Science in the Eyes of Preschool Children: Findings from an Innovative Research Tool

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Roger T. Johnson and Bhaskar Upadhyay, Co-Advisors

August, 2011

Acknowledgements

This work would not have been completed without the guidance, assistance, and support of a number of dear people, to whom I owe many thanks.

First, I would like to express my gratitude to my advisors, Dr. Roger Johnson and Dr. Bhaskar Upadhyay, for their guidance and mentoring throughout my doctoral program, for always being there with a wise advice and exceptional kindness. Thank you so much for supporting me and proving me with the opportunity to grow and develop my skills as an educator and researcher − I have learned a lot from your scholarship and experience. I would also like to thank you for encouraging me to pursue and study my keen interests. I am honored to have had you as my advisors.

I am also indebted to the other members of my committee, Dr. Kathleen Thomas and Dr. Frances Lawrenz, for the invaluable feedback and suggestions they provided from the early stages of the study and up to its analysis. I appreciate the time, ideas, and sharp thinking that you brought to this project.

I would also like to thank Dr. Gillian Roehrig for believing in the idea of the new instrument and supporting its development, and for her time, advices, and words encouragement amid her busy schedule.

This instrument would have stayed on the developer's desk without the work of two gifted programmers: Bjorn Pederson, who developed the skeletal instrument, and Yuichiro Tanabe, who made it come alive with beautiful animation. Special thanks to Shad Petosky, who was willing to invest in the then-unripe project.

I would like also to thank Barbara Murphy, Dr. LaVonne Carlson, Nancy Nelson, and Amanda Awend. These exceptional educators and scholars volunteered their time and valuable ideas, which helped shape the prototype of the instrument.

Many colleagues and friends supported me during the different stages of this research project. I would like to thank Dr. Allison Kirchhoff, Dr. Selcen Guzey, Dr. Brant Miller, and the graduate students Barb Billington, Mary Hoelscher, J McClelland, Younkyeong Nam, Hui Hui Wang, and James Nyachwaya. It was a pleasure being with such an inspiring group of science educators and researchers. Thank you, Jess Barnett, for your help with editing this manuscript.

And finally, I would like to thank my family: my supportive husband Roy, thank you for believing in me, encouraging me and keeping me on track. You are my compass! And to my children, Guy, Noa, and Ido (who also narrated the instructions like a professional) without your love, support, patience, and intelligent insights I could not have completed this research project. Following the words of the current president: You have absolutely earned the new dog that will join our family soon.

This research project was funded in part by a grant from the Department of Health and Human Services, Administration of Children and Families, Office of Head Start (#90YD0241-0), and by a grant from the Department of Curriculum & Instruction, University of Minnesota.

Dedication

This dissertation is dedicated to four dearest people: my father, Yonatan Dubossarsky, who did not live to see its completion, and my mother, Milcah Lamdan-Klein, as well as to my step-parents Rachel Dubossarsky and Eli Klein. The rich early childhood environment you created for me allowed me to be the researcher I am today. Thank you with all my heart.

Abstract

How do young children view science? Do these views reflect cultural stereotypes? When do these views develop?

These fundamental questions in the field of science education have rarely been studied with the population of **preschool children**. One main reason is the lack of an appropriate research instrument that addresses preschool children's developmental competencies. Extensive body of research has pointed at the significance of early childhood experiences in developing positive attitudes and interests toward learning in general and the learning of science in particular. Theoretical and empirical research suggests that stereotypical views of science may be replaced by authentic views following inquiry science experience. However, no preschool science intervention program could be designed without a reliable instrument that provides baseline information about preschool children's current views of science.

The current study presents preschool children's views of science as gathered from a pioneering research tool. This tool, in the form of a computer "game," does not require reading, writing, or expressive language skills and is operated by the children. The program engages children in several simple tasks involving picture recognition and yes/no answers in order to reveal their views about science.

The study was conducted with 120 preschool children in two phases and found that by the age of 4 years, participants possess an emergent concept of science. Gender and school differences were detected. Findings from this interdisciplinary study will

contribute to the fields of early childhood, science education, learning technologies, program evaluation, and early childhood curriculum development.

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Chapter One: Introduction

In the era of rapid changes in technological development, science education is an ever important field of study on two levels. First, it contributes to the growth and self-development of individual students by providing them with critical thinking and problem-solving skills. Second, it supports the development of a scientific literate society that values researchers and innovators. In his 2011 State of the Union Address, President Obama stated, “We need to teach our kids that it’s not just the winner of the Super Bowl who deserves to be celebrated, but the winner of the science fair.”

As hinted at in the President’s quote, science education carries some unfavorable stereotypes. Science is often stereotyped as a difficult, lonely, and masculine subject, which may make it seem inaccessible for some of the population. Researchers have found versions of these stereotypes with populations as young as elementary students and suggest that these impressions form during the early years. Collins, Riess, and Simon (2006) reviewed nearly 200 studies on young people’s attitudes toward science education and concluded that “young people develop stereotypical images of science and scientists from an early age and these images are resistant to change” (p. 2).

These stereotypical views of science might contribute to the decline in positive attitudes toward and interest in science education toward the end of elementary school (Osborne, 2003; Piburn, & Baker, 1993). Trends of gender differences with regard to science have been traced to early grades (Andre, Whigham, Hendrickson & Chambers, 1999; Barman, 1999; Coulson, 1991; Pell & Jarvis 2001). Additionally, research shows that early conceptions tend to stick for many years (Eshach, 2006).

In contrast, research suggests that experience with inquiry science may reduce biased views of science and gender differences in "liking science" (Patrick, Mantzicopoulos & Samarapungava, 2009; Zoldosova & Prokop, 2006).

Young children are natural scientists. Starting in early infancy, the young child acquires and organizes information, forms categories, and constructs mental representation and naïve theories to explain the world (French, 2004; Gelman, 1999; Inagaki & Hanato, 2006; Venville, 2008). Hence, science fits naturally in the early childhood education setting, drawing on young children's innate curiosity and tendency toward meaning making (Eshach, 2006; French, 2004). Early exposure of young children to science may help them develop a sound concept of science, based on firsthand interactions, which may prevent the child from acquiring biased views on science.

Correspondingly, Eshach (2006) lists six reasons for exposing young children to science:

1. Children naturally enjoy observing and thinking about nature.
2. Exposing children to science develops positive attitudes toward science.
3. Early exposure to scientific phenomena leads to better understanding of the scientific concepts studied later in a formal way.
4. The use of scientifically informed language at an early age influences the eventual development of scientific concepts.
5. Children can understand scientific concepts and reason scientifically.
6. Science is an efficient means for developing scientific thinking.

In a forum on early childhood science, mathematics, and technology education organized by the American Association for the Advancement of Science's (AAAS) Project 2061, early childhood educators, scholars, researchers, and policy makers from an array of disciplines emphasized the significance of the early childhood years in the course of development and learning (Johnson, 1999). With the understating that there is not a good synthesis of research on early childhood education in relation to science, the AAAS Project 2061 joined the call for investments in research in the field of early childhood science, mathematics, and technology (Champion, 1999).

Unfortunately, lack of research on science education and developing perceptions toward science during early childhood prevents us from tracing the formation of science views in general, and the formation of differences in subgroups' science views in particular. Research in the field of early childhood science education, especially with children under the age of 6, is limited in scope and volume (Fleer & Hardy, 1993; Zembylas, 2008). One major reason for the lack of research is the characteristics of the early childhood population. Specifically, young children have limited expressive language, and only partially developed reading, writing, and drawing skills. In addition, young children have a short attention span and may not fully engage in the task or provide reliable answers (Coulson, 1991; Fleer & Hardy, 1993; Fritzley & Lee, 2003; Harter & Pike, 1984). Additionally, difficulties in methodology design for studying young children, researchers' expertise, and preconceptions about young children's capabilities also contribute to the lacuna in early childhood science education research (Fleer & Hardy, 1993; Charlton, 2003; Metz, 1995; Ravanis & Bagakis 1998).

There is a clear need for more research focusing on science education during the early years and for the development of age-appropriate research tools that will enable such research.

Research Purpose and Goals

The current research is designed to study an understudied population in the field of science education: preschool children. With the understanding that the first years of life represent a period of concept and attitude formation and that early experiences are strongly associated with future learning, the current study seeks to learn about preschool children's views of science. The study aims at answering the following research questions:

1. Do preschool children possess views about science?
2. What do preschool children perceive as science?
3. Are there differences between the perception of science among subgroups (gender, age, preschool location)?

A secondary goal of the study is to develop a developmentally appropriate computer-based research instrument in order to answer the research questions.

Definitions and Disclaimer

The current study is intended to examine children's views of science. The term *view*, in this context, includes both conceptions and beliefs. In other words, this study explores how young children conceptualize science and what they believe (especially regarding gender) about the concept of science. No affective components (such as feelings, attitudes, or interests) were assessed in this study.

The term *non-science* (NS) is used in chapters 3, 4, and 5 to label images that are not considered science in the realm of the stereotypical views of science held by older students (images such as toy truck, doll, pizza). It must be noted that the author, being a science educator, believes that every item and image could be connected to science or portray a scientific principle. The label of such images as non-science is done with the purpose of differentiating them from the experimental images of science in the context of the study.

Potential Significance of the Study

Due to the scarcity of research in the field of science education focusing on early childhood, the results of this exploratory study will add to the body of knowledge about preschool children's views of science. The study also provides a framework for studying young children, which links together research from the fields of child psychology and child development with learning theories and science education inquiries. The findings of the current study show that the majority of preschool children studied have an emerging concept of science with some subgroup differences; these results could be used for developing early childhood science education programs and interventions. Finally, this study presents a research tool that could be used for future early childhood studies. Due to the multiple limitations of studying preschool children, the developed instrument could help expand science education research into the domain of early childhood and provide more discipline-specific data on this significant period.

Overview of the Following Chapters

Chapter Two ties together literature review of several disciplines to provide a coherent theoretical foundation for this interdisciplinary study. Cognitive development research, learning theories, and science education during early childhood literature are reviewed and integrated to illustrate the factors affecting young children's views about science. Chapter Two also provides a review of research methods employed to study young children's views and affect toward science. Lastly, the chapter ends with a review of instrument development models.

Chapter Three describes the methodology and research design of the current study. It provides the steps taken in developing the computer-based instrument for studying preschoolers' views of science, as well as detailed description of the instrument's tasks and items. Chapter Three reports the findings from a pilot study conducted with 30 preschoolers and the revisions that were taken following the pilot study.

Chapter Four presents the findings of the study. The chapter opens with the methods used for data analysis, followed by statistical analysis of the data. A whole study analysis is followed by an analysis of each set of the picture task, concluding with a visual representation of participants' views of science. The chapter ends with an analysis of the movie task.

Chapter Five provides a discussion of the results, implications, and new questions for possible follow-up studies derived from the current study. Chapter Five also discusses the limitations of the current study as well as alternative explanations for the findings.

Chapter Two: Review of the Literature

Chapter Two reviews the relevant literature regarding early childhood science education. The chapter draws on research from several disciplines in order to create a coherent theoretical and empirical background to support the current research. Literature regarding the interdisciplinary topic of science views' formation during early childhood was found in the disciplines of child and cognitive development, educational psychology, and science education.

The chapter opens with the theoretical framework that guided the design and development of the current study and continues with a review of the literature on the significance of early childhood years, review of the fundamental steps in the process of concept development, and research findings on young children's views of science. The chapter ends with a review of the research methods used to study young children's science views and several models for instrument design.

Theoretical Framework

This study is theoretically framed by two complimentary bodies of research portraying the way young children construct mental representations and acquire new concepts. The first, theory of scripts, comes from the field of child psychology and suggests ways to explain how young children learn from repeating events. The second theoretical support comes from the work of Davis Ausubel and his extensive work on meaningful learning and knowledge construction. Both theories contribute to the understanding of how children conceptualize and develop views about science.

Scripts

Scripts are defined as generalized event representations, mental structures that describe an appropriate sequence of events in a particular context (Nelson & Gruendel, 1981). As they observe the world, children (as well as adults) develop scripts of the events surrounding them that enable them to organize their experiences and predict future events based on the script. A script, like a simple theory, is an organized, interconnected, and dynamic structure of plausible possibilities (slots). Filling one of the slots with content affects the content of another slot, as well as the whole structure. Scripts enable people to infer and interpret events and statements and predict the probable sequence of events to guide decision making. The dynamic nature of a script allows children to understand, process, and predict events and event-related information (Levy & Fivush, 1993).

Nelson and Gruendel (1981) portray scripts as:

1. Temporal and causal sequences of actions
2. General schemas or frames containing variable elements that can be inserted in appropriate contexts

Scripts are also context-based. A specific situation in a school setting may develop differently than it would in the home setting. Repeated experiences lead to well-known scripts. The more experience children have with specific situations, the more robust their scripts are and the better they can predict what will happen next. Nelson and Gruendel (1981) report that when children operate in a familiar, well-understood context, they appear more competent: "The context to which the young child is bound, would not be the immediate situation but cognitive representations of familiar situations, that is – available scripts" (p. 132).

Hudson and Nelson (1983) studied young children's recall of events based on familiar and unfamiliar situations. They found that children recalled more details from a story when the context was familiar. The researchers suggest that a script of familiar events (birthday party) helped the children recall better. Since many young children already possess scripts for birthday parties (e.g. a celebration for a child where a cake is served and presents are given), they were able to remember the details of the story by inserting the details into a well-constructed structure. In contrast, when listening to a story that presents a less familiar situation (baking cookies) that does not follow a well-established script, the "storage" of details in memory is less efficient and children have a harder time recalling those details. The researchers add that, with age and experience, children are better able to predict future events based on their scripts.

French (2004) connects the theory of script formation to the realm of science activities in preschool classrooms. According to French (2004), science activities such as mixing primary colors, creating shadows, trying to make a piece of clay float, or watching an earthworm crawl through dirt constitute "events" for the young child.

> During their first exposure to one of these events, children may simply be interested and perhaps surprised. During the second exposure, they are creating a richer representation of similarities and differences across the two experiences. After several exposures, they have created a generalized understanding of that particular aspect of "how the world works" in that particular situation and freely make predictions about "what will happen next" or "what will happen if . . . ." (p. 140).

Some scripts are not gender-neutral and may carry a gender bias about the performer of the activity; such scripts are labeled gender scripts. Gender scripts are defined as organized event sequences that possess a gender role stereotype component, such as the gender of the performer of the sequence of events (Levy & Fivush, 1993). Different scripts may be created for the event of dinner, depending on the performer's gender; a child may have alternative scripts for the sequence of events performed by his mother during dinner from those of his father. If a child experiences dinner at different houses (friend's house, grandma, etc.) or through books or movies, and every time it is the female who prepares dinner, a gendered script may form. Even young preschool children (particularly boys) possess gender scripts about familiar events, and were observed to have greater and more elaborated knowledge on own-gender information (Levy & Fivush, 1993).

Gender scripts may carry special consequences for conceptualizing science. Young children may experience gender bias with regard to science (via media, books, or different treatment of a parent or teacher to boys and girls with regard to science experiences) and form a stereotyped gender script that includes or excludes their own gender. As scripts and gender scripts are context-related, young children may conceptualize science as being a masculine subject from a very early age.

Meaningful Learning and Concept Formation

David Ausubel's (1968) learning theory complements the script theory as it focuses mainly on conceptual learning. In other words, it describes the learning of more abstract concepts such as science. Ausubel's theory of meaningful learning portrays knowledge construction as a modification of previous mental representation. As children grow and develop, sensual and cognitive inputs are translated into cognitive, conceptual structures. With experience, these units (labeled “subsumers” by Ausubel) expand, are revised, and form connections with other subsumers. Cognitive structures, therefore, are dynamic and keep changing based on everyday experience and interactions. Meaningful learning, according to Ausubel, is learning that builds on the current cognitive structure of the learner and modifies it. In his words: “The most important single factor influencing learning is what the learner already knows” (p. vi). Acquiring new information without connecting it to the learner’s cognitive structure (as in rote memorization) will result in loss of the new information.

Novak (1993) summarizes the three key principles for meaningful learning according to Ausubel:

> First, the material to be learned must itself have potential meaning (an arbitrary list of words does not account as meaningful). Secondly, the learner must possess relevant concepts and propositions that can serve to anchor the new learning and assimilate new ideas. Thirdly, the learner must choose to relate the new information to his/her cognitive structure in a non-verbatim, substantive fashion (p. 4).

The third condition is extremely significant to the field of science in light of the recognized stereotype regarding science as masculine, difficult, and lonely. Stereotypical images of science, which are not contradicted by engaging scientific experience, may cause the learner to choose **not to relate** the new information to a current cognitive structure.

The two theoretical works presented above guide our understanding of the development of science views by young children. Science, from preschoolers' point of view, is both an abstract concept (Ausubel's theory) and an active set of activities (script theory). According to these theories, young children develop a mental representation of science only after exposure to the subject. Science exposure may be explicit (direct), as in a labeled science activity in preschool or at the science museum, or implicit (indirect), as in hearing an older sibling say that science is difficult. Different types of media have also been found to implicitly affect children's views of science (Driver, Leach, Millar & Scott, 1996; Jane, Fleer & Gipps, 2007; Schibeci & Sorensen, 1983). The presented theoretical framework stresses the importance of personal experience in forming mental representations. With experience, the mental representation of the concept or event is being refined and allows better predictions. When studying the formation of science views, as well as the formation of stereotypical views of science, one must consider that repeated experience with science must be in place in order for such views to develop.

Therefore, it is hypothesized that young children with limited exposure to science might have limited views about science and its constructs. On the other hand, the views of science held by children with rich science experience may be more elaborated and less stereotypical.

Significance of the Early Childhood Years

The early years are regarded as a significant period in the development of young children. Since the current study targets the population of preschool children, this section reviews research that provides support for the opening assertion. The supporting research comes from child-development studies, science education studies, and studies in economics. It concludes with a call for early science education interventions.

The first five years of life carry enormous significance in the child's cognitive and emotional development. During this time, the child forms the foundation for future and more abstract learning. Young infants gather information about faces, sounds, language, and events around them (Bowman, Donovan & Burns, 2001). Young children use the information to construct categories, concepts, and theories (Gelman, 1999; French, 2004). Karmiloff-Smith and Inhelder (1974) studied the way young children develop a theory about balance. They provided children with a set of blocks that differed with their weight and geometrical shape and asked them to balance the blocks. The children were observed to form a theory that allowed them to balance the blocks. When they were given some "tricky" blocks with hidden weights, the children had to revise their strategies and expand the theory to include the irregular blocks. Karmiloff-Smith and Inhelder liken their findings to language acquisition and development. When learning a language, young children use irregular words (like *feet* and *went*) in the correct form until they grasp the rule of plural or past tense. Then, they are observed making the expanding the grammatical rule to say "foots" and "goed." These mistakes continue until the child recognizes that there are exceptions to the rule.

As opposed to what was previously suggested by Piaget's stages theory (Inhelder & Piaget, 1958), children's learning and cognitive development may not be defined only by firm stages, but rather may follow a gradual and continuous course (Metz, 1995; Bowman et al., 2001). Learning, including the development of theories and strategies, is deeply rooted in the child's environment and interactions (Bowman et al., 2001; French, 2004; Novak, 1977; Roggof, 2003). Context and experience affect the level of cognitive complexity children employ. According to the theoretical framework, young children develop scripts or mental representations or theories of familiar experiences (such as birthday parties), which help them learn, recall, and make inferences about future or hypothetical events (Hudson & Nelson, 1983; Nelson & Gruendel, 1981). Gobbo and Chi (1986) report on the differences between experts and novice young children's analysis of dinosaurs. Dinosaur-expert children demonstrated higher cognitive abilities, focusing on "deep-level" (abstract) concepts, compared to their novice peers, who focused on basic level concepts. The dinosaur experts were able to classify dinosaurs by multiple criteria, connect multiple concepts, and make inferences regarding an unfamiliar dinosaur. Thus, experience plays a significant role in learning in general and learning science in particular.

Consequently, children who grow up in a rich environment with multiple opportunities for interactions with adults and other children have a wider and more complex cognitive structure than children who grow up in less rich environments or have fewer interactions with experienced caregivers. Johnson (1973) studied kindergarten students' categorization skills. He found that high-socio-economic-status (SES) kindergarteners perform better on the categorization task than low-SES kindergarteners.

Johnson noted that the SES difference go beyond “basic skills” in reading, language arts, and other school tasks.

A large body of research shows that cognitive and skill gaps between disadvantaged and advantaged children open early in life, prior to the beginning of school (Heckman & Masterov, 2007). The authors report that early high quality interventions targeting disadvantaged children were found to reduce crimes, promote high school graduation and college attendance, reduce grade repetition and special education costs, and help prevent teenage births. Similarly, it was found that children from disadvantaged families gained long-lasting benefits from interventions programs in school competence, development of cognitive skills, attitudes, and impact on families (Consortium for Longitudinal Studies, 1983). Reynolds, Temple, Robertson, and Mann (2001) presented the long-term effects of early childhood intervention on school achievement and juvenile arrest rates; children had substantially fewer arrests, class retention, lower special education placement, and lower high school dropout rates than their peers who did not enroll in high-quality child care centers and whose parents did not enroll in parents’ education programs. The authors report that these gains were detected even 20 years after the intervention.

Cost-benefit analyses of these programs reported in the literature show that they are cost-effective. Estimated rates of return are between 16% and 4% for participants and 12% for society at large (Heckman & Masterov, 2007; see Figure 1).

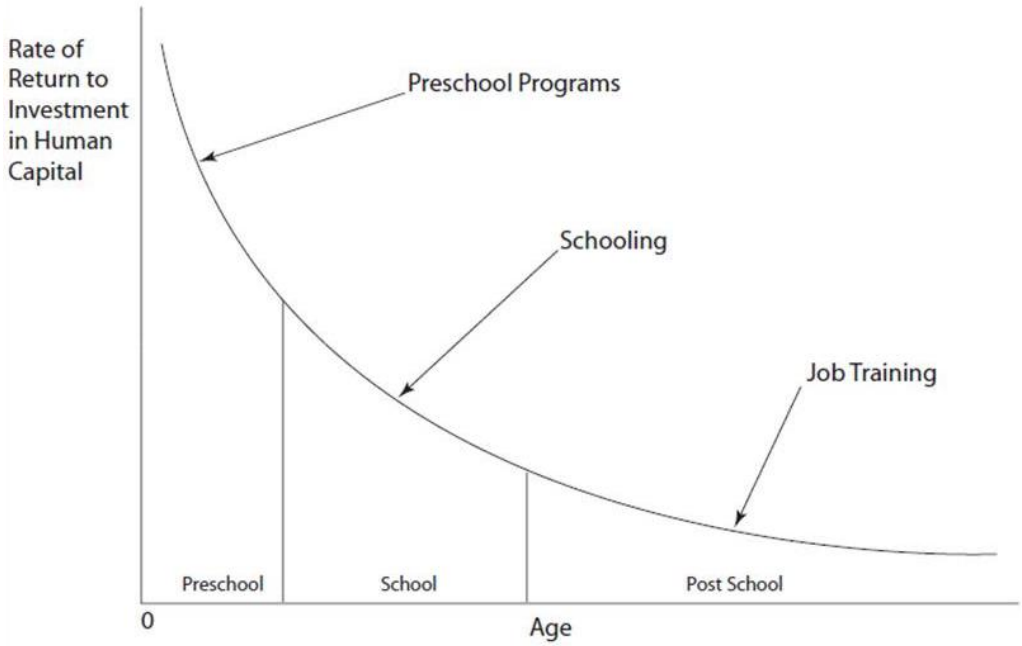


Figure 1. Heckman & Masterov's (2007) rates of return to human capital investment in disadvantaged children

This section highlights the significance of the early years of life. This is the time of concepts and early theories' formation. A high-quality and positive experience with science during the early years may lead to long-lasting effects on children's future views of science and form a foundation for future science learning. Investment in early childhood science education interventions (such as research, curricula, and professional development programs) is highly desired, as research shows that it is better to prevent gaps from widening during the critical period of early childhood than to intervene to close the gaps at an older age.

Concept Development

Studying preschool children's views about science requires a review of research focused on the topic of concept development. This section will review the literature about the formation of concrete and abstract concepts, word learning, children's ability to distinguish animate from inanimate objects, theories about the course of concept development, and the cultural aspect of cognitive development.

Concepts are defined as small units of thought or mental representation that may be embodied by a single word, such as *object, animal, alive, heat,* or *weight* (Carey, 2000, 2004), and provide an efficient way of organizing experience (Gelman, 1999). Information is stored and organized based on cues, even before the child understands the meaning of it (Gelman, 1990). According to Gelman and Medin (1993), concepts are multidimensional and open to restructuring, and conceptual development "involves the interactive influences of perception, language, and conceptual knowledge" (p. 158).

Concepts can be divided into three categories:

1. Concrete concepts – basic-level concepts that represent objects that can be touched or held, such as trucks or apples. Subordinate concepts, such as a Dodge truck or Gala apple, are also defined as concrete concepts.

2. Semi-concrete concepts – concepts that stand for something that can be represented, but not held, such as "green" or "under."

3. Abstract concepts (also categorized as superordinate-level concepts) – concepts that represent an idea, a feeling, a theory, or such; for example, happiness or science.

