like adults” (p. 67), a notion supported by research from Anderson and Pempek (2005), Gunter and McAleer (1990), Salomon (1981), Van Evra (2004), and many others. It is possible that younger children were able to perform better when information density and structural complexity were both low because the messages required so few resources that they were able to thoroughly encode them. As Goswami (1998) suggested, memory development in children benefits from increasing sophistication of other cognitive processes. It may be that the younger children in this study had not yet developed the cognitive resources to process the more complex messages.

The results in this study that yielded the highest level of statistical significance came from the recall memory tests. As with the other tests in this study, results indicated that while information density and structural complexity did not independently affect recall memory, the interaction between the two did affect recall memory. Results also indicated that children recalled more when information density was high and structural complexity was low, and less when information density was low and structural complexity was low. As with the results from the recognition memory test, these results can be explained by the limited capacity model, which explains that messages requiring more resources leave fewer resources available to allocate to other cognitive tasks (Lang, 2000; Lang & Basil, 1998; Lang et al., 2006). In this study, messages with high information density and low structural complexity required an optimal

amount of cognitive resources, resulting in thorough encoding for better recall, where messages low in information density and structural complexity left a surplus of available cognitive resources, which were allocated to other tasks.

Recall memory results also showed that older children recalled more information than younger children, and that older children tended to recall more plot-related elements (i.e. “they went to the mall,” “they had their picture taken,” “Little Bill was scared”), whereas younger children tended to recall more structural-related elements (i.e. “there was a spaceman,” “there was a rocket ship,” “there was a little green alien”). This observation indicates that younger children’s attention is driven more by structural features and older children’s attention is driven more by content features, as observed by Salomon (1981), Van Evra (2004), and Wartella (1981). Since these are the aspects recalled by these children, it is implied that these are the aspects they paid attention to.

While eye-on-screen attention measures were not necessarily conclusive in this study, the results from the memory tests may imply attention, as information cannot be encoded if it has not been attended to. This could explain why eye-on-screen measures showed that attention was highest during messages that were high in information complexity and high in structural complexity, but memory results were not high in that condition. In terms of the limited capacity model, since high information density and high structural complexity require the most cognitive resources, cognitive resources would have been at a deficit, not leaving enough available resources for encoding, resulting in lower recognition and recall memory.

While this study revealed some interesting observations in children’s cognitive processing of television messages, some of the results were not statistically significant, meaning nothing definitive can be concluded. There are many possible reasons for this, and some may be

explained by limitations in the methods of this study. First, a major limitation is the number of participants. Another reason the results may not show significance could be that there were too few participants to produce strong enough results. Typically, 120 participants would produce adequate results in a 2 x 2 between subjects design; however, it is more difficult to recruit this number of children.

Another limitation in this study is that the selected video clips were not standardized to a specific duration, making it difficult to accurately interpret attention times between subjects, since it may be easier to sustain attention for shorter clips than longer clips. In future studies, more sophisticated measures of attention may be used to produce more accurate results, as well as manipulating video clips to a standard duration may help make attention measures more accurate, and, as stated before, more participants should be recruited to increase the power of results. In future studies, it would be interesting to include kindergartners (five year olds) and first graders (six year olds) to compare results across the age groups and attempt to pinpoint where the transition from attention being guided by formal features to content features occurs.

In children between the ages of two years old and eight years old, a transition occurs from attention being driven by structural features to attention being driven by content features (Calvert, et al., 1982; Gunter & McAleer, 1990; Huston and Wright, 1983; Wartella, 1981). By looking at attention and memory, this study has narrowed this transition period to between five and seven years old. This study has also demonstrated that while children pay more eye-on-screen attention to television messages that are high in information density and structural complexity, children are not able to recall those messages as well as those that are lower in either information density or structural complexity or both.

As with any study, more research should be done through replication and refinement in order to reach a better understanding of the way children process the information in the television programs they watch. The results of this study can be used to help the producers of children's programming to determine how whether structural features in a program aid children in processing the message or hinder them from processing the message. The results of this study indicated that while high information density and structural complexity may elicit more attention, messages with lower levels of either information density or structural complexity, or both, elicit better recall of the content of that message, especially in older children in the seven and eight year-old range. The results of this study also indicate that older (second grade) children are better able to recall information from a program than younger (pre-school) children. This can help producers of children's television programming to determine how to best communicate information to their target audience.

