CHILDREN'S COLOR ASSOCIATION FOR DIGITAL IMAGE RETRIEVAL

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In the field of information sciences, attention has been focused on developing mature information retrieval systems that abstract information automatically from the contents of information resources, such as books, images and films. As a subset of information retrieval research, content-based image retrieval systems automatically abstract elementary information from images in terms of colors, shapes, and texture. Color is the most commonly used in similarity measurement for content-based image retrieval systems.

Human-computer interface design and image retrieval methods benefit from studies based on the understanding of their potential users. Today's children are exposed to digital technology at a very young age, and they will be the major technology users in five to ten years. This study focuses on children's color perception and color association with a controlled set of digital images.

The method of survey research was used to gather data for this exploratory study about children's color association from a children's population, third to sixth graders. An online questionnaire with fifteen images was used to collect quantitative data of children's color selections. Face-to-face interviews investigated the rationale and factors affecting the color choices and children's interpretation of the images.

The findings in this study indicate that the color children associated with in the images was the one that took the most space or the biggest part of an image. Another powerful factor in color selection was the vividness or saturation of the color. Colors that

stood out the most generally attracted the greatest attention. Preferences of color, character, or subject matter in an image also strongly affected children's color association with images. One of the most unexpected findings was that children would choose a color to replace a color in an image. In general, children saw more things than what were actually represented in the images. However, the children's interpretation of the images had little effect on their color selections.

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I dedicate this dissertation to my late father, Mi-Chu Chang.

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PERMISSION FOR IMAGES

CHAPTER 1

PROBLEM IDENTIFICATION

This study investigated the factors children use to associate a color with an image. Color analysis has been one of the major concerns in non-linguistic content-based image retrieval systems. Children, with their own norms, culture, and complexities, are believed to interpret things very differently than adults (Berman, 1977; Strommen, 1998). This study centered on children's color perception and color association within a controlled set of digital images.

The research questions lie within the academic disciplines of information science, cognition, and computer science. Along with the prevalence of personal computers and networks, information retrieval systems demand integrating techniques and human factors in order to improve access and retrieval of information. In the past thirty years, information scientists have expanded the field beyond bibliometric analysis and retrieval for physical objects, such as books and art works. Today, more attention has been focused on developing mature information-retrieval systems that abstract information automatically from the contents of information resources, including books, images and films. The abstracted information, then, provides access points for retrieval purposes. Image retrieval study is, therefore, a subset of information retrieval study.

Information professionals work with digital images and multi-media formats that represent a variety of physical objects. As a medium of information, digital images can easily reach a broader audience than the physical objects. However, the retrieval of digital images has problems associated with the lack of knowledge of how people link images with their mental models and how people index and use images. Image retrieval research is often based on user studies (Enser, 1995; Hastings, 1999; Jorgensen, 1998; Keister, 1994; Stephenson, 1999). This research studied young users, children in 3rd to 6th grade. The focus on this age group was based on their particular environment in which computer uses and digital information format are much more intensive than for previous generations.

Statement of the Problem

As mental images use selectivity, visual perception is strongly affected by a persons' constructive schema affected by previous experience and knowledge (Fischler & Firschein, 1987; Moore & Dwyer, 1994). Today's machines code colors, build histograms of images and apply vector analysis for measuring similarity among digital images (Jolion, 2001; Lew, 2001; Sebe & Lew, 2001; Zachary, Iyengar, & Barhen, 2001). These approaches to indexing digital images focus on computing algorithms with low degrees of human elements and concerns. A study that investigates the differences between machine and human color association of images may assist researchers in developing more user friendly, efficient image retrieval systems.

This study is designed to answer the following research questions:

1. Do children associate color with images? How homogeneous is the agreement of children's color association with images?
2. What are the critical factors that contribute to children's color association with images, in terms of primary color, subject, familiarity and complicity variables?
3. When and how often is the dominant color in a picture chosen as the associated color?

4. Do some colors frequently overrule others regardless of their proportion in an image?
5. Is there a relationship between the color selected for the image and the level of meaning the image represents?

Background of the Study

Many questions arise in the discussion of image retrieval, such as the nature of the human visual perception process, machine capacity to abstract information from images, design of systems that facilitate manipulating images and user feedback, and cultural impact on image interpretation. Several studies address these questions; however, children are seldom included in the studies (Hastings, 1999; Stephenson, 1999; Sternberg, 1996; Wu, Narasimhalu, Mehtre, Lam, & Gao, 1995).

Images have long been known as a medium to deliver information (Moore & Dwyer, 1994; Panofsky, 1955; Tufte, 1990). Today museums are evoking public awareness of their collections by providing digital image representations through the Internet. Some issues involve the difficulties of retrieving these images and the information carried by them. First, the sheer number of digital images produced everyday cumulates dramatically. It was reported that over 80 billion new images are taken each year (Lyman & Varian, 2000). As a result, the conventional indexing methods of abstracting information manually by humans are inefficient. Also limited storage space demands information saved in the database to be selective. Second, technology does not allow machines to automatically abstract high conceptual levels of information. The ability to deal with human terminology input is rarely available when a system conducts image retrieval searches. Third, at the content level, such as color, shape, spatial and texture similarity, machines have demonstrated potential uses. However, these are still far from useful outside very specific uses. In addition to the above, the fact of changing information needs, computer experiences, and metal models affect the success of interface design for image retrieval systems. The ability to retrieve unknown images rather than known ones is also becoming more important while the unknown images are cumulating on the Internet.

The major components of these issues are briefly described below. In Chapter 2 the literature about image retrieval is discussed in more detail.

Image Indexing

Levels of Meaning in Images

Panofsky identified in his paper in 1939 the three levels of meaning in the works of art: pre-iconography, iconography and iconology. Shatford (1986) further applies this philosophy of art to build her classification attributes of images. She divides each of Panofsky's levels of meanings into generic of, specific of and about. Shatford's principles of interpreting representational pictorial work provide guides to image attributes; she also points out the problems to get consistency among people at the iconography level, and the iconology level requires even greater cultural knowledge to get an intrinsic meaning of the image.

Information retrieval systems today do not actually retrieve information for problem solving, but search for the representation of the documents that might contain desired information. The representation of images has been an important issue for indexing images. Most of the representations of images are expected to contain information about the creator of and objects in the image, and the subject matter, such as those systems implemented by National Gallery of Art in D.C. and Web Museum in Paris (National Gallery of Art, 2002; Pioch, 1996). The attributes in an image representation usually depend on whether it is a concept-based or content-based image retrieval system.

Concept-Based Image Retrieval

People use images for various reasons. Traditional information systems use keyword matching to search for relevant text documents. However, giving meaning to images requires a high level of conceptual reasoning, which usually has to be done manually by humans. The indexing of images in concept-based image retrieval systems can be aided by the use of controlled vocabularies. Projects such as ICONCLASS, Art & Architecture Thesaurus (AAT), and Thesaurus for Graphic Materials (TGM) have tried to centralize the vocabulary used for indexing images. In addition to text, indexes also may use numerical notation or codes (ICONCLASS) and may be hierarchical or non-hierarchical with levels (Barnett & Petersen, 1989; Busch, 1992).

On the other hand, natural-language image indexing utilizes a text description along with the image in the database, so the system can perform query matching and retrieval. Pictorial and textual information as well as historical background about the images may be included in the text information, which serves users more than the subject matter of the image. The effect of user feedback in image descriptions has been investigated, and the results are positive (Hastings, 1999; O'Connor, O'Connor, & Abbas, 1999; Turner, 1995). Semantic distance between words also has been found more effective in retrieving relevant images than plain keyword-matching (Smeaton & Quigley, 1996). However, besides the disadvantage of cost, indexing concepts in images has a fundamental limitation in that it is not easy to achieve a consistency for the contextual description of images (Greisdorf & O'Connor, 2002). It is difficult to get agreement among individual judgements that are not only subjective but may change with time. As Enser (1995) puts it, "linguistic identifiers…attached to images within a collection offers little promise as an effective pictorial information retrieval procedure" p. 126.

Content-Based Image Retrieval Systems

It is natural for humans to interpret primary or natural subject matter of objects such as a happy face or a child. The system for content-based image retrieval work is on this level of interpretation. However, they work at a more elementary level than the information tasks humans may have in everyday life. The systems automatically identify attributes in an image in terms of color, texture, shape, and spatial similarity. Gupta & Jain (1997) give a discussion of the capabilities of content-based image retrieval systems in great detail. There were at least 20 research groups focusing on content-based image retrieval systems and several commercial products, including IBM's®[1] Query by Image Content (QBIC®), Virage[2] for multimedia management, CORE[3] from the Institute of Systems Science in Singapore, Chabot[4] project at UC Berkeley, VisualSEEK[5], and Photobook[6] for face recognition.

While many sophisticated systems have been developed for identifying color, texture and other attributes in images, grouping images simply by color or texture

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[2] ©2003 by Virage Incorporated. All rights reserved. WWW.Virage.com
[3] Copyright @ 2001- Institute of Systems Science. All rights reserved. WWW.iss.nos.edu/sg
[4] www.cs.berkeley.edu/~ginger/chabot.html
[5] www.ctr.columbia.edu/VisualSeek
[6] www.web.media.mit.edu/~tpminka/photobook/

property of the images does not take human factors into serious consideration. Humans may not see images as a whole piece but as a work consisting of many segments. When people look at a picture of a cat on a horse, they may focus merely on the black cat and ignore the entire horse whose white color skin obviously takes a greater proportion of the image. In this situation, the color perception of the image may be black but not white. However, most systems might categorize this image into the white group because of the large proportion of white color (O'Connor, 1996).

Another issue is to identify images with more than a single subject matter. Dominating color in an image could be its background color or the color of a single object in the image. It is important to know how the background color becomes one person’s focus but is ignored by another. As described by Arnheim (1969) about selecting vision in a nature environment, when vision needs to cope with many objects at one time, the visual field is too crowded to submit to an organization of whole with integration; as a result, we usually concentrate on certain items and areas or some general features leaving out the loose and sketchy structure of the rest. Gestalt Principles of visual perception, on the other hand, suggests that proximity, similarity, continuity, closure, and symmetry play important roles in our perception of forms (Sternberg, 1996).

In addition to grouping by the dominating color of images, some researchers have focused on studying the use of colors in the images. They believe that the images with similar color distribution contain similar information, and various algorithms for calculating similarity of images are developed based on different types of color histograms. However, this type of assumption and research is focused on analyzing images alone without consideration of the human's cognitive process in seeing images (Jolion, 2001; Zachary et al., 2001).

Users

Since the first episode of the television show, Sesame Street[7]™, in 1969, many research studies have been conducted on the program and its viewers. Studies include evaluation research on 'the effects of encouragement and viewing,' 'the probable effects of Sesame Street on the national achievement gap,' and 'the dollar costs of Sesame Street' during 1969 through 1971. In 1970 the dollar costs per regular viewer of Sesame Street were between $0.96 and $1.24, compared with other programs that aimed at the same objectives, such as Headstart, at $1,056 per child (Cook, Appleton, Conner, Shaffer, Tamkin & Weber, 1975). By 1998, Sesame Street had been broadcast in more than 140 countries and seen by more than 120 million children around the world (Borgenicht, 1998). The success of Sesame Street™ contributes to children's preferences for visual presentation. While algorithms for calculating relevance are mainly based on assumptions of user visual perceptions, more user studies are necessary to link visual perception to system design.

During the summer of 2001, the researcher, while interviewing children in the Denton Public Library found that children today generally participate in many extracurricular activities, including sports, arts, music, and computer classes. The knowledge of arts frequently affects children's color association with images. Self-confidence shows up in individualized color association, in which children care little what others' color perception might be. Children also showed a high degree of tolerance

[7] Copyright 1998-2003 Sesame Workshop.

when facing technical difficulties such as low-resolution monitors, slow response time, and insensitive haptic devices.

Importance of the Problem

Different from adults with conventional learning experience, today's children are exposed to digital technology at a very young age and will be the major technology users in five to ten years. It is well known that digital libraries and museums through the Internet have become very important in their educational roles of providing information beyond classroom walls (Delors, & al., 1996; Sheppard, 2001). To perfect online libraries and museums, future human-computer interface design and image retrieval methods would benefit from studies based on the need of their potential users, children today. Understanding children's color perception and association with digital images will provide important knowledge for interface and retrieval design.

Limitations, Delimitations, and Assumptions

Limitations

The following aspects might not be subject to the researcher's control and posed limitations to the study.

1. The researcher conducted the study in public libraries or institutions where potential participants may belong to certain social-economic groups who have easier access to new technologies and higher motivation to appreciate art works. The results of the study might not be generalized to the entire population of children.
2. The measurement of the color perception was based on children's self-reported information.

3. The environment created for the study did not simulate a real image retrieval system. It is not known whether similar results would have been obtained using other image collections. Participants' image perception may be different from real information needs.

Delimitations

The researcher has controlled the following aspects of the research that represent restrictions on the proposed study:

1. Participants were 3rd to 6th grade children.
2. Child participants had no problem operating the mouse and were comfortable with computers.
3. Child participants did not have visual disability with color perception.

Assumptions

1. Children in grades three to six represent the new generation raised in a more technology-intense environment.
2. Color selections represented each individual's visual perception.

Definition of Terms

1. Perception: "The set of processes by which we recognize, organize, and make sense of the sensations we receive from environmental stimuli" (Sternberg, 1996).
2. Color Association: The color most closely related to a particular image.
3. Color: Colors are properties of objects that are seen as reflected or direct light. The three primary colors are red, blue, and, green, which are mixed to form the secondary colors: cyan, magenta, and yellow. In nature concept of

color, primary hues are green, red, blue and yellow, and related to the black/white pair (Maund, 1998).

4. Meaning: Meaning is used in a general way throughout this study. Individual's interpreted meanings of an image include what the individual knows about the image, what he or she can or wants to do with the image, and how he or she feels about the image.
5. Image retrieval: A subset of information retrieval study, in which images are seen as one type of information resources. The access to images may be based on images' abstract concepts and symbolic meanings, or primitive features.
6. Content-based Image Retrieval (CBIR): Retrieval based on an understanding of the semantics of the objects in a collection (Narasimhalu, 1995). Attributes that can be served by CBIR systems are color, texture, sketch, shape, volume, spatial constraints, etc (Gudivada & Raghavan, 1995).
7. Concept-based Image Retrieval: "Indexing of images by describing the concepts they contain with words can be done through application of a controlled vocabulary, by using a natural language description of the image (which can be contextual or a title or caption), or by linking the image to a prototypical image using a visual thesaurus" (Rasmussen, 1997).

Summary

Images contain information. Digital image retrieval (IR) is one subset of information retrieval studies. Automatic abstracting of essential information from images is important for indexing and retrieving digital images, especially when digital images are accumulating rapidly on the Internet everyday. One problem in today's IR systems is that computers do not have the capacity to conceptually interpret images.

On the other hand, content-based IR systems can automatically abstract more elementary information from images in terms of colors, shapes, and texture. Among them, colors are the most commonly used in content-based image retrieval systems. Many algorithms have been developed to compute the relevance among images by their color histograms. However, there is a gap between the relevance among images computed by calculating color compositions and by human judgment.

To refine IR systems, more studies on how humans perceive images and associate images with colors are needed. Today's children, growing up with digital technologies more intensively than previous generations, will be the main users of future IR systems. Children's color perception of digital images might be different from today's adults and should be studied.

While the assumption of this study was to find children's special color association with digital images, the factors affecting color perceptions were fundamentally based on the nature of information in images and the human visual perception process. Moreover, applying the knowledge gained from the study to IR system design also requires understanding of the current developments in content-based image retrieval systems. These issues will be discussed in more detail in the following chapter.

CHAPTER 2

REVIEW OF RELATED LITERATURE

A review of the literature formed the framework for the study of children's color association for digital image retrieval. This chapter is divided into four sections. The first section discusses research about the nature of information embodied in images. The second section reviews the studies that have been done in the human visual perception process. The third section discusses user studies in image retrieval, and the last section describes the major algorithms used for color analysis in content-based image retrieval systems.

The goal of retrieving images is similar to retrieving books; although with different formats, both provide information users need. Books contain texts that provide information verbally; images use colors, shapes, and textures to stimulate an individual's visual perceptions. While verbal information usually is clear and direct, the same visual stimulation very likely evokes different perceptions from each individual. The meanings of images cannot be defined from images per se, but by individuals who have different purposes for retrieving the images. An understanding of common human visual perception may be the beginning of finding commonalities in order to provide appropriate access points for image retrieval. It is also necessary to know how image retrieval methods have developed so far.

Information in Images

Information systems utilize abstracted information from original sources and provide locations of those sources. In text format sources, information is embodied in what the authors wrote in words. Most times information retrieval systems for text format sources are designed from a transmission perspective of information, in which information is passing between two people through language or words, or bits. This viewpoint derives from Shannon's communication theory (Shannon, 1948), which measures the accuracy between the bits sent and received. The accuracy of information received is measured by its similarity to the one from the sender. Word-based messages, dictionaries and grammar rules ensure significant agreement on meaning. That is, the receiver is likely to *get* the intended meaning. For image documents there is a different and problematic situation. There is no dictionary and there is no universal grammar. Therefore, there are few meanings of ensuring that the receiver will get the intended meaning.

Information, by its nature does not need to be sent. A man with some thoughts in his mind should be qualified of having information of his own (Metcalfe & Powell, 1995). A *perceiver-concerns* perspective may be more appropriate when considering the meanings of digital images, in which a viewer constructs information from the content of images, based on her knowledge, experience and environment. The accuracy of a creator's intention has little meaning, since viewers define how they will use and why they need the image without too much concern about original purpose of the creation. What is important in image retrieval study is how users perceive images.

There is correspondence existing between people and an information retrieval system. Users will be able to predict the behavior of the system if they have an appropriate mental model for the process or system (Kieras & Bovair, 1984). The design of an indexing system should provide a representation that matches the mental model built through visual perception of viewers. For an image retrieval system design, that means having the capacity to generate an image that is similar to the one in the viewer's mind. On the other hand, the interface design of image retrieval systems should match a user's cognitive model by which he or she abstracted, organized, and stored the information derived from viewing the image. Therefore, the interface of a retrieval system can provide necessary tools for a user to utilize their searching strategy generated by cognitive system. For example, it has been found that difficulties with textual Boolean query languages forces users to guess terms that were defined by catalogers for subject searching (Borgman, 1986).

Representation is a fundamental concept in indexing and abstracting. O'Connor (1996) has defined representation as a system for highlighting or extracting certain aspects of an original object or concept with explanations of how the system does that. Representation can be done by direct or indirect extraction of some attributes of the original. These are essential attributes that are necessary for a given situation. Examples of direct extraction can be found in the previews for movies and keyword searching systems, in which the key frames and words are extracted directly from the original. Indirect representation can be iconic; for example, a photograph of firefighters hanging flags on the Pentagon represents the concept of determined patriotism to many American people after the attack on September 11, 2001. Direct presentation of some physical attributes is not always practical or possible. Taking some of the physical attributes, we can present the essence of the object to the audience. However, representation systems require some form of codes that generate signs from the original (O'Connor, 1996). When the code is not known, the meaning of the sign cannot be understood.

Human Visual Perception

As recognition memory is virtually always better than recall (Sternberg, 1996), browsing images to provoke the desired one is easier than describing it precisely. Image browsing usually provides images that have been grouped by certain characteristics such as painter or producer, year of creation, or subject matters. Users can therefore find the images they are looking for by identifying it out of the group. Browsing also provokes users' awareness of the existing collection, which usually carry out some degree of educational function rather than merely providing asked information.

Visual Thinking

It is believed by some that people cannot think without images (Arnheim, 1969; Damasio, 1999). The nature of perceiving an image is holistic. That means we perceive the whole image, with every pixel, at the same time. While words or languages provide a sequential reasoning tool, appointing individual signs to individual events or concepts, words or language do not do the work of reasoning, or thinking. On the other hand, parallel processing is required to reason, since abstracting information is to generalize and mapping meaning from the whole. Because an image is necessary for thinking, visual perception is highly involved with the cognitive process. Our eyes do not copy everything we see into our brain. Seeing is highly selective from the very beginning, and depends on our mental schema constructed from prior experiences, such as culture, education, and physiological nature (Arnheim, 1969).