Word Learning

Since concepts are represented by words, the mechanism of learning new concepts can be illustrated by how children learn new words. When young children learn a new word, how do they know what the new word refers to? For example, when a toddler is presented with the word *dog*, does this word mean the whole animal, the tail, the position of the dog? There are limitless possibilities. Markman (1990) suggests that word learning is guided by three assumptions that limit these possibilities and make word learning easier. The first is the "whole object" assumption, which states that a novel word refers to the whole object; the second is the taxonomy assumption, meaning that when asked to find "another dax," the child assumes that "dax" refers to the superordinate, abstract class of the given object. Markman has found that even children as young as 18 months show taxonomy bias. The third assumption is mutual exclusivity, meaning one word per one object, and therefore if a new word is presented to a familiar object, the learner assumes that the new word represents a part or a substance of the object.

Abstract Concepts

Many objects or concepts can be classified into several different categories. A "pickle" is food, is also sour, is of course a cucumber, and is also a fruit. There are also different ways for classifying objects. Objects can be classified thematically (pickle and jar), idiosyncratically (pickle and the Minnesota state fair), and taxonomically (pickle and apple). When asked to classify objects, preschool children tend to classify based on thematic or idiosyncratic relations, while adults classify taxonomically. Are young children capable of classifying taxonomically? Are they aware of more abstract-level concepts such as food, vehicles, or animals? Many researchers set up to test these questions, with the assumption that if children are able to classify taxonomically, they are capable of learning abstract concepts.

Markman and Hutchinson (1984) presented a picture of an object (dog) with two other pictures (dog food, cat). When asked to "find another one," children chose the dog food (thematically related), but when asked to "find another *dax*," they pointed at the cat (taxonomically related). The researchers concluded that children code a novel word as relating to the superordinate category, or the whole, general object. The researchers concluded that there is a taxonomy bias in word learning, evident at the basic level for ages 2−3 years and at the superordinate level for ages 4−5 years. In other words, when children hear a new word labeling an object, they assume that the word describes the whole object or the higher taxonomy level, and not a part of the object.

In an attempt to replicate and clarify Markman and Hutchinson's (1984) findings, Waxman and Gelman (1986) conducted a series of classification studies in which preschool children, ages 3 and 4 years, were asked to classify pictures of familiar and unfamiliar objects by choosing whether to give them to a puppet that likes only one category of objects (such as animals or furniture). Some children received a label cue (this puppet likes only animals), other children got instances cue (this puppet likes pictures like horse, dog, or duck) and another group of children saw some example pictures (this puppet likes only picture like these) but did not receive any verbal hint. The researchers found that 4-year-old children performed well and successfully classified the pictures based on taxonomy regardless of the cues they got. In contrast, younger children

(3 years) were able to classify by taxonomy only when given a label cue even when the label word was given in a foreign language unfamiliar to the children (!). The researchers concluded that a labeled category suggests taxonomy classifications.

Perez-Granados and Callanan (1997) suggest that when young children are given specific instructions regarding the generality of the category requested, they are more likely to show evidence of understanding the superordinate level of categorization. Hence, children are able to categorize at an abstract level, but need clear instructions about the level of categorization.

Animate-Inanimate Distinction

From a very young age, infants and preschool children are able to distinguish animate and inanimate objects, regardless if they are real objects, pictures, or other replicas (Carey, 2000; Gelman, 1990; Simons & Keil, 1994). By age 3 years, children have learned to recognize enough characteristics of animacy that they are able to identify unfamiliar animals as self-moving entities (Gelman, 1990; Massey & Gelman, 1988). Gelman and colleagues claim that young children are capable of conceptualizing animacy at the higher level of taxonomy, but use this knowledge based on the questions or tasks they are asked to perform. For example, when asked to group similar objects together, participantss grouped them based on surface characteristics and put a picture of a person and a figurine together; however, when asked to group objects that can climb a hill, they grouped together pictures of a person and a lizard since they both are capable of self-movement (Massey & Gelman, 1988).

Gelman (1990) claims that the distinction between animate and inanimate objects helps young children make predictions about the objects' self-movement capabilities as well as objects' inside and outside characteristics. Although they had probably never seen or learned about the inside of an elephant, preschool children were able to project their knowledge about the inside of humans (bones, blood) to elephants. In contrast, when asked about the inside structure of inanimate objects (rock, ball, doll, puppet), the children claimed that there was "nothing" inside or provided the type of material they thought the object was made of. The clear distinction between preschoolers' replies about the "insides" of the two groups led Gelman (1990) to conclude that young children have a general concept for animate and inanimate objects. The divider between these two groups, according to Gelman, is not the ability to grow, but rather the ability for self-movement: "A theory of action may distinguish between animate and inanimate objects. It will not however, distinguish between living and nonliving" (p. 102).

Gelman and Wellman's (1991) findings support this conclusion. Their studies about preschoolers' views of the inside of objects led them to conclude that "by age 4 years children assume that members of a particular category are likely to have the same internal parts and substance as one another, claiming for example that all dogs have 'the same kinds of stuff inside'" (p. 217). Following a series of studies about the "insides and essences" of objects, Gelman and Wellman (1991) proposed that there is an essentialistic disposition that affects knowledge acquisition early in children's development.

Innate Categories

Some researchers suggest that infants possess some innate, prime concepts that are used as a foundation for more developed concepts (Carey, 2004; Gelman, 1990; Inagaki & Hanato, 2006). Gelman (1990) and Carey (2004) propose that the concepts of quantities and magnitude are examples of primary concepts, as well as the distinction between animate and inanimate objects. Inagaki and Hanato (2006) suggest that from a very early age, children acquire an initial theory of biology, naïve biology, which helps them better understand their environment. These researchers propose that such "naïve biology" relies on two major components: the knowledge needed to identify biological entities and phenomena, and vitalistic causality.

Carey (2004) claims that the human brain has an "ability to learn sets of symbols and the relations among them directly, independently of any meaning assigned to them in terms of antecedently interpreted mental representations. These external symbols then serve as placeholders, to be filled in with richer and richer meanings" (p. 66). In her explanation about the formation of concepts, Carey (2004) argues that infants are born with some innate mechanism, early conceptions of quantity and magnitude, which form the foundation for the more cultural and language-based number concept.

Simons and Keil (1994) claim that the course of categorization development related to biology may not go from concrete to abstract, but rather the opposite way. For example, infants were able to discriminate animals from vehicles before they were able to categorize basic-level kinds like dogs or fish. In four studies conducted by Simons and Keil (1994), children were able to distinguish between animate and inanimate "insides" without knowing what these insides are. The shift from the initial, innate tendencies to more elaborate concept-system is suggested to be mediated by language.

In summary, Gelman's (1999) four key themes about early conceptions are presented: (a) Research has shown that children's early concepts are not restricted to being concrete or perceptually based; young children are capable of forming abstract concepts from an early age; (b) Children's concepts are multileveled and differ across content areas, tasks, and individuals; (c) Early concepts serve as the foundation for reasoning and, as such, reflect children's emerging theories about the world; And finally, (d) according to some evidence, children are born with innate categories, a concept of quantity, and perhaps "naïve biology" that helps them acquire, organize, and construct new knowledge in a rapid manner and to the mold of their language and culture.

Therefore, asking preschool children to classify images based on their belonging to the superordinate category of "science" is an age-appropriate activity that children ages 4 and 5 years should be able to complete. As science is a man-made word and concept, it is not assumed that children have any innate concept of science, but rather something that they learn as they grow.

The Effect of Culture on Cognitive Development

The discussion about cognitive and concept development is not complete without considering the cultural aspect, the context in which development takes place. In her book *The Cultural Nature of Human Development*, Barbara Rogoff (2003) claims that culture, language, and traditions affect cognitive development and ways of learning (such as where the learner should focus attention). Rogoff (2003) claims that a large percentage of the research focused at human development has been blind to cultural aspects of development and functioning. Rogoff also challenges the “deficit” view, according to which children from minority cultures “lack” some key practices of knowledge. She claims that children from different cultures are not more or less “developed” but rather developed differently, as each culture and community values and stresses different behaviors and cognitive objectives, and call researchers to appreciate this diversity rather than aim for studying unity. Rogoff asserts that indigenous-heritage children are more often engaged in observing and collaborating during ongoing events than are middle-class European-American children. This behavior may affect concept formation, making these children mediated less by language and more by observation of adults performing work.

Fleer and Robbins (2003) adopt Rogoff’s (1998) three-plane analysis to analyze early childhood science education. They assert that just as cognitive development does not happen in a vacuum space, so doesn’t science learning. Science learning happens within three contexts: the personal, individual, student level; the classroom – interactions with the teacher and other students; and cultural or institutional context. Fleer and Robbins call on science education researchers who study young children to design and conduct research with all three lenses in mind.

Young Children’s Views of Science

Despite the relatively few studies focusing on young children’s views about science, the available studies provide us with a coherent picture about these views.

Young children's perspectives on science are quite complex. As children grow and get more exposure to science (either explicitly or implicitly), their mental representation of science grows and expands. As it is challenging to study all the elements included under the concept of science in any one study, researchers have been focusing on studying a variety of elements (e.g., attitudes, beliefs, motivation, interests, conceptualization, etc.). It is important, however, to recognize that the mental representation of science is dynamic and complex. The elements are interconnected and multileveled. A child may enjoy and like science but does not aspire to be a scientist, an instance labeled the *doing-being distinction* by Archer et al. (2010). Another child may be familiar with a real scientist, and still recognize the public stereotype about scientists. Children are also capable of differentiating reality from hypothetical situation with regard to science and scientists (Boylan et al., 1992). For example, Boylan et al. (1992) note that "even though [participants] thought that males were more likely to be involved in science, they saw no inherent reason why females could not be scientists" (p. 474).

This section reviews research conducted to study variable elements of young children's science views, and presents the findings related to attitudes, conceptions, stereotypes and gender beliefs held by children.

Children's Attitudes and Concepts of Science

Overall, the reviewed research has shown that young children enjoy science. The combination of hands-on activities and freedom to explore leads to the development of positive views and enthusiasm about science by young children (Andre et al., 1999; Greenfield, 1997; Pell & Jarvis, 2001; Perrodin, 1966). However, as children grow and progress in school, their positive attitudes toward science decline (Archer et al., 2010; Osborne, 2003; Piburn & Baker, 1993).

The way students conceptualize science also changes with age. When asked about science, elementary school students often associate science with school experiences (Driver, Leach, Millar & Scott, 1996; Stein & McRobbie, 1997). They also associate science with danger and explosions, mostly reflecting on chemical science, although at the same time reflecting on school science as being “safe” (Archer et al., 2010). As students grow, their concepts of science become more complex and multidimensional (Boylan et al., 1992; She, 1998). For example, Boylan et al. provide two replies for the question whether science teachers are scientists. A third grader’s answer was “No, they are teachers,” while an eighth grader replied, “They don’t do science; they teach it.”

Stein and McRobbie (1997) tested students’ conceptions of science across the years of schooling. Students from grades 4, 7, 9, and 11 were engaged in free-writing sessions, answering the question “what is science?” The authors analyzed the assays and found six categories that repeated in children’s replies:

1. *Category 1: Science Is What Is Done or Learnt at School*
2. *Category 2: Science Is a Consumable Product* (e.g., making, inventing, or creating practical and useful items, applications, and cures)
3. *Category 3: Science Is a Study of the World*
4. *Category 4: Science Is a Process*
5. *Category 5: Science Is Dynamic Knowledge*

6. *Category 6: Science Is Influenced by the Social Context*

The categories also show development through age, with the most abstract categories, 5 and 6, mostly mentioned by the older students. Fourth graders contributed mostly to the first and fourth categories, which are closely related to their school experience. Some examples of their comments include:

- "Science is a fun activity that is sometimes dangerous."
- "Science is physics, chemistry, experiments, biology, electronics, chemicals, magnetism, questions, insects, plants, microscopes, testing."
- "Science means experimenting."
- "In a science laboratory they test out liquids that may be poisonous or have unusual chemicals in it."
- "Science is something that scientists have invented; for instance, telephones, lights, typewriters, and lots of other things."

The data gathered from these studies support the theories presented under the theoretical framework section. As children grow and gain more experience with science, their views of science expand and become more complex. They are able to distinguish school science from a general form of science. Thus, we can hypothesize that even young, preschool-aged children, who are the target of this research, will have a simplistic form of science views, assuming they have been exposed to science in some way.

Science Stereotypes

Commonly held public beliefs see science as a difficult, boring, dangerous, and male-ruled domain. Additionally, science is often portrayed as chemical science, dealing with chemical reactions, "potions," and explosions. A review of studies conducted with young children shows that some of these views have been adopted, or at least acknowledged, by young students.

Driver et al. (1996) claim that students of primary age have limited and often stereotyped views regarding science and scientists. The researchers suggest that these ideas may come from exposure to cultural media (films, television, cartoons, comics) and from implicit and explicit messages in school science. Farenga and Joyce (1999) found that science-related stereotypical patterns are in place prior to age 9.

Collins, Reiss and Simon (2006) also conclude that young people develop stereotypical images of science from an early age. These images of science and scientists develop as a result of visual and verbal images from film, television, fiction, and textbooks and are remarkably resistant to change (Schibeci & Sorensen, 1983). Jane, Fleer, and Gipps (2007), studying elementary school children's views of science and scientists, report that children use examples from television as resource for their replies.

A large body of research tested children's stereotypes of science and scientists using the Draw-A-Scientist-Test (DAST). The DAST research provides ample evidence of the way children (as well as college students and teachers) portray science and scientists. The image of scientists that comes out of DAST studies presents scientists as old men, with a lab coat and glasses, usually bald or bearded, working in a laboratory and surrounded with chemicals. These findings were first revealed by Mead and Metreaux (1957), in a study conducted with 35,000 high school students asking them to write essays describing their image of a scientist. In a thorough review of DAST studies, Finson (2002) determine that stereotypical perceptions are persistent: "Since the Mead and Metreaux (1957) study, the same basic elements comprising the stereotypical image have been revealed time and again in student and adult drawings" (p. 341).

However, several researchers (for example, Symington & Spurling, 1990) critique the DAST method, claiming that the drawings produced by participants reflect their knowledge of public stereotypes of scientists rather than what they actually know about scientists.

Indeed, a study by Boylan et al. (1992) suggests that students' views of science (and scientists) are more complex than expressed by a single drawing. Although participants in the study chose pictures that reflect the public stereotype about scientists, their explanations show that they are well aware of the difference between hypothetical and realistic views. At the time of the study, Malaysia (the location of the study) had more men than women scientists; however students were aware that women, too, can be scientists. This study also showed that stereotypes are evident in both eastern and western countries.

The theoretical framework of this study ties the stereotyping of science with the lack of experience. According to Ausubel, meaningful learning results in interaction of the new knowledge with the present concept, assimilation, and "subsumption" of the new acquired information and revision of the cognitive structure based on the new information (Novak, 1977). Thus, students who hold stereotypical views about science most likely revise those science views (conceptualization of science) following a meaningful learning experience. Such examples can be found in the following section on gender.

Gender Differences

Interestingly, gender seemed to be the thread going through all elements of science views. Almost every science views study reviewed reported on some gender differences with regard to science. Science-related gender differences are evident from a very young age and seem to increase as children get older. Coulson (1991) found differences in 4-to-5-year-old boys' and girls' science activity preference, with girls preferring biological activities and boys preferring physical science activities.

The trend of diverging interests based on gender is evident in many studies conducted with elementary school students. Farenga and Joyce (1999) reported that gender differences in school subjects begin as early as kindergarten. The researchers asked elementary school students to choose subjects that they would like to learn in school (from a given list) as well as subjects that they think would be interesting for a friend of the opposite gender (using the same list). They found that science subjects (math, physics, and chemistry) were perceived as masculine while biology was considered a feminine subject. In their study, girls preferred life science courses, while boys preferred physical science. Ormerod and Wood (1983) employed three different methods to study fifth grade students' science interests. They found a clear gender diversion in science interests, on each one of the instruments, with girls favoring natural themes and boys showing a preference toward physical science/space themes. Similar results were found by many other researchers (Baker & Leary, 1995; Collins, Reiss & Simon, 2006; Jones, Howe & Rua, 2000; Rennie & Parker, 1987; Zoldosova & Prokop, 2006).

Gender differences were also found in the out-of-school experience of elementary school students. Farenga and Joyce (1997) examined 400 fourth-through-sixth-grade students' out-of-school experience. The researchers reported that boys had more out-of-school activities related to physical science, while girls had more experience with natural science. Additionally, male students were much more engaged in out-of-school science activities than female students. Similar results were found by Greenfield (1997). The researchers determined that due to the extra science activities, boys have a stronger science foundation, to which male students can apply the scientific knowledge from the school science curriculum. They suggest that girls' insufficient out-of-school science experience may contribute to their struggle with school science.

Gender differences in early childhood are intertwined with and may be affected by the public stereotype about gender roles in science. Greenfield (1997) observed that teachers of lower elementary grades provide more attention to boys than girls during science classes and activities. In a study about beliefs, affect, and stereotypes regarding school science, Andre et al. (1999) studied elementary school students and their parents. The researchers found that parents perceive boys as more competent in science, including parents of the early-grade students (K−3).

Some researchers report that intervention in the form of inquiry science experience may minimize gender differences. Zoldosova and Prokop (2006) examined the books that elementary school students checked out following a weeklong program at a science center. Students who participated in the program chose titles related to their experience, with very minor gender difference. In contrast, a control group presented a gendered diversity, with boys more interested in technical topics (computers, flame, tests, woods) and girls preferring books on colors, flowers, and scents.

Support for the notion that experiential science intervention affects gender differences in students' interest in science comes from a study with kindergarten students. Patrick, Mantzicopoulos, and Samarapungava (2009) studied the effect of inquiry science curriculum on the motivation for learning science in kindergarten. The researchers found that in the regular classrooms, girls reported less competence or motivation to learn science than boys; however, no gender difference was found in the intervention classroom, following an inquiry science program. Additionally, boys and girls in the intervention class recount liking science equally highly, unlike gender differences in "liking science" that were detected in the classroom receiving regular instruction. The authors conclude that providing regular opportunities to interact with meaningful, integrated science inquiry and literacy activities may avert the pattern of boys enjoying science more than do girls.

In summary, the review of research conducted with young children reveals different multileveled conceptualizations of science. Children differentiate the science that is done in schools from a more general view of science. They are aware of the difference between doing science and being a scientist. With age and school progression, the attitude toward and enthusiasm with science declines, and gender differences become more notable. The portrayed picture is that from a very early age, boys and girls diverge on their interests and these differences grow as the children mature. Change in gendered views of science was observed as a result of a science intervention. No longitudinal study that assesses the duration of these changes could be found.

Based on the reviewed data, it is hypothesized that preschool children might show some type of gender difference in the way they view science.

Methods for Studying Children's Views of Science

Review of the research methods for studying young students' views about science reveals that the studies can be divided into two groups in terms of the study design. All reviewed studies use one of two methods: projective or selective, or a combination of these methods. Projective type methods aim at eliciting participants' views and ideas without guiding their thinking in any way. Selective-type methods aim at directing participants' views toward a set of fixed statements. This section reviews the array of methods and concludes with an analysis of the viability of these methods for use with preschool children.

Projective methods are exploratory in nature and aim at gaining participants' deep or associative thoughts with minimal instructions to avoid any bias. The underlying assumption of such methods is that participants' replies to the task project their views of another subject. Perrodin (1966) studied fourth-, sixth-, and eighth-grade students' attitudes toward science. He devised a 20-item survey and asked students to complete each item with the first thought that comes to their minds. Students' answers were then analyzed on a five-point scale from very positive to very negative. For example, the statement "Science is…" elicited replies like *fun, interesting, my favorite subject,* and *a search for the truth.*

A similar method was employed by Stein and McRobbie (1997). Unlike Perrodin's method, they asked students from different grades (4, 7, 9, and 11/12) to write about the concept of science in a 20-minute free-writing session. The replies received in this study were much more elaborate, which enabled a qualitative analysis of students' assays into six main categories (see p. 27 of this manuscript). The researchers tried to study younger students but found that they were insufficiently experienced linguistically to provide meaningful written responses.

Zoldosova and Prokop (2006) used projective methods to learn about students' science interests following a five-day program at a science center. The researchers recorded the books that children checked out following the program and compared the titles of boys, girls, experimental, and control groups. The book titles were then analyzed to find patterns. A second projective method employed in this study was a drawing task. Participants were asked to draw the "ideal science education environment," and the researchers analyzed the drawing for presence of items related to the program.

A well-renowned drawing method was developed by Chambers (1983). In an attempt to learn what elementary school students think about scientists, Chambers' Draw-a-Scientist-Test (DAST) was conducted with thousands of students around the world. Children were simply asked to draw a scientist, and their drawings were analyzed for the presence of stereotypical cues such as gender; workplace; the presence of glasses, lab coat, facial hair, etc. A follow-up task asking the children to draw *another* scientist resulted in less stereotypical drawings, as it allowed for alternative conceptions.

The DAST method has been repeated and replicated by numerous researchers around the world (Barman, 1999; Buldu, 2006; Finson, 2002; Losh, Wilke & Pop, 2008; Monhardt, 2003; Symington & Spurling, 1990, and many others). Since it does not require reading or writing and includes very simple instructions, the DAST can be administered to students of different ages, ethnicities, and languages. However, the DAST method has elicited criticism. Several researchers have questioned whether the DAST method projects participants' own beliefs or their knowledge of the public stereotype. These researchers suggested revising the DAST instructions, claiming that the instructions have an effect on the final drawings. Some of the revised instructions include:

- Draw a man or a woman scientist (Maoldomhnaigh & Mhaolain, 1990).
- Do a drawing which tells me what you know about scientists and their work (Symington & Spurling, 1990).
- Draw two scientists and write a paragraph describing what the scientists are doing (Matthews, 1996).
- Draw a scientist doing science and explain the drawing (Barman, 1999).
- Draw a teacher, draw a scientist, draw a veterinarian (Losh, Wilke & Pop, 2008).
- Draw three scientists (Farland-Smith & McComas, 2009).

Finson (2002) reviewed the variety of DAST revisions and concluded that "the combination of drawings with interviews appeared to be the most useful of these strategies" (p. 342).

Selective methods are a second type of methods employed to study young children's views of science. These methods ask participants to express their views by rating statements (on a Likert-type scale) or choosing a statement that best fits their views (dichotomous or multiple choice tasks). Researchers adjusted standardized surveys in order to use them with young children. The numbers on statement rating scales were replaced with an iconic "smiley" scale to symbolize the level of agreement with the statement (Andre et al. 1999; Chen, Lieu, Chang, Lin & Huang, 2009; Pell & Jarvis, 2001; West, Hailes & Sammons, 1997). Rennie and Parker (1987) asked elementary school participants to rate how much they agreed with a statement by choosing one of four circles of increasing diameter. Since younger children cannot read, Wareing (1982) instructed teachers to read each statement out loud when administering the surveys.

A unique "selective" method is reported by Boylan, Hill, Wallace, and Wheeler (1992). Boylan et al. questioned the validity of the DAST method, claiming that students' views are complex and they know more than their drawings reveal. In their work on third graders' views of scientists, the researchers developed a pictorial test consisting of 30 pairs of pictures. Each pair of pictures illustrates a different trait or environment related to scientists and their work (young – old; lab coat – casual clothes; laboratory environment – outdoor environment). Participants were asked: "Is one of the persons more likely to be a scientist than the other <u>or</u> could they both be scientists <u>or</u> could neither be a scientist – why?" If participants indicated one person, then a second question followed: "Could the other person be a scientist? Why do you think that?"

Boylan et al. (1992) noted that despite the fact that participants' choices revealed similar stereotypes to the DAST method, students' explanation disclosed their complex understanding of the difference between realistic and hypothetical practice. Students replied to the tasks based on their knowledge of reality (scientists are more likely to be men); however, when asked the reason for their choice, they often said that there were no differences in men's and women's abilities to become scientists.

Coulson (1991) used a forced-choice pictorial test to study preschool children's interests in science. Children (4–5 years old) were presented with six sets of three pictures that represented biological science activities, physical science activities, and non-science activities, and were asked to choose one that they would rather do. For example, children were asked: "What would you rather do? Would you rather help set up a fish tank, help set up a torch, or help set up a cubby house?"

Another well-known pictorial test is the scale of perceived competence and social acceptance for young children (Harter & Pike, 1984). The authors suggested that using the pictorial format with young children (ages 4–7 years) helps engage participants' interest, sustain their attention, and is more understandable than verbal statements. In this test participants were presented with a pair of dichotomous pictures, representing opposite early childhood behavior or skill. The experimenter described each picture and then asked the children to point at the picture that was "like them". Following the participants' decision, they were asked to indicate if they were a lot like the picture (by pointing at a large circle) or just a little bit (by pointing at a small circle).

A recent study studying young children's motivational beliefs about learning science (Mantzicopoulos, Patrick & Samarapungavan, 2008) employed another interesting method. Dichotomous statements ("I know how to do science"; "I don't know how to do science") were presented to kindergarten students by two puppets, and the children had to choose the puppet that presented a view similar to their own. The benefit of using puppets over pictures is that they engage the children and reduce the anxiety of interacting with an unfamiliar experimenter, since the children were interacting directly with the puppet. An additional benefit of this method is that children were able to choose a puppet that looked like them from a variety of puppets, which increased the identification of the child with the puppet.