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APPENDIX A:
INFORMATION DENSITY RATING SYSTEM

Seven different aspects of each camera change in a clip were rated with a score of either zero (0) or one (1). The seven aspects are as follows:

Object Change-	if the focal point or object is different from before the camera change
Novelty-	if the focal point or object was not previously seen in the message
Relatedness-	if information after a camera change is not expected or related to information previous to the camera change
Distance-	if information following a camera change is closer than information previous to that camera change
Perspective-	if information following a camera change is seen from a different perspective than before the camera change
Emotion-	if emotion changes, either through valence (i.e. positive/negative, happy/sad) or arousal (i.e. low/high)
Form Change-	if information after a camera change has a new set of formal features (i.e. color to black and white, moving to still pictures, pictures to text, live-action to animation, addition of videographics or frames)




APPENDIX B:
SELECTED SEGMENTS

	High Information Density			Low Information Density		
	Beginning-Ending Timecode	Information Density Score	Structural Complexity Score	Beginning-Ending Timecode	Information Density Score	Structural Complexity Score
High Structural Complexity	00:48-01:41	3.43	0.26	02:59-04:00	2.06	0.26
	02:21-02:59	3.44	0.26	04:00-05:07	2.35	0.30
	18:41-19:36	3.42	0.35	05:59-06:52	2.79	0.36
	20:52-21:38	3.15	0.28	10:15-10:52	2.83	0.32
Low Structural Complexity	05:07-05:59	3.08	0.23	01:41-02:21	2.60	0.15
	09:15-10:15	3.60	0.20	10:52-11:56	2.56	0.25
	14:20-15:12	3.27	0.21	13:18-14:12	1.78	0.17
	15:48-16:47	3.27	0.18	17:35-18:32	2.07	0.24




APPENDIX C:
SELECTED TARGETS

Figure C1: High Information Density, High Structural Complexity




Clip 1-

		
Timecode: 00:55	Timecode: 01:23	Timecode: 01:33
Information Density Score: 5	Information Density Score: 4	Information Density Score: 4




Clip 2-

		
Timecode: 02:21	Timecode: 02:31	Timecode: 02:56
Information Density Score: 6	Information Density Score: 5	Information Density Score: 3

Clip 3-

		
Timecode: 18:46	Timecode: 18:56	Timecode: 19:20
Information Density Score: 4	Information Density Score: 4	Information Density Score: 4




Clip 4-

		
Timecode: 21:05	Timecode: 21:07	Timecode: 21:17
Information Density Score: 5	Information Density Score: 4	Information Density Score: 4




APPENDIX C:
SELECTED TARGETS

Figure C2: High Information Density, Low Structural Complexity

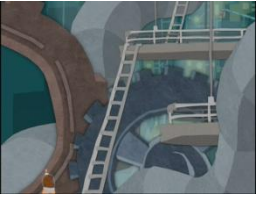


Clip 1-

		
Timecode: 05:25	Timecode: 05:37	Timecode: 05:51
Information Density Score: 5	Information Density Score: 4	Information Density Score: 4


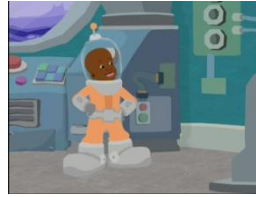

Clip 2-

		
Timecode: 09:22	Timecode: 09:55	Timecode: 10:01
Information Density Score: 4	Information Density Score: 5	Information Density Score: 4

Clip 3-

		
Timecode: 14:23	Timecode: 14:38	Timecode: 14:43
Information Density Score: 4	Information Density Score: 4	Information Density Score: 3




Clip 4-

		
Timecode: 16:25	Timecode: 16:36	Timecode: 16:43
Information Density Score: 4	Information Density Score: 4	Information Density Score: 4




APPENDIX C:
SELECTED TARGETS

Figure C3: Low Information Density, High Structural Complexity




Clip 1-

		
Timecode: 03:07	Timecode: 03:12	Timecode: 03:34
Information Density Score: 2	Information Density Score: 1	Information Density Score: 2




Clip 2-

		
Timecode: 04:13	Timecode: 04:31	Timecode: 04:53
Information Density Score: 2	Information Density Score: 2	Information Density Score: 2