Biological Structure of the Brain

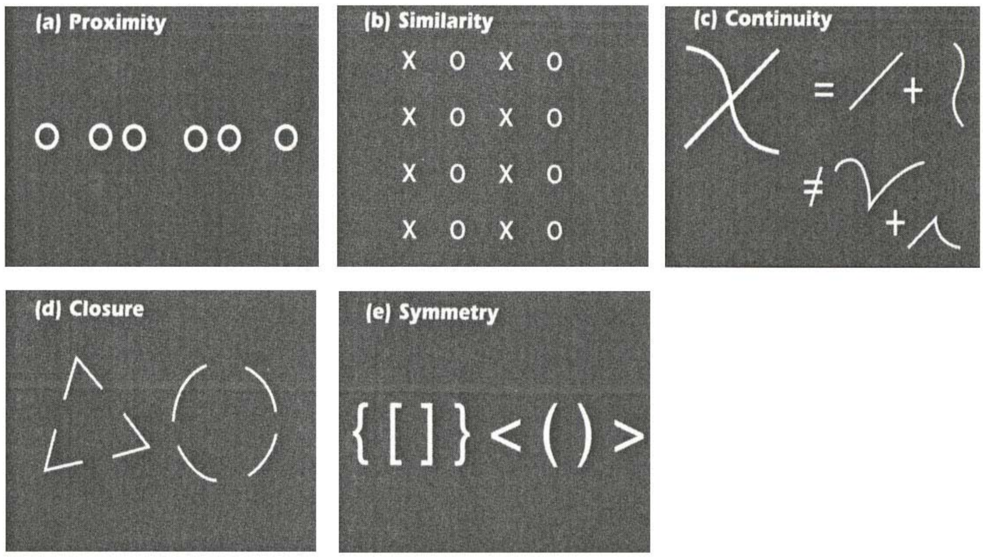
Fischler and Firschein (1987) explain the way in which organic vision evolved and functions. They found that "the memories of past visual experiences and wire-in processing machinery may have a greater influence on how a scene is interpreted than the immediate information provided by the external sense organs."(p.208) From this point, one would expect the previous experience with an image, such as viewing Sesame Street™, would affect the children's attention on a similar image, and consequently affects the color perception of the image. The reason that previous experience affects image perception can be explained by the biological structure of the brain. While firing neurons in our brain creates memory, a frequently fired pattern will leave a stronger impact than seldom patterns. On the other side, strongly fired neurons keep strong impact on it. For example, a so-called flashbulb memory usually happens after a vivid and rich detailed experience (Sternberg, 1996).

Gestalt Principles

While visual perception has been studied for centuries, the focus has always been on how we perceive the shape and size of images or grouping of objects in an image. The Gestalt principles of proximity, similarity, continuity, closure, and symmetry help in our perception of forms, through which we integrate divergent visual stimuli into a united and stable whole picture (Sternberg, 1996). Figure 1 depicts those five principles.

Gestalt principles of visual perception provide a framework for linking the children's color association behavior with the image's content construction condition. Since perception is concerned with the grasping of significant form, children's major color perception of an image might be led by the structure of the image when the subject matter is not clear to them. However, we did expect to find that children perceive color by selecting the color of an object that is, for example, the biggest in the image.

Figure 1. Gestalt principles (Sternberg, 1996)



Color patterns

Few studies have been done on the psychological dimensions of color patterns. Restat (2001) has found four features of color pattern to be directionality, color purity, regularity and complexity, and purpleness. Directionality and orientation of the patterns present continuous straight lines or closed and rounded lines. The amount of white and black in colors decides the purity of colors. Higher purity means that a color is more saturated and vivid. The regularity of patterns is classified by the structure of patterns. The more symmetrical and orthogonal patterns were considered more regular than diagonally oriented and asymmetrical ones. The purpleness of an image is to say if the image overall is purplish. This last feature, however, has to be evaluated. Some people tend to classify images by how greenish they are.

Image Scaling and Scanning

Stephen Kosslyn (1975) studied image scaling and image scanning in order to understand how we create and manipulate mental representations of images. In general, we respond more quickly to questions about larger objects that we observe than to questions about smaller ones. One example is imagining a rabbit and a fly and then imagining a rabbit and an elephant (Sternberg, 1996). It takes effort to zoom in on the fly if we are asked to tell detail about the fly. However, when zooming in on the elephant it is easily found that the elephant seems over mental image size, in that the elephant becomes so large we no longer are able to see the whole elephant when we zoom in, for example, on one of the eyes.

Color Vision

According to the natural concept of color in the Stanford Encyclopedia of Philosophy, “colors are properties that as a group, form an internally related 4+2 structure, built on the four unique, primary hues: green, red, blue and yellow, and related to the black/white pair” (Maund, 1998). Colors comprise the kind of property that makes true a wide range of first order color principles or statement. These four colors are easily found in natural scenes. The sky is blue on a sunny day, and blood is red, and so on. While ripening bananas turn from green to yellow, some ripening apples go from green to red, and so on.

Color plays an important role in visual communication. Color perceived in an image can affect both the focus of attention and emotion. Physiologically, in the eyes there are three types of color-sensitive receptors corresponding to red, green, and blue. However, not only the relative strength of the signals received from those three-receptor systems issue our final color perception in a scene. Colors perceived in other parts of the scene affect the perceived color. “In complex scenes we can perceive colors that cannot be exactly reproduced by a simple mixture of the three primary colors (Fischler et al., 1987).” Moreover, the fewer blue-pigmented cones cause less sensitivity compared with the red and green.

Colors play significant roles in the epistemological, personal and social lives of human beings. While images have three functions of sign, picture, and symbol, colors in nature are signs to identify and re-identify physical objects. For example, red color indicates an apple is ripe. In addition to the function of natural signs, colors also perform as conventional signs, such as uniforms in a ceremony, etc.

As Arnheim (1969) points out, the pictorial interpretation emphasizes the generic qualities with which all thinking is concerned; also the particular character of shapes and colors is determined by their place and function in the whole. To develop a representative system for image retrieval, it is important to know if today’s children differ in their concerns when interpreting an image with subject matters that are familiar to them and those they are unfamiliar with. It is assumed that that shift of concern will affect their color association with images.

Field-Independent and Field-Dependent

Field dependence or field independence is one type of cognitive style. Witkin & Goodenough (1981) defined the “field-dependent as overcoming embedding contexts in perception” (p. 14). In visual perception, field-independent people are better in locating a simple figure in an organized complex design. In other words, it is easier for people who are field-independent to identify an item from its surrounding than field-dependent people. Monzon’s study in 1981 also found that males scored more field-independent than females (Monzon, 1981). Therefore, it may be expected to find out that boys, who are assumed to be more field-independent than girls, may also see images differently from girls; as a result, their color selections might be expected to be different.

User Studies

Color and Position of an Object in an Image

Color and position of an object in an image play important roles on catching people's visual attention. Bang (1991) points out that "color's effect on us is very strong-stronger than that of other picture elements…an object placed higher up on the page has greater pictorial weight…the center of the page is the most effective center of attention. It is the point of greatest attraction…we associate the same or similar colors much more strongly than we associate the same or similar shapes…contrast enables us to see" (p. 78-110).

About Children

Knezek, Miyashita, & Sakamoto (2000) found that "young children in grades 1-3 have stable dispositions which can be measured by self-report inventories" (p. 9). It is not difficult to understand that children should be included in the study if an image indexing system is designed for children. Having children help test new toys is not new; however, recently, Allison Druin brought to the public attention the notion of integrating children into the design phase while toys were being created. In 1998, at the Human-Computer Interaction Laboratory (HCIL) in the University of Maryland, children and adults started working together to develop new technologies for learning, collaborating, storytelling, and exploring (Druin, Hendler, Monte, Boltman, McAlister, Plaisant, Olsen, Smith & Kowaskey, 1999). Druin came up with four main roles that children can play in the technology design process. They are user, tester, informant, and design partner (Druin & Fast, 2002). Although the focus of HCIL is on computerized toys, the model of child and adult working together can also be applied to the image indexing system design (MacPherson, 2000).

Many papers have been published discussing the factors that make the television show Sesame Street™ a success. Two of the factors are the program's broad appeal to children and its adaptability (Gettas, 1991). However, from Gettas' paper, it is easy to see the actual factor for the success is their concern of children in all aspects. The program's curriculum goals are set by the researchers, producers, educators, and other child development experts, and then "tested with preschool-age children for clarity and appeal. This progress gives the Sesame Street producers maximum flexibility to respond to the changing needs of their target audience (Gettas, 1991, p.56)."

Entropy

Because of the success of Sesame Street's commercial type of tempo, for many years children were believed to pay more attention to faster animation. However, in a recent study by Kearns (2001), no significant difference in terms of children's visual attention between slower and faster animation was found. Hawkins, Yong-Ho, & Pingree (1991) also found that "children seem to control their own attention to television actively in response to the comprehensibility of the contents even when the basic stimulus attributes (for example, types of voices, sound effects animation, child actors) do not vary" and elder children are more willing to think about incomprehensible stimulation than younger children. (p.53)

Gender

Many researchers have reported gender stereotypes of computer ability and attitude. Men or boys were found to have superior computing ability (Clarke &

Chambers, 1989; Felter, 1985; Zelman, 1986; Lockhead, Nielson & Stone, 1985), and were more confident to use computers (Gardner, McEwen, & Curry, 1986; Sanders, 1990). There were also more males than females taking extracurricular computer classes or summer computer camps (Hess & Miura, 1985; Levin & Gordon, 1989). In general, male teachers use more computers than female teachers at the elementary, secondary, and university level (Hattie & Fitzgerald, 1987). However, in her 1997 report, Christie has defied these stereotypes. Christie's major observation was focused on the language children used to discuss technology and computers and the meaning they gave computers (Christie, 1997). Christie found nine times as many instances of girls than boys mentioning computers as tools for personal productivity. Also, more frequently than boys, girls viewed the computer as a future career or a wholesome hobby. While both boys and girls found computers frustrating, girls mentioned computers as frustrating less often than did boys. Moreover, girls use more technical language to describe telecommunications and computers than did boys (Christie, 1997).

Knezek and colleagues have found an interesting pattern of gender differences. There is no significant difference in their perceived importance of computers among first grade boys and girls (Knezek et al., 2000). The girls showed higher enjoyment of using computers than boys at the fourth and fifth grade. However, by grade six, girls have a less positive attitude toward computers (Christensen & Knezek, 2001).

Clearly children today are very different from those twenty years ago, so the methods of indexing by children's color association for image retrieval should not merely be based on previous studies, especially when children today are growing up with fast-changing technology, both females and males.

Technical Development

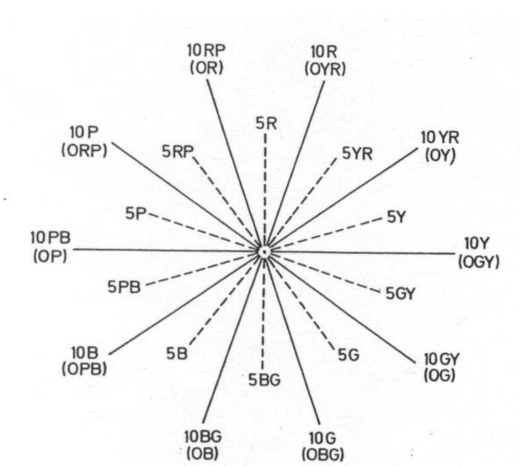
Content-based image retrieval is based on an understanding of the semantics of the objects in a collection. Attributes that can be served by CBIR systems are color, texture, shape and spatial constraints, etc. However, texture, shape and spatial attribute are basically identified by the similarity of neighboring pixels. Pixels with similar color form lines or clusters that result in certain shapes or texture. Discussion of the use and measure of color in content-based image retrieval research follows.

Color Representation

There are many studies about colors in art design and different concepts bring different naming system for colors, such as Munsell color system and the natural color system.

The Munsell system for color samples and color stimuli is described by the dimensions: Hue, Value, and Chroma. Five major colors of principal hue are red, green, blue, yellow and purple. By inserting five intermediate hues between the five colors, Munsell achieved the ten hues around the circle: R-YR-Y-GY-G-BG-B-PB-P-RP. Figure 2 is the Munsell Hue circle.

Figure. 2. The 10 Hue Ranges of the Munsell Hue Circle (Agoston, 1979)



The hue circle is further divided into several steps. Values represent the reflectance of light in percentage with 10 steps; the zero-point of the scale equals zero percent of reflected light, and the value 10 equals 100% of reflected light. In the *Munsell Book of Color* (Munsell, 1929) the values are scaled from 0.5 to 9.5. Chroma scale indicates the degree of departure of a given Hue from a neutral gray of the same value. For color specification, Munsell prepared color samples by implementing his color system. As a result, the samples are related to each other through progressive changes in hue, value, and chroma with visually equal steps. Each sample color is identified by a code, which provides convenience for commercial applications (Agoston, 1979).

In the Natural Color System (NCS), colors resemble elementary colors: red, green, yellow, blue, black and white, the colors most likely found in nature. Conceptually, and cognitively NCS deals with four separate scales, namely one variation between yellow and red, one between red and blue, one between blue and green, one between green and yellow. In the NCS circle, the color that looks equally yellowish and reddish is marked in the middle of the arc between Y and R. The notation for this hue will be Y50R. The other two points W and S represent the imaginable elementary colors white and black. Each of W and S is scaled with equal spacing of 100 steps. When estimating colors by the NCS method, a person simply estimates how much there is of yellowness, redness, whiteness, and blackness in a given color. A notation 10 70 Y60R, represents 10 units of blackness, 70 units of chromaticness of hue by 40% yellow and 60% red (Sivik, 1997).

Colors can also be measured by matching them to the standard samples. Colorimeters are used for higher accuracy. An internationally accepted method for specifying color has been developed by the Commission Internationale de l'Eclairage (CIE). Three monochromatic primaries are wavelengths 435.8, 546.1 and 700 nm and perceived as color red, color green and color blue by the human eyes. Since, it is impossible to match all the colors of the spectrum with these three primaries, CIE invented the three imaginary additive primaries. Three numbers, known as CIE tristimulus values, are derived by analyzing the relative amount of three imaginary primary colors (red, green, blue) needed to match the energy of the wavelength of the sample color. A CIE color specification is written CIE (x,y,Y); *x* and *y* are the fractional amounts of red and green, Y is the luminance factor (Agoston, 1979).

Color Space

For content-based indexing, a color histogram is the standard representation of color in images. Before constructing the color histogram, types of color space have to be defined. In digital images, color pixels are most commonly given values using color-coding systems such as CIELAB, RGB, CMYK, and ROMM RGB.

CIELAB Color Space

"The CIE tristimulus values *x, y*, and *z* can be transformed by simple calculations to three quantities L, A, and B. These three quantities provide a different color space of which the complete name is CIELAB (1976) uniform color space" (Agoston, 1979, p.83); L is defined as brightness, A ordinate shows the redness to greenness, and the B ordinate describes the yellowness to blueness of a color. "…equal distances between colors in any parts of CIELAB color space represent approximately equal perceptual differences; hence, it provides a useful measure for determining color differences numerically. The formula used for calculating color differences in terms of CIELAB units presents distances in CIELAB color space" (Agoston, 1979, p.83). However, "the CIELAB formula is recommended primarily for object colors. Another formula, CIELUV (1976) is recommended for expressing color differences in lighting, photography, television, and the graphic arts" (Agoston, 1979, p.76).

RGB

"RGB is the most common color space for digital images and computer graphics, in which colors are described as linear combinations of red, green, and blue color channels. By varying the voltage of each channel and combining the output, cathode ray tubes (CRT) can generate a great array of colors for each pixel on a monitor. Moreover, the use of color raster graphics devices and CRT monitors results in the prevalence of RGB color space. Digital cameras and videos mostly use RGB NTSC recommended by National Television System Committee" (Gevers, 2001). The draw back of the RGB color space is that it is not perceptually uniform. That means the colors that are close to each other in the color space do not tell whether they are similar or not.

CMYK

Another commonly used color space is CMYK. Dyes that produce cyan, magenta, yellow and black color are used in color photography and the printing process. To generate color lights through CRTs, beams of different colors are added together, known as additive color mixture. Printers, on the other hand, utilize the method of subtracting colors from the input lights. The dye used for printing abstracts light to produce desired colors. However, converting RGB color space to CMYK often results in noticeable differences between what we see on the screen and what we get from a printer.

ROMM RGB

Reference Output Medium Metric RGB (ROMM RGB) color space was created for Kodak's[8] color management system is an attempt to bridge those so-called device-dependent color spaces, such as scanner RGB, video RGB, or CMYK. This color space is said to have a large enough color gamut to include most common output devices. While the International Color Consortium (ICC) has defined a Profile Connection Space (PCS) comprising a device-independent color encoding used to specify the color of an image with respect to a reference viewing condition for color transform, PCS was never intended for use in storing or manipulating images. By defining the reproduction-viewing environment, ROMM RGB can convert PCS image tristimulus values to ROMM RGB values, or ROMM RGB values to PCS values. Therefore, the new standard color space, ROMM RGB, can be used for storage and manipulation of color images with device-independent characteristics. ROMM RGB now has compatibility with usage as an Adobe® Photoshop® [9] V5.0 software RGB working space, which allows multiple systems with different monitor spaces to view the same image accurately.

Similarity Measurements

For a query by example type of search, the fundamental aspect is to group images with similar visual features. One of the visual features is texture. Texture is certain repeated patterns formed by variations of intensity and color. "The patterns can be the result of physical surface properties such as roughness… or of reflectance differences such as the color on a surface" (Sebe et.al., 2001, p.51). Different from intensity-based image comparison, geometry based comparison is used by another

[8] Copyright © Eastman Kodak Company, 1994-2003, www.kodak.com
[9] Copyright 2003. Adobe Systems Incorporated. All Rights Reserved; www.adobe.com/products/photoshop

visual feature, shape. Applications of shape matching include fingerprint matching and industrial inspection (Veltkamp & Hagedoorn, 2001). While texture, color, and shape are most common visual features researchers have been studying, color is still the most commonly studied in content-based image retrieval system. While the distance between two colors in the color space represents the color similarity, the color similarity of images usually involves a color histogram of images.

The distance between two points in the color histogram space is described as the similarity between two images. Many researchers have defined formula to compute the distance, which is also called distance function or similarity function (Rorvig & Jeong, 2000; Stricker & Orengo, 1995).

Basically, the similarity is defined using a distance function. The distance between the query object and reference objects is computed by their defined function first. Then, the *k*-nearest neighbor form is employed, in which a borderline distance is set. At the end, the referenced objects located inside this upper bound are retrieved as the resulting set.

Summary

This chapter presents an overview of the theory and research related to the image meaning, human visual perception, users, and color used in content-based image retrieval.

While, shape, texture, and color are major visual features in images, color has been the most studied. To apply color in image retrieval design, one of the most important steps is to decide what color system should be applied to color analysis. The RGB color system has been the most commonly used among other color systems.

However, the nature color system with four color- red, green, blue, yellow- and black and white, representing the brightness and darkness, were more appropriate for a study with children.

To frame the proposed study, several variables abstracted from the reviewed literature were used. First, from a biological point of view, prior experiences have a strong impact on how we perceive a present scene. As a result, familiarity to the subject in an image will have impact on how children perceive the image. Second, the position of objects in the images has impact on focus of attention. Third, the Gestalt Principle suggests that proximity, similarity, continuity, closure and symmetry help in our perception. Finally, many recent studies have challenged gender stereotype in children's attitude toward new technologies (Christie, 1997).

Additionally, the way children associate colors with images will be very different from what we have expected, for they are growing up in an environment with intense technology use. The design of this study will be discussed in more details in the next chapter.

CHAPTER 3

METHODOLOGY

This study investigated children's color association for digital image retrieval. Many image retrieval algorithms have been developed based on machine computational vision (Gevers, 2001; Jolion, 2001; Lew, 2001; Veltkamp et al., 2001). By computing basic shapes in an image or analyzing distribution of the color histogram, machines have utilized some aspects of our knowledge about human visual perception. However, not only do humans see things by the shapes and colors, but they also give meanings and different degrees of attention to portions of what they see. The given meaning and attention make an image different from or similar to another one.