Finally, some researchers employed a multimethod practice in order to complement each method's shortcomings. Ormerod and Wood (1983) employed three comparative methods for studying 10-to-11-year-old students' attitudes toward science. The researchers used an attitudinal Likert scale, a sentence completion task, and a third projective task in which they asked participants to write down the kind of books they considered interesting.

She (1998) studied elementary and middle school Taiwanese students' stereotypes of science and scientists. Her research methods included the DAST protocol followed by a 45-minute interview that followed Boylan et al.'s method. The study concluded with open-ended questions, asking students, "Would you like to become a scientist in the future? Why or why not?" and "Do you think it's possible for you to become a scientist? Why or why not?"

In summary, a variety of research methods were used to study young children's views about science. Some researchers relied on projective methods assuming that one task (such as drawing) may elicit children's views about science. Other researchers look for children's rating or reaction to given statements. A third group of researchers employed multiple methods in their studies.

In the context of studying preschool children, some methods are inapplicable. Preschool children know more than they can express by language or drawing. Some of their ideas are not translated in the form of words, and the children's attention span is short. Additionally, preschool children may feel uncomfortable in the presence of an unfamiliar experimenter or may answer in ways they think would please the experimenter. Therefore, a new method is needed for studying preschool children's views of science.

Instrument Development Review

The previous chapter emphasized that a new research instrument would have to be developed in order to study preschool children's views of science. This section summarizes two key points in the development of an instrument. First, a review of opposite opinions with regard to the type of instrument is presented. Then the section reviews different models for instrument development.

Personal vs. Standardized Instrument

Researchers' views about the structure of an instrument for studying views and conceptions of science diverge along the qualitative-quantitative continuum, presenting positions for and against standardized instruments. Lederman, Abd-El-Khalick, Bell and Schwartz (2002) criticized the usefulness of standardized instruments and claimed that for the purpose of research, standardized tests with forced choices do not provide the reasoning behind students' choices or the true meaning of their beliefs. They argued for the need of an open-ended questionnaire, followed by an interview session in order to understand students' replies within the context of their school and culture. In an earlier study, Lederman and O'Malley (1990) compared the data gathered through open-ended paragraphs written by high school students to those acquired during interview sessions, commenting:

> "The responses given by students using this data collection format are vague and are often misinterpreted by researchers… Consequently, the use of the interview to gather and clarify data about students' beliefs appears to be essential if one is to avoid the pitfalls of misinterpretation" (p. 235).

Following a review of multiple versions of DAST studies, Finson (2002) commented that the combination of drawings with interviews appears to be the most useful strategy. Boylan et al. (1992), in their adaptation of the DAST, added an interview component in order to get "beyond the superficial data obtained by the DAST" (p. 466).

On the other side of the continuum stand researchers who adopt a more practical view, aiming for a large-scale use of the instrument. Andre et al. (1999) recognized the value of personal interview with each research participant but claimed that teachers or practitioners cannot find the time to conduct an extensive interview with each of their students, not to mention analyze the results. According to this view, an instrument should be short and easy to administer so that it can be valuable for practitioners to develop intervention programs to address the findings of such studies. A simple-to-administer tool enables the study of large and diverse groups with minimal cost and training and simplifies data analysis.

Instrument Development Steps

The development of an instrument for studying preschool children's views requires a thorough review of instrument development process. Several researchers who designed instruments for studying children have reported the steps of instrument design. The following section reviews the steps and concludes with commentary on the viability of the recommended steps for the current study.

Aikenhead and Ryan (1992) described the development of a new multiple-choice instrument, Views on Science-Technology-Society (VOSTS), intended to learn about high school students' views on science and technology. The researchers presented a five-step model for instrument and item development. The first step included a thorough review of the literature and formation of conceptual schemes. Statements and opposite statements were then developed for each topic. These initial statements were given to students, who marked whether they agree, disagree, or cannot decide on opinion regarding the statement and wrote a paragraph explaining their position. The goal of this step was to filter and refine the statements that will be used in the research. Therefore, the second step included an analysis of students' written paragraphs for common arguments and viewpoints. These arguments were written in the students' language and became one of several statements forming a multiple-choice question. The third step aimed to validate the accuracy of capturing students' ideas. A new group of students was asked to write a paragraph response for each of the items. Some students were interviewed to determine whether the wording of the multiple-choice items captured students' viewpoints accurately. The items were revised following students' comments. During the fourth step, a new group of students was asked to go through the revised items with an evaluator. The students were asked to talk aloud and provide the reasons for their choices, which allowed the evaluator to get a better understanding of whether students understood the items. The fifth and last step of item development included a pilot study of the instrument. This step intended to eliminate items that receive little or no response and shorten the instrument without losing valuable information.

Chen et al. (2009) reported on the development of an instrument for studying elementary school students' views of the nature of science. Questionnaire items were developed over several years, based on written responses of sixth-grade students to a series of open-ended questions. The responses were analyzed, and categories were formed. Further interviews with 12 sixth graders were conducted in order to complete some missing details and to broaden researchers' understanding regarding gender issues, which were missing from the written responses. Then 83 statements were grouped as 12 multiple-choice items. A Likert-type scale of smiley faces was added next to each statement. The second step in developing the questionnaire was pilot testing session with more than 1,000 students. Item analysis was conducted on the results of the pilot test. Items with more than 10% missing data were eliminated, and following factor analysis results, the revised instrument contained 47 statements. The last step in the development process was reliability and validity testing. Interviews were conducted to assess whether students understood the items.

Rennie and Parker (1987) reported on an expert-based procedure for developing a scale for studying elementary school students' interests in science. In this Likert-type survey, the researchers formed the scale's items after considering three factors: elementary school students' hobbies; a review of other scales targeting similar populations; and local elementary science curricula. The items were designed to be very specific (for example, use the word "mice" rather than "animals") in order to avoid ambiguity. A second step in developing the scale included a pilot trial with one classroom of each grade level in order to test the level of difficulty and the task format. Items with small standard deviations and high means were revised in an attempt to increase the spread of responses. The revised instrument was then tested with 750 elementary school students. A factor analysis was conducted following this step. .

Boylan et al. (1992) developed their instrument for studying young children's views and stereotypes about science and scientists over several years. The initial 15 pairs of illustrations were derived following review of the literature and in matching with Chambers' (1983) DAST findings. The illustrations were reviewed by a panel of three science educators for face validity. The illustrations were revised following a set of pilot trials (Hill & Wheeler, 1991; Boylan, Wallace & Sharman, 1990) in which the order of the illustrations and the maximum quantity of illustrations per participant were determined. Test-retest reliability results and student comments were used to make further revisions in the content of some items (illustrations).

A comparison of the different instrument-construction methods described above illustrates several similarities and differences. All four research teams started the design of the instrument with a review of the literature in order to lay out the main components of the tool. Additionally, they all followed several steps of revision prior to the final application of the instrument with the target population; in particular, almost all went through one or more pilot phases. However, there are some differences in the processes described above. The differences among the methods stem from theoretical differences, target population characteristics, and goals for the new instrument. The most distinct difference is related to the question of which view the instrument should reflect. Aikenhead and Ryan (1992), Chen et al. (2009), and other researchers (e.g., Aikenhead, 1988; Lederman & O'Malley, 1990) assert that a survey should reflect authentic participants' views from the target population, and not expert views. Such empirical design, they claim, reduces the chance of misinterpretation of the instrument's items and the chance that participants would not find a statement that correctly represents their view. These reasons are especially significant when creating a paper-pencil survey, as language and wording may be ambiguous and carry different meanings. When studying young children, whose language skills are not fully developed, designing an instrument from a participant view may be difficult. The researcher may get young children's perspectives by other means, such as observations, curriculum review, or interviews with caregivers. A distinct disadvantage of designing instruments from the participant view is the fact that it is very labor-intensive and time-consuming. The VOSTS items were developed over the course of six years. Not every researcher or project could invest such a long time for designing its research instrument.

Chapter Three: Methodology and Research Design

Chapter Three presents the design of the research by portraying the different stages of the study. The current study was conducted through three main phases: exploratory phase, instrument formation, and experimental phase (see Figure 2). Chapter Three describes in detail each step of the research, from the early stages of exploration, through item formation and pilot testing, and up to the revisions that led to the final instrument.

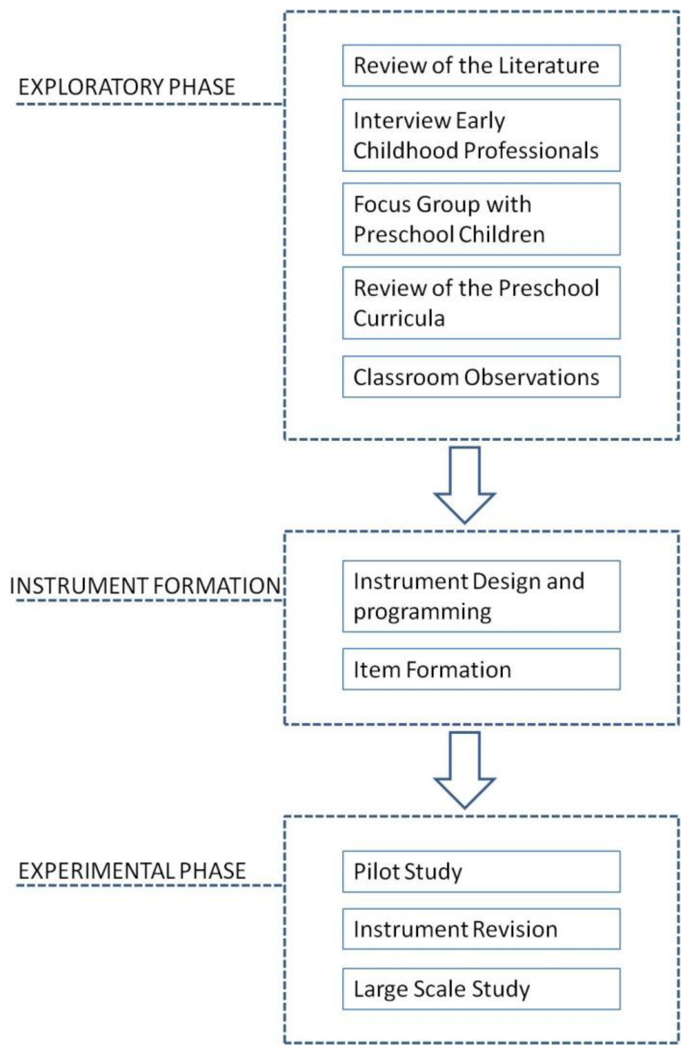


Figure 2. Phases of study design

Exploratory Phase

Review of the Literature

The exploratory phase began with an extensive review of the literature in search of studies that looked at young children's views about science. The review of the literature revealed many forms of assessment instruments designed to gauge participants' conceptions of science, stereotypes about science and scientists, and attitudes toward science. Since the goal of this research was to develop an instrument for studying preschoolers' views of science, the review of the literature focused on studies performed with participants who are elementary school children and younger with the hope of adapting one of the designs to accommodate preschool children's cognitive and physical abilities. As seen in the review presented in Chapter Two, it was found that most studies targeting elementary school students used pencil-paper instruments, adapted from studies conducted with middle- and high- school students. A variety of methods was employed: open-ended essays and paragraphs, Likert-type and multiple-choice questionnaires, personal interviews, drawing, and a combination of these methods (see Chapter Two for a review of those methods). Some adjustments for the young population included a change of the Likert-type scale from numbers or phrases into "smiley"–"frowny" scale, use of puppets, stories, read-aloud questions (instead of having participants read the questions), recorded interviews (instead of writing), observation protocols, and drawing. A combination of different methods (drawing, interviews, and pointing at pictures) was found as well.

One method, developed by Boylan, Hill, Wallace and Wheeler (1992), was found to be adaptable for studying preschool children. In this study, young children were presented with sets of two pictures showing opposite ends of common stereotypes about scientists. Participants were asked a question, for example: “who might be a scientist?” and replied by choosing one, both or none of the pictures. The author of the current study decided to use the Boylan et al.’s study structure as a foundation for studying preschool children, as it seemed to match preschool children’s abilities.

Interviews with Early Childhood Experts

A series of interviews with early childhood experts were conducted. The interviewees included an early childhood scholar from the University of Minnesota’s Institute of Child Development; a preschool teacher; and an environmental educator who works at the Minnesota Landscape Arboretum’s preschool program. These interviews provided useful information. Some of the key points include:

1. Large diversity among preschoolers’ skills and language. According to one of the interviewees:

> “Relying on language with 4-year-olds is really... well… it’s tricky because children’s vocabularies at this age vary dramatically, depending on the environment they have been in.”

The interviewee continued and claimed that any reliance on verbal skills of preschoolers is problematic, since many of them (especially coming from low-SES families) do not have the verbal skills to explain their thoughts about science or even to understand complex instructions. This position about discrepancy between the young child’s knowledge and expressive language is mentioned by several other researchers (Bowman, Donovan, & Burns, 2001; Glauert, 2005; Mantzicopoulos, Patrick, & Samarapungavan, 2008).

2. Large diversity among preschoolers with regard to the concept of science. Preschool children's conceptions are based on their everyday experiences. If they participate in a preschool where science activities are not practiced, the children may not have a formed concept of science.

3. School is not the only source for learning about science. Children learn about science at home and through siblings, parents, television shows, and enrichment activities. As one interviewee noted:

> "…There is a child in the school that his parents are scientists, and I hear the way this child talks and he talks about it…"

4. Teachers' philosophies affect activities in the classroom. All three interviewees presented different conceptions of science. This may suggest that each teacher's philosophy is projected on the way this teacher designs and conducts classroom activities. Based on this finding, it was decided to analyze the data by classroom and not by individual student.

Review of Preschool Science Curricula

Several preschool science curricula were reviewed in addition to the academic literature. The review found that natural themes (e.g. habitats, plants, animals, insects) repeat in many of preschool level books and curricula. Other themes that appeared in many of the books and sources are water, the seasons, the human body, and colors. Sackes, Trundle, and Flevares (2009) reviewed 12 states' standards of preschool science curricula. They found that the three common content areas were physical science, earth and space science, and life science. The most common themes within these areas were identified as:

- Physical properties of objects and materials, such as solid-liquid and hard-soft, was the most common theme across the states (all 12 states);
- Classification of objects and materials based on their qualities such as weight and shape (nine states);
- Life cycle of plants and animals (nine states);
- Weather (eight states);
- Plant and animal habitats (eight states); and
- Classification of plants and animals (seven states).

In a study titled "Preschool science environment: What is available in a preschool classroom?" Tu (2006) created a checklist of early childhood science-center items. The list included natural items such as birds' nests, feathers, fossils, pinecones, insects, seeds, plants, and seashells. Other items included living animals, magnets, magnifying glasses, balance (scale), microscope, mirrors, thermometers, binoculars, funnels, prisms, and pulleys (the list includes more items).

Focus Group Interviews

Following the curriculum and literature review as well as classroom visits, a group of 20 pictures was created to be used as reference pictures for focus-group sessions with preschoolers. The pictures featured children engaged in variety of science and non-science activities. Stereotypical science activities included observing through binoculars, magnifying glass, telescope, and microscope and conducting experiments using test tubes and beakers. Non-science activities included listening to music, making art projects, reading a book, coloring, playing basketball, eating, and practicing gymnastics. Ambiguous pictures included blowing dandelion seeds and blowing bubbles, mixing colors, and planting.

Three focus groups (with four children in each group), two groups of girls and one group of boys, were conducted. The interviews were conducted at the laboratory school within the University of Minnesota's Institute of Child Development (see Appendix A for a focus group interview protocol). The interviews consisted of two types of tasks. The first task was an open-ended question with the purpose of eliciting children's ideas about science (the children were asked to tell Froggy, the puppet, what science is). The second task involved looking at the laminated pictures and pointing at the pictures that show science or science activity. These knowledgeable children, who probably do not represent an average preschool child, were able to articulate their views about science as an active and purposeful process of learning (girls) or experimenting (boys). Colors and mixing colors were mentioned in all three groups. Girls brought up natural themes more than boys and stressed the learning aspect of science, while boys mentioned "potions" and "making stuff." These children were clearly making assertions based on concrete experience and interaction with science. Table 1 presents the main themes brought up by the focus group participants.

Table 1

Focus Groups' Data

	What is Science? (open-ended question)	Identified Science Activities Pictures	Identified Science Objects Pictures
Boys	- You do science and it is really fun - you experiment stuff - you are making stuff, creating magical potion	- Coloring - Making a science potion (points at a picture showing beakers and test tubes) - A boy with binoculars looking at animals	- Binoculars - Telescope - Beakers, test tubes (making science)
Girls	- You can mix colors and see what color it turn to - Crystals - Nature is science - Things that change - Leaves, animals - Nature, and once I found a feather - Museum with dinosaurs that died - Science is looking at stuff really really closely…You got to look at them and write about them, write about what you see - When you have a magnifying glass and look at things - You can find caterpillar and bring it home	- Learning about plants -Painting, mixing colors - Looking at a flower, because he is learning about nature - She is looking at something closely and trying to figure something out - Coloring and painting - Science is doing something - Using binoculars	- Binoculars - Telescope - Beakers, test tubes (this is real science)

Instrument Formation

Instrument Design

Based on data from the exploratory phase, a prototype of the instrument was created. Considering that preschool children's favorite activity is play (Wiltz & Klein, 2001), it was decided to develop an instrument in the form of a computer game. Using a computer offers several advantages for studying the preschool population:

- *Participants listen to instructions and reply by touching the screen*. This simple task is developmentally appropriate and does not require the reading, writing or use of other fine motor skills.

- *Consistency of presentation and bias reduction.* All participants hear exactly the same instructions, thereby reducing possible experimenter bias. Cordón, Seatermoe, and Goodman (2005) assert that "preschool children tend to be a particularly suggestible group." Using computers as a delivery tool (instead of an experimenter asking the questions) reduces the threat of children trying to satisfy the experimenter with their answers.

- *Individualized training sessions.* Computer program allows children who require more time to learn the process of the "playing the game" to have a longer training session. Children who do not complete the training after number of trials will not participate in the actual assessment.

- *Data collection and analysis of results.* The use of a computer eases and accelerates the process of data analysis and prevents the need for another researcher to be present to code the children's responses.

- *Increase use of technology.* The availability of touch-screen computers (ATM machines, airports check in stands, personal tablet computers) makes this technology familiar enough and not threatening. Children have seen their parents use these computers and would be interested to use them themselves.

With the development of technology, a computer-based instrument could be improved with time. Using a touch-screen computer (that enables children to express their choice by touching the screen) is simple and developmentally appropriate and does not require the use of fine motor skills.

Appearance and function. The instrument's prototype was designed as a FLASH based computer program. It was designed to be child-friendly, colorful, and attractive, using animated figures to engage the children. Instructions were recorded in a child's voice, giving the instrument a feel of a game rather than a test. Affirmative feedback was designed to be voiced following each step (e.g. "Good job! You are doing great!") regardless of the participants' choice.

In order for the instrument to be developmentally appropriate, it was designed for a touch-screen computer with voice-recorded instructions. Participants are requested to simply listen to instructions and reply by touching the screen. The program opened with a training session that introduces the child to the different tasks. Some children may experience a longer training session if they require a longer time to become accustomed to the program. The training was also used to determine whether children understand the task and whether they have reached a developmental level that allows them to perform and complete the task (see Appendix B for detailed descriptions of the picture and movie training sessions).

In addition, the instrument was designed with the potential of being self-operated. The final version would not require adult assistance and could be left in a classroom and collected at the end of the week for data analysis.

Instrument's subcategories. The instrument assesses children's views of science by engaging them in a picture recognition task in three sub-categories: science, science objects, and science activities. All pictures represent objects, topics, and activities that are part of the children's preschool experiences, in order to avoid a nay-bias due to incomprehensible questions (Fritzley & Lee, 2003). For example, the subcategory of science topics includes pictures representing weather, dinosaurs, plants, and space (to name few); the subcategory of science objects includes pictures of objects that can be found in the science area, such as magnifying glasses and scale; and the science activity subcategory includes pictures of children engaging in butterfly watching and experimentation. A list of instrument's pilot items are presented in the section Item Formation, as well as in Appendix C.

Instrument's tasks. The instrument is multidimensional and contains two components: picture game (multiple choice recognition task) and movie game (yes/no task). Since research has shown that preschool children are capable of forming quite complex concepts, it is important that the instrument will engage them in variety of tasks in order to assess their views.

Picture task. Participants are first introduced to the picture game. Following a short training session, they are presented with 11 sets of four pictures. What guided the decision to use four pictures for comparison? By using a four-picture comparison, the children are asked to evaluate whether a specific picture qualifies for a specific category. This task, which is in fact a multiple-choice question, could have been designed with a different number of pictures (1, 2, 4). Below is the rationale for choosing the four-picture design.

One-picture test? Using one picture per page turns the task into a yes/no task. Additionally, it would make the test too long or force the instrument to use fewer pictures. Furthermore, presenting one picture may result in bias. According to Fritzley and Lee (2003), preschool children ages 4-to-5-years tend to answer negatively (nay bias) when they do not understand the question or not familiar with the item. If one picture is presented followed by a question, "Does this picture show a science activity?" the results may be biased.

Two-picture test? Boylan et al. (1992) used a two-picture task, with the following question: "Is one of the persons more likely to be a scientist than the other or could they both be scientists or could neither be a scientist – why?" If the participant pointed at one image, a second question followed: "Could the other person be a scientist – why do you think that?"

This freedom of choice may tell us more about the child's perspective and reasoning for her/his choice (if the two pictures vary across one variable, it is possible to assume that this variable plays a role in the participant's view of science or scientists).

However, preschool children will not be able to follow the above multi-staged question. In order to adopt Boylan et al.'s instrument, the questions would have to be broken down for simplification. But if the instrument presents two pictures and asks the child to point at one (which picture shows a science activity?) with the intent to learn about the child's conceptions of science, another question should follow − what about the other one? −which brings us back to the bias problem attached to the one-picture option.

Four-picture test. There are several reasons for using a four-picture comparison. First, it provides more options to participants and allows the researcher to learn more from participants' choice. Second, using a four-picture test will allow asking a follow-up question ("is there another one?") after the child's first choice without the risk of bias. The significance of a follow-up question was voiced by some researchers using the DAST method (Maoldomhnaigh & Hunt, 1989; Matthews, 1994) following Chambers' (1983) report of asking to "draw another scientist." These researchers claimed that when asked to "draw a scientist," participants drew an image based on the expectations of the examiner. When asked to draw *another* scientist, participants drew images that were less stereotypical, allowing alternative conceptions to surface. In other words, the first image represents the well-known societal stereotype of scientists, while the second one allows for an alternative image to be drawn. Adapting the use of a follow-up question into a four-picture comparison will provide information about the child's first choice but also his/her thoughts regarding the remaining pictures.

Additional support for using a four-picture comparison comes from a receptive vocabulary assessment product made for preschool children, the Peabody Picture

Vocabulary Test (PPVT; Dunn & Dunn, 2007), which includes cards with four pictures that the child has to observe and describe (Figure 3).

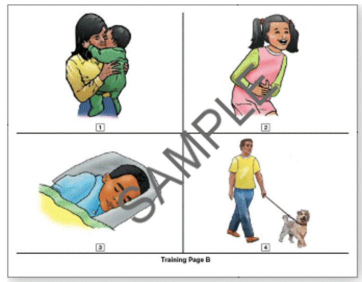


Figure 3. Peabody picture vocabulary test sample card

The picture task was then designed as a dual question task. First, the child is asked to choose (touch) one picture that applies to the category presented − for example: “Touch a picture showing a science object.”

After the child responds, she is prompted to touch any other picture from the set that applies to the category. For example: “Are there any other pictures showing science objects? Touch all science objects you see. If there aren’t any – touch the arrow.”

During the second part of each question, the child can touch any number of pictures between 0 and 3. All the picture-sets contain one picture that does not match the category, and labeled here non-science (NS). For example, in one of the science object sets, a picture of soccer ball represents a non-science object.

Movie task. The movie component opens with a short training session, during which the children are introduced to three animated dog figures. The first figure nods yes, the second gestures no, and the third gestures “I don’t know” (see Figure 4). The movie component is comprised of four short videos (15 seconds each) presenting children performing different activities (science). A set of five questions follows each video, and the child is asked to touch the doggy figure that represents his/her answer to the question. The questions follow the same subcategories presented in the picture component.

Figure 4. "Doggy" animated figures used in the movie task

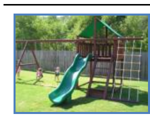
Item Formation

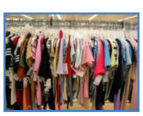
Science. Non science (NS) picture was included in each set in order to create a contrast to the science pictures and therefore allowing researchers to determine whether children have developed a stereotypical view of science. The NS pictures were chosen based on their fun and exciting nature for young children. One of the early childhood experts interviewed at the beginning of the study noted that if preschool children choose a picture of a science object over a picture of a pizza, it means that they know what science is and are not simply touching pictures of things they like. However, some of the NS pictures seem to be more "boring" and less attractive to young children and as a result may be less challenging to the children. See discussion in Chapter Five.