Clip 3-

		
Timecode: 06:20	Timecode: 06:22	Timecode: 06:50
Information Density Score: 2	Information Density Score: 1	Information Density Score: 3




Clip 4-

		
Timecode: 10:33	Timecode: 10:43	Timecode: 10:49
Information Density Score: 2	Information Density Score: 2	Information Density Score: 2




APPENDIX C:
SELECTED TARGETS

Figure C4: Low Information Density, Low Structural Complexity




Clip 1-

		
Timecode: 1:56	Timecode: 02:02	Timecode: 02:15
Information Density Score: 2	Information Density Score: 1	Information Density Score: 1




Clip 2-

		
Timecode: 10:59	Timecode: 11:31	Timecode: 11:39
Information Density Score: 1	Information Density Score: 2	Information Density Score: 2

Clip 3-

		
Timecode: 13:34	Timecode: 13:51	Timecode: 14:04
Information Density Score: 1	Information Density Score: 2	Information Density Score: 2

Clip 4-

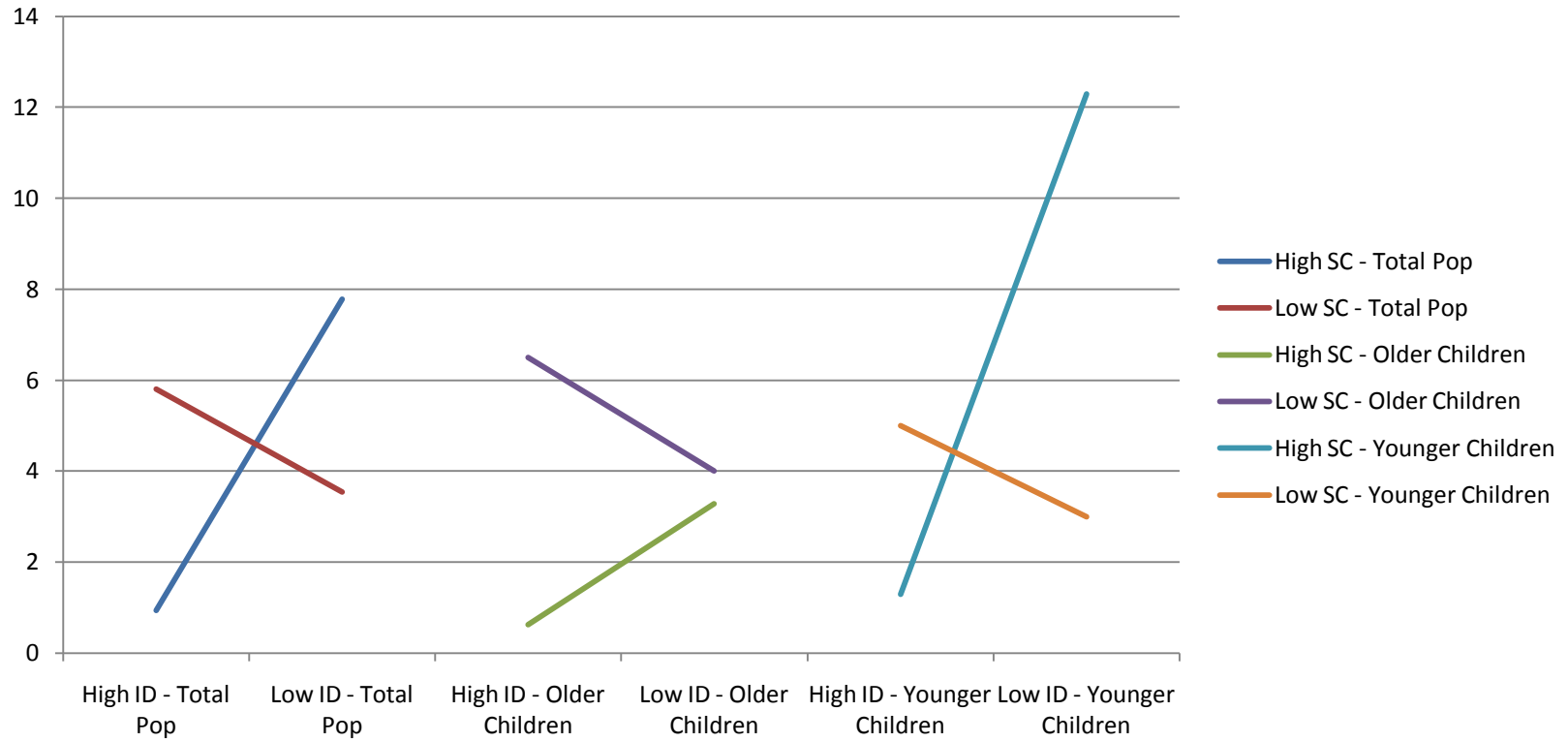
		
Timecode: 17:37	Timecode: 17:54	Timecode: 18:17
Information Density Score: 1	Information Density Score: 2	Information Density Score: 1