To create an image retrieval system for children, it is necessary to know how children see images and the degree of agreement on assigning meanings and focusing attention to images. From physiological aspects and the nature of human color perception, people do perceive colors with similar vision capacity, except those who have visual disabilities (Fischler et al., 1987). We can only see colors between certain ranges of wavelength; easily caught by red color and green color more than blue color, and give more weight to subject at the center and upper half of the image (Bang, 1991). However, culture background and gender differences may also affect those behaviors (Cooper & Matthews, 2000; Gage, 1995).

During June 25 to 29, 2001, the research conducted a pilot study with participants recruited at the Denton Public Library in the United States (U.S.) and Good Time English School in Taiwan. Participants in the pilot study were children age 7 to 11. At the end of the week, 23 children finished the online survey in the Denton Public

Library with the researcher present. On the other side, through the director of Good Time English School, children in Taiwan were invited to participate in the study. Eleven children finished the online survey. The total participants included 34 children. Participation was voluntary and parental consent was required.

An online questionnaire with 45 images was used to gain the color association data from children. Fifteen key frames captured from Sesame Street™ video, 15 from Mr. Roger's Neighborhood™[10], and 15 digital images of Caribbean art comprised the selection. Along with each image were checkboxes for selecting red, green, blue, yellow, black or white color for the image, for they are the four unique, primary hues and indication to brightness in the images. A sample of the survey is attached in Appendix A. Since the online form created for this study was located on a UNT server, the e-mail received by the researcher contains the sender named Web User <webadm@www.unt.edu>. Therefore, the data were kept anonymous regardless of the location of the sender. Appendix A also includes a copy in which the UNT Committee for the Protection of Human Subjects issued approval for the study.

Code numbers were required in the survey to ensure the participants whose parents had given consent. These code numbers were designed to be unpredictable and non sequential. The received e-mailed data must contain the code number that matches to one of those on the code number list composed from the received consent forms. The code numbers used also indicated whether the participant was in the U.S. or Taiwan. The participants chose one color for each image. The time to finish the questionnaire ranged from 10 to 20 minutes. Age and gender were asked in the questionnaire in order to assist in data analysis. Each participant's data was sent to the

[10] © 2001 Family Communications, Inc. and PBS

researcher's e-mail account. Sample data are attached in Appendix A.

The frequency of each color selected for each image, the mode of the color selected for each image (with agreement level), and the number of images in each range of agreement level are listed at the end of Appendix A. Findings from the pilot study include the following.

The overall agreement level is about 41 to 50%. From the analysis, the U.S. children demonstrated a lower level of agreement on the color selection for images than children in Taiwan did. Also, girls had higher level of agreement than boys. In most cases, the color selected by the majority for each image did reflect the preference for the dominant color in the image. However, many factors affected the color selection when the primary color was not the selection observed or reported by the children. The following are some of the findings from the pilot study.

1. Complete objects or shapes provided hints to children's color selection.
2. Object over background color sometimes was chosen when the child was familiar with the subject of the image, for example, the red trolley over blue castle background and the blue monster over yellow background curtain. Other examples included that Big Bird had more emphasis than other complete figures.
3. Living subjects were more important than non-living objects, especially the clothing of a living subject is usually chosen over other objects.
4. The color at the center of an image usually gained more attention.
5. The colors of objects for the indicative character were the selections in some images.

6. The most vibrant color in an image was very likely the choice.
7. Other behavior included selecting the favorite colors, selecting the missing colors, and selecting colors that appear in most of the images. Younger children showed more of these types of behavior.
8. When told that chosen colors would be used in grouping images, children tended to choose the primary color in the image.

Based on the pilot study results, some modifications to the study design were needed. The modifications included reducing the number of images and developing an interview script. The 45 image pilot study likely generated children's fatigue before they finished the session. Fifteen images were used in the final study and five of the fifteen images were repeated at the end of the survey to measure the consistency of the answers. Also, an interview script was created to understand the rationale for children's color selection behavior. Since in the pilot study children seemed to anticipate the researcher's expectation when looking at images, it was decided to minimize the instruction when asking children to choose a color for an image. In addition, using children's grade levels seemed to be more appropriate than their ages due to the homogeneous nature of psychobiological maturity.

Research Questions and Research Design

The following research questions framed the study:

1. Do children associate color with images? How homogeneous is the agreement of children's color association with images?
2. What are the critical factors that contribute to children's color association with images, in terms of primary color, subject, and familiarity and complicity

variables?

3. When and how often is the dominant color in a picture chosen as the associated color?
4. Do some colors frequently overrule others regardless of their proportion in an image?
5. Is there a relationship between the color selected for the image and the degree of meaning the image represents?

Sample Population

The population of this study is children from 3rd to 6th grade. The selection of the sample within this population was based on the willingness of the subjects and their parents' consent for participating in the study. The researcher recruited 76 children in the Denton Public Libraries; complete data sets collected from 69 children were used for the final analysis; they are 32 boys and 37 girls. Table 1 shows the composition of the participants by gender and grade level.

Table 1

Participants in the Sample by Gender and Age

Gender	3rd grade	4th grade	5th grade	6th grade	Total
Boy	8	7	10	7	32
Girl	10	13	7	7	37
Total	18	20	17	14	69

Instruments

An online questionnaire with fifteen images was used to gain preliminary color association data from children. Six key frames captured from a Sesame Street™ video, three from Mr. Roger's Neighborhood™, and six digital images of Caribbean arts compose the selection, for the diversity of color, composition, and subject matter, as well as the familiarity to children. Key frames captured from the shows contained both close shots and non-close shots. In addition, each of the selected images had at least two colors that almost occupied equal proportion of the image. This was to reduce the bias that a color might direct participants' perception if it appeared to be the single strongest or most appearing color alone in an image. It was also assumed that children would be familiar with images captured from Sesame Street™ and Mr. Roger's Neighborhood™ and unfamiliar with the Caribbean arts.

Along with each image were checkboxes for selecting red, green, blue, yellow, black or white color for the image. The RGB figures for these six colors were red (255, 0, 0), green (0, 150, 0), blue (0, 0, 255), yellow (255, 255, 0), black (0, 0, 0), and white (255, 255, 255). Children were asked to choose one color for each image. A 17-inch monitor with 1280*1024 resolution was used in displaying the images. The online questionnaire is located at http://courses.unt.edu/shastings/Yunkeresearch/home.htm. Images used in the online questionnaire are listed in Appendix B.

The length of time each child spent in making a color selection for each image was measured by hundredths of a second using a chronometer. This data was compared with the agreement level.

An interview script was used to understand the rationale and factors affecting children's color selections. The following four questions were asked, and the answers from the participants were recorded for the last five repeated images in the online survey.

1. Do you know where this picture is from? (Have you seen this picture before

this study?)

2. Why did you choose the color for this picture?
3. What do you think this picture is about?
4. What is your favorite color?

Method

The method of survey research was used to gather data for this exploratory study about children's color association from a children population, 3rd to 6th grade. Online survey collected quantitative data of their color selections and demographic data. Qualitative data collected by face-to-face interview questions investigated the actual reasons for selecting a color for an image and children's interpretations of the images.

In addition to the online questionnaire for children's color selections, this study was conducted with a more comprehensive survey interview. A face-to-face interviewing process provided information of how children associated images to further reconfirm the factors found in the initial stage. The researcher recorded children's rationale for selecting colors and their interpretation of images. Coding transcriptions of the interviews was part of the analysis process. This part of the analysis was the focus especially when a chosen color was not the dominant color in the image.

As in most qualitative studies, there were several threats to the validity of interpretation in this study. One of the problems is called instrument decay (Krathwohl, 1998). Instrument decay indicates that a change in an observation procedure or measuring instrument causes the inconsistency in observation or measurement. To avoid the inconsistency of rules for checklist used in the survey interview, the researcher chose to record the conversation and code the rationales from transcriptions by more than one person.

In addition to avoiding instrument decay caused by researchers, other things to watch for in the process of analysis include uneven reliability of information and revision of ideas. From the pilot study, it was found that some children's color selection decision involved little rationale. This kind of unreliable information can affect data analysis and sometimes the conclusion. Using and comparing the color selections of five repeated images at the end of the online questionnaire with previous responses helped to tell the reliability of the data. In addition to self-reported rationale from the participants, the researcher also used observational methods while the participants were selecting colors and answering the interview questions. Revision of ideas usually happened to the researcher when new information was either underweighted or overweighed. Therefore, using transcription and a coding sheet reduced the chance of biased judgment.

Data Collection Procedures

Before conducting this study, the researcher applied for approval of the study modification from the Institutional Review Board (IRB) at the University of North Texas (UNT), for changing questionnaire items and adding the tape-recorded procedure in the study. Appendix C includes a copy in which the UNT Committee for the Protection of Human Subjects issued approval for the study and copies of the modified child's assent form and parent's consent form.

The researcher, then, contacted the managers in two Denton public libraries: Emily Fowler Central Library and the South Branch. After the managers agreed, the researcher started collecting data. The researcher invited children in the library to participate in the study everyday for one month. The researcher asked children about their grade level and whether their parents were with them and introduced the study to both the child and parent. The assent from each child and the consent from the parent or legal guardian were obtained before the child participated in the study. A unique code number was given to each participant in the consent form. Participants were asked to *choose one color for each picture* in the online survey.

A chronometer measured the length of time spent in selecting a color for an image. The researcher started the chronometer each time a new image appeared on the screen and stopped the chronometer when the participant made a color selection. After finishing selecting colors for 20 images, the participants were asked if they agreed for the interview to be tape-recorded. All the participants accepted the tape-recording process. Then, four questions about each of the five repeated images were asked, and the answers were recorded. Data collected by the online questionnaire was sent to the researchers' email account with participants' code numbers. The recorded interview was transcribed for content analysis. Appendix D includes a sample of the data sent to the researcher and samples from the interview transcription.

Data Analysis Procedures

The statistical tests used were not intended to prove correlation. They were used to describe the data for discussion. For example, when running Chi-square analysis, not all the cells contained the suggested number of responses due to the nature of the data set.

Correlation Coefficient Analysis

The percentage of the participants selecting the most chosen color for an image was defined as the agreement level for that image. The relationship between the average amount of time children used to make a color selection for an image and the agreement level was measured using Pearson's correlation coefficient. It was expected that the more time needed to make a selection, the less the agreement level.

Chi-Square (x^2) Analysis of Color Selections

The color selections of the five repeated images were compared using *(x^2)* analysis to test the reliability of the children's responses in selecting colors. The null hypothesis was that there was no difference between the first time and second time color selections were made for the same image.

Chi-Square analysis was also used to see if there was any difference between boys and girls color selection behavior for each of the fifteen images. It was found that there were no significant differences between the distributions of boys' and girls' color selection for the 15 images, except for two images, image six and image 14.

T-test

The data collected from online questionnaire included the following variables, gender and grade level of the participant and color selection for each image. The distributions of agreement level of color selection were compared by genders through paired-samples t test. It was estimated that girls would have higher level of agreement than boys, as found in the pilot study; however, the results didn't support this assumption. More details will be discussed in the next chapter.

Interview Content Analysis

A descriptive report was generated from the interview transcription. A list of factors affecting children's color selections were used by two research assistants to ensure the inter-coding reliability. A list of children-defined attributes was generated from their description of images through content analysis, too.

Summary

Colors strongly affect our visual attention in perceiving images. This study investigated factors of how children associate color with images. An online survey instrument was used to gather data of children's color selections for images. The transcription of face-to-face interview sessions revealed the rationale for children's color association with images.

The population of participants in this study was children from 3^{rd} to 6^{th} grade. The researcher recruited participants in the public libraries in north Texas. The complete data set for the final analysis was gathered from 69 children in the Denton Public Library, consisting of 32 boys and 37 girls. Children's participation was voluntary and with their parents' consent. The online questionnaire contained 20 images—15 images with five repeated at the end of the session. Children were asked questions for those five repeated images about why they chose a certain color for each image, their familiarity with the images and their understanding of the subject matters in images. The average time for each participant was measured.

Factors affecting children's color association were estimated to be the location, proportion, familiarity, and completeness of objects in images. The face-to-face interview yielded other factors. The overall level of agreement for color selection was calculated, and it was found to be very different from the estimated 50 percent. The researcher also expected to find different but insignificant agreement level between boys and girls. Chapter 4 contains the analysis of data in greater detail.

CHAPTER 4

RESULTS AND ANALYSIS

There were five phases in the data analysis for this study. First, the descriptive data is presented in two parts. Table 2 shows the most chosen color for each image by grade and gender groups; Table 3 shows the level of agreement on the most chosen color by grade and gender groups. In the second phase, additional descriptive data and analysis to support the statistical tests are shown in Table 4. The reliability of data were tested by comparing the color selections of the five repeated data using Chi-square and the results are listed in Table 5. The relationship between lengths of time spent in selecting a color and the agreement level for each image was measured using Pearson's correlation coefficient and shown in Table 6 and Table 7. At the third phase, boys' and girls' color selections and agreement level were compared using Chi-square and *t* test shown in Tables 8 to 13. Again, the use of these statistical measurements provided a framework for the discussions. For the nature of the data, it is difficult to guarantee each cell has the minimum number of five for Chi-Square analysis. At the fourth phase, content analysis was applied to categorize children's descriptions of the five repeated images. Tables 14 to 18 list the words used by children. At the fifth phase, content analysis was used to discover the factors that affected children's color selections, and table 19 lists the categories of these factors.

Descriptive Data

There are three kinds of data collected from 69 participants in this study: the color selections of images, the length of time spent in selecting a color for an image, and four hours of tape-recorded interview. Appendix E includes a table listing all the color selection for images by each participant sorted by the code numbers, and samples of interview transcriptions.

The cells in Table 2 list the most frequently chosen color for each image by grade-level and gender groups. The cells in Table 3 list the percentages of the participants who selected the most chosen color by grade-level and gender group. For example, the column *Boy 3 4* in Table 2 shows that blue color is the most chosen color for image 1 by third-grade and fourth-grade boys, and Table 3 tells that 53.3% of the third-grade and fourth-grade boys chose blue for image 1.

Table 2

The Most Frequently Chosen Color for Each Image by Grade and Gender Groups

Image Number	Boy 3 4	Boy 5 6	Girl 3 4	Girl 5 6	Boy	Girl	All
image 1	blue	blue	blue	blue	blue	blue	blue
image 2	blue	yellow	yellow	blue	yellow	yellow	yellow
image 3	green	red	green	red	red/green	green	green
image 4	yellow	yellow	yellow	yellow	yellow	yellow	yellow
image 5	green	green	green	blue	green	green/blue	green
image 6	blue	blue	yellow	yellow	blue	yellow	blue
image 7	black	blue	red	blue	red/blue	red	blue
image 8	green	green	red	green	green	green	green
image 9	yellow	green	green	green	yellow	green	green
image 10	green	yellow	red	yellow	yellow	yellow	yellow
image 11	black	red	green	black	green	green	green
image 12	blue	green	red	green	red	green	green
image 13	yellow	blue	yellow	blue	blue	blue	blue
image 14	blue	green	yellow	blue	green	blue/yellow	blue
image 15	green	yellow	yellow	yellow	yellow	yellow	yellow

Table 3

Agreement Level of The Most Frequently Chosen Color for Each Image by Grade and Gender Groups

Image Number	Boy 3 4	Boy 5 6	Girl 3 4	Girl 5 6	Boy	Girl	All
image 1	53.3%	58.8%	60.9%	71.4%	56.3%	64.9%	60.9%
image 2	33.3%	47.1%	43.5%	35.7%	37.5%	40.5%	39.1%
image 3	33.3%	29.4%	39.1%	35.7%	28.1%	35.1%	31.9%
image 4	46.7%	64.7%	39.1%	35.7%	56.3%	37.8%	46.4%
image 5	40.0%	64.7%	34.8%	42.9%	53.1%	32.4%	42.0%
image 6	33.3%	47.1%	30.4%	42.9%	40.6%	35.1%	30.4%
image 7	26.7%	41.2%	26.1%	35.7%	31.3%	27.0%	29.0%
image 8	40.0%	64.7%	39.1%	35.7%	53.1%	35.1%	43.5%
image 9	40.0%	47.1%	39.1%	35.7%	37.5%	37.8%	31.9%
image 10	40.0%	47.1%	34.8%	35.7%	34.4%	35.1%	34.8%
image 11	33.3%	35.3%	30.4%	35.7%	31.3%	29.7%	30.4%
image 12	26.7%	41.2%	30.4%	57.1%	28.1%	37.8%	31.9%
image 13	40.0%	41.2%	47.8%	71.4%	31.3%	48.6%	40.6%
image 14	33.3%	41.2%	30.4%	28.6%	31.3%	24.3%	26.1%
image 15	33.3%	41.2%	43.5%	35.7%	31.3%	40.5%	36.2%
Average	36.88%	47.47%	37.96%	42.37%	38.77%	37.45%	37.01%

Reliability of Responses

Table 4 lists the numbers of participants selecting a color for an image, the average length of time spent in selecting a color for an image by the participants, and the agreement level of the most chosen color. For instance, for image one, among 69 participants, 16 chose the color red, two chose green, 42 chose blue, four chose yellow, four chose black, and one chose white. It also shows that participants spent an average of 6.11 seconds making the selection, and blue is the most frequently chosen color with agreement level of 60.9%.

Table 4

Measures of Color Selection for Each Image

Image Number	Red	Green	Blue	Yellow	Black	White	Agreement Level (%)	Length of Time(sec)
image 1	16	2	42	4	4	1	60.9	6.11
image 2	6	12	17	27	4	3	39.1	8.62
image 3	19	22	13	9	2	4	31.9	11.29
image 4	16	6	4	32	6	5	46.4	9.34
image 5	3	29	15	7	6	9	42	7.78
image 6	8	5	21	17	9	9	30.4	8.60
image 7	18	6	20	9	14	2	29	9.66
image 8	18	30	8	5	3	5	43.5	6.20
image 9	7	22	12	19	2	7	31.9	8.02
image 10	12	12	16	24	2	3	34.8	7.25
image 11	15	21	8	2	15	8	30.4	6.39
image 12	19	22	10	10	3	5	31.9	7.36
image 13	8	5	28	22	0	6	40.6	6.59
image 14	8	16	18	9	13	5	26.1	10.51
image 15	7	16	6	25	5	10	36.2	6.76
image 16	3	2	28	17	8	11	40.6	6.78
image 17	18	19	6	5	9	12	27.5	5.60
image 18	9	8	23	22	3	4	33.3	4.65
image 19	8	23	17	17	2	2	33.3	4.21
image 20	18	4	31	8	4	4	44.9	5.32

Comparing the color selections between the first time and second time for the same image using Chi-Square analysis tested the consistency of responses. Appendix F includes the SPSS™[11] results for each image in detail. As seen in Table 5, while there seems to be a difference between the first and second time, the value of Chi-Square for each of the five images does not exceed the critical value (11.070) for five degrees of freedom at the significance level of 0.05.

Table 5

The Distributions of Color Selection in the Five Repeated Images and The Value of Chi-Square for Each Image

Image Number	File Name	Red	Green	Blue	Yellow	Black	White	Chi Square
Image 16	ca050	3	2	28	17	8	11	4.817
Image 6	ca050	8	5	21	17	9	9	
Image 17	ss041	18	19	6	5	9	12	4.244
Image 11	ss041	15	21	8	2	15	8	
Image 18	ss033	9	8	23	22	3	4	2.915
Image 10	ss033	12	12	16	24	2	3	
Image 19	ca047	8	23	17	17	2	2	3.840
Image 9	ca047	7	22	12	19	2	7	
Image 20	rg023	18	4	31	8	4	4	5.575
Image 1	rg023	16	2	42	4	4	1	

Second, it was assumed that the longer time spent in selecting a color would generate higher variance in the color selections, which means lower agreement level. The assumption is that the longer the thinking process involved in the decision making, the more factors were taken into consideration; as a result, a negative correlation between the time and agreement level was expected. Therefore, the relationship between the average length of time spent in selecting a color and the agreement level for an image was measured using Pearson’s correlation coefficient. Table 7 shows that the average time spent in selecting a color and the agreement level are negatively correlated with correlation coefficient -0.477 at the significant level of 0.036.