Table 2 presents the science pictures that were chosen for the pilot study and the rationale for choosing each one. Overall, the science pictures were chosen with the attempt to address science topics that are taught in preschools. In addition, there was an effort to present pictures that represent a variety of science subjects and disciplines (life science, earth science, and physical science). Images representing the science stereotype were added in order to test whether the children are aware of the stereotypical views of science.

Table 2

Instrument's Items for Pilot Study − Science

Set #1	Description	Rationale for Including This Picture
	Weather	Weather is a subject that many preschool children address daily. Children also hear about weather on the news (TV or radio).
	Human body	Human body is a topic that appears in many preschool curricula, as children learn about their own bodies.
	Pizza (NS)	The pizza picture was suggested by an early childhood expert as a picture that shows something children like but do not associate with science.
	Electronics	A picture illustrating electronics, to contrast the earth science and life science pictures in the set. This picture was replaced following the pilot study, as it was not clear whether children associated it with science (electronics) or with a fun remote-control car.
Set #2	**Description**	**Rationale for Including This Picture**
	Playground set (NS)	A picture of an attractive playground, not directly associated with science.
	Volcano	A stereotypical image of science. Erupting volcano experiment (using vinegar and baking soda) is a very popular early-childhood experiment.
	Snowflake	Observing snowflakes is a popular preschool winter activity (in Northern states). However, this picture was replaced following the pilot due to low vote. Children may associate snowflake activities with art and not science, and this is a

		seasonal and geographical location–based image.
	Paints and paintbrushes	Preschool curricula include colors and the mixing of colors as science activities. Support for that picture came from a focus group with preschool children. The children picked the picture of paints as science and reasoned it by mixing colors and creating new ones.
Set #3	Description	Rationale for Including This Picture
	Dinosaurs	A popular and stereotypical science topic. Children learn about dinosaurs in preschool as well as in TV shows, books, and movies.
	Plant	Another popular activity in preschool is to plant a seed and follow its growth.
	Bubbling liquid/gas	This stereotypical image of chemical reaction does not represent preschool activities and was chosen to test whether children acquire the stereotype associating science with chemical reaction (something they could learn from TV shows and movies).
	Sofa (NS)	This somewhat “boring” picture was chosen for its bright red color.
Set # 4	Description	Rationale for Including This Picture
	Animals	Young children love animals, and many books and activities address animals and their habitats.
	Rack of clothes (NS)	Although not an exciting image, children are familiar with seeing racks of clothes in stores.
	Test tubes and beaker	Another image presenting stereotypical image of science “tools.” This picture was replaced with a simpler picture of beakers.
	Space; solar system	Space and the solar system are frequently addressed in preschools. This is also a very stereotypical image of science.

Science objects. The rationale for choosing science-object pictures was to look for objects that are present in preschool science areas. Obviously, not all the classrooms have all those items. See Table 3 for science objects pictures and the rationale for their selection.

Table 3

Instrument's Items for Pilot Study – Science Object

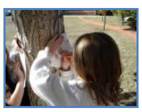
Set #5	Description	Rationale for Including This Picture
	Pinecone	Pinecones are sound in preschools' science areas. However, the image may not be familiar to children who grow up in areas with no pine trees.
	Scale	A scale is present in almost every preschool science area.
	Binoculars	The picture of binoculars was added following a focus group with children who picked this picture as representing a science object.
	Soccer ball (NS)	A soccer ball is an attractive picture for children and is not associated with science.
Set #6	Description	Rationale for Including This Picture
	Baby bottle (NS)	A baby bottle may be in the dramatic area, but clearly not in the science area. This picture may be too "easy" of an NS image, since is belongs to a different population. Some children laughed when they saw this picture during the test.
	Play magnets	This image of play magnets is classroom-specific. All pilot classrooms had the magnets in their science areas; however, it is very hard to guess what this picture features simply from looking.
	Magnifying glass	Magnifying glasses are found in preschool science areas. It is also a stereotypical science object.

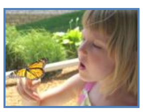
	Butterfly	A picture of a butterfly was added to represent a natural object. Observing butterflies’ life cycle is a common preschool activity. However, since the butterfly is an animated “object” unlike the rest of the pictures in the set, it was replaced following the pilot study.
Set #7	Description	Rationale for Including This Picture
	Shells	This picture was chosen since the surveyed classrooms had shells in their science areas.
	Doll (NS)	A doll can be found in any preschool dramatic play area. One limitation regarding this picture is that it may look like, or represent, a real baby.
	Spider in an observation cup	Many preschool science curricula involve observation of insects or small animals.
	Globe	A globe can be found in many preschool science areas. It represents the earth, its movement, continents, and oceans.
Set #8	Description	Rationale for Including This Picture
	Leaves	This image serves as the “natural” image. Fall leaf activities are very popular in preschools. However, it is a seasonal and location-based image and may need to be replaced in future versions of the instrument.
	Colored liquids in different containers	Although not often found in preschools, this stereotypical image taps at children’s concept of science. Home science kits may include bottles, measuring cups, and chemicals.
	Toy truck (NS)	A toy truck is an attractive toy for preschool children. A limitation of this picture is that it presents a single object in a set of collections. As this is the eighth set, the children may have been “trained” to look for the one exceptional picture, and this may give them a hint.
	Rocks	Some preschool classrooms have rock collections in their science area. Some preschool curricula suggest units on rocks.

Science activities. The rationale for choosing items for the science-activity subcategory was to focus on activities that preschool children do or are familiar with. All the images feature children, and there was an attempt to balance pictures of genders, indoor/outdoor activities, and group/single activities (See Table 4 for the full list of science activity pictures and the rationale for including them).

Table 4

Instrument's Items for Pilot Study – Science Activity

Set #9	Description	Rationale for Including This Picture
	Boy weighs using scale	A scale is an object that found in many of preschool classrooms. Hence, the activity of weighing should be familiar to participants.
	Girl records a tree bark	An outdoor activity featuring a girl
	Girl observes a rock held by tweezers	Young girl observes a rock
	Boy ties his shoelaces (NS)	The NS picture features a boy tying his shoelaces, an activity familiar to young children.
Set #10	**Description**	**Rationale for Including This Picture**
	Girl observes with magnifying glass	Indoor, a girl uses a magnifying glass to observe a tree trunk. Magnifying glass is a familiar and stereotypical object.
	Group of children and teacher study a pond	Outdoor, group activity of studying a pond
	Children play "pattycake" (NS)	Outdoor, group activity. Children are familiar with the game. The children featured in the picture seem happy, which makes the picture attractive to children.

	A boy with goggles observes a test tube	This stereotypical image is not part of a preschool science activity; however, it's familiar to the children via other media (TV, movies, books).
Set #11	Description	Rationale for Including This Picture
	Children build with blocks (NS)	Indoor, kids build with blocks. This activity is familiar to preschoolers. The picture was replaced following the pilot study, since science may be associated with blocks.
	Girls conduct an experiment	Indoor, young girls conduct an experiment. Stereotypical science image.
	Boy looks through binoculars	Outdoor, boy observes with binoculars. This picture was chosen as science in a focus group session with preschoolers.
	Girl holds and observes a butterfly	Outdoor, a girl observing butterfly. Butterflies' life cycle activities are very common in preschools.

Videos. Four video clips (10−15 seconds each) were created and embedded in the instrument. Each video was followed by a set of five questions. The questions were designed with the intention of breaking the science activity into subcategories similar to the ones addressed during the picture task (science, science objects, and science activities). Additionally, some questions inquired about participants' beliefs about gender roles in science. The first question following each clip asked the child whether this clip was science. The following questions attempted to get to the component or components that make the video science. Is it due to the tool or object that is used in the clip? Is it due to the type of activity? Finally, in each set of questions, there was one designated "No" question that was used to test the reliability of answers.

Video #1 presented two boys sitting at a table and examining tree bark using magnifying glasses. While looking at the bark, the boys ask many questions about their observations. This video is followed by the following questions:

Q1 Does this movie show a science activity?

Q2 The children were talking. Is talking part of science?

Q3 The children in the movie asked many questions. Is asking questions part of science?

Q4 The children studied a tree trunk. Are tree trunks part of science?

Q5 The children in the movie used a magnifying glass. Is a magnifying glass a science object?

Video #2 featured a boy conducting a volcano experiment by mixing together vinegar and baking soda. The boy is very excited and shouts, “Explosion!” The video is followed by the questions:

Q21 Does this movie show a science activity?

Q22 The boy in the movie mixed things. Is mixing part of science?

Q23 The boy in the movie sat at a table. Is sitting at a table part of science?

Q24 The boy in the movie had a volcano. Are volcanoes part of science?

Q25 Is science only for boys?

Video #3 shows a girl collecting caterpillars on the playground. The following questions are:

Q31 Does this movie show a science activity?

Q32 The girl in the movie picked up caterpillars. Is picking up part of science?

Q33 Are caterpillars part of science?

Q34 The girl in the movie had a yellow shirt. Are yellow shirts part of science?

Q35 Is science only for girls?

Video #4 featured a group of children and their teacher. The children sit around a table and examine salt crystals with magnifying glass. The teacher is heard saying that following their observations, the children will record their observation in their science journals.

Q41 Does this movie show a science activity?

Q42 The children in the movie observed salt crystals. Is observing part of science?

Q43 Later, the children will draw salt crystals in their journals. Are journals science objects?

Q44 Are salt crystals part of science?

Q45 Have you ever looked at salt crystals with a magnifying glass?

Experimental Phase

Pilot Study

A pilot study was conducted during winter 2010. The pilot study was set up to test the instrument's level of difficulty, clarity of instructions, appropriateness of the task length, and overall willingness of the children to complete the tasks. The pilot study was also intended to gather information on the different items (images and videos), as well as to enable preliminary analysis of children's responses.

Thirty-eight preschool children, 20 boys and 18 girls, ages 4−5 years, participated in the pilot study. Due to some changes in the recorded instructions and order of items, only data of 30 children, 16 boys and 14 girls, were included for the final pilot analysis. The children came from three preschools in Minnesota. The population of participants varied on their SES, level of science enrichment conducted in the preschool, and geographical location. The first preschool was located in Minneapolis and served the families of the University of Minnesota (children of students, staff, and faculty). The second school was a private preschool located in one of the suburbs of Minneapolis. The third preschool was a Head Start classroom, located on an American Indian reservation. The three schools differed on the average SES of the attending children and families, as well as on the level of science conducted in each classroom (see Table 5 for description of the three participating schools).

Table 5

Descriptive SES and Science Instruction Level for Participating Preschools

	Location	SES	Science Instructions
PS 1 – University	Within a central campus of a large university	Medium-high	High – Designated science area; daily science activity; frequent discussions about science and scientists
PS2 – Private	In a wealthy suburb	High	Low – No designated science area within the classroom. No science curriculum. Weekly science activity for after-school kids.

	Location	SES	Science Instructions
PS3 – Head Start	On an American Indian reservation	Low	Medium – Designated science area in each classroom. Teachers go through science professional development and implement it in the classroom.

The pilot sessions were first administered in a quiet office in the preschool, but soon it was apparent that the children did not feel comfortable being with a stranger away from the classroom. The location was then changed, and the rest of the testing took place at a table just out of the classroom. Half of the group was asked to repeat the task by pointing at printouts of the pictures. The children were also asked to point at pictures that are *not* science in order to check their understanding of the task. Revisions were done until it was clear that the children understood the tasks without experimenter intervention.

Analysis of participants' reply behavior led to minor changes in the recorded instructions and the programming of the pictures. For example, prior to the pilot study, the children could touch each picture multiple times. Following the pilot sessions, the program was revised, and chosen pictures were marked as chosen. A change in the order of the sets was conducted following the first few participants.

The pilot study found the program to be very engaging for the children. Participants enjoyed the tasks and happily volunteered to do the second task. The tasks did not seem difficult for the children, as the large majority completed all the training sessions on the first attempt. In addition, the children were able to sit attentively through the entire session and did not seem to lose interest of the tasks.

The pilot study also found that overall, the group of pilot participants clearly distinguished between science and non-science pictures, suggesting that their concept of science has emerged. Table 6 presents the total number of touches for all pictures following three attempts (see Appendix C for a complete list of the pilot study pictures and raw data).

Table 6

Total Number of Touches During Picture Task Following Third Choice

Set #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Position 1	14	6*	23	16	16	6*	17	18	24	22	10*
Position 2	22	24	21	7*	24	23	9*	20	21	21	22
Position 3	5*	10	22	21	24	24	24	9*	20	8*	22
Position 4	17	22	2*	23	6*	17	22	18	8*	20	17

** denotes non-science picture*

Further analysis of subgroup differences has provided additional interesting results. While no significant differences were found overall between boys' and girls' pattern of choices, comparison of the non-science choices of the younger and older groups revealed that the younger group chose significantly more non-science pictures. This finding may suggest that 4-year-old children are in the process of forming their concept of science and/or may find the task more difficult, hence the larger frequency in choosing non-science pictures.

Furthermore, picture analysis revealed differences between the subgroups in relation to particular pictures. Figure 5 presents the four pictures of Set 4 and the choice distribution produced by the whole group's data. While picture #4 in the set (space, the solar system) was chosen by the majority of children, age group analysis reveals that younger children chose this picture considerably less than older children (Figure 6, left). Picture #1 in the same set (animals) was chosen less than the other two science pictures, however a gender subgroup analysis reveals that girls preferred this picture over boys (Figure 6, right). Similar differences across gender, age, and classroom were also found in other picture sets.

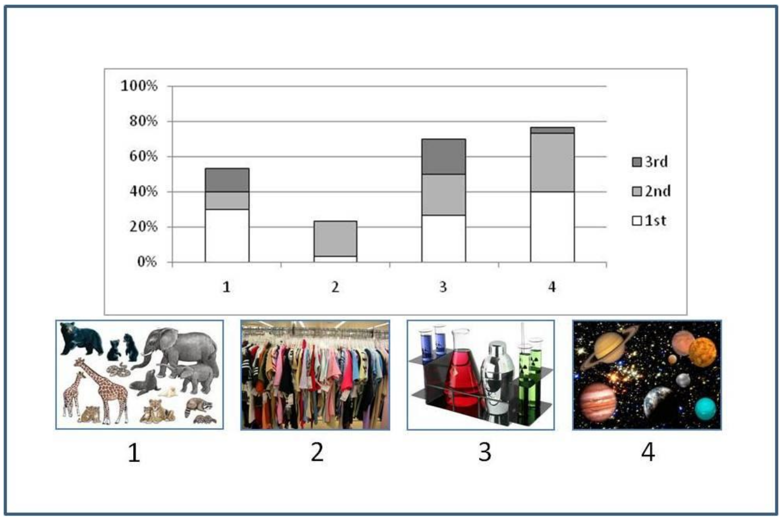


Figure 5. Set 4 whole group choice distribution following three tries

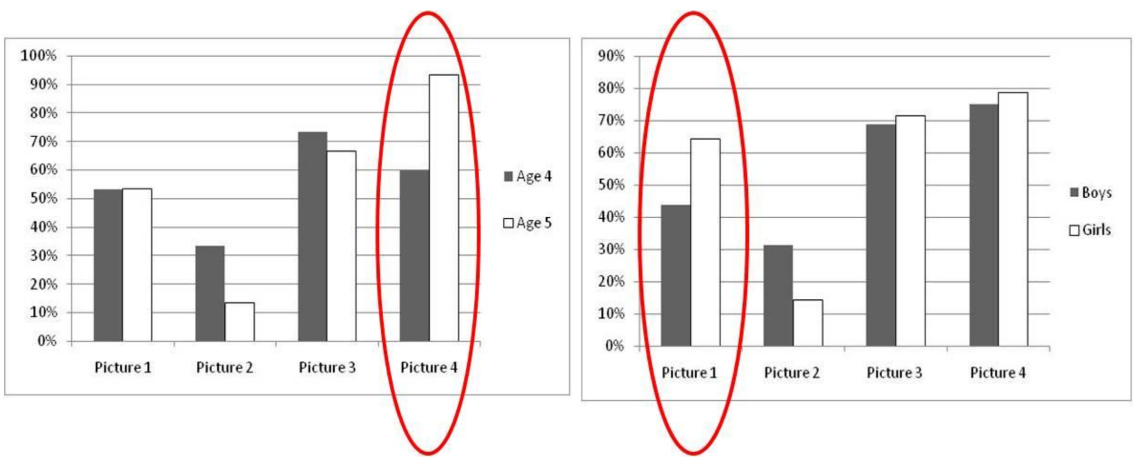


Figure 6. Set 4 age (left) and gender (right) differences following three tries

Pilot participants clearly distinguished between science and non-science pictures, suggesting that for this group, the concept of science or the stereotypical views of science had emerged. An age group comparison revealed that the younger group (4 years old) touched more non-science pictures than the older group (5 years old). This response pattern fits initial (and very few) testing sessions with children younger than age 4, which revealed no significant differences between choices of science and non-science pictures. The young children could complete the training tasks but voted randomly on the science tasks. Some of the younger children may not have known the meaning of the words *science, science object,* or *science activity,* and we expect more "mistakes" from the younger group. Alternatively, it may suggest that younger children have a more inclusive concept of science that is being refined and narrowed with development.

The instrument detected other group differences. For example, girls chose pictures showing life sciences (animals, plant, shells) significantly more than boys. These findings align with previous research looking at gender differences in science interests (Jones et al., 2000). A review of the literature conducted by Mantzicopoulos and Patrick (2010) found that "girls are more interested in the life sciences than they are in physical science; they are also more interested in the life sciences than boys are" (p. 417). Classroom comparison revealed differences in choice patterns; however, due to the small number of participants in each classroom, these differences lack statistical power.

Some science pictures were chosen less frequently than others. Analysis of these pictures revealed that these were mostly pictures of weather and natural objects, such as shells, rocks, leaves, pinecones, butterflies, and animals. This finding was surprising, since these objects and topics were found in all three classrooms and dealt with on a daily basis. A plausible explanation could be that these topics are not labeled as science, but rather as weather or nature, and therefore fewer children associated them with science.

Limitations of pilot study findings. The findings and conclusions of the pilot study data must be put in the context of the following limitations. First, the small number of participants (30) does not carry enough power to make conclusive statements. Second, participants were not asked to identify the pictures prior to their participation, and so the possibility of children making choices that are not based on the content of the pictures cannot be ruled out. Third, the fixed item arrangement makes each picture choice relative to the other pictures in each set. Some items were too gender-stereotypical − for example, a butterfly. Girls may have chosen the butterfly picture more than boys because of its aesthetic value, rather than its taxonomy (an animal, part of nature).

Revisions Following the Pilot Testing

Several revisions were made following the results of the pilot study.

Picture replacement. Several pictures were replaced following the pilot study. These were science pictures that did not get high votes from pilot participants or pictures that might have been too stereotypical. Table 7 presents the replaced pictures and the rationale for the revisions.

Table 7

Item Revision Following Pilot Testing

Set #	Original Picture		Replaced With	Rationale for Change
1		→		Despite considerably high votes for the original picture, there is a debate whether the children associate it with electronics.
2		→		The snowflake picture received a low number of votes. Also, question whether children consider electricity/light as science.
4		→		The original picture was not clear, complicated-looking. The new picture presents the concept with a simpler image.
6		→		The butterfly picture received fewer votes than the other science pictures mainly from girls. The change of the picture was intended to test whether girls will vote for a natural object even if it is not "pretty." In addition, a butterfly is not an "object," which may be confusing for the children.
11		→		The NS picture of blocks received the highest number of votes in all the NS pictures. Building with blocks involves some science, and therefore it was decided to change the picture into a picture showing children reading.

A second change following the pilot study was a change in the position of pictures in set #4. The change was done since sets 3 and 4 looked too much alike. Both had an image featuring animals in the top left corner (position #1) and "chemicals" in the bottom left corner (position #3). The position change can be seen in Figure 7.

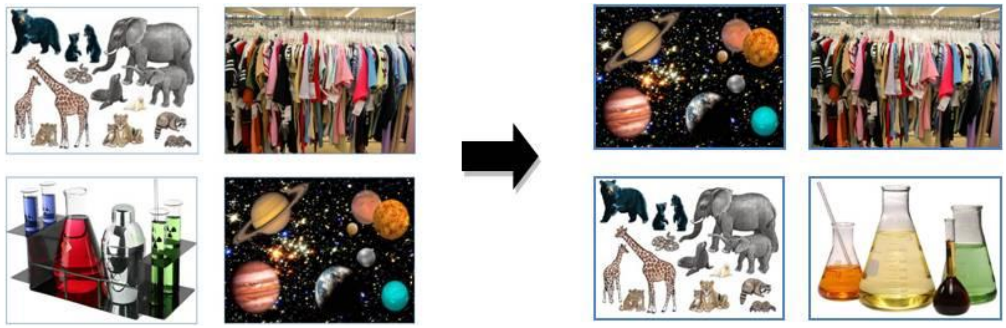


Figure 7. Set 4 revision following pilot study

Chapter 4 presents the data and analysis of the large-scale data.

Chapter Four: Data Analysis

The analysis of the collected data attempted to answer the following research questions:

1. Do sample-group children possess views about science?
2. What do sample-group children perceive as science?
3. Are there differences between the perception of science among subgroups (gender, age, preschool location)?

This chapter presents the analysis of the large-scale study data. The study is compiled of two tasks, a picture task and a movie task. The chapter opens with a whole picture-task analysis (data from all 11 sets compiled), followed by a set of analyses examining each one of the 11 sets separately. The picture task section ends with a visual presentation of picture analysis, portraying the most and least chosen pictures. An analysis of the movie task data follows, and the chapter ends with a summary of the large-scale study findings.

Picture Task

The picture task contained eleven four-picture sets. A whole-task analysis, examining a total of 864 trials (all trials completed by all participants), is presented first, followed by a separate analysis of each set.

Methods of Analysis

The current study uses a number of statistical methods to answer the research questions. Since this is an exploratory study, there are no previous data to serve as a comparison, and therefore using more than one analysis method may add to the robustness of the conclusions.

Due to the exploratory nature of the study, as well as small subgroups, the analysis relies on non-parametric statistical methods that have fewer assumptions about the normality of the sample's distribution.

Several methods were used in order to answer the first research question:

1. Chi-Squared test of goodness of fit was used to test the null hypothesis that study participants possess no stereotypical concept of science and therefore their picture choice distribution follows a chance distribution (randomly voting, no difference between the pictures). In that case the expected count of each picture equals a quarter of the ""votes" (after the first try). Significant differences among the count of each picture suggest that the children did not vote randomly. If the NS picture got significantly fewer votes than the other pictures in the set, across sets, it might hint that participants did not vote randomly or prefer pictures based on qualitative properties, but rather responded to the question with their perception of science.

2. A Chi-Squared test of independence was used to compare choice frequencies of different subgroups (for example, boys vs. girls) as well as the success/failure proportions of different subgroups.

3. The Binomial test, another non-parametric method, was used to assess whether the observed proportion of success/failure was different than the expected random proportion.

4. Finally, a logistic regression was conducted to examine the relationship between success/failure (success = choice of science picture; fail = choice of the NS picture) and variables such as gender, age, and school. The logistic regression was used to model outcome binary variables. The log odds of the outcome were modeled as a linear combination of the predictor variables (see references for Logit regression). Since the success/failure ratio is presented as a dichotomous variable, results from the logistic regression may point to relationships between the outcome and participants' characteristics. Specifically, it helps explain the variation between success and failure. If the study's population does possess a concept of science, it is expected that their success/failure ratio will improve with age, assuming that older children's views of science are more defined.

Population

The picture task's population included 92 preschool children (40 boys and 52 girls) from four schools and one museum setting across Minnesota. The children's age ranged from 45 to 71 months, with the mean of 54.5 months. For analysis purposes, the group was divided into two groups, 4 and 5 years, based on participants' age. The cutoff was 60 months. Children younger than 60 months were grouped as 4-year-olds (49 children), and the rest were grouped to the 5-year-olds (43 children). Table 8 presents the division of participants based on school, gender, and age.

Schools. Participants in this study came from four schools and one museum setting. The low number of participants from Schools 1, 4, and 5 excluded these schools from between-school comparisons. A description of each of the schools is followed by a summary table (Table 8) of participants' demographics (age, gender and school affiliation).

School 1 was a private preschool located in a high-income suburb of Minneapolis. The school did not emphasize science as part of the curriculum, although the afternoon program (which all participants were part of) did provide weekly science activity. The low number of participants from this school was due to the fact that many of the children in this school participated in the pilot study, which had slightly different pictures.

School 2 was a private preschool located in a middle-income suburb of Minneapolis. The school emphasized science as part of the curriculum.

School 3 was a laboratory school, located at the Institute of Child Development at the University of Minnesota. The school emphasized science as part of the curriculum.

School 4 represented a group of children who were tested at the Minnesota Children's Museum with the attempt to reach children who were not part of a whole-day preschool. A table with two computers and information about the study was placed in the atrium of the Minnesota Children's Museum, and interested children were invited to participate in the study. The low number of participants in this group was due to a loss of data.

School 5 represented a Head Start classroom on an American Indian reservation in northwest Minnesota. The classroom emphasis on science was medium-low. The low number of participants was due to a computer program failure (not recording some of the data).