APPENDIX D:
SELECTED FOILS

from the *Little Bill* episode “Ready, Set, Read/I Got a Letter”

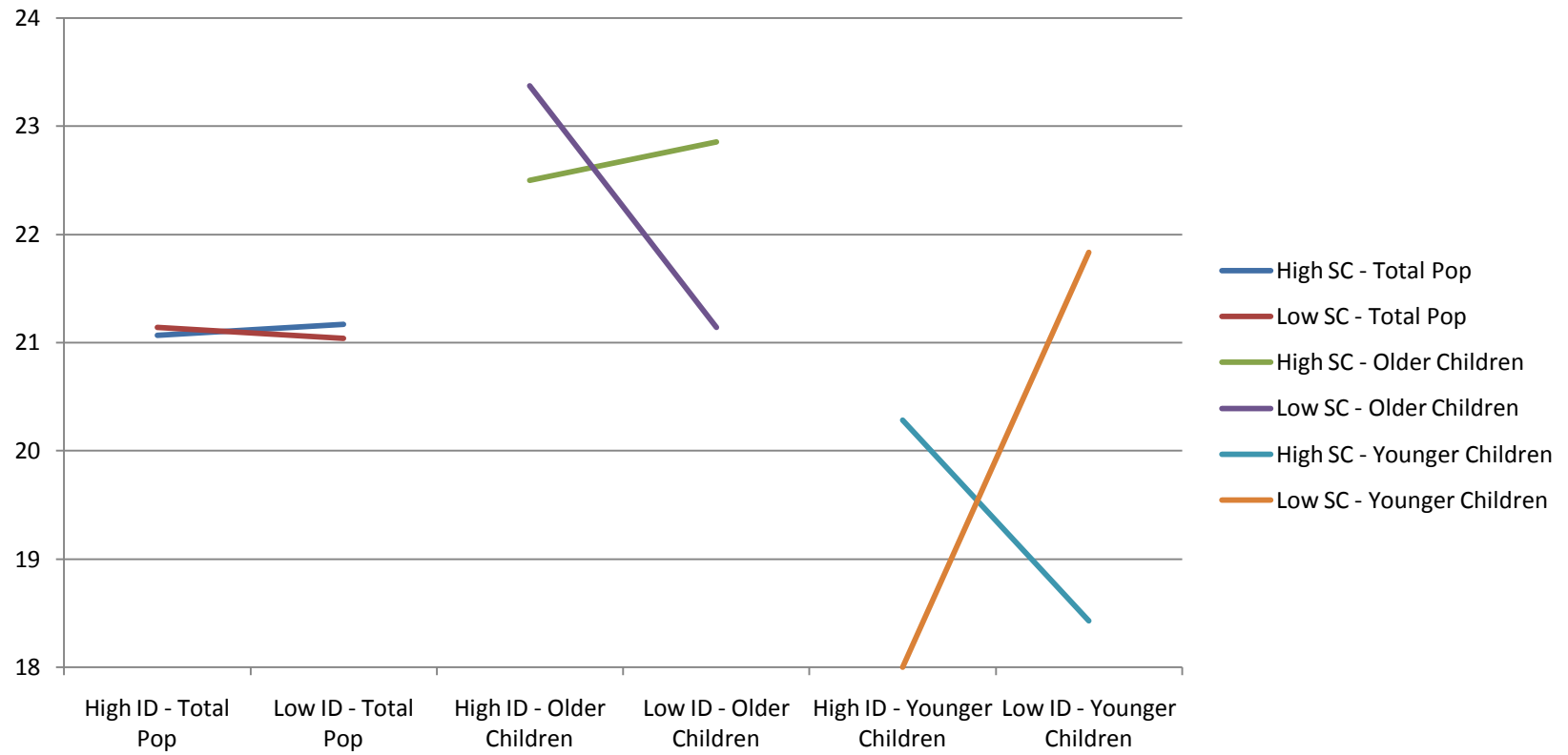


APPENDIX E: MISSED ATTENTION



ID = Information Density
SC = Structural Complexity

APPENDIX F: RECOGNITION MEMORY

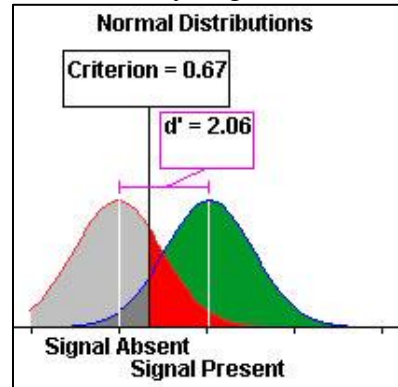


ID = Information Density
SC = Structural Complexity

APPENDIX G:
d' SENSITIVITY MEASURE

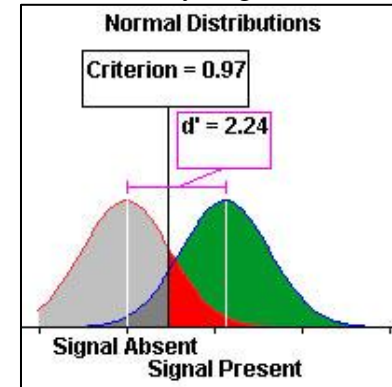
Figure G1: Total Population

High Information Density/High Structural Complexity



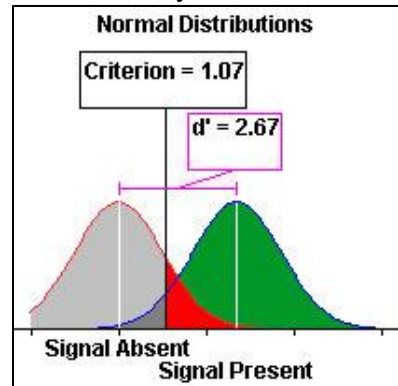
Hit Rate: 0.917
False Alarm Rate: 0.250

Low information Density/High Structural Complexity



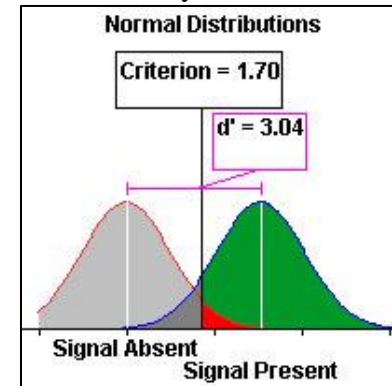