Table 6

Average Time Spent in Selecting A Color and The Agreement Level for Each Image

Image Number	Average Time (seconds)	Agreement Level of the color most chosen (%)
image 1	6.11	60.9
image 2	8.62	39.1
image 3	11.29	31.9
image 4	9.34	46.4
image 5	7.78	42.0
image 6	8.60	30.4
image 7	9.66	29.0
image 8	6.20	43.5
image 9	8.02	31.9
image 10	7.25	34.8
image 11	6.39	30.4
image 12	7.36	31.9
image 13	6.59	40.6
image 14	10.51	26.1
image 15	6.76	36.2

Table 7

Correlation between Average Length of Time for Selecting a Color and Agreement Level for Each Image

		AVETIME	AGREE
AVETIME	Pearson Correlation	1	-0.477(*)
	Sig. (1-tailed)	.	.036
	Sum of Squares and Cross-products	36.612	-95.670
	Covariance	2.615	-6.834
	N	15	15
AGREE	Pearson Correlation	-0.477(*)	1
	Sig. (1-tailed)	.036	.
	Sum of Squares and Cross-products	-95.670	1097.629
	Covariance	-6.834	78.402
	N	15	15

Correlation is significant at the 0.05 level (1-tailed).

Gender Comparison

The last five repeated images in the online questionnaire were used for testing the reliability of responses, so the gender comparison of color selections and agreement level were done without those five images. The number in each cell in Table 8 represents the number of participants selecting the color for the image by gender. For example, 11 boys chose the color red for image one, one green, 18 blue, zero yellow, two black, zero white, and five girls chose the color red for image one, one green, 24 blue, four yellow, two black and one white. This table will be used for comparing the color selections between boys and girls. Table 9 lists the value of Chi-Square for each image in a simplified format.

Table 8

Distributions of Color Selections by Gender

Image Number	Gender	Red	Green	Blue	Yellow	Black	White
Image 1	boy	**11**	**1**	**18**	**0**	**2**	**0**
	girl	**5**	**1**	**24**	**4**	**2**	**1**
Image 2	boy	2	7	10	12	1	0
	girl	4	5	7	15	3	3
Image 3	boy	9	9	8	3	0	3
	girl	10	13	5	6	2	1
Image 4	boy	6	2	0	18	3	3
	girl	10	4	4	14	3	2
Image 5	boy	0	17	3	3	4	5
	girl	3	12	12	4	2	4
Image 6	boy	4	1	13	4	**8**	2
	girl	4	4	8	13	**1**	7
Image 7	boy	8	2	10	3	8	1
	girl	10	4	10	6	6	1
Image 8	boy	8	17	2	2	0	3
	girl	10	13	6	3	3	2
Image 9	boy	4	8	3	12	1	4
	girl	3	14	9	7	1	3

Table 8 continues

Table 8 continued.

Image Number	Gender	Red	Green	Blue	Yellow	Black	White
Image 10	boy	3	8	9	11	0	1
	girl	9	4	7	13	2	2
Image 11	Boy	8	10	4	1	6	3
	Girl	7	11	4	1	9	5
Image 12	boy	9	8	6	5	2	2
	girl	10	14	4	5	1	3
Image 13	boy	6	3	10	10	0	3
	girl	2	2	18	12	0	3
Image 14	boy	2	10	9	**0**	8	3
	girl	6	6	9	**9**	5	2
Image 15	boy	3	8	2	10	2	7
	girl	4	8	4	15	3	3

Gender Differences for Color Selection

Chi square analysis was used to test the gender difference for color selection. Appendix G includes the SPSS™ results for each of the fifteen images in detail. Overall gender effect in color selections was not obvious. As shown in Table 9, among 15 images, there were significant gender differences in selecting colors for image 6 and image 14 with the critical value (11.070) for five degrees of freedom at the significant level of 0.05. The results from residual analysis (Table 10) indicated that the behavior in selecting black for image six and selecting yellow for image 14 contributed to the difference. From Table 8, it is also easy to see that while there were eight boys selecting black for image six, only one girl did so. On the other hand, there were no boys selecting yellow for image 14, but a great number of girls, nine, had yellow as their selection. These two cases suggested that girls might be more hesitant in selecting darker colors than boys did. While the yellow shirt in image six and the yellow impression from Sesame Street™ in image 14 evoked higher preferences on girls, boys may see yellow as a girlish color.

Table 9

Chi-Square Value of Each Image for Comparing Color Selection Between Boys and Girls

Image #	x^2	Image #	x^2	Image #	x^2	Image #	x^2
Image 1	7.786	image 5	9.872	image 9	5.907	image 13	4.328
Image 2	5.529	image 6	15.698*	image 10	6.756	image 14	12.596*
Image 3	5.137	image 7	1.822	image 11	0.856	image 15	3.264
Image 4	6.036	image 8	5.824	image 12	2.272		

Table 10

Standardized Residual for Each Color by Gender

Image Number	Gender	Red	Green	Blue	Yellow	Black	White
Image 6	Boys	0.15	-0.87	1.04	-1.38	**1.87**	-1.06
	Girls	-0.14	0.81	-0.97	1.29	**-1.74**	0.99
Image14	Boys	-0.89	0.95	0.23	**-2.04**	0.80	0.45
	Girls	0.83	-0.88	-0.21	**1.90**	-0.75	-0.42

Gender Differences for Agreement Level

To test the color selecting behavior between boys and girls, it was considered that both boys' and girls' agreement level of the most chosen color for each image were affected by characteristics of the image. As a result, the boys' agreement level for each image was paired with the agreement level of the girls', and Paired-Samples *T*- Test was used to compare the agreement level between boys and girls.

Table 11

Paired Samples Statistics

		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	BOYS	38.7667	15	10.54810	2.72351
	GIRLS	37.45	15	9.586	2.475

Table 12

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	BOYS & GIRLS	15	0.376	0.167

Table 13

Paired Samples Test

		Paired Differences					*t*	*df*	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BOYS - GIRLS	1.3200	11.27407	2.91095	-4.9234	7.5634	0.453	14	0.657

In Table 11, it appeared that boys have slightly higher average agreement level than girls, but there is also a slightly higher variance among boys than girls. However, the paired-samples *t* test analysis (Table 13) indicates that for the 15 images, the average agreement level among boys (M = 38.7667) was not significantly greater than the average agreement level among girls (M = 37.45) at the $p < 0.05$ level (note: p = 0.657). The results in Table 12 also indicate that no significant correlation exists between the agreement levels between boys and girls for each image (note: p = 0.167). This suggests that there might be different agreement levels for each image between boys and girls. While the average agreement levels are similar, some images have higher level of agreement among boys than girls, and others have higher level of agreement among girls than boys.

Meanings in the Images

The last five repeated images were used to find out how children gave meaning to the images and their color selections. Again, *meaning* is used in a general way throughout this study. Individual's interpreted meanings of an image include what the individual knows about the image, what they can or want to do with the image, and how they feel about the image. Children's descriptions of images were tape recorded and transcribed. A sample of the children's description is included in Appendix E. The researcher broke down each sentence to find the words children used to describe images. These words were further grouped into the following categories: subject, action, objects, location, event, reasoning, (character's) emotion, and (personal) feeling about the image. Tables 14 to 18 list the words by categories and omit non-specific words such as *a*, *she*, *he something* and *some stuff* as well as suffix words like *ing* and *ed*.

It is easy to see that the children described the content of an image in greater detail when there were more items in the image, and almost all the items appearing in an image were included in the their descriptions. The children also described more things than what were actually in the images when they associated images with previous experiences, such as the memory of the stories from which the image was captured. For instance, the treasure hunt was not directly shown in image 18, the puppy show and prince were not in image 20, and the trolley was not moving either, but children's knowledge about these shows was reflected in their descriptions. Even during this short study, some children had generated a relationship between image 16 and image 19 because of their similarity, and suggested that the lady in image 16 was going to the marketplace in image 19.

When asked what a picture was about, the children tended to get clues from the images and recalled or created stories. The character's emotion was usually recalled when the images were familiar even if the character did not show that emotion in the image, such as the smiling Oscar was interpreted as grumpy, mad, or mean, and Bert was always in a bad mood. When the characters are unfamiliar, social influences had an impact on the descriptions of images. For instance, the lady in image 16 was frequently interpreted as an African America slave, and the people in image 19 were often seen as tribe people sharing goods and helping each other.

Despite their vivid description of the images, children did not use all the categories to judge what color to choose for an image. For instance, children might describe a whole hunting story about the invisible husband of the lady in image 16, but simply chose the color white for the image because of the white pattern on the background was considered beautiful, although the pattern was not mentioned by children when asked about the meaning of the image. This is not to say that the interpretation of an image was totally excluded in color association; however, children's rationale in the following section seems to suggest that children interpreted the image differently when asked to choose a color for an image.

Table 14

Words used to describe what Image 16 was about

Image 16 		
Subject	slave, lady, African American, a person, woman, girl, servant, African woman, cook, slave cook, African lady, someone, slave people, a lady and her bird, native lady, a lady that used to live in Africa, a girl with animal, her husband,	
Action	Work, hang up, hunt, carry, prepare, gather, tie, hold, come back, get, cook, come from, sell, go home, kill, bring, put on, take, pick, balance, take care of, go, do choir and clean up, fix, make, look for, buy, do like normal people do	with animals, with things she's gotten, with a stick, with woods attached to the sides by rope, on her head, on top, on her hand, from their feet, from a stick, behind her, two left, two right, over her head, to dry, for her family, for people, for someone, to eat,
Objects	Animals, food, lot of things, pie, meat, stuff, dead animals, two owls, two birds, a bird, what she hunted, some berries, fruit, goose, duck, a pole, vegetable,	
Location	on the farm, in the wood, in the fields, in Africa, market, marketplace, home, in the wild, on the plantation, village, an Indian rural world, in the middle of the town	
Event	Curse, business, hunting, art, about not having enough, a big dinner, about birds, harvesting	
Reason	Because her husband…	
Feeling about the image	her life is hard, the pattern in the background is nice, I like it, it's pretty, it's very good, it does and does not look colorful, about Latin America, Indian, it's weird "It looks like it was painted by a black in the earlier days…it looks like an older person's view because we don't ordinarily do that kind of thing nowadays."	

Table 15

Words used to describe what Image 17 was about

Image 17 		
Subject	That guy, red person, the red guy, his eyeballs, somebody, Telly, the brat, the little red,	The green guy, Oscar, bugler, the monster, the grouch, the animal, the rooster, the man over there,
Action	Be spotted, talk, argue, be scared,	Threw, dump, jump out, goes wuoa, say, scare, smile, get mad, beat, plan a trick, be mean, laugh at
Objects	Snow, trash, stuff, confetti, feather, trash can, milk, water,	
Location	In, from, out of the trash can, right there, on top of Tally,	
Event	Snowing, Something going on, throwing a party, movies,	
Reason (using 'because')	cause they always do, because the eyes are really big, surprise, for fun	
Character's emotion	Worried, surprise, disappointed, mad, disturbed, grumpy	
Feeling about the image	it's kind of funny, I remember the grumpy guy, he looks like that most time	

Table 16

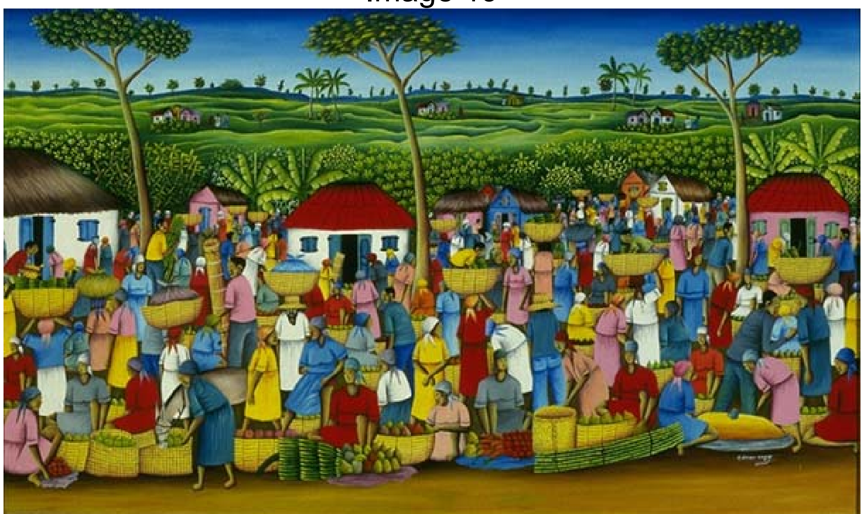
Words used To describe what Image 18 was about

Image 18 		
Subject	Burt, Ernie, the person, somebody, that guy,	blue sign, arrow, direction
Action	Decide which way to go, follow, put up, look at, read, figure out, goes, hold, look for, notice, find, be lost, laid, go outside, do not know, find direction, try to find, get clues, be told, change, want to go outside, find the way, go to get	Tell, point out, show, for him to go/ follow,
Objects	Arrows, sign, yellow hat, umbrella, arrow, guide, the blue one, a wall, the purple arrow,	
Location	Somewhere, closet, his room, in a school, a library, sesame street, at the background, on the hanger, the place, on the shelf, in his house, over there, a place he's never been before	
Event	Raining, on a treasure hunt, there is something at the end of it that he might want	
Reason (using ‘because’)	Because it’s raining	
Character’s emotion	Surprise, always in bad mood	
Feeling about the image		

Table 17

Words used to describe what Image 19 was about

Image 19



Subject	They, people, trader, everybody, a lot of people, a whole bunch of people, jungle people, African American, from Mexico
Action	shop, trade, be ready, eat, go to, gather, buy, get, talk, came up, move, leave, help, give, pick, work, take, go back, collect, hurry up
Objects	Food, supply, fruit, snack, fresh vegetables, baskets, things,
Location	Farm, marketplace, somewhere, flea market, market, Indian tribe, group huts, village, place, foreign country, by the lake, African American tribe, normal city, somewhere exotic, south America, a street, boat, home, very important area
Event	Going on a trip, having a picnic, harvest, market day, shop day, a festival, market, family gathering, village thing, some sort of celebration, feast
Reason (using 'because')	
Character's emotion	
Feeling about the image	pretty busy, really cool, neat, they are all together, very colorful, a group that stays together all the time, their custom, she probably going to this marketplace, there is a problem or something

Table 18

Words used to describe what Image 20 was about

Image 20 		
Subject	a lady, a person, that girl	trolley, train
Action	Looking, talk to, say hello, say good-bye, say, look outside, wave to, look around, conduct, talk about, point out, greeting, introduce, describe, tell, play a scene, get stuff, say something, give speaks	Going, coming in, going into, going out, passing by, going by, (sending a message), comes by, coming around, crossing, going through
Objects	Somebody, train, (king), Mr. Rogers, puppy, person, mailman, all the things, a friend, people, audience, caboose, the man,	
Location	At the back, a little place, a castle, neighborhood, on the other end, this side of the picture	
Event	Start or the end, a puppy show, the make believe, until it came back, they went to a different story, a TV show, going into those little thing,	
Reason (using 'because')		
Character's emotion	Surprised, amazed, happy	
Feeling about the image	I don't know if the trolley talked, every time…	

Factors Affecting Color Selection

Appendix E includes some examples of children's self-reported reasons for selecting colors. Analysis of the interview transcriptions identified several factors affecting children's rationale for selecting a color for an image. After the factors were identified and refined by the researcher, Table 19 was given to two persons other than the researcher to test its validity. These two people were given the transcription and asked to identify 69 children's rationale for selecting a color. There was a 96% agreement between them by using the categories listed in Table 19. It concludes that the factors include the followings:

Characters associated with the overall image

- Stands out: the color that stands out the most
- Most: the dominant color in the image
- Change: the color change wanted for the image
- Impression: the color that reflects the preference of the image
- Too many colors

Characters associated with a specific motif in the image

- The color: the color of a certain item in the image
- Change: the color change wanted for an item in the image
- Impression: the color reflect the emotion of a character in the image
- Preference: the color reflect the preference of an item

Others

- Personal favorite color

Table 19

Factors Affecting Children's Color Association with Images

	Category	Key points in a sentence
Picture	stands out	appearing, stand out, the brighter color
	most	background; a lot of the color; biggest; most color; overall the image presents the color
	change	add the color to make the picture look better/ proper; or blend in with the picture; the color is missing in the picture; not enough; too dark, the color makes the picture brighter; too light, the color makes the picture bolder; change the picture to another color scheme, e.g. black and white
	impression	the image is bright, dark, dirty; color evoked the same feeling as that from the picture; the image/ show is remembered by the color; the color symbolizes the message delivered by the picture, e.g. peaceful; environment should be the color
	preference	match the picture, looks good, e.g. given as a frame color; the color in the picture makes the picture pretty; the color is related to the likeness or dislike ness of the show
	too many colors	black and white are the colors more neutral, so either one was chosen
Motif	the color	the color of an object or character; the objects thought to be the most important part/ theme, or the believed main character, having action
	change	change color of an object to look good/ better; change color of a character to look happier, more interesting; add the color to objects
	impression	the emotion of a certain character in the picture; the remembered temper of a character
	preference	like the color of an object; like the object or the character, pretty, funny, cool; the favorite color of the character in the picture
Others		don't know; favorite color; close to the color given in the questionnaire

Summary

This chapter included the basic analyses for the data collected in this study. Statistical analyses were used to test the reliability of children's responses and to compare the gender differences in color selection and degree of agreement. Although not all of the assumptions and criteria for using these statistical analyses were followed due to the nature of the data set, the results of these tests helped us to better understand children's color association with digital images. In addition to statistical analyses, content analyses were used to understand how children interpreted images and their rationale for selecting colors. Categories of children's interpretations of images 16 to 20 were generated, and in each category, words used by children were grouped. The factors that affected children's color selection were also listed in this chapter. In the next chapter, each of the five research questions will be answered and further discussions pertaining to each question and the results of the study will be addressed.

CHAPTER 5

DISCUSSION AND CONCLUSION

Although color is one of the most studied attributes in the design of content-based image retrieval systems, not many studies have been done to understand how humans associate color with digital images, especially children. Since today's children will be the main users of image retrieval systems in the future, the purpose of this study was to expand the knowledge of how children associated colors with digital images and to contribute to improving the design of the future systems with higher usability and friendliness.

The search for the answers followed the five research questions in this study by using an online survey questionnaire and face-to-face interviews. Each of these five questions will be answered in the following sections with the results of the data analysis in the previous chapter. Issues pertaining to each question are derived from the researcher's observations during the study and are addressed using discussion subtitles.

Answers to the Research Questions

Research Question One: Do children associate color with images? How homogeneous is the agreement of children's color association with images?

From children's color selection data collected for this study, children associated color with images in many ways. Since there were six colors for children to choose from, the probability of 16.67% of agreement level was expected if a color is randomly chosen for an image. However, the average agreement level is 37.01% among fifteen images, ranging from 26.1% to 60.9%.

Discussion 1. While there is no significant difference between boys' and girls' average agreement level, it was found that some images had higher level of agreement among boys than girls, and others had higher level of agreement among girls than boys. If the length of time and agreement level of making a color selection for an image presented the easiness or difficulty of making a color selection, this result suggested that the difficulty of selecting a color for an image might differ between boys and girls.

Previous studies have shown that females tended to see the colors of the figures in an image while boys tended to perceive the background colors as the most dominating. The observation in this study reconfirmed previous findings. Three examples are shown in Table 20. In image five (RG057) the background color was mainly green; therefore, it might be relatively easier for boys to choose the color, with higher degree of agreement, but presented challenge for girls to choose between the background color and the color of the shirt in the image. On the other hand, in image 13 (CA34), the background color was mixed with yellow and blue; while this presented a challenge for boys to decide which color to select, the blue shirts of the girls offered girls an easy selection. However, when there is no strong background or figure color standing-out, boys tended to choose the biggest color in the image while girls gave more consideration to the colors of all the figures in it. This phenomenon can be seen in the color selections for image four (SS005).