Table 8

Participants' Age, Gender, and School Affiliation

SCHOOL			AGE (years)		Total
			4	5	
1		Boys	2	2	4
		Girls	1	1	2
	Total		3	3	6
2		Boys	4	7	11
		Girls	13	9	22
	Total		17	16	33
3		Boys	15	4	19
		Girls	9	9	18
	Total		24	13	37
4		Boys	0	1	1
		Girls	2	3	5
	Total		2	4	6
5		Boys	1	4	5
		Girls	2	3	5
	Total		3	7	10

Missing Data

Ninety-two participants took part in the study. However, not all participants completed all 11 sets. There are several reasons for the missing data:

***Replies that follow a pattern*.** Prior to the study, it was decided that responses that follow a pattern (for example, 1-2-3-4 for all sessions) would be taken out and not considered for analysis. The decision was made based on the assumption that children who respond with a pattern touch the pictures on the screen based on their location and not on the content of the pictures. Since the position of each picture is fixed and the NS picture rotates across the four possible positions, a pattern response included a mix of science and NS pictures regardless of the child's possession of a concept. Patterned responding was defined as four identical and consecutive choices (since there are four pictures in each set, four or more identical choices signals response that is not based on the content of the pictures).

Analysis of the data found no children who responded with a patterned response across all 11 sets. However, three out of 92 children responded in a pattern to some of the trials (4; 4; 8). One child showed this pattern at the beginning of the study, and two presented patterned choices toward the end of the study, which may suggest that they got bored. It was decided to exclude the responses that followed a pattern, but to leave the rest of the responses that did not follow a patterned choice.

No reply. Forty-two children (46%) did not reply to at least one trial throughout the study (overall 99 sessions, 10%, range 1−8). There are several explanations for no reply (below); however, no assumptions may be made regarding the science views of no-reply participants. The children may have not replied because of the difficulty of the task; lack of knowledge regarding the specific pictures presented in the set; waiting too long before responding, which resulted in moving on to the next set; or other factors interfering with their performance (loud noise, a friend standing by, etc.). Since there is no way to tell what caused the no-reply, any of the following explanations are plausible:

- Some participants did not finish the sessions and stopped “playing before completing all 11 sessions; five participants did not reply to 19 sessions overall at the end of the task.
- Some participants did not see any science picture (or had no science view) and moved to the next session by touching the blue arrow (as instructed during the training).
- Some participants waited too long before touching a picture, and the program moved on to the next session. The computer program was programmed to move on if a child did not reply within 10 seconds. After 10 seconds from the first question, participants who did not answer heard the second question asking them about other pictures. If the child did not reply within 10 seconds, the program continued to the next set.

Computer error. A bug in the program caused an error value when a child touched the pictures multiple times. A total of 17 children’s responses in 30 sessions resulted in error codes. These children DID make a choice; however, due to the error, the data are missing. Again, no assumption regarding the children’s possession of a science concept can be made.

In very few cases, the program stopped working and had to be restarted. In these cases (that were too few to keep note of), there are only the trials that the child completed.

Observer's error. A few children used the program before the recording function was working properly. In these sessions, the researcher recorded their choices. When distracted, the researcher missed recording several trials.

Due to the reasons above, there are missing data in each of the sets. An average of 12 responses is missing from each set (20 in the first set, seven in the last). The growing number of replies (from first trial to last) hints that a large number of children were still intimidated or hesitant to reply at first; however, they felt more comfortable as the trials went on.

For the purposes of analysis, it was decided to treat each trial's responders as a separate N and examine the distribution of replies based on the proportions of available replies. The main reason for this decision is that the exact reason for each missing reply cannot be determined, and therefore considering the missing data as children who have no perception of science may lead to error. However, when examining the proportion of success for all participants, the total N is considered to be the total number of responders.

Whole-study Analysis

A holistic analysis of the entire study was conducted in order to assess the overall observed success/failure proportion and compare it to chance. Ninety-two children completed 864 sessions during the study. Eighty-seven percent of the sessions were successful following the first choice (e.g., 87% of the pictures chosen first were pictures representing science). The success/failure proportion of random choice pattern would be 0.75; a binomial test comparing the observed proportion to a random selection test proportion found the difference to be significantly different than chance (Table 9).

Table 9

Binomial Test Comparing First Choice to Random Choice Proportion

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success following First choice		1.00	755	.87	.75	.000(a)
		.00	109	.13		
	Total		864	1.00		

a Based on Z approximation

A second binomial test was conducted to assess the proportion of success/failure following two tries. Following the first touch (with 0.75 chance for success, including only those participants who made a choice), participants now had again 0.75 chance to succeed (two science pictures + arrow option lead to success, while touching the NS picture leads to failure). The test proportion was therefore set to 0.56 (0.75*0.75). The results of the second binomial test showed that the proportion of success/failure (0.77) was still significantly different than the test proportion when considering the second vote of the children (Table 10).

Table 10

Binomial Test Comparing Second Choice to Random Choice Proportion

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success following second choice		1.00	662	.77	.56	.000(a)
		.00	202	.23		
	Total		864	1.0		

a Based on Z approximation

Similarly, a third binomial test was conducted to assess the proportion of success/failure following the third try. The test proportion for the third choice was set to 0.38 (0.75 chance to succeed on the first try * 0.75 chance to succeed on the second try, including the arrow option * 0.67 to succeed on the third try, including the arrow option). The third binomial test found the observed proportion (0.68) to be significantly different than the test proportion of random selection (Table 11).

Table 11

Binomial Test Comparing Third Choice to Random Choice Proportion

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success following third choice		1.00	590	.68	.38	.000(a)
		.00	274	.32		
	Total		864	1.00		

a Based on Z approximation

The results of the three binomial tests suggest that a significant number of the participants did not choose the pictures randomly, but rather meaningfully, according to a certain perception of science each possessed at the time of the study.

Gender. Analysis of the proportion of success/failure with regard to gender found no differences between boys and girls following the first choice, with 13% failure on the task following first choice (Table 12). No gender difference was found following the second choice (24% failure for boys; 23% failure for girls) and third choice (33% failure for boys and 31% failure for girls). These findings show that successful task completion was not related to the gender of the participants and suggest that the lack of possession of a concept of science does not differ between boys and girls of the study population.

Table 12

Cross-tabulation of Task Success Count and Gender

Task Success		GENDER		
		Boys	Girls	Total
First Choice	0	46 (12.7%)	63 (12.5%)	109 (12.6%)
	1	316 (87.3%)	439 (87.5%)	755 (87.4)
Total		362 (100%)	502 (100%)	864 (100%)
Second Choice	0	85 (23.5%)	117 (23.3%)	202 (23.4%)
	1	277 (76.5%)	385 (76.7%)	662 (76.6%)
Total		362 (100%)	502 (100%)	864 (100%)
Third Choice	0	120 (33.1%)	154 (30.7%)	274 (31.7%)
	1	242 (66.9%)	348 (69.3%)	590 (68.3%)
Total		362 (100%)	502 (100%)	864 (100%)

Age. Analysis of the proportion of success/failure with regard to the age of participants found a statistically significant difference between younger and older children. Sixteen percent of younger children failed on the first task compared to 9% of older children. This trend continued with 28% of younger children failing following the second choice, compared to 18% failure of older children. The difference in success/failure proportion grows after the third choice with 39% of young children failing on the task, compared to 24% of older children (Table 13).

Table 13

Cross-tabulation of Task Success Count and Age

Task Success		AGE (years)		
		4	5	Total
First Choice	0	72 (15.7%)	37 (9.1%)	109 (12.6%)
	1	387 (84.3%)	368 (90.9%)	755 (87.4%)
Total		459 (100%)	405 (100%)	864 (100%)
Second Choice	0	129 (28.1%)	73 (18%)	202 (23.4%)
	1	330 (71.9)	332 (82%)	662 (76.6%)
Total		459 (100%)	405 (100%)	864 (100%)
Third Choice	0	179 (39%)	95 (23.5%)	274 (31.7%)
	1	280 (61%)	310 (76.5%)	590 (68.3%)
Total		459 (100%)	405 (100%)	864 (100%)

School. While separate-set analysis could not provide clear assertions about school differences due to the low number of participants in some of the schools, a whole-study analysis enables such comparison. Even schools with a low number of participants (1, 4) have 50 or more sessions to be included in the analysis.

The analysis shows that in schools with equal numbers of older and younger children (Schools 1, 2), there is a similar success proportion of 0.9 (following the first touch), 0.82 (following the second touch), and 0.71−0.76 (following the third touch). The success proportions are lower for School 3, which includes more young children, and higher for School 4, with a majority of older children. The only exception is School 5. Although there is a low number of younger children, the success proportion is significantly lower, at chance for the first two choices, and above chance for the third choice. School 5 is located on an American Indian reservation. Although the teachers in this school bring into the classroom science activities, it might be that these children are less familiar with the concept of science than their peers. Alternatively, it might be that the children did not understand the task, although all of them completed the training session (See Table 14 for details).

Table 14

Cross-tabulation of Task Success Count and School

		SCHOOL (% of sessions completed by young children in school)					
Task Success		1 (50%)	2 (51%)	3 (65%)	4 (30%)	5 (28%)	Total
First Choice	0	7 (11%)	29 (10%)	48 (14%)	3 (6%)	22 (24%)	109 (13%)
	1	59 (89%)	273 (90%)	308 (86%)	47 (94%)	68 (76%)	755 (87%)
Total		66 (100%)	302 (100%)	356 (100%)	50 (100%)	90 (100%)	864 (100%)
Second Choice	0	12 (18%)	54 (18%)	93 (26%)	6 (12%)	37 (41%)	202 (23%)
	1	54 (82%)	248 (82%)	263 (74%)	44 (88%)	53 (59%)	662 (77%)
Total		66 (100%)	302 (100%)	356 (100%)	50 (100%)	90 (100%)	864 (100%)
Third Choice	0	16 (24%)	86 (29%)	125 (35%)	8 (16%)	39 (43%)	274 (32%)
	1	50 (76%)	216 (71%)	231 (65%)	42 (84%)	51 (57%)	590 (68%)
Total		66 (100%)	302 (100%)	356 (100%)	50 (100%)	90 (100%)	864 (100%)

A further breakdown of the results into classroom grouping show that the age of the children does play a key role in the success/failure proportion within schools (with the exception of School 5). The three classrooms in School 2 (classrooms A, B, and C) differed on the percentage of 5-year-old children in the classroom. Participants from classroom A, who are mostly age 5, failed at the task considerably less often than children from classrooms B and C, who are age 4 (see Table 15). In School 3, participants from classroom F failed considerably less that their schoolmates from classrooms D and E, regardless of the age percentage, suggesting a classroom effect.

Table 15

Cross-tabulation of Task Success Count and Classroom

		Classroom (% young)						
		School 2			School 3			
Task Success		A (5%)	B (100%)	C (100%)	D (63%)	E (74%)	F (63%)	Total
First Choice	0	8 (5%)	11 (15%)	10 (14%)	15 (16%)	11 (15%)	22 (12%)	109 (13%)
	1	147 (95%)	64 (85%)	62 (86%)	82 (85%)	65 (86%)	161 (88%)	755 (87%)
Total		155 (100%)	75 (100%)	72 (100%)	97 (100%)	76 (100%)	183 (100%)	864
Second Choice	0	16 (10%)	19 (25%)	19 (26%)	26 (27%)	29 (38%)	38 (21%)	202 (23%)
	1	139 (90%)	56 (75%)	53 (74%)	71 (73%)	47 (62%)	145 (79%)	662 (77%)
Total		155	75	72	97	76	183	864
Third Choice	0	30 (19%)	30 (40%)	26 (36%)	43 (44%)	35 (46%)	47 (26%)	274 (32%)
	1	125 (81%)	45 (60%)	46 (64%)	54 (56%)	41 (54%)	136 (74%)	590 (68%)
Total		155	75	72	97	76	183	864

Top and bottom performers. On average, the group of participants responded to all sessions in a proportion that is better than chance (0.87, compared 0.75). A further breakdown of the results (Figure 8) showed that 19 children responded under the chance proportion (red bars on Figure 8), while 73 children responded with proportions that are higher than chance. The group of successful participants consisted of 42 children who completed all sessions successfully; however, not all of them completed all 11 sessions. Figure 9 presents the distribution of successful participants based on the number of sets completed.

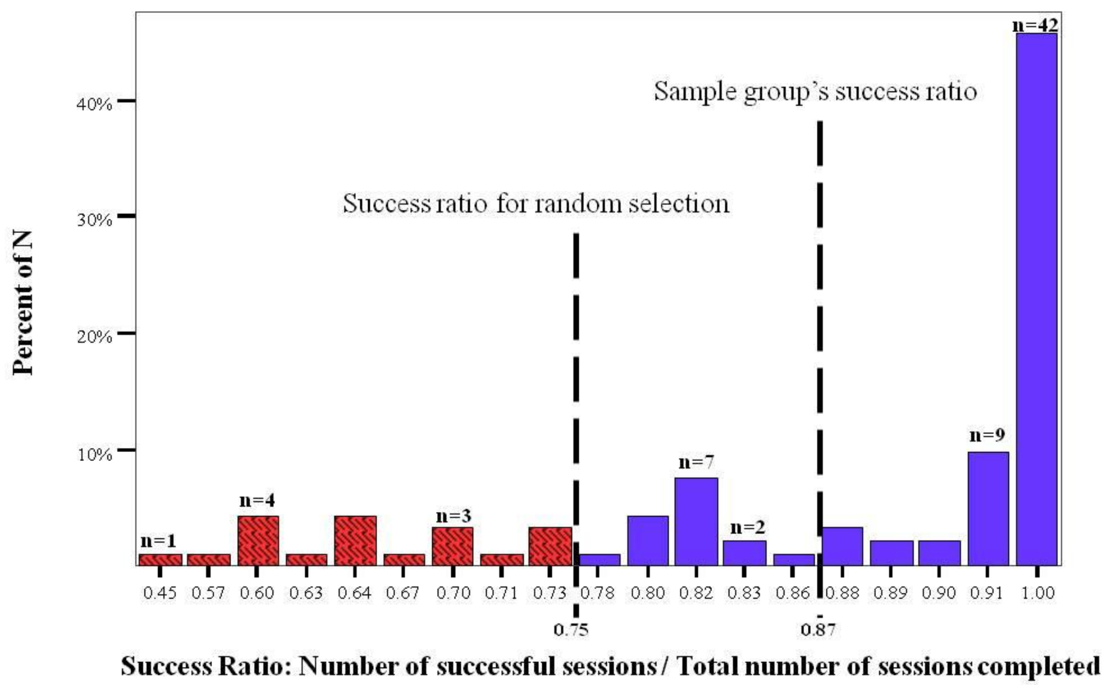


Figure 8. First choice success ratio (successful sessions/number of sessions) of study participants

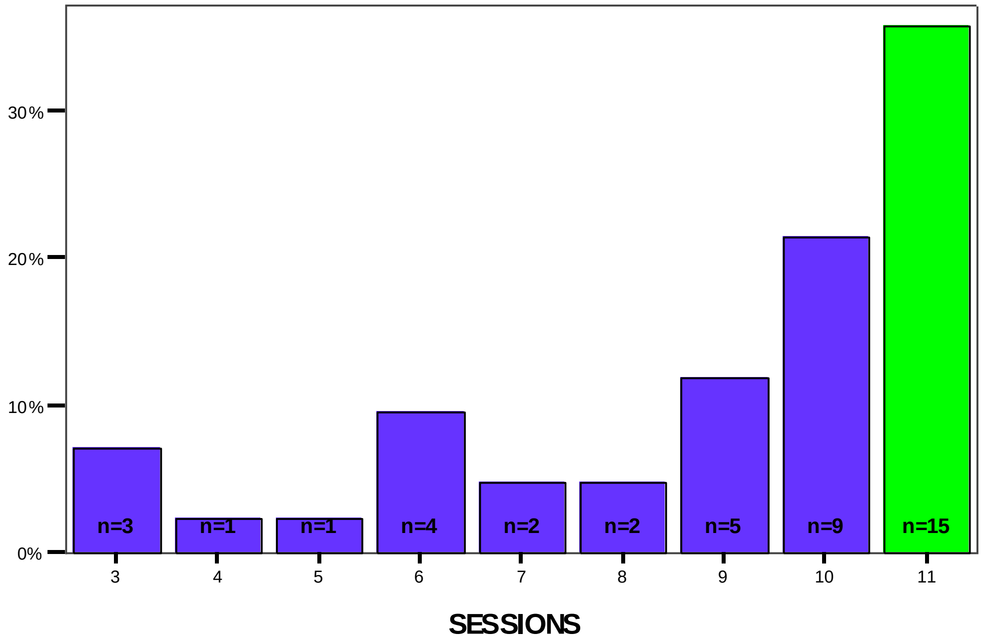


Figure 9. Number of sessions completed by successful participants

Fifteen children who were successful on all 11 sessions (Figure 9) were defined as top performers (TP). A group of the lowest-performing 15 children were defined as bottom performers (BP). This section will present the profiles of the two groups.

TP Group. The chance to answer correctly in all the sessions (e.g., not choose the NS picture in all 11 sets) is 4%. Fifteen children (16% of all children; 38% of all participants who completed 11 sets) were identified as TP. An analysis of the demographic of TP participants shows that the group consisted of five boys (13% of all boys) and 10 girls (19% of all girls) whose age ranged from 52 to 67 months (average 60 months). Nine of the TP participants were older children (21% of all 5-year-old children); six of the TP participants belong to the younger age group (12%). TP participants come from Schools 1−4: Two children were from School 1 (33%), four children were from

School 2 (12%), seven children were from School 3 (19%), and two children were from School 4 (33%), which is a museum location. Interestingly, 40% of all TP children came from one classroom, classroom E, which constituted 33% of the children in this class.

BP Group. It is impossible to determine whether these children did or did not possess a concept of science. It may be that they knew what science is but did not understand (or did not want to respond to) the task. It is also possible that their concept of science is wider than the one targeted by the study (the shared public concept).

Fifteen participants of the lower end of the success/failure proportion were identified as BP. The mean success/failure proportion of this group was 0.62. An analysis of the demographic of BP participants showed that the group consisted of seven boys (18% of all boys) and eight girls (15% of all girls), whose ages ranged from 48 to 69 months (average 56 months). The BP group included more children from the younger age group (10, 20% of younger participants) than older children (five, 12% of older participants). Finally, BP participants came from Schools 2−5: Five children were from School 2 (15%), six children were from School 3 (16%), one child was from School 4 (16%), and three children were from School 5 (30%).

Individual-Set Analysis

Following the whole-picture-task analysis, each set was analyzed separately. The raw data and list of instrument pictures can be found in Appendix D. All the statistical tables referenced in this section, can be found in Appendix F.

Set 1

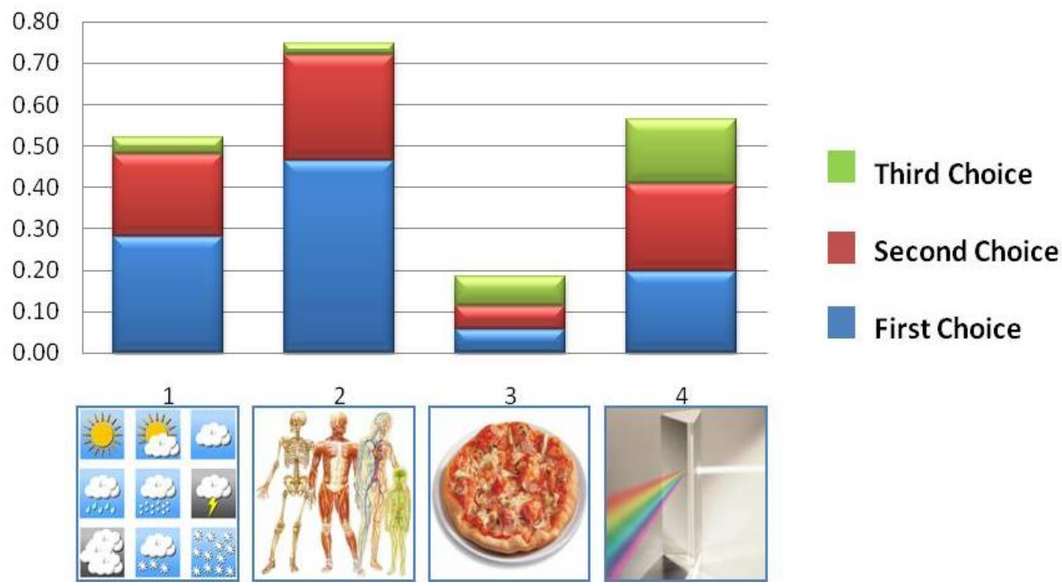


Figure 10. Set 1 pictures and choice distribution

Seventy-one children (33 boys and 38 girls; see Table 8 for demographics) replied to the first set of pictures (trial). All responders chose one picture as a “science picture” (VOTE_1 variable in Table 1-3, Appendix F). A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 17.8 (see Table 1-2, Appendix F). The residual column in Table 1-3 shows that the NS picture (PIZZA) was chosen significantly less often than the expected value, and the human body picture was chosen significantly more than the expected value.

The binomial test assessing the proportion of success/failure in the first choice (choice of any one of the three science pictures is considered as success = 1; while a vote for the non science picture is considered as failure = 0) found the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 1-4).

A second binomial test was conducted to assess the proportion of success/failure following two tries. Following the first touch (with 0.75 chance for success, including only those participants who made a choice), participants now had again 0.75 chance to succeed (two science pictures + arrow option lead to success; while touching the NS picture leads to failure). The test proportion was therefore set to 0.56 (0.75*0.75). The results of the second binomial test showed that the proportion of success/failure was still significantly different than the test proportion when considering the second vote of the children (see Table 1-5).

A third binomial test was conducted to assess the proportion of success/failure following the third try. The test proportion for the third choice was set to 0.38 (0.75 chance to succeed on the first try * 0.75 chance to succeed on the second try * 0.67 to succeed on the third try). The third test found the observed proportion to be significantly different than the test proportion, as can be seen in Table 1-6.

The tests discussed so far suggest that the children's responses for the first set of four pictures did not follow an equal, random-choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. The fact that the NS picture was chosen significantly less often than the other pictures suggests that the group has some idea about what science is, or what is considered as science. A cross-tabulation table (Table 1-7) presents the breakdown of success/failure based on gender and age. The data presented in Table 1-7 show no significant gender difference among participants who succeeded or failed the task; however, a majority of the failing participants are from the younger age group.

Another method for assessing the cause of the variability in the success/failure proportion is conducting a logistic regression. The binary dependent variable was the proportion of success/failure following three choices of pictures. The categorical variables were gender (33 boys and 38 girls) and school. The continuous variable was age in months (Table 1-8).

The results of the logit model show that the gender variable does not explain the variability in the first set's success/failure proportion. However, age was found to significantly affect the variability of success/failure proportion. Increasing age is associated with better success on the first set task. For every month change in age, the log odds of success increased by 0.1. The school variable was also found to be associated with the proportion of success. As can be seen in Table 1-9, belonging to School 2 was associated with better success on the task. Schools 1 and 4, with 100% successful participants, were not considered here due to the low number of participants (Table 1-10).

It must be noted, however, that the data presented here are only of children who made a choice on the first set, excluding any missing data.

In summary, analysis of the data gathered from the responses to the first set shows that participants chose the NS picture significantly less often than the expected value, even after three tries. The data show that age and school affiliation play a role in the proportion of success on the task; however, no gender differences were found. The stereotypical science views of School 2 participants are not correlated with age, as half of its participants are young. The findings suggest that the majority of the children distinguished between science and non-science pictures.

The Concept of Science

Analysis of the first response of Set 1 participants show that the picture presenting human body was chosen significantly more than other pictures by both boys and girls. The picture presenting weather systems was chosen second with equal number of responses from boys and girls. The picture showing a breaking of light into rainbow by a prism was chosen by girls more than boys. Overall, it seems that boys tended to choose the human body and weather pictures, and girls' choices divided more equally among the three science pictures. The prism/rainbow picture poses a problem in explaining the data. This picture shows two entities that may be perceived differently to a child without a prior knowledge about light properties. The prism is a clear object that may be unfamiliar to young children, while the rainbow may be associated more with weather or colors. The rainbow may also be considered a "pretty" picture, which may be more attractive to girls than boys.

Examining the breakdown of choices by schools (Table 1-12) reveals that participants' responses distribute differently across schools. School 1 participants' responses distributed evenly among the three science pictures. Participants from Schools 2 and 5 chose the human body picture more than the other science pictures, while participants from School 3 chose the human body and weather pictures. It must be noted that the small number of participants from Schools 1, 4, and 5 does not allow making any claims about the choice pattern. Still, analysis of the responses shows that the instrument was successful in detecting such differences.