Hit Rate: 0.899
False Alarm Rate: 0.167

High Information Density/Low Structural Complexity



Hit Rate: 0.946
False Alarm Rate: 0.143

Low Information Density/Low Structural Complexity

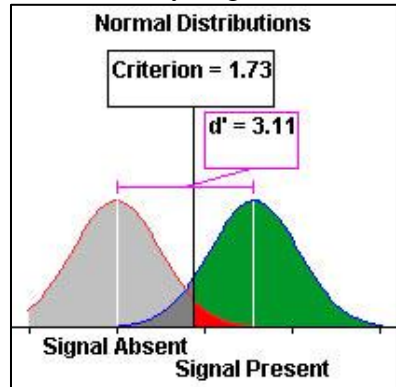


Hit Rate: 0.910
False Alarm Rate: 0.045

APPENDIX G:
d' SENSITIVITY MEASURE

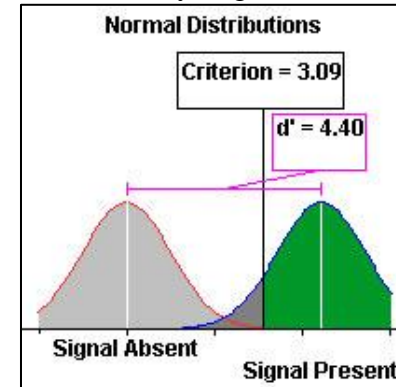
Figure G2: Older Children

High Information Density/High Structural Complexity



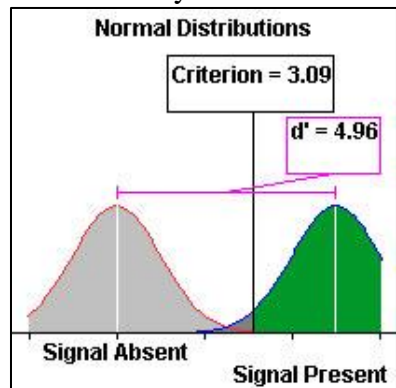
Hit Rate: 0.917
False Alarm Rate: 0.042

Low information Density/High Structural Complexity



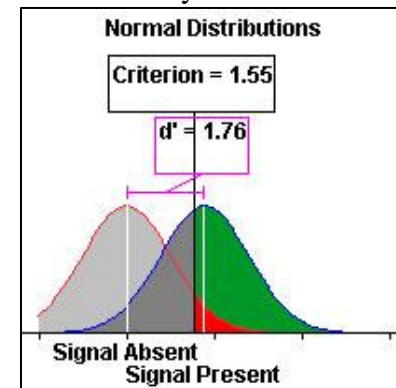
Hit Rate: 0.905
False Alarm Rate: 0.001