Table 20

Agreement Levels of Three Sample Images by Gender

	Image 5 (RG057)	Image 13 (CA34)	Image 4 (SS005)
			
Boy	53.0% Green	31.3% Blue	53.6% Yellow
Girl	32.4% Green	48.6% Blue	37.8% Yellow

Discussion 2. It shows that fifth and sixth grade boys demonstrated much higher agreement level than other three groups: third and fourth grade boys, third and fourth grade girls, and fifth and sixth grade girls; on the other hand, the third and fourth grade boys and girls had higher similarity in their color selections in terms of the agreement level (see Appendix H, table 29). It suggested that boys might develop some different cognitive processing pattern from girls' at the age of the fifth and sixth grade.

Studies in children's attitude toward computers have found that girls show obvious higher levels of frustration and anxiety in using computers than boys in fifth and sixth grade, while they are more enthusiastic than boys in third and fourth grade. The girls' motivation and enjoyment of using computers decreased with the increased age, from fourth to sixth grade. Previous studies have indicated no significant gender differences existed at the first to third grade, "boys have more positive attitudes toward computers than girls by grade six" (Christensen et al., 2001, p. 52). It suggested that conventional social environment and expectation for girls might have an impact on their attitude changes. The results from this study may suggest that boys develop more enthusiasm for technology in fifth and sixth grade also because they may have developed a different way to look at things, which consequently aids their acquisition of knowledge in technologies and sciences. In other words, the design of instructions for science and technology may favor learning styles of boys over girls.

Research Question Two: What are the critical factors that contribute to children's color association with images, in terms of primary color, subject, and familiarity and complicity variables?

In order to be objective, two people other than the researcher were invited to assist in categorizing children's rationale. They were told to interpret the interview literally. Table 18 lists the factors that contribute to children's color association with images found through content analysis of children's description about their rationale for selecting colors for the five repeated images.

However, the researcher had found the observed explanations of children's color selection behavior sometimes were simpler than what children had described and sometimes more complex. Observed children's behavior and interpreted rationale from the images other than those five repeated indicated the following.

Discussion 3. The colors of living objects or their clothing had often been children's focal points and mentioned frequently. The lady's dress, Bert's cloth, and the clothing of the villagers were frequently mentioned. Moreover, when the background of an image was dark, living objects or their clothing usually presented brighter colors to choose from.

Discussion 4. Locations of objects in an image might have affected children's color selections. The object that appeared closer to the audience seemed to have higher pictorial weight for children's color perception. It was found that in images four, seven and 14, the color most frequently chosen happened to be the color of the objects that seemed to be closer to the audiences.

Discussion 5. The colors of the subjects with emotional expression or action were frequently children's focus, sometimes even an interpreted emotion or action. For example, some children interpreted that Bert was usually in a bad mood, so the color blue was chosen. The lady in the first image had been seen as slow and nice; therefore, the yellow was chosen, for it presented the same feeling of the image.

Discussion 6. Meaningful objects were more likely to be chosen. For example, in image three, the green leaves were perceived with more attention than the red circular object that was harder to tell what it was. It was observed that children had difficulty understanding what the image was about, and the green leaves were the most understandable objects among other objects. This observation recalled a previous research finding that children paid more attention to what they could understand (Hawkins et al., 1991).

Discussion 7. Symbolic meanings of colors were used for selecting colors, although not frequently. The most obvious evidence was found in image 10 that some children chose white color because they felt the villagers were helping each other and white color meant peaceful feelings.

Discussion 8. The colors of objects in an image that were more familiar to children usually got more attention, and the interpreted subjects of an image also affected children's color selection. This phenomenon, for instance, happened to children's perception of image four, in which Big Bird strongly represented the show from which the image was captured. Despite not being the biggest proportion of the image, yellow was the most chosen color by the participants.

<u>Research Question Three:</u> When and how often is the dominant color in a picture chosen as the associated color?

It was found that children usually associated color with images by the color perceived as occupying the largest area of an image. However, some children also gave other personal reasons why they chose the dominant color. Matching a color with an image was one of the most frequent reasons. The most complete part of an image, or the color of a biggest continuous portion in an image, was sometimes perceived as the *most* color, such as landscapes in image 19. While the dominant color from the landscape was the most chosen color, its domination in the image was not very obvious. Children sometimes interpreted different color as the most color. In the case of image nine, children who did not choose green because of the landscape had chosen the most color differently, either to be yellow, blue, white, or red.

<u>Discussion 9.</u> It is important to notice that most children in this study were trying to choose the *correct* color for an image despite being told there was no right or wrong answer. This was observed when sometimes children said, "because…, this is the right color" or "I think it should be this color." It was easy to understand that most children believed the color taking the most space in an image should be the *correct answer* for many reasons. Therefore, they might report that selection, for example, because the blue was the background, the favorite color, beautiful, or a good match for the image. From the researcher's observation, sometimes it might be that blue was simply the first

color they saw, for it took the biggest part of the image.

Research Question Four: Do some colors frequently overrule others regardless of their proportion in an image?

It was not observed that a certain color frequently overruled other color selections by children simply because of the color per se. However, bolder or brighter colors in an image usually stood out more and became the color of choice, whether it was green, yellow, blue, or red. However children perceived differently what color occupied the greatest part of an image was. In the example of image 9, there were people wearing clothes with different colors - blue, red, yellow, and white. Although each one of these colors almost took equal space in the image, children still claimed the color they chose was the most color that people wore. In general, black color and white color were seldom considered as the color of choice. Black was usually chosen for its semantic meaning of darkness; on the other hand, white was usually chosen for feeling bright or peaceful about an image.

Discussion 10. Gender difference in color selection was observed in this study. It is a belief that has been generally accepted that girls tended to like soft colors and boys liked bolder colors better. While it was observed in this study that girls slightly tended to choose yellow and red, and boys tended to prefer blue and green, many girls reported that their favorite color was blue and many boys liked red. Again, gender did not decide which color would be the favorite one. However, a favorite color sometimes did affect children’s color selection. Several children answered that it was their favorite one when asked why they chose a color.

As shown in Chapter Four, boys and girls significantly differ in choosing color yellow for image 14. It was speculated that color yellow preference effect might have affected all other images as well. Fisher Exact Test was conducted for each of the 15 images by dividing color selections into yellow and non-yellow (see Appendix I). Again, there were no significant gender differences in choosing color yellow for images at the significant level of 0.05, except image six and image14. This might conclude that there were some attributes exclusively shared by image six and image 14 that provoke different color association between boys and girls.

Research Question Five: Is there a relationship between the color selected for the image and the degree of meaning the image represents?

Very slight relationship was observed between the selected color and the iconological meaning children gave to an image. This happened when children gave semantic meaning to an image, such as happy, peaceful, weird, or dark. Oftentimes children also indicated that something or someone in an image was funny, interesting, or beautiful. However, when asked what they thought an image was about, children's imaginations took over their rationale expression. Children might say that the image was about an African American girl who cooked for her family because she had fruits, ducks, and a goose, but they would later say that they had chosen the white color simply because the white pattern on the background was pretty.

Discussion 11. The analysis of the children's color selections and their rationale for selecting the color revealed that the cues of most children's color selections were drawn from colors of the objects in images, besides the most color. In terms of the three levels of meaning in works of art proposed by Panofsky, pre-iconography, iconography and iconology (Panofsky 1955), the pre-iconography level meaning had more impact on children's color selections. Although interesting recollections from the past experiences about television shows (e.g. Mr. Roger's Neighborhood™) were shown on children's interpretation of images, they contributed little to the color selections.

Other Observations

Personality

The personality of the children also appeared to affect their color selection. Children who were more self-confident used more consistent criteria for selecting colors and finished the survey in shorter time. Monzon (1981) found that males who were more field-independent would score higher on the Active Self-Assertion Factor test. Although the relationship between field dependence theory and personality theory was not the focus of this study, the observed behavior in this study might suggest that children's color association with images could be affected by their personalities. The following shows the relationship among those factors in this assumption. Personality → field-dependency → visual perception → color association.

Reliability

In their description of why a color is chosen, children expressed personal judgments. Usually the most appearing or the most color in an image was chosen by children, the variance occurred when children interpreted images involving their personal feelings and preferences of a certain character or color, and the past experiences with the images. The factors reported by children in this study have been accepted using the interview transcription and by focusing on the content's manifest meaning rather than connotative meaning. However, it should not be overlooked that there were discrepancies between the stated and actual motives.

An Aside

In this study, by displaying digital images on the computer monitor to two participants with autism, the author found that the participants had difficulty in separating the image from the background screen. These two children considered the whole monitor display as one image. A study conducted by Vander Geest et al in 2002 indicated that autistic children did not have specific problems in processing socially loaded visual stimuli, based on “fixation behavior of autistic children was similar to that of their age-and IQ-matched normal peers” (Vander Geest, Kemmer, Verbaten, & Van Engeland, 2002, p.69). It might suggest that, although autistic children have no problems identifying single objects in a display, their different visual perception of images may be the result of the lack of skills in separating figures from the surroundings. This assumption seems to confirm the previous findings that when pictures were put together next to each other, autistic children had difficulty separating one picture from the one next to it. Since this study did not include a large enough sample of autistic children, no conclusion should be made from the author’s observation. However, it indicated the need for further studies on human visual perception in digital environments.

Implication

Factors affecting children’s color association with images found in this study may benefit designers in a variety of image-related fields, such as image retrieval systems, library and museum environments, instructional or educational programs, and information visualization for children. This study confirmed that children did associate colors with images with a relatively low level of meanings in images.

It was found that basically children associate colors with images using pre-iconographical description and iconographical analysis (e.g. what is in images and recalled stories of the images), and no children applied iconological interpretation when asked about the meaning of images. This might be explained by the fact in general that children at this young age have not acquired enough knowledge about the essential tendencies of the human mind under varying historical conditions- the iconological meaning. It could be assumed that average adults would not have this kind of knowledge without special training or education in art. The findings from this study also justified content-based approaches to designing image retrieval systems, for people oftentimes have knowledge about images at this level. However, color association cannot be the only factor used for image retrieval.

Future Studies

The results of this study suggested some areas that need further research. These are listed here and discussed in the following sections.

- Increase sample size and diversity of image used and children participation
- Gender and age cross analysis
- Instruments to quantify the factors found in this study
- Personality effects in image perception
- Understanding Children

Increase Sample Size and Diversity

The design of this study was not meant to generate data for quantitative analysis, but to explore the probable factors that affect children's color selections. The sample size and diversity of images and participants were adequate for this purpose. However, the results from this type of design may be indicative, not conclusive.

Image

The image samples used in this study were purposely chosen from children-friendly television programs and art works. Because of the nature of children's programs, the shots and colors are usually selectively designed in order to present a pleasant viewing experience or to emphasize certain characters. This resulted in a high degree of uniformity in the captured images from television programs that were not foreseen. For instance, most images used in this study had one or two main characters and consisted of up to three major colors, which directed the motives of children's color selections.

It was found that in those fifteen images there were more female subjects than male subjects. Considering the gender identity effect could affect children color selections, boys might tend to choose colors from male figures and girls might tend to choose colors from female figures. This factor was not considered in the design of this study; therefore, future research should investigate if this assumption affects children's color association with images.

Many researchers have defined formula to compute the similarity of color histograms of images (Rorvig et al., 2000; Stricker et al., 1995). This study could also benefit from a further comparison of the color histogram by image source. The images used in this study were selected from three sources. It was observed that images from the same source might have similar effects on children's color association due to the overall color scheme of each collection. Images captured from Sesame Street™ tended to have dark backgrounds with colorful figures; images captured from Mr. Roger's Neighborhood™ tended to have very light colors on both backgrounds and figures; images from the Caribbean arts tended to be very colorful and bold. Since color similarity within each group of images seems obvious, the knowledge of how color schemes affect children's color association and the criteria of categorizing images by their histogram would improve the future image retrieval system.

Participants

The same color may provoke different reactions from people with different culture backgrounds. For example, color white has symbolic meaning of purity and is commonly used in weddings in the western culture, but some cultures relate color white with death and funerals. In U.S., a green face means jealousy, while it means the person is furious in China. However, culture background effects on color association were not taken into serious consideration in this study. Children said that the color yellow gave a joyful or slow feeling and the color white was peaceful. It would be appropriate to understand if these feeling about colors were exclusive in the western culture or to what extent they can be applied to children with different cultural backgrounds.

The children participants in this study were recruited in the Denton public libraries. Although children came from a variety of ethnic backgrounds, the majority were Anglo-Saxons. Other similarities among these children were that all of them were regular library visitors with their parents. It could be assumed that these children represented one type of population at a certain social-economical level, not the whole population, although they did represent the population who had access to computers at a very young age. It would be appropriate to do further research focusing on other ethnic groups and in different environments in order to confirm the validity of the results.

Gender and Age Cross Analysis

Some gender differences in color association behavior were observed, but little was validated statistically in this study. It appeared that the differences between boys and girls might also change during their growing up. Most of the time younger boys and girls showed more similar behavior than older kids in color selecting strategies. On the other hand, while older boys and girls also showed similar color selecting strategies that is different from younger children's, there were also differences between older boys and girls in the frequency of choosing one strategy over another. This may suggest that there is a difference in the progress between boys' and girls' visual or cognitive development. Therefore, it is suggested to have a bigger sample size and test the differences by gender and age cross analysis.

Girls usually were more articulate than boys in this study, but verbal ability was assumed to be closely related to the individual's personality and environmental stimulation. In this study some younger-age boys demonstrated very high levels of verbal skills. However differences in verbal and visual-spatial abilities between boys and girls have been found in some literature. It is generally believed that boys tend to have better visual-spatial ability than girls, and girls are better in verbal performance (Witkin et al., 1981). It will be appropriate to take these differences into account in the future when interpreting children's self-reported rationales in order to understand how they associate colors with images.

Instruments to Quantify the Factors

Factors affecting children's color association were found to closely pertain to the content of images. It is important to quantify the factors found in this study in order to assign proper weights to those factors for system design. Therefore, a well-constructed instrument with more controls should be developed to further verify the factors found in this study. Many multidimensional scaling methods have been used to test the similarity of images (Goodrum, 1997; Restat, 2001; Rogowitz, Frese, Smith, Bouman, & Kalin, 1998). It might be useful to apply free clustering method in the following manner.

Using a collection of images to measure the relationship among different factors affecting color association can be accomplished in the following categories. Participants should be randomly selected into several groups. Each group, then, is asked to assign colors to images by one of the following criteria examples:

- Category 1: The color that best represents the image
- Category 2:The color that best expresses the feeling about the image
- Category 3:The color that takes most space in the image
- Category 4:The color that best matches the image (used as a frame)
- Category 5:The color that stands out most in the image
- Category 6:The color that is unusual and needs to be changed
- Category 7:The color that is the most impressive in the image

The most chosen color for each image in each category, then, will form a data set that can be treated as derived by free clustering method, and the percentage overlap between each pair of categories can be determined. The percentage overlaps between category 1 and each one of the above categories can be seen as the weight of that factor affecting color association with images.

Personality Effects in Image Perception

Children's cognitive styles were not tested in this study, but the evidence suggests it may affect color-selecting behavior, both in the chosen color and the time spent in making a decision. Moreover, images with complex color composition were beautiful for some children but considered too busy by others. While some children chose colors with confident personal reason, others were observed to be guessing the researcher's expectation.

In one of their studies in field-dependence and field-independence, (Witkin & Goodenough, 1981) found behavior indicating high apparent self-esteem in the field-independent group and low self-esteem behavior in the field-dependent group. Field-independent people also tend to impose structure on a "field that lacks clear inherent organization" (p.17). This suggests that focal points of the viewer may be affected by their personality, for they apply a different strategy to comprehend the outside world, or images. Memory of colors and objects in images, therefore, may differ among people with different cognitive styles. Therefore, future studies may consider testing the personality differences in color association with images.

For designing systems that stress retrieving a known image, it is also important to understand what parts of an image are the most impressive, which likely will be the attributes most frequently used to find images by users. It is known that the more comprehensible a subject is, the longer it can keep children's attention, by leaving a greater impression in their memory. Therefore, it can be expected that it is more difficult to recall colors of meaningless objects in images. An instrument that tests the recall of colors in images may reveal what children remember about an image. For example, showing images with meaningful objects (e.g. tree, house, etc) and meaningless objects (e.g. simple shapes) to children and asking them to recall the colors in the images might be a good start. Connecting children's attention to their personality could be the next step.

Understanding Children

One of the most important lessons learned from this study was that children's color association with images was not completely the same as the adults, especially when they were not trying to guess what adults might think. One of the special behaviors in selecting colors was that children liked to change colors in images, especially when the overall color was too dark or too light. Personal preferences also affected the colors children chose to change. As Druin pointed out in her article, it is necessary that children are supported by technologies in a way that make sense for them as explorers, young learners, and technology users (Druin et al., 2002). The results of this study suggested that including children into the design phase of systems would be one of the most beneficial steps especially if children will be the primary users of the system.

To include children as partners in system design, adults need to know more about children. In their study of how and why children take pictures with a digital camera, Ruth, Yong, & Gillingham, 2002) found that among other picture-taking behaviors similar with adults, children tended to be more comfortable with unfamiliarity.

They did not helplessly depend on adults for information, and their impulse was to figure things out when new technology was presented. One of the future studies may focus on understanding how children may use images in different circumstances, such as writing a report or enhancing environment like libraries, museums, or hospitals. In addition, studying a group of children together rather than each child separately may also reveal different results, for social interaction may modify an individual's behavior.

Summary

When asked what color is associated with winter, some people may choose white color because of snow, some may choose red and green colors because of Christmas, and others may as well choose gray color for the dormant atmosphere. As we may associate color with seasons by weather, holiday, or emotion, we might as well associate color with images by various factors.

In order to explore how children associate colors with images without the restrains of pre-defined assumptions, children were simply asked to choose a color for each of the 15 images followed by the last five repeated. They were not directed to choose the biggest, most prominent, or prettiest color in the images. In another words, children were free to choose any color for their very own reasons. The visual perception theories from the reviewed literature served as guides in the analysis of children's reported rationale for selecting colors and their interpretation of images.

Generally, children associate color with images by what they see and how they feel about images. There were observed gender and age differences affecting children's color selection behavior; however, the findings in this study were obtained from a relatively small sample size both in terms of images used and children participants, which may be not big enough to generalize the results to the whole child population of the U. S. However, this study indicated the factors that affected children's color association with images and provided ideas of how children comprehended images.

The data presented in this study confirmed that there were more factors affecting children's color association than the mere colors in images. The color that took the biggest part of an image usually motivated children to choose that color. Another powerful factor was the vividness or saturation of the color, and colors that stood out most attracted greater attention. Preferences of color, character, or subject matter in an image also strongly affected children's color association with images. One of the most interesting findings was that children would choose a color to replace a color in the image. This behavior was not expected prior to the study.

Additional studies are needed in order to further validate and apply the findings in this study to image retrieval system design. The suggested five areas for future studies include larger sample size, considering gender and age covariate, creating instruments for quantitative analysis, considering personality effects, and understanding children better. Among them, understanding today's children is considered the major point, for very few studies have been done with children in this subject area.

This study was done in public libraries, and each participant spent 10 to 15 minutes to finish the session, including an online questionnaire and an interview. However, it was difficult to involve children into a more practical study, as children have to go to school, and their participation in any research requires parental consent. Therefore, studies with children have to be done in a place where they will stay for a reasonable amount of time with their parents' present to sign the consent form.

Public libraries provide a good opportunity for researchers, but an open environment also attracts other potential participants to see how others have done with the questionnaire or answered the interview questions. Some parents may also ask to stay with their children during the session. Children's span of attention is short; therefore, longer sessions can cause them to fatigue easily. Moreover, being interesting is a must when involving children in any activity. Fortunately, this study was conducted in a staff office; it was modified to be short enough because of the experience from a pilot study; also, it was considered pretty interesting by most of the children.

The fundamental idea of this study was to understand human factors for content-base image retrieval system design. Content-base image retrieval systems have shown that machines can automatically abstract information from image content. However, machines calculating colors, shapes, or textures of images should be designed based on the understanding of how humans perceive these attributes, since humans use them. Color is one of the most considered among other attributes, and this study has revealed some factors that affect children's color association with images.