Set 2

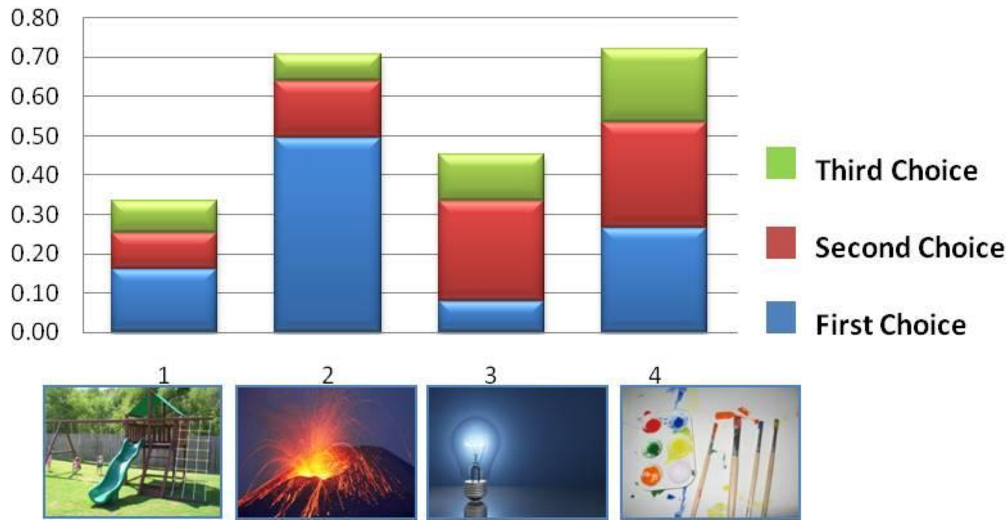


Figure 11. Set 2 pictures and choice distribution

Seventy-five children from five schools replied to the second set (33 boys and 42 girls with mean age of 58 months; see Table 2-1 for demographics). All responders chose one picture as a "science picture" (VOTE_2 variable). A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 18.8" (see Table 2-2, Appendix F). The residual column in Table 2-2 show that two pictures, the NS picture (Playground) and the science picture (Lightbulb) were chosen less often than the expected value. The science picture of volcano was chosen significantly more than expected by random selection.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 2-4).

A second binomial test was conducted to assess the proportion of success/failure after two tries. The results of the second binomial test show that the proportion of success/failure is still significantly different than the test proportion considering the second vote of the children (see Table 2-5).

A third binomial test was conducted to assess the proportion of success/failure after three tries. The third test found the observed proportion to be significantly different than the test proportion, as can be seen in Table 2-6.

The tests discussed so far suggest that the children's responses for the first set of four pictures did not follow equal, random-choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. The NS picture was chosen more often than the NS picture in Set 1; however, it was still chosen less often than the three science pictures (after three attempts). Set 2 choice patterns provide support to the decision to assess children's view by allowing them to choose multiple pictures. As the results show, a tendency to vote for the NS picture first is balanced and reversed following the third choice. These analyses suggest that participants who responded to the second task do hold some concept of science. A cross-tabulation table (Table 2-7) presents the breakdown of success/failure based on gender and age. The data presented in Table 2-7 show that about 50% of the children who failed on the task are young girls (from the 4-year age group). Girls belonging to the older age group (5 years) tended to succeed on the task. In this set, age seems to be a critical factor in success or fail for girls, but not for boys.

A logistic regression was conducted to assess the relationship between the dependent variable (success/failure) and response variables (age, gender, and school).

The results of the regression (Table 2-9) show that neither gender nor school variables explain the variability in the second set's success/failure proportion. However, the age variable was found to significantly affect the variability of success/failure proportion. Increasing age is associated with better success on the second set. For every month change in age, the log odds of success increased by 0.12. The NS picture in this set, a picture showing a playground, may look attractive to young children and affect the frequency of choices.

In summary, analysis of the data gathered from the responses to the second set show that the responses of the participants are significantly different than chance. Although not as robust as the first set, participants chose the NS picture less often than the other science pictures in the set. The distribution of the responses to the first question are significantly different than chance, success/failure proportions for the first, second, and third choices differ from chance as well. The success/failure response is positively associated with age. The data suggest that, as expected, the ability to successfully respond to the task improves with age.

The Concept of Science

Analysis of the first response of Set 2 participants show that older boys and girls tended to choose the picture showing a volcano over the rest of the pictures. Younger children tended to choose the volcano and colors as their first choice. The lightbulb picture was not chosen often in the first try; however, following two more attempts, it got more votes than the NS picture. These findings, again, stress the significance of allowing children to choose multiple pictures, as the view of science is more complex than simply one picture.

Examining the breakdown of choices by schools (Table 2-11) reveals no distribution diversity among the schools with regard to the science pictures chosen on the first try. The only difference would be in the choice of the NS picture. Participants from School 3 tended to choose the playground picture more than participants from other schools. This may be associated with age, as two-thirds of School 3 participants are young children.

Set 3

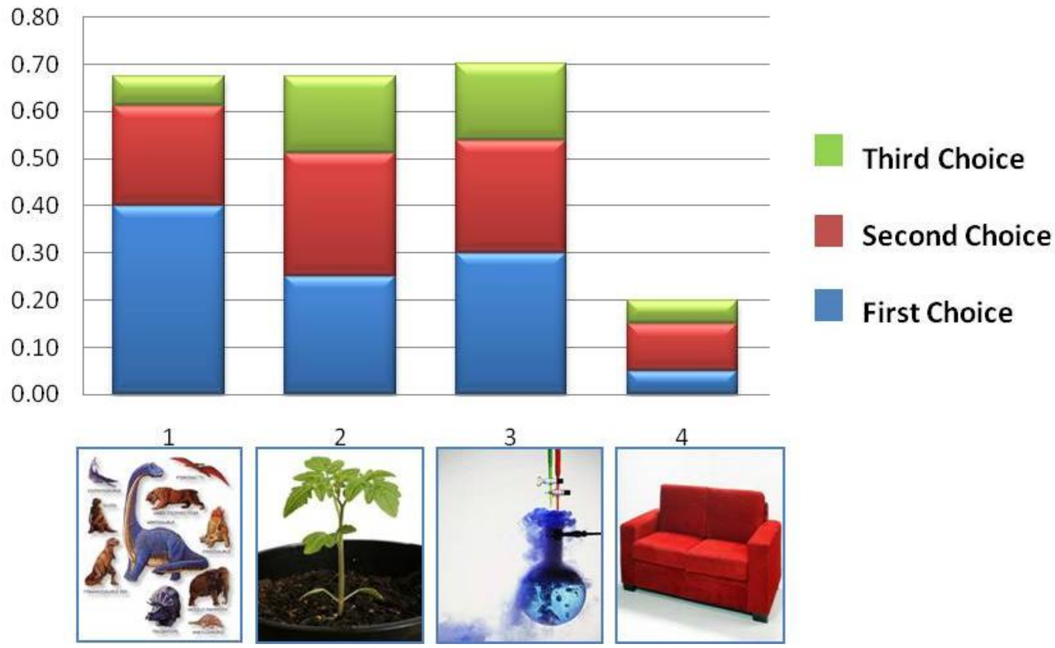


Figure 12. Set 3 pictures and choice distribution

Eighty children, 45 girls and 35 boys with a mean age of 58 months, responded to Set 3 instructions by choosing a picture that "shows science." As can be seen in Table 3-1, younger boys were less represented than the other groups. A Chi-Squared test performed on the first choice distribution found the observed data to be significantly different than the expected random count of 20 (see Table 3-2, Appendix F). The residual column in Table 3-2 shows the NS picture (sofa) was chosen significantly less often than the expected value, as well as the other science pictures. The science picture showing dinosaurs was chosen significantly more times than the expected value.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 3-4).

A second binomial test was conducted to assess the proportion of success/failure after two tries. The results of the second binomial test show that the proportion of success/failure is still significantly different than the test proportion considering the second vote of the children (see Table 3-5).

A third binomial test was conducted to assess the proportion of success/failure after three tries. The third test found the observed proportion to be significantly different than the test proportion, as can be seen in Table 3-6.

The tests discussed so far suggest that the children's responses for the third set of four pictures did not follow an equal, random-choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. Similar to the results of Set 1, the NS picture was chosen significantly less often than the three science pictures. These analyses suggest that participants who responded to the third set task do hold some concept of science. A cross-tabulation table (Table 3-7) presents the breakdown of success/failure after three tries based on gender and age. The data presented in Table 3-7 show no significant difference between genders in task performance. However, examination of the group who "failed" on the task shows that children from the younger group (4 years) failed more often than older children (5 years), and a larger percentage of the boys (35%) failed on the task compared to girls (18%).

A logistic regression was conducted, but no relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school) was found.

Unlike the two previous sets, where the older the children were, the better they performed on the task, in Set 3, this effect was not present. Although from Table 3-7 above it can be seen that the majority of failure on the task came from younger children, these differences were found to be not significant in the logistic regression test. It suggests that the task was "easy" enough that even young children performed well on the task. "Easy" relates to both the science and NS pictures. The NS picture featuring a red sofa is static and not attractive to young children, while the three science pictures feature stereotypical images of science topics.

In summary, analysis of the data gathered from the responses to the third task showed that the responses of the participants were significantly different than chance. The NS picture was chosen significantly less often than the other three science pictures. The task seemed "easy" enough that both younger and older children performed well on it. The data suggest that the children do have a concept of science, which does not include the image of a red sofa.

The Concept of Science

Analysis of the first response of Set 3 participants shows an interesting gender divergence. While boys' first responses focus mainly on the pictures of dinosaurs (about 50% of the votes) and chemical reaction, girls responses distribute evenly among the three science pictures. The picture of the plant is especially noteworthy as it was chosen significantly more by girls than by boys on the first vote. Similar to pilot study results, and aligning with gender differences found in older children, these data confirm that gendered views or preferences regarding what constitutes as science are present at age 4.

Examining the breakdown of choices by schools (Table 3-11) reveals differences in choice pattern among the schools. Because of the small number of participants from Schools 1 and 4, only Schools 2, 3, and 5 will be discussed here. School 2 participants, two-thirds of whom are girls, present a “female” choice pattern with equal number of choices to the three science pictures. School 3 participants, half of whom are girls, present an interesting “male” choice pattern, choosing mostly the dinosaur and chemical reaction pictures. School 5 participants, half boys and half girls, present a choice pattern similar to female pattern. It is important to note that school differences may be due to curricula or cultural differences, which were not examined in this study. Overall it can be said that girls tended to choose the plant picture more than boys on their first choice of picture representing science.

Set 4

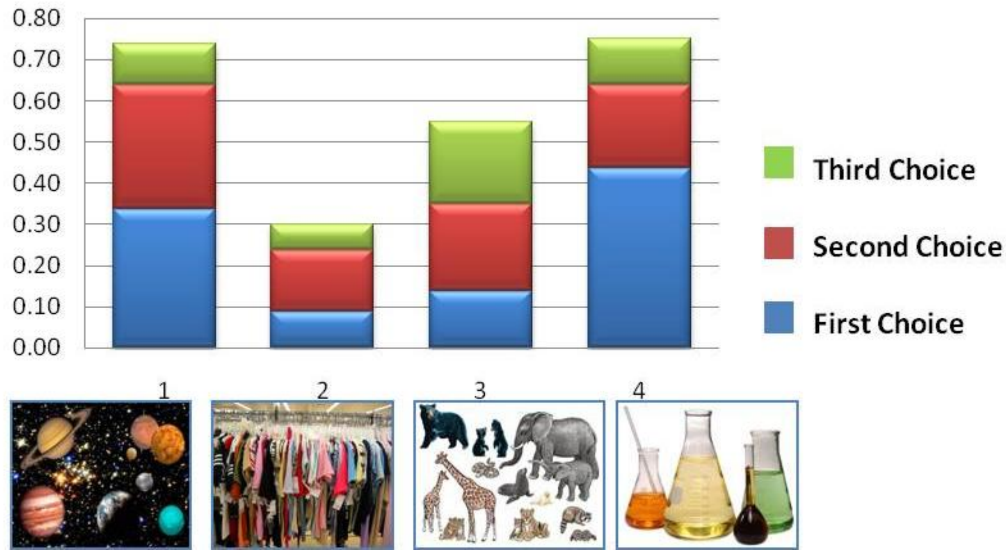


Figure 13. Set 4 pictures and choice distribution

Eighty children participated in Set 4: 46 girls and 34 boys with mean age of 58.5 months.A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 20 (see Tables 4-2 and 4-3, Appendix F). The residual column in Table 4-2 shows the NS picture (clothes) was chosen significantly less often than the expected value, while the picture showing chemicals was chosen significantly more times than the expected value.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different (at a 99% level) than the expected proportion of a random selection (Table 4-4).

A second binomial test was conducted to assess the proportion of success/failure after two tries. The results of the second binomial test show that the proportion of success/failure is still significantly different than the test proportion considering the second vote of the children (see Table 4-5). A third binomial test found that the success/failure proportion to be significantly different than chance, with 70% success, following the third choice (Table 4-6).

The tests discussed so far suggest that the children's responses for the fourth set of four pictures did not follow an equal, random-choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. Similar to the results of Sets 1 and 3, the NS picture was chosen significantly less often than the three science pictures. These analyses suggest that participants who responded to the fourth set task do hold some concept of science. A cross-tabulation table (Table 4-7) presents the breakdown of success/failure after three tries based on gender and age. The data presented in Table 4-7 show that younger girls failed on the task – chose the NS picture of clothes – more than the other subgroups. No gender or age difference was found within the group of children who completed the task successfully. Examination of the proportion of success/failure by school (Table 4-8) shows a (relatively) large proportion of participants from School 5 failing on the task (although all the children who failed are older children).

A logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school).

The results of the regression (Table 4-10) show that the age variable significantly explains the variability in the dependent variable at a 95% level. Each addition of one month to participants' age adds 0.9 t to the log odds of the success on the task.

In summary, analysis of the data gathered from the responses to the fourth task shows that the responses of the participants are significantly different than chance. The NS picture was chosen significantly less often than the other three science pictures. Older children performed better than younger children in not choosing the NS picture. The subgroup of young girls was found to fail more often than the other subgroups.

The Concept of Science

Analysis of the first response of Set 4 participants shows a small age difference in choice pattern. While younger children (age 4 years) chose the stereotypical pictures of space and chemicals, the older children chose these pictures as well but tended to choose the picture of the chemicals more than the picture showing space. No gender difference was found within the older group; however, within the younger group girls tended to choose the space picture twice more often than boys.

Examining the breakdown of choices by schools (Table 4-12) reveals differences in choice pattern among the schools that seem to be driven by age. School 2 older participants (age 5 years) tended to choose the chemicals picture over the rest of the pictures. School 3 younger participants tended to choose the picture showing space over the rest of the pictures. School 5 participants' choices were equally distributed over the three science pictures.

Set 5

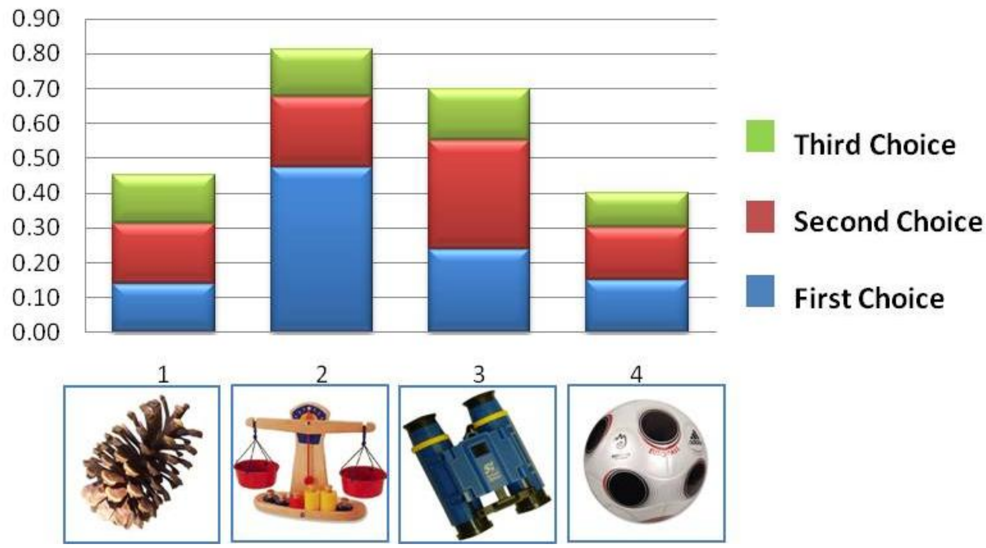


Figure 14. Set 5 pictures and choice distribution

Set 5 is the first set asking children to touch a picture showing science object (rather than pictures showing science as instructed in the previous four sets). Eighty children participated in Set 5: 47 girls and 33 boys with mean age of 58.7 months.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 20 (see Table 5-3, Appendix F). The residual column in Table 5-2 shows that two pictures, the NS picture (soccer ball) and the science picture showing pinecone, were chosen significantly less often than the expected value, while the picture showing scale was chosen significantly more times than the expected value.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different (at a 95% level) than the expected proportion of a random selection (Table 5-4).

A second and third binomial tests found the proportions of success/failure significantly different than a chance test proportion (Tables 5-5 and 5-6).

The tests discussed so far suggest that children's responses for the fifth set did not follow an equal, random choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. However, similar to Set 2, the NS picture was chosen considerably more frequently following the first choice. Still, it was chosen significantly less often than the leading science picture.

A cross-tabulation table (Table 5-7) presents the breakdown of success/failure after three tries based on gender and age. The data presented in Table 5-7 show that 50% of the boys and 30% of the girls failed on the task. Additionally, 50% of the children belonging to the younger age group (4 years) failed on the task. The subgroup of older girls was especially successful on the task, compared to the other subgroups. It may be due to the fact that the NS picture, soccer ball, may be more appealing to boys than to girls.

Table 5-8 shows that participants from Schools 2 and 5 failed on the task in proportions considerably larger than in other schools.

A logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school).

The results of the regression (Table 5-10) show that the age variable significantly explains the variability in the dependent variable at a 99% level, and the gender variable significantly explains the variability in the success on the task at 95% level. The differences in choice patterns in the different schools were not found to be significant and probably are due to the age and gender differences. Girls performed better on the task than boys, and older children performed better than younger children.

In summary, analysis of the data gathered from the responses to the fifth task show that the responses of the participants are significantly different than chance. The NS was chosen significantly less often than the science pictures by girls, as well as older children. Young children and boys tended to choose the NS picture more.

The Concept of Science

Analysis of the first response of Set 5 participants show differences in choosing science pictures based on age and gender. Young boys (4 years) tended to choose the pinecone and scale as pictures showing science objects, while older boys (5 years) tended to choose binoculars and scale as pictures showing science objects. Young girls voted similar to the older boys, choosing scale and binoculars, while older girls voted for the picture showing scale over the other two science pictures.

Examination of the breakdown of choices by schools (Table 5-12) reveals differences in choice pattern among the schools that assumed to be based on gender and age differences. The majority of votes for pinecone come from School 3, where the majority (seven-eighths) of voters are young children (4 years).

Set 6

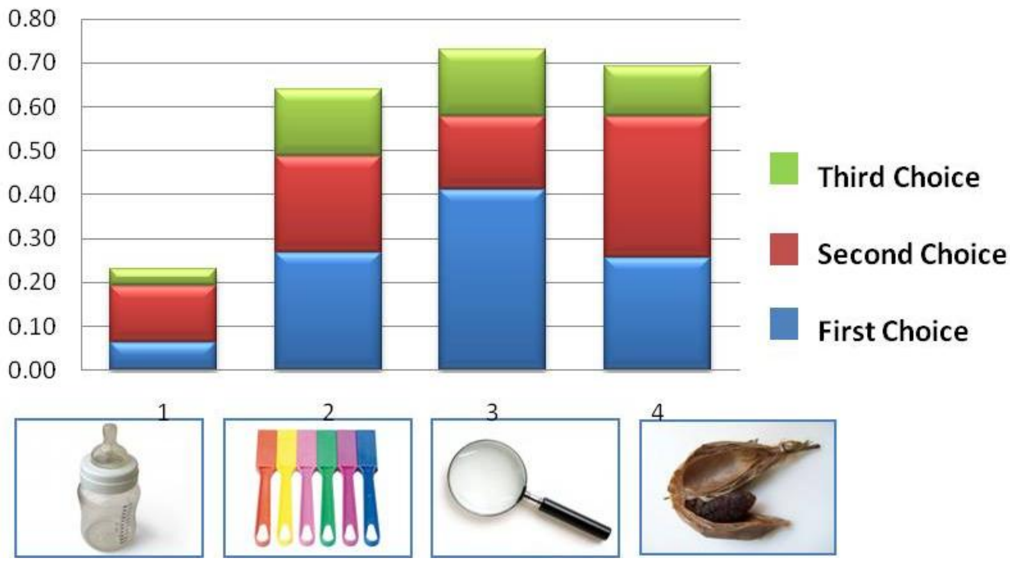


Figure 15. Set 6 pictures and choice distribution

Seventy-eight children participated in Set 6: 47 girls and 31 boys with mean age of 58.6 months. The breakdown of schools shows six participants from School 1; 28 participants from School 2; 33 participants from School 3; three participants from School 4; and eight participants from School 5.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 19.5 (see Tables 6-2 and 6-3, Appendix F). The residual column in Table 6-2 shows the NS picture (baby bottle) was chosen significantly less often than the expected value and significantly less often than the rest of the science pictures, while the picture showing the magnifying glass was chosen significantly more times than the expected value.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 6-4), with proportion of 0.94 success on the task.

Similarly, second and third binomial tests found the proportion of success/failure to be significantly different than the test proportion considering the second and third votes of the children (Tables 6-5 and 6-6).

The tests discussed so far suggest that the children's responses for the sixth set of four pictures did not follow an equal, random-choice pattern. It seems that most children responded to the task and meaningfully followed the instructions. The NS picture (baby bottle) was chosen considerably less often than the science pictures by the participants, similar to sets 1, 3, and 4.

A cross-tabulation table (Table 6-7) presents the breakdown of success/failure after three tries based on gender and age. Examination of the failing group shows that the majority of children who failed are girls and younger children. No boys from the older group (age 5) failed the task by choosing the NS picture (baby bottle) during one of the three attempts. No significant differences based on age or gender were found within the group who completed the task successfully.

Table 6-8 shows that children from School 3 failed on the task in larger proportion than Schools 2 and 5, which may be due to a large percentage of young children.

A logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school).

The results of the regression (Table 6-10) show that the age variable significantly explains the variability in the dependent variable. For each addition of one month to the age of participants, the log odds of the dependent variable (task success) improve in 0.13.

In summary, analysis of the data gathered from the responses to the sixth task show that the responses of the participants are significantly different than chance. The NS was chosen significantly less often than the science pictures by boys and older children. Young children and girls tended to choose the NS picture more. This pattern may be due to the content of the NS picture; baby bottles may be more appealing to girls, who engage a lot in sociodramatic play and like to play "house," than to boys. See discussion in the limitation section.

The Concept of Science

Analysis of the first response of Set 6 participants show differences in choosing science pictures based on age and gender. For boys, the two leading science pictures are the pictures showing magnets and seed, with younger children favoring magnets and older boys favoring the seed as their first choice. For girls, both younger and older girls preferred the picture showing the magnifying glass as first choice. Older girls also favored the seed picture, while younger girls favored the magnets.

The presence of science objects in each school/classroom may affect the choice of the pictures. Examination of the breakdown of choices by schools (Table 6-12) shows some school effects that may go beyond age and gender. By looking at the each classroom data, some classroom differences appear. While five out of six School 1 children voted for the magnets, the majority of children in Class 7 voted for the seed (eight votes, all subgroups). Classrooms 2 and 3 showed preference toward the magnifying glass, but this may be gender-related.

Set 7

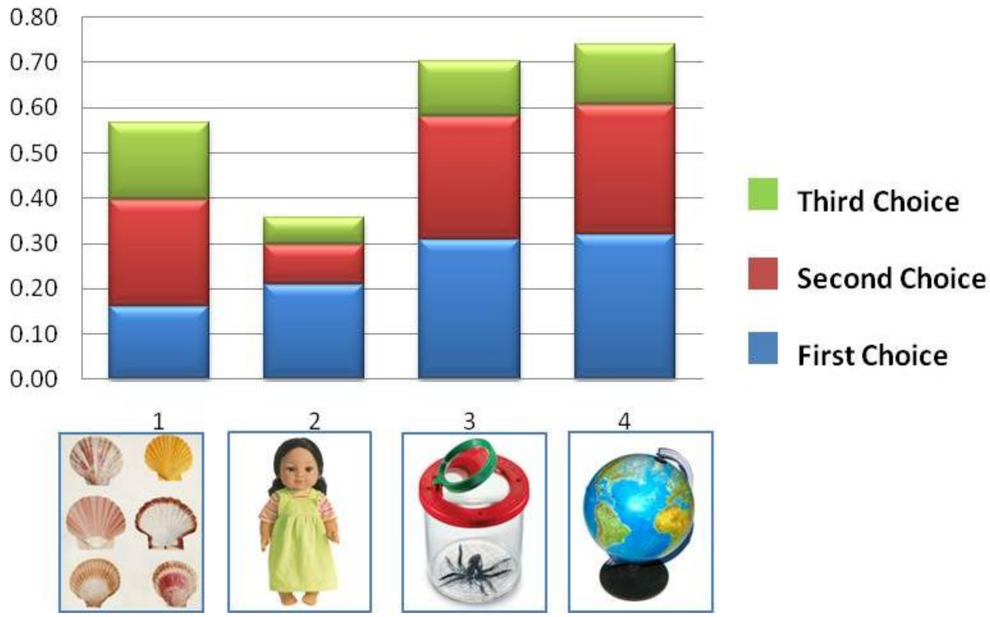


Figure 16. Set 7 pictures and choice distribution

Eighty-one children participated in Set 7: 47 girls and 34 boys with a mean age of 58.4 months. The largest subgroup is younger girls, and the smallest subgroup is older boys. The breakdown by schools show six participants from School 1; 31 participants from School 2; 31 participants from School 3; five participants from School 4; and eight participants from School 5.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern different than the expected random count of 20.3; however, the difference is not statistically significant (see Tables 7-2 and 7-3, Appendix F). The residual column in Table 7-2 shows that the NS picture (doll) was chosen less often than the expected value but more times than the science picture showing shells, while the pictures showing globe and spider viewing cup were chosen more than the expected random value.