High Information Density/Low Structural Complexity



Hit Rate: 0.969
False Alarm Rate: 0.001

Low Information Density/Low Structural Complexity

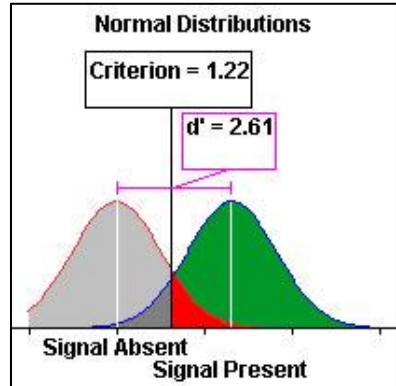


Hit Rate: 0.583
False Alarm Rate: 0.060

APPENDIX G:
d' SENSITIVITY MEASURE

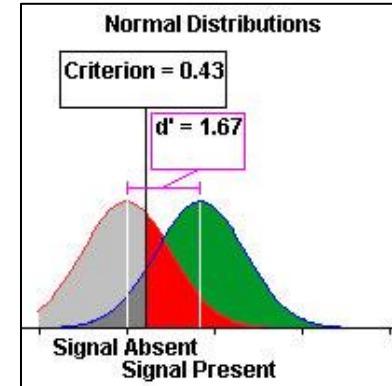
Figure G3: Younger Children

High Information Density/High Structural Complexity



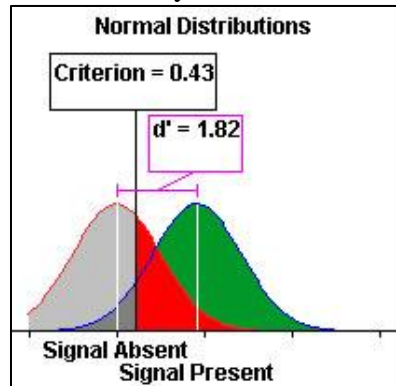
Hit Rate: 0.917
False Alarm Rate: 0.111

Low information Density/High Structural Complexity



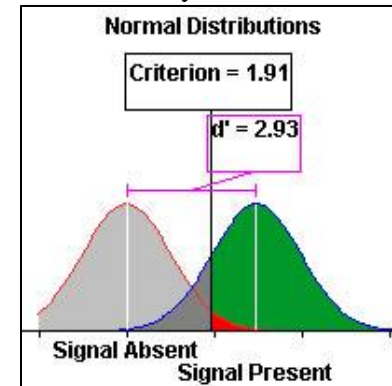
Hit Rate: 0.893
False Alarm Rate: 0.333

High Information Density/Low Structural Complexity



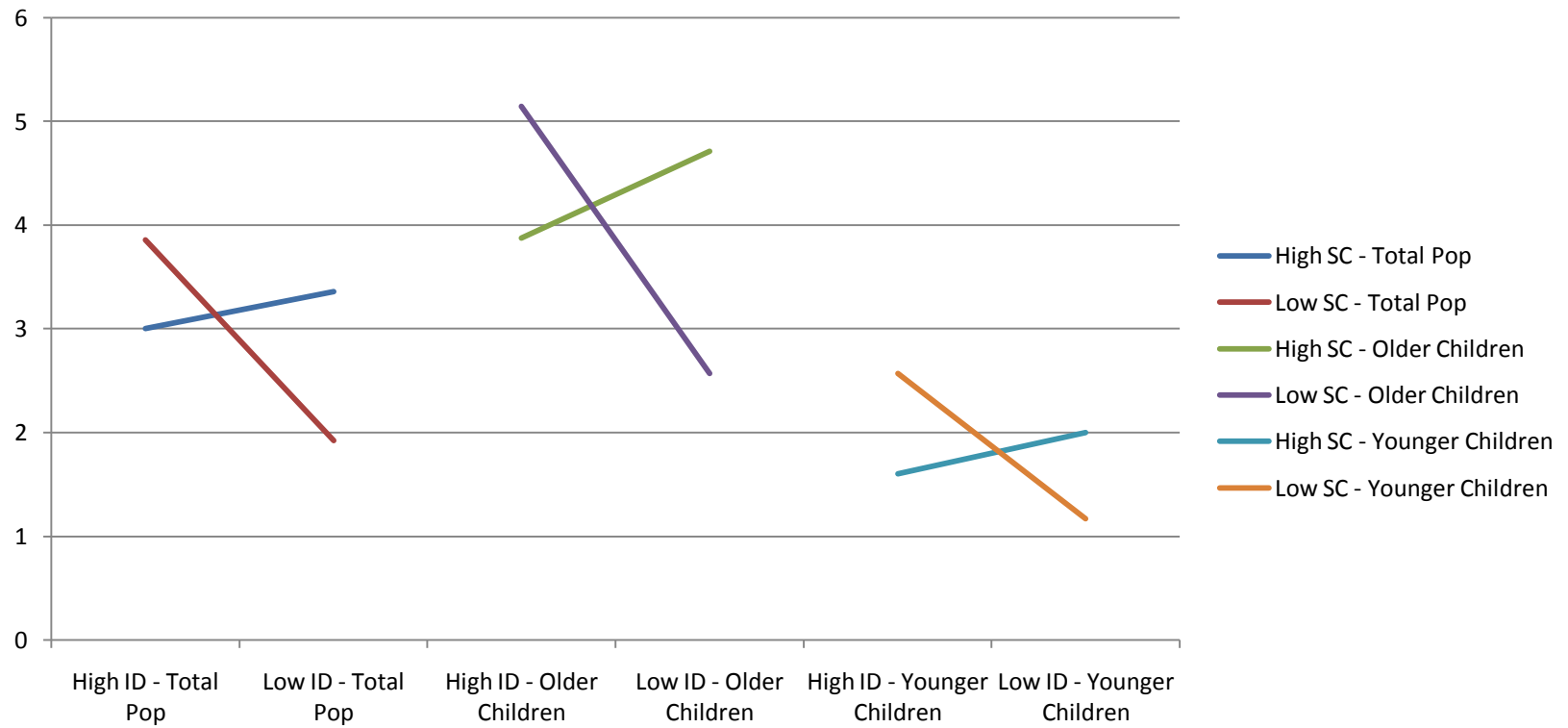
Hit Rate: 0.917
False Alarm Rate: 0.333

Low Information Density/Low Structural Complexity



Hit Rate: 0.847
False Alarm Rate: 0.028

APPENDIX H: RECALL MEMORY



ID = Information Density
SC = Structural Complexity

APPENDIX I:
SUMMARY TABLE

Hypothesis	df	Statistic	<i>p</i>	ε^2 Effect Size	Supported?
H1a	1, 56	0.90	0.35	0.02	No
H1b	1, 56	0.02	0.90	0.00	No
RQ1	1, 56	3.50	0.07	0.06	Yes-Approaching Significance
H1c	1, 56	0.64	0.43	0.01	No
H2a	1, 56	0.02	0.90	0.00	No
H2b	1, 56	0.02	0.90	0.00	No
RQ2	1, 56	0.62	0.44	0.01	No
H2c	1, 56	7.15	0.01	0.13	Yes
H3a	1, 53	2.12	0.15	0.04	No
H3b	1, 53	0.28	0.60	0.01	No
RQ3	1, 53	4.47	0.04	0.08	Yes
H3c	1, 53	24.21	0.00	0.35	Yes