APPENDIX A

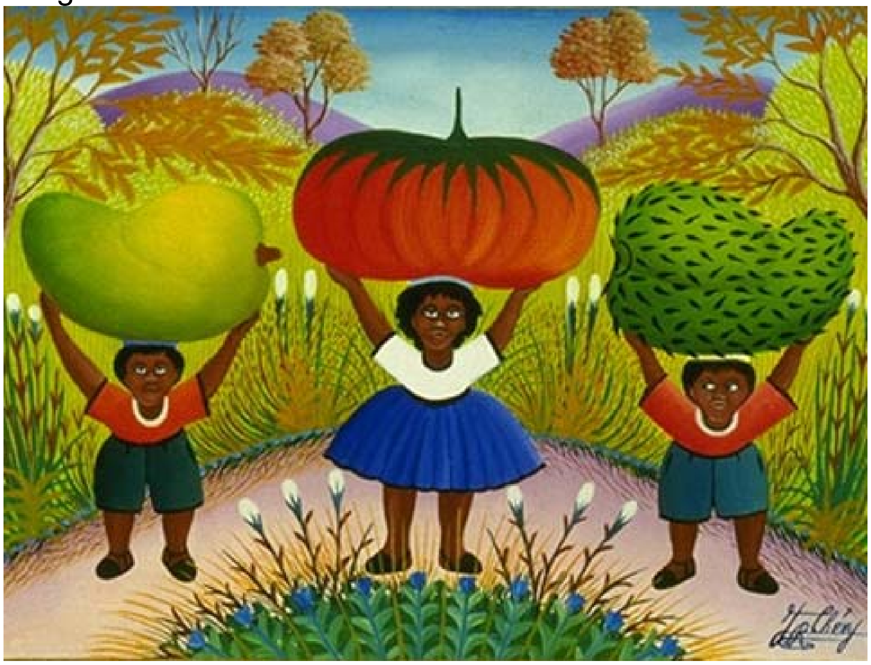
PILOT STUDY

Sample of the Online Questionnaire

Color Perception Project

Please choose one color for each picture.

Image 8



8 of 20

next

I am a ☐ boy ☒ girl.

I am ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 years old.

Code number : ______.

Thank you for participating in the Children's Color Perception Project.

Please click on the Submit button below.

Submit Reset

UNIVERSITY of NORTH TEXAS

Office of Research Services

May 21, 2001

Yun-ke Chang
[redacted]

RE: Human Subjects Application No. 01-093

Dear Ms. Chang:

The University of North Texas Institutional Review Board has conducted a review of your project titled "Children's Color Perception and Association with Digital Images." The Board feels that the risks inherent in this research are minimal, and the potential benefits to the subjects outweigh those risks. The study is hereby approved for the use of human subjects on this project.

Enclosed is the consent document with stamped IRB approval. Please copy and **use this form only** for your study subjects.

U.S. Department of Health and Human Services regulations require that you submit annual and terminal progress reports to the UNT Institutional Review Board. Further, the UNT IRB must re-review this project annually and/or prior to any modifications you make in the approved project. Please contact me if you wish to make such changes or need additional information.

Sincerely,

Peter L. Shillingsburg
Chair
Institutional Review Board

PS:sb

P.O. Box 305250 • Denton, Texas 76203-5250 • (940) 565-3940
Fax (940) 565-4277 • TDD (800) 735-2989 • www.unt.edu

Children's Color Perception Project

Assent Form

Description of the Research Project

We have designed a web site with 45 pictures; some of them are familiar to you, and some are not. We would like you to help us to choose one color for each picture. It takes about 15 to 20 minutes to finish, but you can take as much time as you like.

To participate in this study, you need to ask your parent to sign the consent form at the next page. Please give us your agreement to participate.

Respondent Consent

I _________________________(Name) agree to participate in the above study of color perception in children. I have been told that my responses will be confidential and that I am free to withdraw at anytime as I wish.

______________________________ ______________________________

Signature Date

Thank you for agreeing to participate in this study.

For further information, contact:
Yun-Ke Chang
[redacted]
Doctoral Candidate in Information Science
University of North Texas
[redacted], Denton, TX 76203

School of Library and Information Sciences
University of North Texas
940-565-4538

APPROVED BY THE UNT IRB
FROM 5/21/01 TO 5/20/02

This Project has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940-565-3945).

Children's Color Perception Project

Consent Form

Description of the Research Project

Different from adults with conventional learning experience, today's children are exposed to digital technology at a very young age and will be the major technology users in five to ten years. It is well known that digital libraries and museums through the Internet have become very important at their educational roles of providing information beyond classroom walls. To perfect on-line libraries and museums, future human-computer interface design and image retrieval methods should be based on the need of their potential users, children today. Understanding children's color perception and association with digital images, as proposed in this study, will provide very important knowledge for interface and retrieval design.

This study is a one-time on-line survey. It is anticipated to take 15 to 20 minutes to finish. The web site designed for this study is located at http://courses.unt.edu/shastings/Yunkeresearch/. You are welcome to visit it before granting your consent.

Respondent Consent

I ________________________(Name), the legal parent/Guardian of ______________________(Name), hereby grant consent for participation in the above study of color perception in children. I have been told that my child's responses will be confidential and that he/she is free to withdraw at anytime as he/she wishes.

_____________________________________   _____________________________________

Signature   Date

Thank you for agreeing to participate in this study. Please keep one copy of this form for your own record. You will use the code number _____________ at the survey.

For further information, contact:

[redacted]
ychang@lis.admin.unt.edu
Doctoral Candidate in Information Science
University of North Texas
[redacted] Denton, TX 76203

School of Library and Information Sciences
University of North Texas
940-565-4538

APPROVED BY THE UNT IRB
FROM 5/21/01 TO 5/20/02
SB

This Project has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940-565-3945).

Mail Message

Novell

Close

Previous Next Reply to Sender Reply All Forward Move Delete Properties

From: Web User <webadm@www.unt.edu>
To:
Date: Monday - June 25, 2001 11:10 AM
Subject: Data posted to form 1 of http://courses.unt.edu/shastings/Yunkeresearch/home.htm
Mime.822 (1725 bytes) [Save As]

****

ss123: yellow
ss032: white
ca001: white
rg000: red
rg021: red
ca064: blue
ss074: yellow
rg023: red
ca039: red
ss055: black
rg011: blue
ca061: green
rg019: red
ss005: yellow
rg057: blue
ca050: yellow
ss018: white
ca041: blue
rg089: white
ss022: yellow
ca047: yellow
rg044: red
ss033: yellow
ss041: white
rg078: white
ca042: blue
rg059: yellow
ss038: red
ca035: red
ss084: yellow
rg033: green
ss085: yellow
ca034: blue
ca019: black
rg109: yellow
ss096: red
ss107: green
ca031: blue
ss114: red
ca003: yellow
rg058: yellow
ca007: green
rg061: red
ca015: white
rg052: blue
gender: girl
age: 10
code: 1044
B1: Submit

Table 21

Pilot Study Data Analysis –Frequency of each Color Selected for each Image

Image #	File name	Red	Green	Blue	Yellow	Black	White	Total
1	Ss123	2	6	4	20	2	0	34
2	ss032	5	4	6	11	2	6	34
3	ca001	4	4	20	3	2	1	34
4	rg000	5	13	9	3	2	1	33
5	rg021	4	3	17	3	4	3	34
6	ca064	2	6	11	0	5	10	34
7	ss074	7	2	4	14	6	0	33
8	rg023	10	1	18	2	0	3	34
9	ca039	8	12	5	6	0	3	34
10	ss055	1	3	13	8	7	2	34
11	rg011	2	7	20	3	2	0	34
12	ca061	20	7	2	4	1	0	34
13	rg019	10	9	4	5	2	4	34
14	ss005	5	2	5	17	5	0	34
15	rg057	0	17	6	3	1	7	34
16	ca050	2	6	7	16	2	1	34
17	ss018	6	3	8	2	12	3	34
18	ca041	5	18	3	7	1	0	34
19	rg089	1	5	6	0	17	5	34
20	ss022	5	2	3	15	8	1	34
21	ca047	7	15	5	6	0	1	34
22	rg044	2	7	16	4	2	3	34
23	ss033	2	5	7	19	1	0	34
24	ss041	9	11	5	0	6	3	34
25	rg078	3	2	3	8	13	5	34
26	ca042	3	4	6	16	2	3	34
27	rg059	2	6	17	4	4	1	34
28	ss038	15	7	3	4	3	2	34
29	ca035	18	9	2	4	0	1	34
30	ss084	2	1	1	28	2	0	34
31	rg033	2	23	2	2	0	5	34
32	ss085	6	4	7	9	6	2	34
33	ca034	4	2	7	19	0	2	34
34	ca019	2	24	1	2	2	3	34
35	rg109	24	1	1	4	1	2	33
36	ss096	10	3	7	5	9	0	34
37	ss107	1	21	2	9	1	0	34
38	ca031	1	13	13	4	0	3	34
39	ss114	4	1	25	2	2	0	34
40	ca003	3	2	1	26	2	0	34
41	rg058	0	11	3	5	0	15	34
42	ca007	7	8	12	2	1	4	34
43	rg061	4	9	16	3	1	1	34
44	ca015	2	2	3	0	1	26	34
45	rg052	2	14	5	3	3	7	34

Table 22

Primarily Selected Color of each Image (with agreement level)

Image #	File name	Mode	% of agreement		Image #	File name	Mode	% of agreement
1	ss123	Yellow	59%		26	ca042	Yellow	47%
2	ss032	Yellow	32%		27	rg059	blue	50%
3	ca001	blue	59%		28	ss038	red	44%
4	rg000	green	39%		29	ca035	red	53%
5	rg021	blue	50%		30	ss084	Yellow	82%
6	ca064	blue	32%		31	rg033	green	68%
7	ss074	Yellow	42%		32	ss085	Yellow	26%
8	rg023	blue	53%		33	ca034	Yellow	56%
9	ca039	green	35%		34	ca019	green	71%
10	ss055	blue	38%		35	rg109	red	73%
11	rg011	blue	59%		36	ss096	red	29%
12	ca061	red	59%		37	ss107	green	62%
13	rg019	red	29%		38	ca031	green/blue	38%
14	ss005	Yellow	50%		39	ss114	blue	74%
15	rg057	green	50%		40	ca003	Yellow	76%
16	ca050	Yellow	47%		41	rg058	white	44%
17	ss018	black	35%		42	ca007	blue	35%
18	ca041	green	53%		43	rg061	blue	47%
19	rg089	black	50%		44	ca015	white	76%
20	ss022	Yellow	44%		45	rg052	green	41%
21	ca047	green	44%					
22	rg044	blue	47%					
23	ss033	Yellow	56%					
24	ss041	green	32%					
25	rg078	black	38%					

Table 23

Number of Images in each Range of Agreement Level

	Girl	Boy	Together	U.S.	Taiwan
21%-30%	6	2	3	11	3
31%-40%	5	10	10	10	4
41%-50%	14	20	15	9	10
51%-60%	4	4	9	6	6
61%-70%	9	7	2	8	7
71%-80%	4	2	5	1	5
81%-90%	3		1		4

APPENDIX B

SAMPLE IMAGES

Image 1

Image 2

Image 3

Image 4

Image 5

Image 6

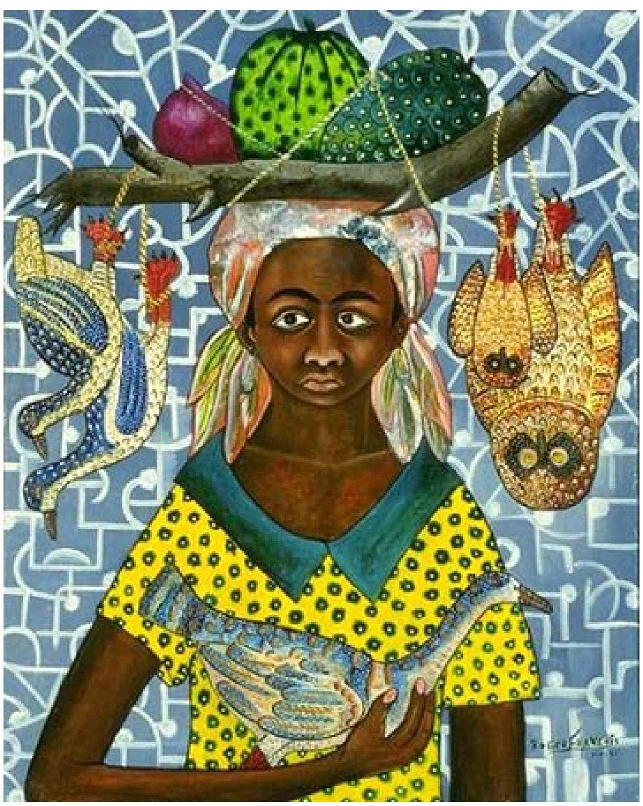


Image 7

Image 8

Image 9

Image10

Image 11

Image 12

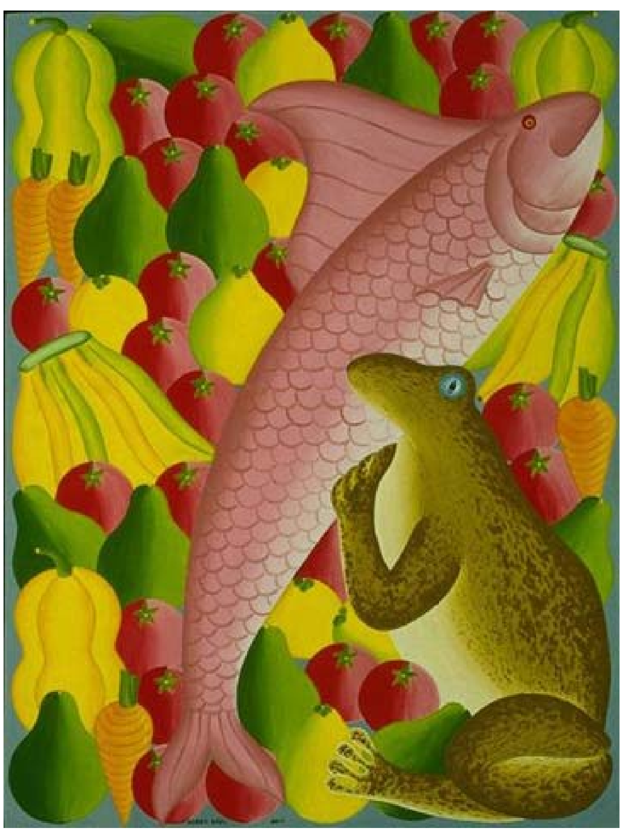


Image 13

Image 14

Image 15

Image 16

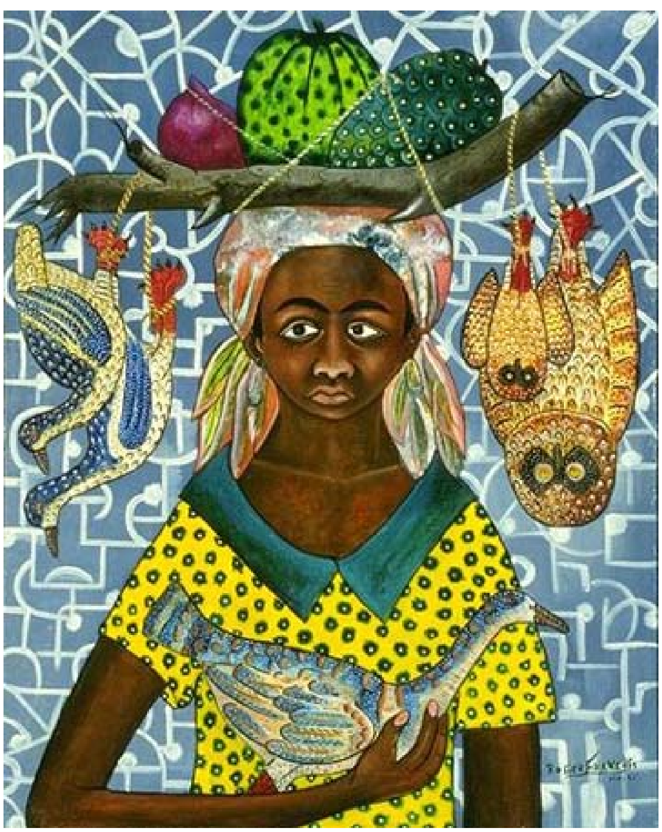


Image 17

Image18

Image 19

Image 20

APPENDIX C

LETTERS FROM THE INSTITUTIONAL REVIEW BOARD

UNIVERSITY of NORTH TEXAS

Office of Research Services

February 27, 2002

Yun-ke Chang
[redacted]

Institutional Review Board for the Protection of Human Subjects in Research (IRB)
RE: Human Subject Application #01-093

Dear Ms. Chang,

The UNT IRB has received your request to modify your study titled "Children's Color Perception and Association with Digital Images." As required by federal law and regulations governing the use of human subjects in research projects, the UNT IRB has examined the requested changes. The modification to this study is hereby approved for the use of human subjects.

Enclosed is the consent document with stamped IRB approval. Please copy and **use this form only** for your study subjects.

U.S. Department of Health and Human Services regulations require that you submit annual and terminal progress reports to the UNT Institutional Review Board. The UNT IRB must re-review this project prior to any other changes you make in the approved project. **Federal policy 21 CFR 56.109(e) stipulates that IRB approval is for one year only.**

Please contact me if you wish to make changes or need additional information.

Sincerely,

Peter L. Shillingsburg
Chair
Institutional Review Board

PS:sb

P.O. Box 305250 • Denton, Texas 76203-5250 • (940) 565-3940
Fax (940) 565-4277 • TTY (800) RELAY TX • www.unt.edu

Children's Color Perception Project

Assent Form

Description of the Research Project

We have designed a web site with 20 pictures; some of them are familiar to you, and some are not. We would like you to help us to choose one color for each picture. At the end, you will be asked some simple questions, and your answers will be audiotape recorded. It takes about 15 to 20 minutes total to finish, but you can take as much time as you like.

To participate in this study, you need to ask your parent to sign the consent form at the next page. Please give us your agreement to participate.

Respondent Consent

I ____________________________(Name) agree to participate in the above study of color perception in children. I have been told that my responses will be confidential and that I am free to withdraw at anytime as I wish.

____________________________ ____________________________

Signature Date

Thank you for agreeing the participation in this study.

For further information, contact:
Yun-Ke Chang
[redacted]
Doctoral Candidate in Information Science
University of North Texas
[redacted], Denton, TX 76203

School of Library and Information Sciences
University of North Texas
940-565-4538

APPROVED BY THE UNT IRB
FROM 5/21/01 TO 5/20/02

This Project has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940-565-3945).

Children's Color Perception Project

Consent Form

Description of the Research Project

Different from adults with conventional learning experience, today's children are exposed to digital technology at a very young age and will be the major technology users in five to ten years. It is well known that digital libraries and museums through the Internet have become very important at their educational roles of providing information beyond classroom walls. To perfect on-line libraries and museums, future human-computer interface design and image retrieval methods should be based on the need of their potential users, children today. Understanding children's color perception and association with digital images, as proposed in this study, will provide very important knowledge for interface and retrieval design.

This study is a one-time on-line survey. The online questionnaire contains 20 images- 15images with 5 repeated at the end of the session. Children will be asked questions for those five images about why they chose a certain color for each image, their familiarity with the images and their understanding of the subject matters in images. The interview session will be audiotape recorded. It is anticipated to take 15 to 20 minutes to finish the whole process. The web site designed for this study is located at http://courses.unt.edu/shastings/Yunkeresearch/. You are welcome to visit it before granting your consent.

Respondent Consent

I _______________________(Name), the legal parent/Guardian of _____________________(Name), hereby grant consent to participate in the above study of color perception in children. I have been told that my child's responses will be confidential and that he/she is free to withdraw at anytime as he/she wishes.

________________________________ ________________________________

Signature Date

Thank you for agreeing the participation in this study. Please keep one copy of this form for your own record. You will use the code number ____________ at the survey.