A binomial test assessing the proportion of success/failure in responders' first choice did not find the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 7-4), with a proportion of 0.79 success on the task.

However, binomial tests assessing the proportion of success/failure following the second and third tries found the success rate to be significantly different than chance, with a success rate of 0.7 and 0.64, respectively. This finding stresses the need to look beyond children's first choice.

The results of the tests discussed so far suggest that a combination of Set 7 pictures may have posed a problem for some of the children for first choice; however, following the second and third tries, the choice pattern does not seem to be random.

A cross-tabulation table (Table 7-7) presents the breakdown of success/failure following the third vote based on gender and age. Examination of the failing group shows that within the group that failed on the task, the largest subgroup is younger girls (50% of the failing children). No significant differences were found within the group of children who completed the task successfully, yet the subgroup of older girls is the largest of all subgroups (~30%).

Table 7-8 shows that the large number of children failing on the task goes across school grouping, with School 2 showing the lowest failure percentage.

A logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school).

The results of the regression (Table 7-10) show that the age variable significantly explains the variability in the dependent variable. For each addition of one month to the age of participants, the log-odds of the dependent variable (task success) grow in 0.1. The gender and school variables were not found to significantly affect the variability of the success/failure proportion.

In summary, analysis of the data gathered from the responses to the seventh task shows that unlike any of the previous sets, the responses of the participants change pattern after the first choice. The first choice pattern cannot be determined significantly different than random vote; however, as participants continue to choose pictures that show "science objects," the overall choice pattern changes and illustrates a pattern that is significantly different than chance. The age of the children has an effect on success/failure proportion, with success proportion growing with participants' age. The change in pattern may be due to the following reasons. First, all pictures featured in this set, including the NS picture, represent natural science (which is different from other sets, where natural science was represented by one or two pictures). Second, no one of the three science pictures show a stereotypical science image. The picture of a doll may resemble a real baby or representation of a baby, which fits the category of pictures featured in this set. It also might be that the doll image is more appealing to young children (and girls) who chose the picture regardless of the instructions.

The Concept of Science

Analysis of the first response of Set 7 participants shows differences in choosing science pictures based mainly on the school variable. Examination of Table 7-11 shows that significant gender and age differences were found only with regard to the NS picture (doll), getting more votes from younger children (13;4) and girls (12;5). The group of younger boys tended toward the image of spider, while the older girls showed a tendency toward the globe. As noted in Chapter 3, the globe − although not stereotypical science picture − is found in many science areas and used as representation of the earth. However, these are small numbers that may not represent any preference.

Interestingly, it seems like the school grouping had an effect on the vote for the picture showing shells. The majority of the votes for this picture come from School 3, which may be due to a special activity with shells in this school or simply the presence of shells in the science center of the school. The majority of votes for the globe image came from School 2 participants. It seems like each school has a difference choice pattern for the preferred science pictures, which is reasonably since school activities and diversity of science objects in each school directly affect children's perception of "science objects."

Set 8

Figure 17. Set 8 pictures and choice distribution

Seventy-nine children participated in Set 8: 49 girls and 30 boys with mean age of 58.5 months. The largest subgroup is younger girls, and the smallest subgroup is older boys. The breakdown by schools show six participants from School 1; 29 participants from School 2; 33 participants from School 3; five participants from School 4; and six participants from School 5.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 19.8 (see Tables 8-2 and 8-3, Appendix F). The residual column in Table 8-2 shows that the NS picture (truck) and the science picture rocks were chosen less frequent than the expected value, while the picture showing bottles with liquids was chosen more frequently than the expected random value.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different (at a 95% level) than the expected proportion of a random selection (Table 8-4), with a proportion of 0.85 success on the task.

Binomial tests assessing the proportion of success/failure following the second and third choices found the proportions to be statistically different than chance test proportions, with a success rate of 0.8 and 0.7, respectively.

The tests discussed so far show that the responds did not follow random pattern, suggesting that participants follow some perception of science to guide their votes. The NS picture (truck) was chosen considerably less often than the expected value and two of the science pictures. A cross-tabulation table (Table 8-7) presents the breakdown of success/failure on the third try based on gender and age. The data presented at Table 8-7 show that two-thirds of the children failing the task are young children (4 years), and half of the younger boys failed on the task.

Table 8-8 shows that Schools 2 and 3 had high proportions of children failing on the task.

Logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school). However, no significant statistical relationships were found.

In summary, analysis of the data gathered from the responses to Set 8 task shows the choice pattern is significantly different than chance. A large number of younger boys voted for the NS picture, which may be attributed to the fact that the NS picture is a truck. However, this picture is qualitatively different than the three other science pictures since it shows a single object, while the rest of the pictures show collections of multiple objects. Additionally, the truck is the only “play object” in the set, which may be attractive to children. Lastly, one must consider that this is the eighth set for the majority of the children, and they may be tired and therefore touch pictures that are more attractive rather than concentrate and answer the question. Still, the results of the binomial tests show that the NS picture was chosen less frequently than the expected random frequency.

The Concept of Science

Analysis of the first response of Set 8 participants shows some gender difference in choice pattern. Almost half of the girls chose the picture showing bottles, while only third of the boys did so. The picture showing leaves was chosen more by younger participants than older participants. The picture of rocks was not favored by older girls as first choice (Table 8-11).

The table of first choice by school show that the picture showing rocks was chosen considerably more often by children from School 3, which presented a choice pattern that is relatively balanced (with a tendency toward the bottles image) across the three science pictures; children from School 2 tended to vote for the pictures showing leaves and bottles as their first choice (Table 8-12).

Set 9

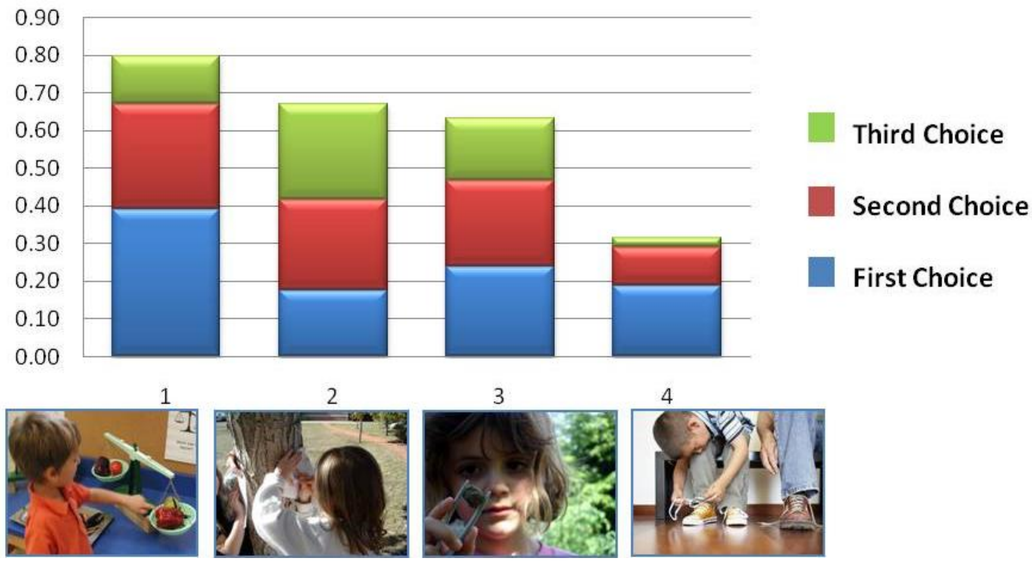


Figure 18. Set 9 pictures and choice distribution

Set 9 is the first set to ask participants about science activities. Seventy-nine children participated in Set 9: 48 girls and 31 boys with mean age of 58.5 months. Girls' age is equally divided between younger and older groups, while there are slightly more younger boys than older boys. The smallest subgroup is the one with older boys. The breakdown by schools show six participants from School 1; 27 participants from School 2; 33 participants from School 3; six participants from School 4; and seven participants from School 5.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different than the expected random count of 19.8 (see Tables 9-2 and 9-3, Appendix F). The residual column in Table 9-2 shows that the NS picture (tying shoes) and the science picture (writing on bark) were chosen less frequent than the expected value; while the picture showing a boy using a scale was chosen more frequently than the expected random value.

A binomial test assessing the proportion of success/failure in responders' first choice did not find the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 9-4), with proportion of 0.81 success on the task.

In contrast, binomial tests assessing the proportion of success following the second and third choices found the proportions (0.7; 0.68) to be statistically significant than chance.

A cross-tabulation table (Table 9-7) presents the breakdown of success/failure after three tries based on gender and age. The data presented at Table 9-7 show that a slightly larger percentage of boys (35%) than girls (29%) failed on the task, mostly due to older boys. A larger percentage of older children (37%) failed on the test compared to younger children (26%). This is interesting since it is the first set where older participants fail more than younger participants.

Table 9-8 shows that participants from School 5 failed on the test in a pattern that is different from the other schools. Still, there are only seven participants from School 5, which is a small number to make any robust assertions.

A logistic regression was conducted to further test the relationship between the dependent variable (success/failure after three tries) and response variables (age, gender, and school).

The results of the regression (Table 9-10) show no significant relationship between the proportion of success on the task and the variables of age, gender, and school. The regression does point at an interesting trend: Girls and younger children had better success on the task (column B), but not statistically significant proportions. This is different than previous sets. All the schools performed better than School 5 participants.

In summary, analysis of the data gathered from the responses to Set 9 task shows that while the response pattern following the first choice did not differ than chance, the second and third choice pattern differ significantly from a random choice pattern. Surprisingly, the NS picture (tie shoe) got half of the votes of older boys. This may be due to the fact that the NS picture shows a boy tying his shoe. Since this is the ninth set AND a new category to consider (science activity), it may have added to the confusion of the children who voted based on gender. The next section will test whether participants' votes were affected by the gender of the children featured in the pictures. Alternatively, the tying shoe image may represent a purposefully and difficult activity, which may fall under the perception of science activity.

The Concept of Science

Analysis of the first response of Set 9 participants (Table 9-11) shows that younger boys preferred the picture presenting a boy weighing with scale and a girl holding a rock with tweezers. This group did not seem to vote based on the gender of the child featured in the picture. These two pictures are the only two showing a "science tool," and it might be the reason for this group's first vote. Older boys voted for these two pictures as well; however, half of them chose the NS picture. Girls overall were less inclined to vote for the NS picture. Among the science pictures, the group of older girls showed preference for the weighing picture, while the younger girls voted almost equally for the three science pictures. This group chose the picture featuring a girl writing on bark considerably more than the other subgroups. It might be due to the fact that the picture presents a girl. However, the small number of children (especially in the boys' subgroups) makes it hard to make any robust assertions.

The table of first choice by school shows that the preference for the weighing picture goes across schools, and the picture showing a girl writing on bark, which may not be an intuitive science picture, did not get votes from Schools 1 and 4.

Set 10

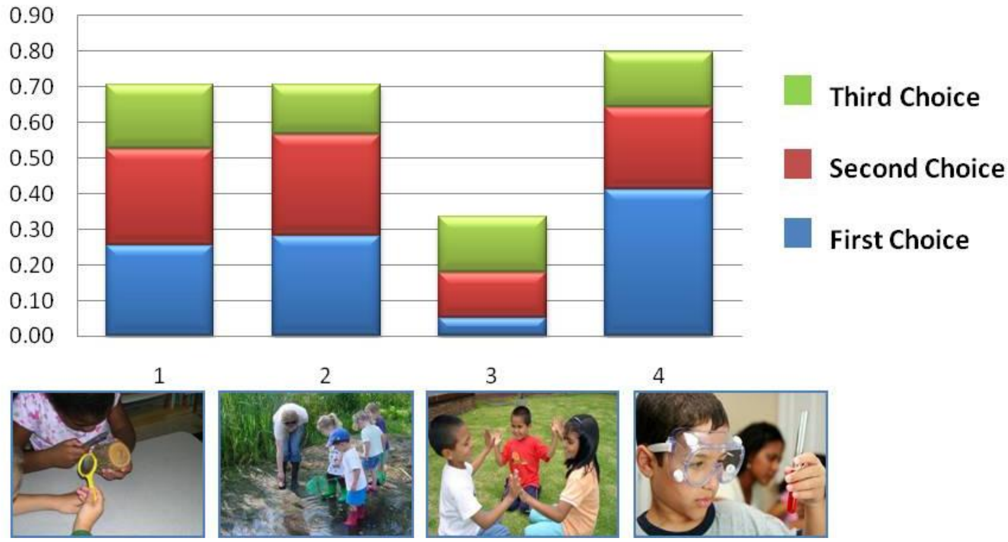


Figure 19. Set 10 pictures and choice distribution

Seventy-eight children participated in Set 10: 46 girls and 32 boys with a mean age of 58.5 months. As in previous sets, the group of the older boys is the smallest among the subgroups with 14 participants. The breakdown to schools show six participants from School 1; 30 participants from School 2; 31 participants from School 3; four participants from School 4; and seven participants from School 5.

A Chi-Squared test performed on the distribution of the first choice found the observed choice pattern significantly different (at a 99% level) than the expected random count of 19.5 (see Tables 10-2 and 10-3, Appendix F). The residual column in Table 10-2 shows that the NS picture (playing game) was chosen significantly less often than the expected value, while the picture showing a boy with goggles holding a test tube was chosen more frequently than the expected random value. The pictures showing girls using a magnifying glass and children doing pond investigation got votes similar to random choice count.

A binomial test assessing the proportion of success/failure in responders' first choice found the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 10-4), with proportion of 0.95 success on the task.

Similarly, binomial tests assessing the proportion of task success following the second and third choices found them to be significantly different than chance, with success proportion of 0.8 and 0.67.

A cross-tabulation table (Table 10-7) presents the breakdown of success/failure after three tries based on gender and age. The data presented at Table 10-7 show that girls from the older age group (5 years) did not fail on the task as much as children from other subgroups. Younger children failed more than older children (69%; 31%). Older girls seem to do better on the task. No significant age difference was found among the group of children who succeeded on the task.

Table 10-8 presents a cross-tabulation of task success and schools. The data in Table 10-8 show that children from Schools 3 and 5 failed on the task in larger percentages compared with School 2. It may be due to the fact that the majority of participants from School 3 are young children. Overall it does not seem that there was a school effect on the proportion of success/failure in this task.

A logistic regression did not find statistically significant relationship between the dependent variable (success/failure after three tries) and response variables (age in months, age in years, gender, and school).

In summary, analysis of the data gathered from the responses to the Set 10 task shows that the choice pattern is significantly different than chance, with significantly less votes to the NS picture. Young children failed on the task more than older children. It might be due to the less concrete concept of science they have or their shorter attention span. This is the tenth task, and they may have been tired or found it hard to concentrate.

The Concept of Science

Analysis of the first response to Set 10 task participants shows some differences based on school, gender, and age. This set poses a contrast between a stereotypical image (a boy with goggle and test tube, which is not an activity done in preschools) and some investigative activities that could be done in a preschool setting. The first choice, which tends to elicit the stereotype perception, brought up the goggles image by older children (mostly older girls, while young children's choices were divided equally between the magnifying observation in class and the goggles image). Older boys tended to choose the pond image.

The table of first choice by school shows that participants from Schools 2 and 3 present a very similar choice distribution. The picture showing magnifying glass investigation was chosen by children in these two schools and not others. Interestingly, children from Schools 1, 4, and 5 did not choose the first image featuring examination with magnifying glass. School 5 children chose the pond picture in a larger percentage than other schools. However, the small number of participants does not allow any robust assertions. The picture showing goggles was the favorite of all children across school groupings (excluding School 5 participants).

Set 11

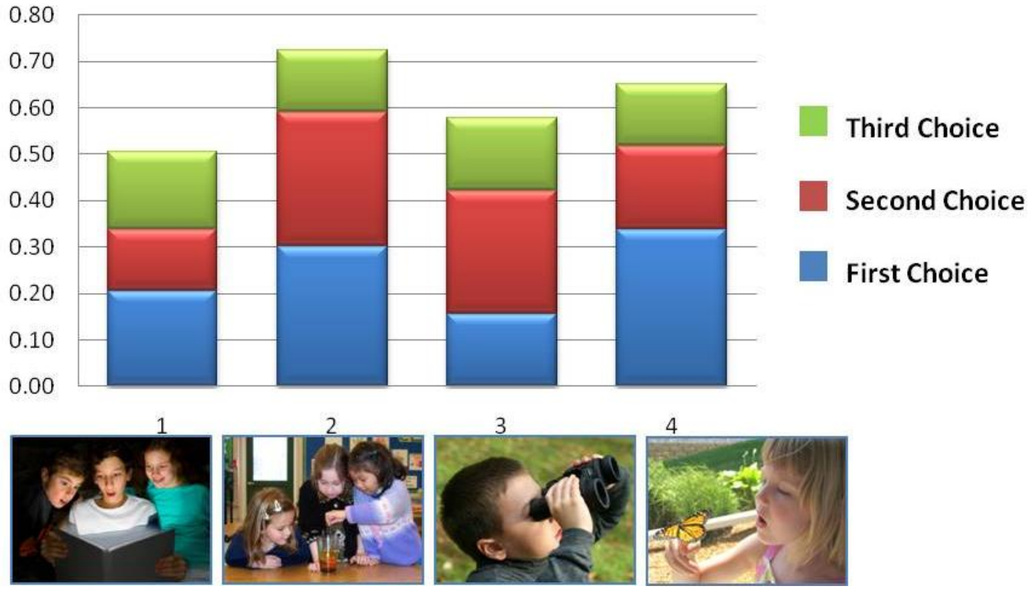


Figure 20. Set 11 pictures and choice distribution

Eighty-three children participated in Set 11: 47 girls and 36 boys with mean age of 58.6 months. As in previous sets, the group of the older boys is the smallest among the subgroups with 16 participants. The breakdown by schools show six participants from School 1; 30 participants from School 2; 35 participants from School 3; five participants from School 4; and seven participants from School 5.

A Chi-Squared test performed on the distribution of the first choice did not find the observed choice pattern significantly different than the expected random count of 20.8 (see Tables 11-2 and 11-3, Appendix F). The residual column in Table 11-2 shows that the NS picture (reading a book) and the science picture featuring a boy with binoculars were chosen less often than the expected value, while the pictures showing a group of girls doing and experiment and a girl observing butterfly were chosen more frequently than the expected random value. However, these differences are not statistically significant.

A binomial test assessing the proportion of success/failure in responders' first choice did not find the observed success/failure proportion to be significantly different than the expected proportion of a random selection (Table 11-4), with proportion of 0.80 success on the task.

Binomial tests assessing the proportion of task success following the second and third choices found the proportions to be significantly different than chance.

Table 11-7 shows the means success proportions for the different age groups. Examination of the table shows that the older children success proportion is significantly different than chance, while the younger group performed at chance level for each choice level.

A cross-tabulation table (Table 11-8) presents the breakdown of success/failure after three tries based on gender and age. The data presented at Table 11-7 show young children failed on the task more frequent than older children.

Table 11-9 shows that task-failure crosses school grouping, with School 3 presenting the largest percentage of failure, probably due to the large percentage of young participants.

Logistic regression did not find relationship between the dependent variable (success/failure after three tries) and response variables (age in months, age in years, gender, and school).

In summary, analysis of the data gathered from the responses to the Set 11 task showed that the group choice resembles a chance pattern on the first choice; however, it was significantly different from chance for the second and third choices. Examination of the subgroup means shows that the confusion in picture choice was mostly due to the younger children. The older group (both boys and girls) voted with success proportions that are different than chance at all three votes. There might be several reasons that explain the results in this set:

1. This is the last set, and therefore many of the young children were tired and replied to this set by randomly touching pictures.
2. The NS picture may represent science, and therefore the responses were distributed evenly across the four pictures.

The Concept of Science

Analysis of the **first** response of Set 11 participants shows that younger children tended to vote for the reading and butterfly observation pictures, while older children voted for the butterfly observation and experiment pictures. All the pictures in this set represent activities that can be done in a preschool. No stereotypical image is present in this set.

No school effect was detected. The majority of votes for the reading image came from School 3 (11/17), but that was due to the age of the children.

Picture Analysis

This section summarizes and brings together the images of all 11 sets. Analysis of the science and non-science (NS) pictures attempts to present the concept of science as revealed by the data. First, an analysis of the NS pictures is presented, followed by analysis of the science pictures.

Non science pictures

Analysis of the NS pictures may reveal what children considered as non-science. In all the sessions, except for Set 11, the NS pictures were chosen less frequently than the science pictures following three touches. However, review of the number of votes each picture got following the first touch only reveals that the NS pictures can be divided into two groups. Pictures belonging to the first group (Figure 21) received the least amount of votes in the set following participants' first choice. Pictures included in the second group (Figure 22) got more votes than **one** of the science pictures in the set – following participants' first choice. Voting for the NS pictures depends on both the science and the NS pictures in the set. The NS picture analysis attempts to characterize the NS pictures in each group.

Figure 21. NS pictures with least number of votes following first touch

The pictures presented in Figure 21 show NS pictures that were ignored by most of the participants during the first choice of science picture. Three of the pictures may be described as “boring” and not attractive to young children (baby bottle, sofa and clothes rack), while the pictures featuring pizza and patty-cake game are very attractive to young children. Four of the pictures represent an object that is static, except for the picture featuring a patty-cake game. This picture, however, was featured in a set that was focused on science activities, and therefore all four pictures in this set showed a specific activity.

Figure 22. NS pictures with second to last number of votes following first touch

The pictures featured in Figure 22 got more votes than **one** of the science pictures following the first choice (however, they all got the least amount of votes following the third choice). These pictures may be more attractive to young children, and therefore children who have no clear views about science or have not understood the task will be more likely to touch a picture they like. Two pictures may be confusing. The picture of children reading may illustrate a science activity, while the picture of a doll may seem to represent a child or a baby. In contrast to the previous group, the majority of pictures in this group possesses some kind of action and seems more dynamic. Further studies would have to determine whether children associate science with “action.”

Most chosen science pictures

This section of Chapter Four reviews the science pictures that were chosen significantly more than others and together creates the concept of science shared by the study’s participants. The illustration of the science concept by pictures is due to, and therefore narrowed by, the presented pictures and the fixed sets. This section reports on two analyses: The first is an analysis of the pictures that got the most votes following the first touch (illustrated by the red oval in Figure 23). The second analysis examined the pictures that got more than 70% of the votes following the third touch (illustrated by the purple oval in Figure 23).

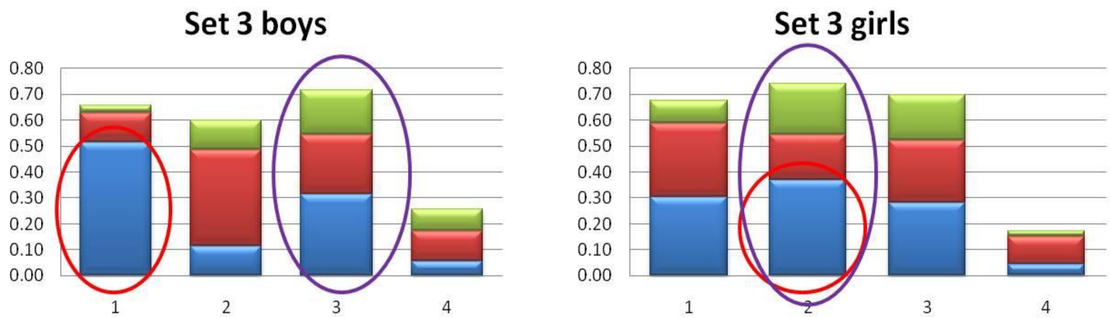


Figure 23. Illustration of two science pictures analyses

Science. The collage presented in Figure 24 shows pictures most chosen following first choice. Out of 12 science pictures in the first four sets of the study, the pictures featuring volcano, human body, and beakers were chosen as the most representing "science" in the eyes of the study participants. Boys chose dinosaurs, while girls chose the picture featuring a plant.