For further information, contact:
Yun-Ke Chang
[redacted]
Doctoral Candidate in Information Science
University of North Texas
[redacted]Denton, TX 76203

School of Library and Information Sciences
University of North Texas
940-565-4538

APPROVED BY THE UNT IRB
FROM 5/21/01 TO 5/20/02
SB

This Project has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940-565-3945).

Investigación para entender la percepcion de color en niños

Formato para solicitar permiso de participación del padre (madre) o tutor

Descripción del proyecto de investigación

A diferencia de la percepción de los adultos que tienen experiencias de aprendizaje convencionales, los niños de hoy están espuestos a tecnología digital a muy temprana edad, y serán la mayor parte de los usuarios de esa tecnología en los próximos cinco a diez años. Es bien sabido que bibliotecas electrónicas y museos a través del Internet serán muy importantes en sus roles educativos proveyendo información más allá de las paredes del salón de clases. Para mejorar bibliotecas y museos que ofrezcan recursos en la Internet, en el futuro, el diseño de interfaces de computadora y métodos de recuperación de imagenes deberán estar basados en las necesidades de sus potenciales usuarios, los niños de hoy. Es propuesto en este estudio que entendiendo como los niños perciben color y su relación con imagenes digitales proverán muy importante conocimientos para el diseño de interfaces y métodos para recuperación de imagenes.

Este estudio consta de un cuestionario único en línea. El cuestionario en línea contiene 20 imagenes – 15 imagenes con 5 repetidas al final de la sesión. A los niños se les formularán preguntas acerca de esas cinco imagenes: por que ellos escogieron un determinado color por cada imagen, su familiaridad con las imagenes y su entendimiento respecto al significado de las imagenes. La entrevista será grabada, y se considera que se llevará de 15 a 20 minutos para terminar todo el proceso. El web site diseñado para este estudio está localizado en la siguiente dirección de internet http://courses.unt.edu/shastings/Yunkeresearch/. Usted puede visitar el web site antes de otorgar su permiso

Permiso del participante

Yo ________________________________ (Nombre), el padre/madre/guardian legal de ________________________________(Nombre). Por medio de la presente otorgo permiso en el estudio arriba mencionado para entender la percepción de color en niños. Se me ha informado que las respuestas de mi hijo(a) serán confidenciales y que él o ella está en libertad de abandonar el estudio en cualquier momento que él o ella lo deseé.

________________________________ ________________________________
Firma Fecha

Gracias por otorgar su permiso para la participación en este estudio. Por favor conserve una copia de esta forma para su archivo personal. Usted usará el código numérico __________ en la entrevista.

Para mayor información, por favor contacte:

Yun-Ke Chang
[redacted]
Candidata al Doctorado en Ciencias de la Información
Universidad del Norte de Texas
[redacted], Denton, TX 76203

Escuela de Biblioteconomía y Ciencias de la Información
Universidad del Norte de Texas
940-565-4538

Este proyecto de investigación ha sido revisado y aprovado por el comité de la universidad para la protección de los participantes (940-565-3945).

APPROVED BY THE UNT IRB
FROM 5/21/01 TO 5/20/02

APPENDIX D

A SAMPLE OF EMAILED DATA

Mail Message

Novell

Close

Previous Forward Reply to Sender Reply All Move Delete Properties

From: Web User <webadm@www.unt.edu>
To:
Date: Wednesday - April 3, 2002 3:46 PM
Subject: Data posted to form 1 of http://courses.unt.edu/shastings/Yunkeresearch/home.htm
Mime.822 (1365 bytes) [View] [Save As]

****

rg023: blue
ss055: green
ca061: red
ss005: yellow
rg057: white
ca050: blue
ss018: black
ca041: green
ca047: blue
ss033: blue
ss041: black
ca035: red
ca034: yellow
ss096: black
rg058: white
ca050_2: red
ss041_2: black
ss033_2: blue
ca047_2: yellow
rg023_2: green
gender: boy
grade: 3rd
code: 00110
B1: Submit

APPENDIX E

COLOR SELECTION DATA AND SAMPLES OF INTERVIEW TRANSCRIPTION

Table 24

Color Selection Data

gender	grade	code #	rg023	ss055	ca061	ss005	rg057	ca050	ss018	ca041	ca047	ss033	ss041	ca035	ca034	ss096	rg058	ca050_ 2	ss041_ 2	ss033_ 2	ca047_ 2	rg023_2
1	5	1614	1	2	3	6	4	1	3	6	3	2	2	3	6	2	6	3	4	2	3	1
0	4	8119	3	4	2	1	3	4	1	1	3	3	1	1	3	3	4	4	1	3	3	3
0	6	14841	3	2	1	4	2	4	1	2	3	4	5	2	3	3	4	4	5	4	3	1
0	5	10010	3	5	2	5	3	3	5	2	2	3	5	2	3	1	3	3	3	3	2	3
1	5	11211	1	4	2	4	3	4	3	6	1	4	3	2	1	5	1	5	1	5	1	1
0	4	11441	3	5	2	1	3	6	4	2	3	5	2	4	3	1	2	2	6	2	3	3
1	3	11691	5	2	3	1	4	5	3	2	4	2	5	5	2	5	6	5	3	2	4	5
1	5	11961	3	4	2	4	2	3	3	1	2	4	2	1	2	6	4	4	1	3	4	1
1	5	12561	3	3	1	4	2	3	1	2	4	4	1	2	1	5	4	3	2	5	2	1
0	5	12891	3	3	1	4	6	4	3	2	4	4	1	2	2	3	6	4	1	4	4	3
0	4	13241	4	6	4	3	1	6	2	6	3	1	3	6	3	4	3	6	3	1	3	4
0	3	13611	2	4	2	4	5	6	2	4	2	4	6	4	4	6	2	6	6	4	2	2
0	4	19611	3	4	1	3	4	1	4	3	4	4	6	1	4	4	4	6	6	1	2	1
0	4	110893	3	4	3	4	2	4	5	1	4	4	1	1	3	3	4	4	1	4	2	1
0	3	111563	3	2	4	1	2	4	3	1	4	1	2	2	4	3	1	4	1	4	1	3
1	5	112253	1	3	4	4	5	5	3	2	4	3	2	2	3	2	4	5	6	3	4	1
0	5	112963	1	3	3	1	4	3	2	1	3	4	2	2	3	4	3	3	2	3	1	1
0	3	115214	3	6	2	4	2	4	1	2	2	3	6	4	4	5	2	3	6	3	4	3
0	4	15761	3	1	4	3	6	1	4	2	4	1	2	6	1	4	2	3	2	4	1	4
1	3	16761	3	2	4	6	5	2	3	1	4	2	1	5	1	3	5	4	6	1	3	6
0	4	19001	1	4	2	3	1	4	3	5	2	2	2	1	4	4	1	4	2	1	4	1
0	4	113694	3	4	1	4	3	4	1	1	2	4	1	2	4	4	4	4	2	4	2	1
1	6	114444	3	4	3	4	2	3	1	2	4	6	5	4	3	6	2	3	6	6	4	3
1	6	17291	1	3	2	4	3	4	1	2	4	3	6	1	3	3	3	4	6	3	4	1

Table 24 continues

Table 24 continued.

gender	grade	code #	rg023	ss055	ca061	ss005	rg057	ca050	ss018	ca041	ca047	ss033	ss041	ca035	ca034	ss096	rg058	ca050_2	ss041_2	ss033_2	ca047_2	rg023_2
0	4	17841	3	1	4	1	3	2	4	1	4	1	3	2	3	4	1	3	4	1	2	4
0	3	18411	3	4	2	1	6	5	1	4	3	2	5	3	3	2	4	1	4	2	3	4
0	4	116005	5	5	3	4	3	6	3	1	6	1	3	3	6	2	1	3	3	4	2	4
1	4	177241	3	4	1	4	2	3	5	2	4	4	5	4	4	3	2	3	6	3	2	3
0	6	194481	3	2	1	1	4	4	3	6	2	4	2	5	1	6	5	3	2	4	2	3
1	4	203401	3	1	4	1	6	5	4	2	6	1	2	6	3	1	2	4	2	6	5	3
0	3	221841	3	2	4	1	1	6	3	2	4	1	2	6	3	3	4	2	4	2	3	3
0	4	231361	3	1	4	2	3	4	1	2	2	1	6	2	4	1	5	6	2	4	4	3
0	5	240181	3	4	1	1	3	6	3	3	2	3	6	2	4	3	3	6	6	3	2	3
0	3	251001	4	6	3	1	2	3	6	1	6	4	5	2	6	1	6	6	4	6	3	6
1	5	168921	3	4	1	4	2	6	5	2	1	4	6	2	4	2	6	6	1	3	1	3
0	6	261121	1	3	1	4	2	4	3	3	2	3	1	2	3	4	4	4	1	3	2	1
1	3	640096	1	3	2	4	6	4	4	1	1	4	1	2	4	3	4	3	1	1	4	6
1	5	635046	1	2	3	1	2	3	1	2	2	4	1	2	4	2	2	3	1	4	2	1
1	6	645166	3	4	3	6	2	3	3	2	2	4	1	1	3	3	6	4	1	4	2	3
1	4	650256	1	3	3	4	2	5	1	6	3	1	3	3	1	6	1	5	3	1	3	1
0	5	655366	3	4	5	2	3	1	5	4	3	2	5	1	3	2	2	1	5	3	3	3
0	3	11170	1	4	2	5	2	3	5	2	2	4	5	1	4	5	4	3	5	4	1	3
1	6	665646	3	4	1	4	2	5	5	2	2	4	1	2	4	3	4	3	2	3	4	4
1	6	11539	3	4	6	4	3	3	6	2	2	3	2	1	3	3	3	3	2	3	2	3
0	4	12295	3	2	1	4	2	3	5	2	2	3	5	1	4	5	2	3	5	3	2	3
1	6	13879	5	2	1	5	2	6	5	2	4	2	2	3	6	5	2	6	2	2	4	5
0	4	13474	5	3	2	4	6	1	2	5	6	1	4	3	4	2	4	6	1	4	6	3
0	6	13075	3	1	6	2	5	4	1	3	1	2	2	3	3	5	2	4	2	3	3	1
1	5	14290	3	2	6	1	2	5	1	1	4	3	6	4	3	2	4	5	1	4	2	3
1	3	14707	1	3	2	4	2	3	1	2	4	3	2	4	3	3	4	4	1	4	2	3
0	5	15130	3	4	2	5	3	3	5	3	3	6	5	4	3	1	4	3	5	3	3	4

Table 24 continues

Table 24 continued.

gender	grade	code #	rg023	ss055	ca061	ss005	rg057	ca050	ss018	ca041	ca047	ss033	ss041	ca035	ca034	ss096	rg058	ca050_2	ss041_2	ss033_2	ca047_2	rg023_2
1	5	15559	1	3	1	4	6	3	3	1	2	3	2	2	4	2	4	3	2	3	2	1
0	3	15994	3	4	1	6	4	2	4	2	1	5	3	4	6	5	2	3	5	3	2	5
0	5	16435	3	4	3	4	3	2	3	2	1	3	1	2	3	2	4	3	5	3	1	3
1	3	16882	3	4	2	1	2	4	5	4	6	2	5	1	3	5	2	5	2	4	3	3
1	6	17794	3	4	3	4	2	5	3	1	2	4	1	1	2	2	4	5	2	6	2	3
0	6	18730	1	3	2	4	2	4	1	5	3	1	2	2	3	2	5	6	1	4	5	6
1	4	19207	1	3	2	4	2	3	3	1	1	4	2	1	4	3	2	3	2	4	1	3
1	4	531445	1	4	3	2	5	1	4	1	5	2	3	3	1	5	1	5	6	1	2	4
0	3	551372	4	3	1	4	2	2	3	1	2	4	2	2	4	4	4	4	2	4	3	3
0	6	571791	3	4	5	2	3	6	1	3	2	4	5	1	2	3	6	6	2	4	3	3
0	6	592708	4	3	2	6	2	3	4	2	5	6	1	1	3	1	4	4	1	4	4	3
0	3	614129	6	4	2	4	2	3	1	1	2	4	2	1	3	3	4	3	1	2	4	1
1	3	12682	3	5	6	2	5	1	5	3	6	2	4	3	6	2	5	3	6	2	6	5
1	5	17335	3	3	2	5	2	3	5	2	2	3	1	1	3	5	6	3	1	3	2	3
1	4	636060	3	4	1	1	2	3	1	2	4	3	2	4	4	2	2	3	2	3	4	3
1	4	75727	3	1	2	5	4	1	2	4	6	2	5	3	4	1	6	3	5	1	4	2
1	3	77477	2	3	1	4	6	5	2	3	4	1	3	6	1	2	4	3	3	5	3	2
1	3	110	3	2	1	4	6	3	5	2	3	3	5	1	4	5	6	1	5	3	4	2

Gender: 1 = boy, 2 =girl

Color Selection: 1 = red, 2 = green, 3 = blue, 4 = yellow, 5 = black, 6 = white

Table 25

Code number 18411; 3rd grade girl; favorite color is blue.

Image # and Color selected		Saw it before? Where from?	Why the color?	What is it about?
16	red		It will look good with it.	It's about a lady with two owl and also two birds hanging from their feet from a stick and that lady's holding a bird
17	yellow	Sesame street	There are more things yellow in the sesame street then just about anything else.	Oscar is beating. the brat
18	green	Sesame street	I don't remember his name. He usually wears more green than anything else. He is ok. My favorite is Maria.	I never really see this picture on Sesame street. You know, we don't have a TV any more. It looks like he is looking at that arrow that is pointing that way.
19	blue		Because a lot of people around are wearing blue. A lots of blue, a lots, lots of them. (because your favorite color is blue?) That's one of the reasons	It looks like a lot of people just came up, it looks like a lot, lot of stuff.
20	yellow		Because the trolley, it has some yellow on it.	It is a trolley it goes through a place, a little place, it's a castle. It is going like that. it is not going backward, it is going forward. The head is pointing to, it's facing that way.

Table 25 a

Code number 12891; 5th grade girl; favorite color is purple.

Image # and Color selected		Saw it before? Where from?	Why the color?	What is it about?
16	yellow		Because the first color that really caught my eyes was yellow in her tee shirt.	, I think it's like slavery sort of, like carrying ,or like African Americans
17	red	Sesame street	I chose red because he was, the red guy he was the first color that I saw.	Maybe like he jumped out the can and he goes wooaa
18	yellow	Sesame street	I chose yellow because the first thing I see was his really big head.	He is reading the sign.
19	yellow		Because there is a lot of weed basket and every body, a lot of people were wearing yellow.	Looks like sort of like Indian tribe something like a group that stays together all the time, group hubs, other. Looks like they about to eat because there is a bunch of food
20	Blue	What's the name I forgot the name like Mr. Roger's his something Mr. Roger's neighborhood™	the back ground got the colors like bluish greenish, that's the closest color I could find.	looks like she's saying hi to Mr. Roger.

Table 25b

Code number 645166; 6th grade boy; favorite color is red.

Image # and Color selected		Saw it before? Where from?	Why the color?	What is it about?
16	yellow	Yes. It's from another picture in this.	Because the color on her shirt seems to stand out.	I think it's someone get some animals at her hat.
17	red	Yes, it's from sesame street	It stands out a lot. He is red.	It looks like he is pretty surprised.
18	yellow	Sesame street	The head	He is looking at something.
19	green	No.	Because green seems to stand out a lot because there's whole bunch green in there.	a village somewhere, maybe south America
20	blue		The background. It's pretty much blue	I really don't have pretty much idea. Someone introducing the neighborhood trolley on a TV show. KERA?

Table 25c

Code number 650256; 4th grade boy; favorite color is red.

Image # and Color selected		Saw it before? Where from?	Why the color?	What is it about?
16	black	Yes, the first one	Because this color is not really in there that much. That's the reason.	It's like the slavery back then.
17	blue	Sesame street.	Because there is no blue in the picture.	The green thing right there is dumping trash on the red thing.
18	red	Sesame street again.	Well, it needs some red somewhere.	He is looking for something.
19	blue	I think it's like back in Mexico. It's from Japan. It looks like China, or Japan, or Mexico.	Because the fields like blue flowers stuff like there. The picture is pretty	I think it's like a market or like a village.
20	red		The trolley.	She is describing what that trolley is.

APPENDIX F

SPSS OUTPUT OF CHI-SQUARE ANALYSIS 1

Reliability of Responses: Chi-squares test generated by SPSS

Table 26

Image 6 and Image 16

CA050 * COLOR050 Crosstabulation

			COLOR050						Total
			black	blue	green	red	white	yellow	
CA050	image 6	Count	9	21	5	8	9	17	69
		Expected Count	8.5	24.5	3.5	5.5	10.0	17.0	69.0
		Std. Residual	0.2	-0.7	0.8	1.1	-0.3	.0	
	image16	Count	8	28	2	3	11	17	69
		Expected Count	8.5	24.5	3.5	5.5	10.0	17.0	69.0
		Std. Residual	-0.2	0.7	-0.8	-1.1	0.3	.0	
Total		Count	17	49	7	11	20	34	138
		Expected Count	17.0	49.0	7.0	11.0	20.0	34.0	138.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.817(a)	5	0.439
Likelihood Ratio	4.949	5	0.422
N of Valid Cases	138		

a 2 cells (16.7%) have expected count less than 5.
The minimum expected count is 3.50.

Table 26a

Image 11 and Image 17

SS041 * COLOR041 Crosstabulation

			COLOR041						Total
			black	blue	green	red	white	yellow	
SS041	image11	Count	15	8	21	15	8	2	69
		Expected Count	12.0	7.0	20.0	16.5	10.0	3.5	69.0
		Std. Residual	0.9	0.4	0.2	-0.4	-0.6	-0.8	
	image17	Count	9	6	19	18	12	5	69
		Expected Count	12.0	7.0	20.0	16.5	10.0	3.5	69.0
		Std. Residual	-0.9	-0.4	-0.2	0.4	0.6	0.8	
Total		Count	24	14	40	33	20	7	138
		Expected Count	24.0	14.0	40.0	33.0	20.0	7.0	138.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.244(a)	5	0.515
Likelihood Ratio	4.310	5	0.506
N of Valid Cases	138		

a 2 cells (16.7%) have expected count less than 5.
The minimum expected count is 3.50.

Table 26b

Image 10 and Image 18

SS033 * COLOR033 Crosstabulation

			COLOR033						Total
			black	blue	green	red	white	yellow	
SS033	image10	Count	2	16	12	12	3	24	69
		Expected Count	2.5	19.5	10.0	10.5	3.5	23.0	69.0
		Std. Residual	-0.3	-0.8	0.6	0.5	-0.3	0.2	
	image18	Count	3	23	8	9	4	22	69
		Expected Count	2.5	19.5	10.0	10.5	3.5	23.0	69.0
		Std. Residual	0.3	0.8	-0.6	-0.5	0.3	-0.2	
Total		Count	5	39	20	21	7	46	138
		Expected Count	5.0	39.0	20.0	21.0	7.0	46.0	138.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.915(a)	5	0.713
Likelihood Ratio	2.930	5	0.711
N of Valid Cases	138		

a 4 cells (33.3%) have expected count less than 5. The minimum expected count is 2.50.

Table 26c

Image 9 and Image 19

CA047 * COLOR047 Crosstabulation

			COLOR047						Total
			black	blue	green	red	white	yellow	
CA047	image 9	Count	2	12	22	7	7	19	69
		Expected Count	2.0	14.5	22.5	7.5	4.5	18.0	69.0
		Std. Residual	.0	-0.7	-0.1	-.02	1.2	0.2	
	image19	Count	2	17	23	8	2	17	69
		Expected Count	2.0	14.5	22.5	7.5	4.5	18.0	69.0
		Std. Residual	.0	0.7	0.1	0.2	-1.2	-0.2	
Total		Count	4	29	45	15	9	36	138
		Expected Count	4.0	29.0	45.0	15.0	9.0	36.0	138.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.840(a)	5	0.573
Likelihood Ratio	4.008	5	0.548
N of Valid Cases	138		

a 4 cells (33.3%) have expected count less than 5. The minimum expected count is 2.00.

Table 26d

Image 1 and Image 20

RG023 * COLOR023 Crosstabulation

			COLOR023						Total
			Black	blue	green	red	white	yellow	
RG023	Image 20	Count	4	31	4	18	4	8	69
		Expected Count	4.0	36.5	3.0	17.0	2.5	6.0	69.0
		Std. Residual	.0	-0.9	0.6	0.2	0.9	0.8	
	image1	Count	4	42	2	16	1	4	69
		Expected Count	4.0	36.5	3.0	17.0	2.5	6.0	69.0
		Std. Residual	.0	0.9	-0.6	-0.2	-0.9	-0.8	
Total		Count	8	73	6	34	5	12	138
		Expected Count	8.0	73.0	6.0	34.0	5.0	12.0	138.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.575(a)	5	0.350
Likelihood Ratio	5.748	5	0.332
N of Valid Cases	138		

a 6 cells (50.0%) have expected count less than 5. The minimum expected count is 2.50.

APPENDIX G

SPSS OUTPUT OF CHI-SQUARE ANALYSIS II

Chi-Square Results By SPSS: Color Selection Comparison By Gender

Table 27

Image 1

GENDER * RG023 Crosstabulation

			RG023						Total
			1	2	3	4	5	6	
GENDER	0	Count	5	1	24	4	2	1	37
		Expected Count	8.6	1.1	22.5	2.1	2.1	.5	37.0
		Std. Residual	-1.2	-0.1	0.3	1.3	-0.1	0.6	
	1	Count	11	1	18	0	2	0	32
		Expected Count	7.4	0.9	19.5	1.9	1.9	0.5	32.0
		Std. Residual	1.3	0.1	-0.3	-1.4	0.1	-0.7	
Total		Count	16	2	42	4	4	1	69
		Expected Count	16.0	2.0	42.0	4.0	4.0	1.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.786(a)	5	0.168
Likelihood Ratio	9.735	5	0.083
Linear-by-Linear Association	4.582	1	0.032
N of Valid Cases	69		

a 8 cells (66.7%) have expected count less than 5. The minimum expected count is 0.46.

Table 27a

Image 2

GENDER * SS055 Crosstabulation

			SS055						Total
			1	2	3	4	5	6	
GENDER	0	Count	4	5	7	15	3	3	37
		Expected Count	3.2	6.4	9.1	14.5	2.1	1.6	37.0
		Std. Residual	0.4	-0.6	-0.7	0.1	0.6	1.1	
	1	Count	2	7	10	12	1	0	32
		Expected Count	2.8	5.6	7.9	12.5	1.9	1.4	32.0
		Std. Residual	-0.5	0.6	0.8	-0.1	-0.6	-1.2	
Total		Count	6	12	17	27	4	3	69
		Expected Count	6.0	12.0	17.0	27.0	4.0	3.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.529(a)	5	0.355
Likelihood Ratio	6.723	5	0.242
Linear-by-Linear Association	1.557	1	0.212
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5. The minimum expected count is 1.39.

Table 27b

Image 3

GENDER * CA061 Crosstabulation

			CA061						Total
			1	2	3	4	5	6	
GENDER	0	Count	10	13	5	6	2	1	37
		Expected Count	10.2	11.8	7.0	4.8	1.1	2.1	37.0
		Std. Residual	-0.1	0.4	-0.7	0.5	0.9	-0.8	
	1	Count	9	9	8	3	0	3	32
		Expected Count	8.8	10.2	6.0	4.2	.9	1.9	32.0
		Std. Residual	0.1	-0.4	0.8	-0.6	-1.0	0.8	
Total		Count	19	22	13	9	2	4	69
		Expected Count	19.0	22.0	13.0	9.0	2.0	4.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.137(a)	5	0.399
Likelihood Ratio	5.958	5	0.310
Linear-by-Linear Association	0.045	1	0.832
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5.
The minimum expected count is 0.93.

Table 27c

Image 4

GENDER * SS005 Crosstabulation

			SS005						Total
			1	2	3	4	5	6	
GENDER	0	Count	10	4	4	14	3	2	37
		Expected Count	8.6	3.2	2.1	17.2	3.2	2.7	37.0
		Std. Residual	0.5	0.4	1.3	-0.8	-0.1	-0.4	
	1	Count	6	2	0	18	3	3	32
		Expected Count	7.4	2.8	1.9	14.8	2.8	2.3	32.0
		Std. Residual	-0.5	-0.5	-1.4	0.8	0.1	0.4	
Total		Count	16	6	4	32	6	5	69
		Expected Count	16.0	6.0	4.0	32.0	6.0	5.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.036(a)	5	0.303
Likelihood Ratio	7.575	5	0.181
Linear-by-Linear Association	2.065	1	0.151
N of Valid Cases	69		

a 8 cells (66.7%) have expected count less than 5. The minimum expected count is 1.86.

Table 27d

Image 5

GENDER * RG057 Crosstabulation

			RG057						Total
			1	2	3	4	5	6	
GENDER	0	Count	3	12	12	4	2	4	37
		Expected Count	1.6	15.6	8.0	3.8	3.2	4.8	37.0
		Std. Residual	1.1	-0.9	1.4	0.1	-0.7	-0.4	
	1	Count	0	17	3	3	4	5	32
		Expected Count	1.4	13.4	7.0	3.2	2.8	4.2	32.0
		Std. Residual	-1.2	1.0	-1.5	-0.1	0.7	0.4	
Total		Count	3	29	15	7	6	9	69
		Expected Count	3.0	29.0	15.0	7.0	6.0	9.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.872(a)	5	0.079
Likelihood Ratio	11.379	5	0.044
Linear-by-Linear Association	0.398	1	0.528
N of Valid Cases	69		

a 8 cells (66.7%) have expected count less than 5. The minimum expected count is 1.39.

Table 27e

Image 6

GENDER * CA050 Crosstabulation

			CA050						Total
			1	2	3	4	5	6	
GENDER	0	Count	4	4	8	13	1	7	37
		Expected Count	4.3	2.7	11.3	9.1	4.8	4.8	37.0
		Std. Residual	-0.1	0.8	-1.0	1.3	-1.7	1.0	
	1	Count	4	1	13	4	8	2	32
		Expected Count	3.7	2.3	9.7	7.9	4.2	4.2	32.0
		Std. Residual	0.2	-0.9	1.0	-1.4	1.9	-1.1	
Total		Count	8	5	21	17	9	9	69
		Expected Count	8.0	5.0	21.0	17.0	9.0	9.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.698(a)	5	0.008
Likelihood Ratio	16.923	5	0.005
Linear-by-Linear Association	0.110	1	0.741
N of Valid Cases	69		

a 8 cells (66.7%) have expected count less than 5.
The minimum expected count is 2.32.

Table 27f

Image 7

GENDER * SS018 Crosstabulation

			SS018						Total
			1	2	3	4	5	6	
GENDER	0	Count	10	4	10	6	6	1	37
		Expected Count	9.7	3.2	10.7	4.8	7.5	1.1	37.0
		Std. Residual	0.1	0.4	-0.2	0.5	-0.6	-0.1	
	1	Count	8	2	10	3	8	1	32
		Expected Count	8.3	2.8	9.3	4.2	6.5	.9	32.0
		Std. Residual	-0.1	-0.5	0.2	-0.6	0.6	0.1	
Total		Count	18	6	20	9	14	2	69
		Expected Count	18.0	6.0	20.0	9.0	14.0	2.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.822(a)	5	0.873
Likelihood Ratio	1.846	5	0.870
Linear-by-Linear Association	0.308	1	0.579
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5. The minimum expected count is 0.93.

Table 27g

Image 8

GENDER * CA041 Crosstabulation

			CA041						Total
			1	2	3	4	5	6	
GENDER	0	Count	10	13	6	3	3	2	37
		Expected Count	9.7	16.1	4.3	2.7	1.6	2.7	37.0
		Std. Residual	0.1	-0.8	0.8	0.2	1.1	-0.4	
	1	Count	8	17	2	2	0	3	32
		Expected Count	8.3	13.9	3.7	2.3	1.4	2.3	32.0
		Std. Residual	-0.1	0.8	-0.9	-0.2	-1.2	0.4	
Total		Count	18	30	8	5	3	5	69
		Expected Count	18.0	30.0	8.0	5.0	3.0	5.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.824(a)	5	0.324
Likelihood Ratio	7.050	5	0.217
Linear-by-Linear Association	0.335	1	0.563
N of Valid Cases	69		

a 8 cells (66.7%) have expected count less than 5. The minimum expected count is 1.39.

Table 27h

Image 9

GENDER * CA047 Crosstabulation

			CA047						Total
			1	2	3	4	5	6	
GENDER	0	Count	3	14	9	7	1	3	37
		Expected Count	3.8	11.8	6.4	10.2	1.1	3.8	37.0
		Std. Residual	-0.4	0.6	1.0	-1.0	-0.1	-0.4	
	1	Count	4	8	3	12	1	4	32
		Expected Count	3.2	10.2	5.6	8.8	.9	3.2	32.0
		Std. Residual	0.4	-0.7	-1.1	1.1	0.1	0.4	
Total		Count	7	22	12	19	2	7	69
		Expected Count	7.0	22.0	12.0	19.0	2.0	7.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.907(a)	5	0.315
Likelihood Ratio	6.052	5	0.301
Linear-by-Linear Association	1.127	1	0.288
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5.
The minimum expected count is 0.93.

Table 27i

Image 10

GENDER * SS033 Crosstabulation

			SS033						Total
			1	2	3	4	5	6	
GENDER	0	Count	9	4	7	13	2	2	37
		Expected Count	6.4	6.4	8.6	12.9	1.1	1.6	37.0
		Std. Residual	1.0	-1.0	-0.5	.0	0.9	0.3	
	1	Count	3	8	9	11	0	1	32
		Expected Count	5.6	5.6	7.4	11.1	0.9	1.4	32.0
		Std. Residual	-1.1	1.0	0.6	.0	-1.0	-0.3	
Total		Count	12	12	16	24	2	3	69
		Expected Count	12.0	12.0	16.0	24.0	2.0	3.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.756(a)	5	0.239
Likelihood Ratio	7.666	5	0.176
Linear-by-Linear Association	0.007	1	0.933
N of Valid Cases	69		

a 4 cells (33.3%) have expected count less than 5. The minimum expected count is 0.93.

Table 27j

Image 11

GENDER * SS041 Crosstabulation

			SS041						Total
			1	2	3	4	5	6	
GENDER	0	Count	7	11	4	1	9	5	37
		Expected Count	8.0	11.3	4.3	1.1	8.0	4.3	37.0
		Std. Residual	-0.4	-0.1	-0.1	-0.1	0.3	0.3	
	1	Count	8	10	4	1	6	3	32
		Expected Count	7.0	9.7	3.7	0.9	7.0	3.7	32.0
		Std. Residual	0.4	0.1	0.2	0.1	-0.4	-0.4	
Total		Count	15	21	8	2	15	8	69
		Expected Count	15.0	21.0	8.0	2.0	15.0	8.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	.856(a)	5	0.973
Likelihood Ratio	0.861	5	0.973
Linear-by-Linear Association	0.737	1	0.391
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5. The minimum expected count is 0.93.

Table 27k

Image 12

GENDER * CA035 Crosstabulation

			CA035						Total
			1	2	3	4	5	6	
GENDER	0	Count	10	14	4	5	1	3	37
		Expected Count	10.2	11.8	5.4	5.4	1.6	2.7	37.0
		Std. Residual	-0.1	0.6	-0.6	-0.2	-0.5	0.2	
	1	Count	9	8	6	5	2	2	32
		Expected Count	8.8	10.2	4.6	4.6	1.4	2.3	32.0
		Std. Residual	0.1	-0.7	0.6	0.2	0.5	-0.2	
Total		Count	19	22	10	10	3	5	69
		Expected Count	19.0	22.0	10.0	10.0	3.0	5.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.272(a)	5	0.810
Likelihood Ratio	2.291	5	0.808
Linear-by-Linear Association	0.156	1	0.693
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5.
The minimum expected count is 1.39.

Table 27L

Image 13

GENDER * CA034 Crosstabulation

			CA034					Total
			1	2	3	4	6	
GENDER	0	Count	2	2	18	12	3	37
		Expected Count	4.3	2.7	15.0	11.8	3.2	37.0
		Std. Residual	-1.1	-0.4	0.8	0.1	-0.1	
	1	Count	6	3	10	10	3	32
		Expected Count	3.7	2.3	13.0	10.2	2.8	32.0
		Std. Residual	1.2	0.4	-0.8	-0.1	0.1	
Total		Count	8	5	28	22	6	69
		Expected Count	8.0	5.0	28.0	22.0	6.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.328(a)	4	0.363
Likelihood Ratio	4.432	4	0.351
Linear-by-Linear Association	0.851	1	0.356
N of Valid Cases	69		

a 6 cells (60.0%) have expected count less than 5. T
The minimum expected count is 2.32.

Table 27m

Image 14

GENDER * SS096 Crosstabulation

			SS096						Total
			1	2	3	4	5	6	
GENDER	0	Count	6	6	9	9	5	2	37
		Expected Count	4.3	8.6	9.7	4.8	7.0	2.7	37.0
		Std. Residual	0.8	-0.9	-0.2	1.9	-0.7	-0.4	
	1	Count	2	10	9	0	8	3	32
		Expected Count	3.7	7.4	8.3	4.2	6.0	2.3	32.0
		Std. Residual	-0.9	0.9	0.2	-2.0	0.8	0.4	
Total		Count	8	16	18	9	13	5	69
		Expected Count	8.0	16.0	18.0	9.0	13.0	5.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.596(a)	5	0.027
Likelihood Ratio	16.118	5	0.007
Linear-by-Linear Association	0.187	1	0.666
N of Valid Cases	69		

a 6 cells (50.0%) have expected count less than 5.
The minimum expected count is 2.32.

Table 27n

Image 15

GENDER * RG058 Crosstabulation

			RG058						
			1	2	3	4	5	6	Total
GENDER	0	Count	4	8	4	15	3	3	37
		Expected Count	3.8	8.6	3.2	13.4	2.7	5.4	37.0
		Std. Residual	0.1	-0.2	0.4	0.4	0.2	-1.0	
	1	Count	3	8	2	10	2	7	32
		Expected Count	3.2	7.4	2.8	11.6	2.3	4.6	32.0
		Std. Residual	-0.1	0.2	-0.5	-0.5	-0.2	1.1	
Total		Count	7	16	6	25	5	10	69
		Expected Count	7.0	16.0	6.0	25.0	5.0	10.0	69.0

Chi-Square Tests

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.264(a)	5	0659
Likelihood Ratio	3.314	5	0652
Linear-by-Linear Association	0.559	1	0455
N of Valid Cases	69		

a 7 cells (58.3%) have expected count less than 5. The minimum expected count is 2.32.

APPENDIX H

SPSS OUTPUT OF PAIRED-SAMPLES T-TEST BY GENDER AND GRADE

Table 28

Paired Samples Statistics

		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	BOY34	36.8800	15	7.06543	1.82429
	BOY56	47.4667	15	10.98939	2.83745
Pair 2	GIRL34	37.9600	15	8.77861	2.26663
	GIRL56	42.3733	15	13.34442	3.44551
Pair 3	BOY34	36.8800	15	7.06543	1.82429
	GIRL34	37.9600	15	8.77861	2.26663
Pair 4	BOY34	36.8800	15	7.06543	1.82429
	GIRL56	42.3733	15	13.34442	3.44551
Pair 5	BOY56	47.4667	15	10.98939	2.83745
	GIRL34	37.9600	15	8.77861	2.26663
Pair 6	BOY56	47.4667	15	10.98939	2.83745
	GIRL56	42.3733	15	13.34442	3.44551

Table 29

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	BOY34 & BOY56	15	0.666	0.007
Pair 2	GIRL34 & GIRL56	15	0.601	0.018
Pair 3	BOY34 & GIRL34	15	0.738	0.002
Pair 4	BOY34 & GIRL56	15	0.380	0.162
Pair 5	BOY56 & GIRL34	15	0.289	0.296
Pair 6	BOY56 & GIRL56	15	0.104	0.713

Table 30

Paired Samples Test

		Paired Differences					*t*	*df*	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	BOY34 - BOY56	-10.5867	8.19816	2.11676	-15.1267	-6.0467	-5.001	14	0.000
Pair 2	GIRL34 - GIRL56	-4.4133	10.69719	2.76200	-10.3372	1.5106	-1.598	14	0.132
Pair 3	BOY34 - GIRL34	-1.0800	5.94957	1.53617	-4.3748	2.2148	-0.703	14	0.494
Pair 4	BOY34 - GIRL56	-5.4933	12.50214	3.22804	-12.4168	1.4301	-1.702	14	0.111
Pair 5	BOY56 - GIRL34	9.5067	11.91898	3.07747	2.9062	16.1072	3.089	14	0.008
Pair 6	BOY56 - GIRL56	5.0933	16.38455	4.23047	-3.9801	14.1668	1.204	14	0.249

APPENDIX I

RESULTS OF FISHER'S EXACT TEST

Table 31

2×2 Table of Yellow Color Selections by Gender

Image #	1		2		3		4		5	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
Yellow	4	0	15	12	6	3	14	18	4	3
Not Yellow	33	32	22	20	31	29	23	14	33	29

Image #	6		7		8		9		10	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
Yellow	13	4	6	3	3	2	7	12	13	11
Not Yellow	24	28	31	29	34	30	30	20	24	21

Image #	11		12		13		14		15	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
Yellow	1	1	5	5	12	10	9	0	15	10
Not Yellow	36	31	32	27	25	22	28	32	22	22

Results of Fisher's Exact Test
(Using online program at http://www.matforsk.no/ola/fisher.htm)

Image 1
TABLE = [4, 0, 33, 32]
Left: p-value = 1
Right: p-value = 0.07639667276266955
2-Tail: p-value = 0.1179929230851102

Image 2
TABLE = [15, 12, 22, 20]
Left: p-value = 0.6927839800447905
Right: p-value = 0.49624780973656224
2-Tail: p-value = 0.810335996874931

Image 3
TABLE = [6, 3, 31, 29]
Left: p-value = 0.8858976950326978
Right: p-value = 0.3175698621864173
2-Tail: p-value = 0.4887299592036881

Image 4
TABLE = [14, 18, 23, 14]
Left: p-value = 0.09887065357524717
Right: p-value = 0.9620631224667326
2-Tail: p-value = 0.15138425405242364

Image 5
TABLE = [4, 3, 33, 29]
Left: p-value = 0.7211101682224323
Right: p-value = 0.5825176337830473
2-Tail: p-value = 1

Image 6
TABLE = [13, 4, 24, 28]
Left: p-value = 0.9940711849697363
Right: p-value = 0.027406154488214582
2-Tail: p-value = 0.04843435613035485

Image 7
TABLE = [6, 3, 31, 29]
Left: p-value = 0.8858976950326978
Right: p-value = 0.3175698621864173
2-Tail: p-value = 0.4887299592036881

Image 8
TABLE = [3, 2, 34, 30]
Left: p-value = 0.773160648566233
Right: p-value = 0.5697601631105421
2-Tail: p-value = 1

Image 9
TABLE = [7, 12, 30, 20]
Left: p-value = 0.07307972762859116
Right: p-value = 0.9771798605779974
2-Tail: p-value = 0.10851315921737972

Image 10
TABLE = [13, 11, 24, 21]
Left: p-value = 0.624476840548917
Right: p-value = 0.5748811005136926
2-Tail: p-value = 1

Image 11
TABLE = [1, 1, 36, 31]
Left: p-value = 0.7161125319693052
Right: p-value = 0.7885763000852635
2-Tail: p-value = 1

Image 12
TABLE = [5 , 5 , 32 , 27]
Left   : p-value = 0.5349161588297251
Right : p-value = 0.7232333043920303
2-Tail : p-value = 1

Image 13
TABLE = [12, 10, 25, 22]
Left: p-value = 0.6410900023041316
Right: p-value = 0.561922834344632
2-Tail: p-value = 1

Image 14
TABLE = [9, 0, 28, 32]
Left: p-value = 1
Right: p-value = 0.002195148496783644
2-Tail: p-value = 0.002690080084438281

Image 15
TABLE = [15, 10, 22, 22]
Left: p-value = 0.8535802521827743
Right: p-value = 0.29198268891055607
2-Tail: p-value = 0.4612588973665558

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