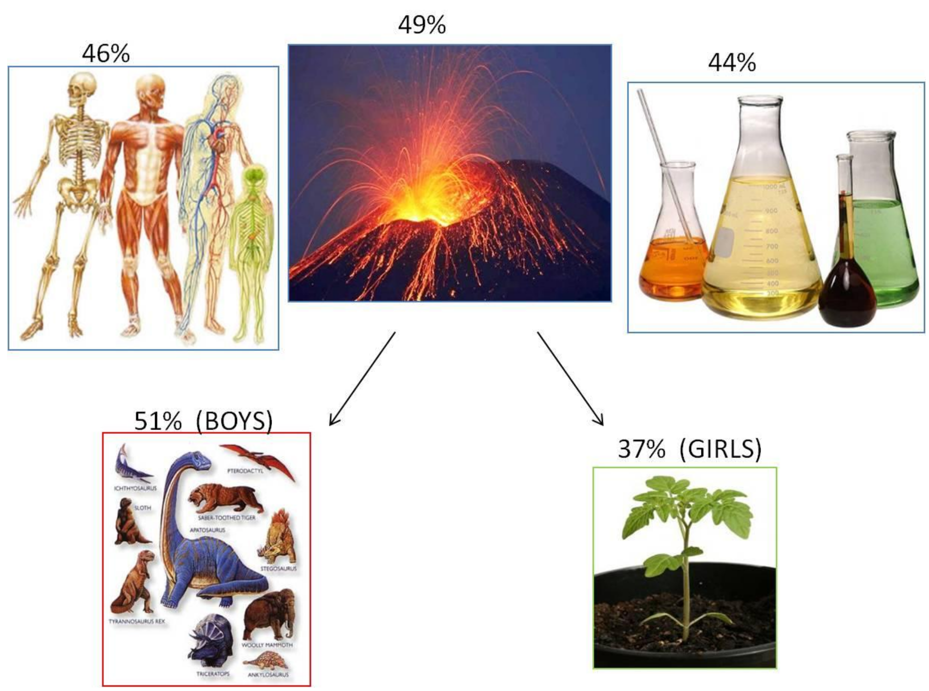


Figure 24. Science pictures chosen most often following the first choice

The second analysis of science pictures presents the pictures that got 70% or more of the votes (Figure 25). As previous studies have noted, the concept of science is more complex than a single picture. It is important to look beyond the children's first instinct and gauge their wider perception of science. The expanded group of pictures representing science now includes pictures featuring space, colors, and chemical reaction.

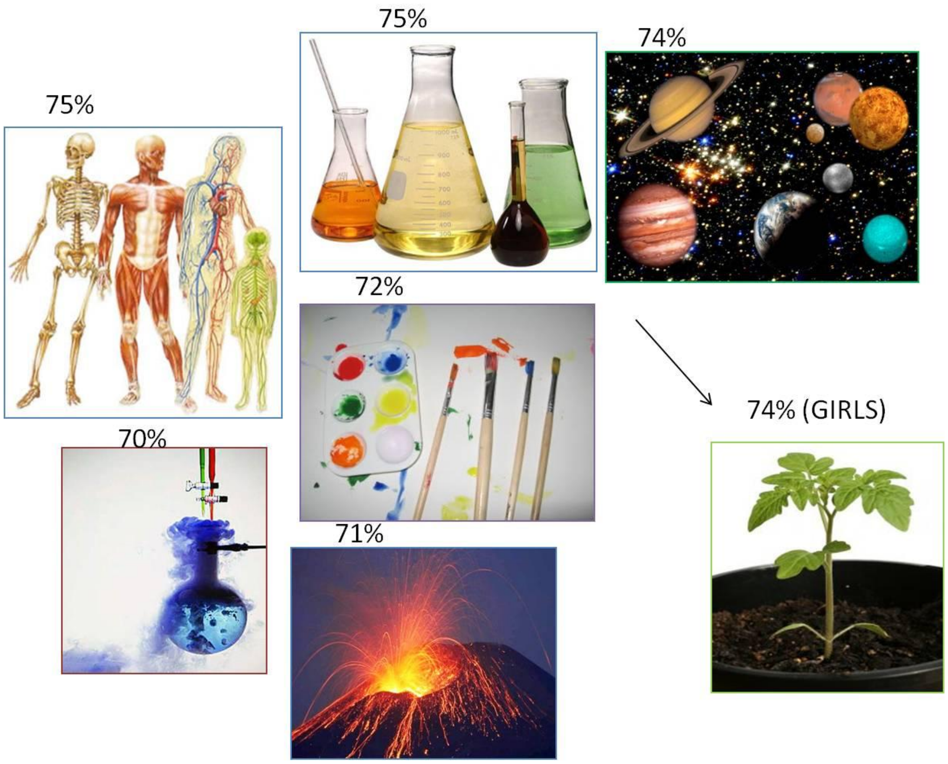


Figure 25. Science pictures chosen most often following three choices

Science Objects. The "science object" subcategory analysis of first touch presents larger variability in children's choices. Only two pictures, featuring a scale and liquids, were voted by the majority of the group to represent science objects. Boys and girls seem to have different preferences or views about the featured objects. The boys first touched pictures featuring objects from nature, while the girls tended to choose more “stereotypical science” objects, such as a magnifying glass (Figure 26). No age difference in choice pattern was detected, except of one picture – leaves – that got the majority of votes in the set following the first touch.

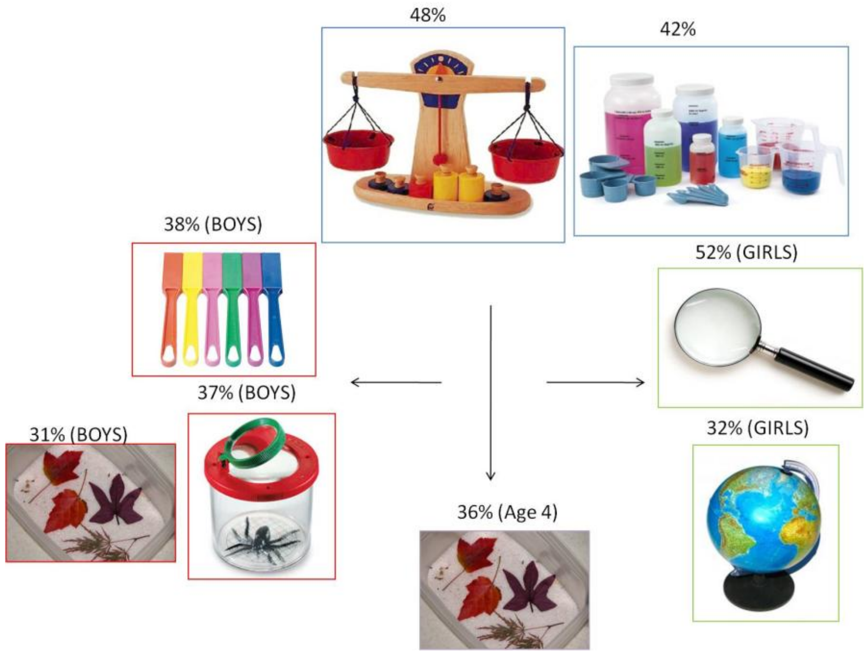


Figure 26. Science object pictures chosen most often following the first choice

The second science-object pictures analysis, featuring pictures that obtained at least 70% of the votes in the set, shows that three pictures, chemicals, scale, and binoculars, were voted as representing science objects by the entire group (Figure 27). Interestingly, the magnifying glass picture, a very stereotypical science object, got high votes from the girls, but not from the boys.

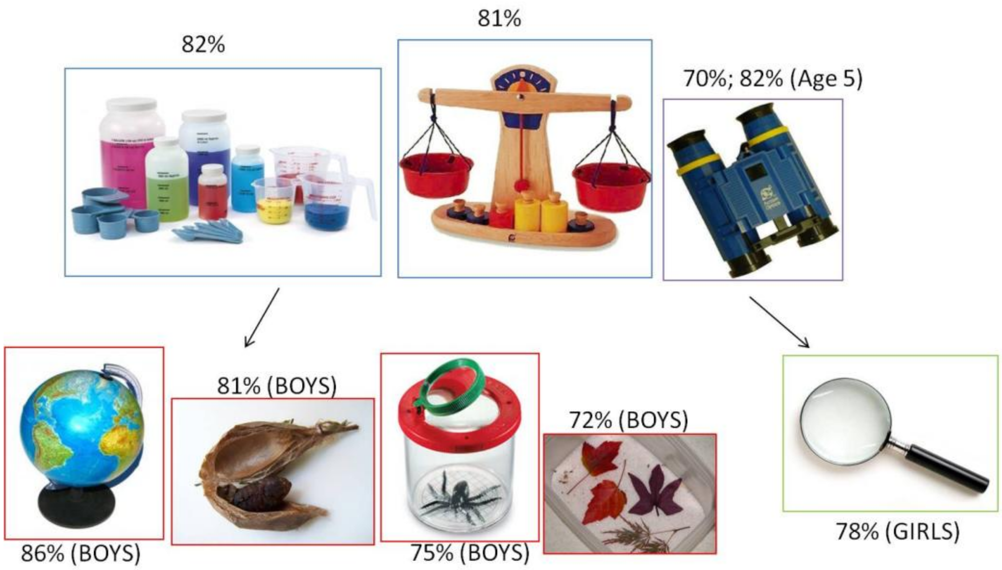


Figure 27. Science object pictures chosen most often following three choices

Science Activities. First touch science-activity pictures analysis show consistency with the science-object picture analysis (Figure 28). A picture featuring a boy weighing objects got the high number of the group's votes, as did the picture featuring a scale in the science-object subcategory. A girl observing a butterfly and girls conducting experiments were also chosen by the group. Boys and younger children chose the picture showing children examining a tree bark with a magnifying glass, while girls and older children chose the (stereotypical) picture showing a boy with goggles observing a test tube.

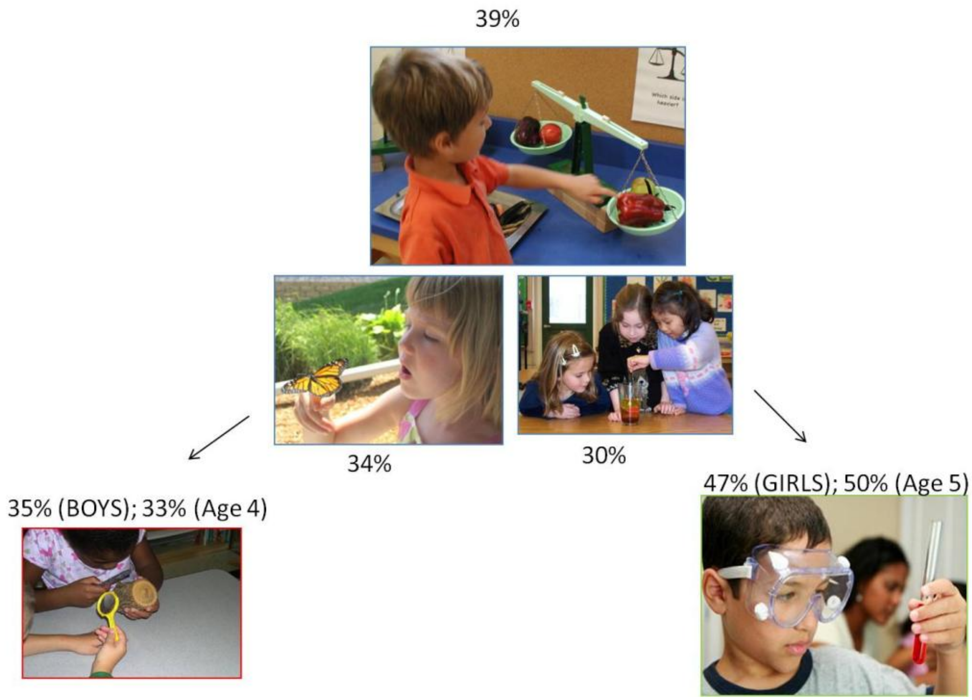


Figure 28. Science activity pictures chosen most following the first choice

A second analysis looking at the pictures chosen by at least 70% of participants following three attempts presents four pictures chosen by the whole group (weighing, experimenting, examining a tree bark, and a pond activity). The picture featuring butterfly observation was chosen by more than 71% of the boys' votes, and the picture featuring girls experimenting got high percentage of girls and older children's votes. A child doing an activity on a tree bark was chosen with 74% of the votes of the 4 years old children (Figure 29).

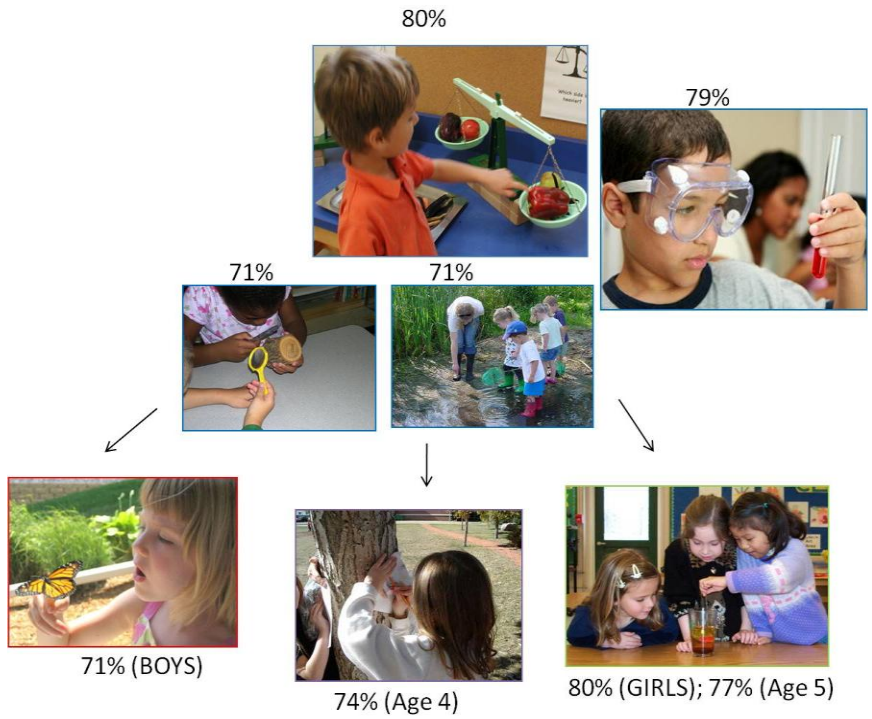


Figure 29. Science activity pictures chosen most often following three choices

Least chosen science pictures

The picture analyses conducted so far have presented pictures chosen by the majority of the group or subgroups. Figure 30 presents a collage of science pictures that were not chosen as frequently as the rest of the science pictures. These pictures are not considered NS, since all were chosen more than the NS pictures following three choices; however, they were less favored by the group. Two of the pictures, featuring a lightbulb and prism, may not be familiar to preschool children as the topics of electricity or light are not often addressed in preschool. The rest of the pictures feature objects from the natural world. Although preschool curriculum is rich with discussions about weather and animals, and obviously recognized by the children, these two pictures may be less associated with science than the more stereotypical pictures. The rocks and shells collections, as well as the pinecone, may not be present in all classrooms' science centers and therefore may not be considered as "science objects." Interestingly, the boy using binoculars was less frequently chosen while the picture showing binoculars got more than 70% of the votes. These results are similar to what was found in the pilot study.

Figure 30. Least chosen science pictures

Movie Task

The second task of the study was a movie task. Following a short training session, participants were presented with four short video clips, each followed by five yes/no/I don't know questions. The children touched three animated figures on the screen that signed yes, no, and I don't know.

Methods of Analysis

The set of five questions following each video was analyzed using two main methods. First, a binomial test was used to analyze whether the pattern of responses was different than chance. The binomial test was used to test the null hypothesis stating that the children have no concept of science and therefore answered the questions randomly.

The second method used was means comparison. Group and subgroup means were constructed and compared and used to gauge the groups' thoughts regarding the questions presented.

Population

Ninety-eight children participated in the movie task, 41 boys and 57 girls. Fifty-three children were age 4 at the time of the study, while 45 children were age 5. Participants' age ranged from 45 to 71 months, with a mean age of 58 months. Participants came from the same five schools as described at the beginning of the chapter: five participants from School 1; 33 participants from School 2; 39 participants from School 3; 12 participants from School 4, which is a museum setting; and nine participants from School 5.

Missing Data

There are several reasons for missing data for this task:

1. "I don't know" reply – During the task children were given the option to answer "I don't know," and many of them used it. For analysis purposes, these replies are excluded from the data.
2. Recording error – A program error during testing in Schools 4 and 5 caused a partial recording of the data. Therefore, the replies of 11 participants were recorded only for the first two videos.

3. Special cases – The data of one preschooler with Down's syndrome and one girl who replied "I don't know" to all the questions were removed from the dataset prior to the analysis.

Data Analysis

Video no. 1: Two boys examine a tree trunk

Five questions (Q1-Q5) were presented to the children following video 1:

Q1 Does this movie show a science activity?

Q2 The children were talking. Is talking part of science?

Q3 The children in the movie asked many questions. Is asking questions part of science?

Q4 The children studied a tree trunk. Are tree trunks part of science?

Q5 The children in the movie used a magnifying glass. Is a magnifying glass a science object?

A binomial test conducted on the reply to these questions show that except for question number 2 (Q2), the observed proportion is significantly different than the test proportion of random selection. Participants were divided on Q2, which was intended to be the "no" question; however, it may be confusing due to the ambiguous nature of talking in science. Some science activities do require talking (discussions, presentations). A further analysis of the different subgroups shows that all subgroups were divided on this question, as can be seen in Tables 16 and 17. The pattern of the replies to Q2 may also point at a response bias, the tendency of young children to answer affirmatively to questions. This possibility will have to be compared with response pattern to other "no" questions.

Table 16

Binomial Test Results for Q1-Q5

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Q 1		Yes	66	.81	.50	.000(a)
		No	15	.19		
	Total		81	1.00		
Q 2		No	45	.54	.50	.586(a)
		Yes	39	.46		
	Total		84	1.00		
Q 3		Yes	49	.64	.50	.022(a)
		No	28	.36		
	Total		77	1.00		
Q 4		Yes	56	.68	.50	.001(a)
		No	26	.32		
	Total		82	1.00		
Q 5		Yes	73	.86	.50	.000(a)
		No	12	.14		
	Total		85	1.00		

a Based on Z Approximation.

Table 17 compares the means of the different subgroups in their reply to the questions for video 1.

Overall, the large majority of participants thought that the video clip of two boys examining a tree trunk represented a science activity (Q1). The group was also in agreement that a magnifying glass is a science object (Q5), with the group of older children replying almost entirely yes to this question. The group was divided on whether talking is part of science (Q2). While older girls and younger boys tended to disagree, younger girls tended to agree and older boys were divided on this question. Somewhat less agreement was regarding the question whether asking questions is part of science (Q3). All subgroups tended to answer affirmatively; however, the young boys' group was almost divided about this question. More children replied with "I don't know" to this question than to other questions in the set. The groups were more affirmative about Q4 with regard to tree trunks being part of science. The only hesitant subgroup was the younger girls.

Table 17

Means Comparison of Video 1 Replies

Subgroup			Q1	Q2	Q3	Q4	Q5
Boys (4)	Mean	(yes=1,no=2)	1.05	1.60	1.44	1.28	1.29
	N		20	20	18	18	21
Girls (4)	Mean	(yes=1,no=2)	1.32	1.44	1.36	1.41	1.13
	N		22	27	22	27	23
Boys (5)	Mean	(yes=1,no=2)	1.24	1.53	1.33	1.27	1.06
	N		17	15	15	15	18
Girls (5)	Mean	(yes=1,no=2)	1.14	1.59	1.32	1.27	1.09
	N		22	22	22	22	23
Age 4	Mean	(yes=1,no=2)	1.19	1.51	1.40	1.36	1.20
	N		42	47	40	45	44
Age 5	Mean	(yes=1,no=2)	1.18	1.57	1.32	1.27	1.07
	N		39	37	37	37	41
Boys	Mean	(yes=1,no=2)	1.14	1.57	1.39	1.27	1.18
	N		37	35	33	33	39
Girls	Mean	(yes=1,no=2)	1.23	1.51	1.34	1.35	1.11
	N		44	49	44	49	46
Total	Mean	(yes=1,no=2)	1.19	1.54	1.36	1.32	1.14
	N		81	84	77	82	85

Video no. 2: A boy conducts a volcano experiment

The second video presented during the movie task was a video showing a boy conducting a volcano experiment. The boy was adding baking soda and vinegar into the volcano until the volcano "erupted."

Q21 Does this movie show science activity?

Q22 The boy in the movie mixed things. Is mixing part of science?

Q23 The boy in the movie sat at a table. Is sitting at a table part of science?

Q24 The boy in the movie had a volcano. Are volcanoes part of science?

Q25 Is science only for boys?

Binomial tests conducted on the results for questions 21-25 (Table 18) show that the children replied with a pattern that is significantly different than chance – all except for the third question. It is plausible that since the children replied meaningfully to the other questions, they were divided on the answer to Q23. This question, similar to the question Q2 following video 1, is confounding since a lot of science, especially the stereotypical lab work, is done while sitting at a table. Although it is not a requirement for science, it may be the way some of the children perceive scientific work. The possibility of response bias may have affected how children responded to Q23; however, the response pattern to Q25 hints that response bias is not the sole factor affecting the way children responded to Q23.

Table 18

Binomial Test Results for Q21-Q25

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Q21		Yes	77	.87	.50	.000(a)
		No	12	.13		
	Total		89	1.00		
Q22		Yes	68	.80	.50	.000(a)
		No	17	.20		
	Total		85	1.00		
Q23		Yes	34	.45	.50	.489(a)
		No	41	.55		
	Total		75	1.00		
Q24		Yes	65	.79	.50	.000(a)
		No	17	.21		
	Total		82	1.00		
Q25		No	63	.80	.50	.000(a)
		Yes	16	.20		
	Total		79	1.00		

a Based on Z Approximation.

The majority of the children considered the volcano experiment to be a science activity (Q21). The majority of participants considered the act of mixing to be a part of science (Q22). The children were divided on the third question, which was intended to be a "no" question, but may be ambiguous. Younger and older boys, as well as older girls tended to answer negatively to the question, while younger girls tended to be more positive on the answer. A relatively large number of children replied "I don't know" to the question. The group considered volcanoes to be part of science (Q24), and older children tended to answer more positively this question more than younger children (1.05; 1.37). The large majority of the group seemed to be in agreement that science is not only for boys; the vote of the younger girls' group was not as clear-cut as the other subgroups. Overall, it seems that the group of younger girls tended to be more divided on all answers compared to the rest of the subgroups. Interestingly, more girls than boys replied yes to Q25 (Tables 19, 20), asking whether science is only for boys; however, the majority of the girls (9/11) are from the younger age group. No distinct differences were found among children from different schools.

Table 19

Means Comparison of Video 2 Replies

Group		Q21	Q22	Q23	Q24	Q25
Boys (4)	Mean (yes=1,no=2)	1.00	1.24	1.61	1.32	1.88
	N	22	17	18	19	17
Boys (5)	Mean (yes=1,no=2)	1.16	1.19	1.57	1.11	1.79
	N	19	16	14	18	14
Girls (4)	Mean (yes=1,no=2)	1.28	1.25	1.43	1.41	1.64
	N	25	28	23	22	25
Girls (5)	Mean (yes=1,no=2)	1.09	1.13	1.60	1.00	1.91
	N	23	24	20	23	23
Boys	Mean (yes=1,no=2)	1.07	1.21	1.59	1.22	1.84
	N	41	33	32	37	31
Girls	Mean (yes=1,no=2)	1.19	1.19	1.51	1.20	1.77
	N	48	52	43	45	48
Age 4	Mean (yes=1,no=2)	1.15	1.24	1.51	1.37	1.74
	N	47	45	41	41	42
Age 5	Mean (yes=1,no=2)	1.12	1.15	1.59	1.05	1.86
	N	42	40	34	41	37
Total	Mean (yes=1,no=2)	1.13	1.20	1.55	1.21	1.80
	N	89	85	75	82	79

Table 20

A Cross-tabulation of Q25 Replies and Gender

	Q25		
	YES	NO	Total

Boys	Count (%)	5 (16%)	26 (84%)	31 (100%)
Girls	Count (%)	11 (23%)	37 (77%)	48 (100%)
Total	Count (%)	16 (20%)	63 (80%)	79 (100%)

Video no. 3: A girl picking up caterpillars in the playground

Video 3 featured a young girl picking up and collecting caterpillars at a preschool's playground. After watching the video, the children were presented with the following questions:

Q31 Does this movie show science activity?

Q32 The girl in the movie picked up caterpillars. Is picking-up part of science?

Q33 Are caterpillars part of science?

Q34 The girl in the movie had a yellow shirt. Are yellow shirts part of science?

Q35 Is science only for girls?

Binomial tests conducted on the distribution of the replies found the replies to questions 31 and 32 not different than a chance distribution. The distribution of replies to questions 33-35 was found to be statistically different than chance (Table 21). The responses to Q34 and Q35 suggest that participants do not show a strong response bias (tending to answer affirmatively to questions). It strengthens the supposition that the choice pattern to previous "no" questions was due to the ambiguity of the questions.

Table 21

Binomial Test Results for Q31-Q35

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Q31		Yes	38	.52	.50	.815(a)
		No	35	.48		
	Total		73	1.00		
Q32		Yes	36	.50	.50	1.000(a)
		No	36	.50		
	Total		72	1.00		
Q33		Yes	48	.63	.50	.029(a)
		No	28	.37		
	Total		76	1.00		
Q34		No	57	.80	.50	.000(a)
		Yes	14	.20		
	Total		71	1.00		
Q35		No	70	.89	.50	.000(a)
		Yes	9	.11		
	Total		79	1.00		

a Based on Z Approximation.

The group of participants was divided on the answers to questions 31 and 32. All subgroups were divided whether picking up caterpillars is a scientific activity. They were also divided on the action itself, whether picking up is part of science. Older children tended to answer affirmatively to the question, while younger children tended to answer negatively. The group reply to Q33 suggests that the children consider caterpillars to be a part of science, with the exception of the young boys' subgroup, which was divided on this question. Clearer-cut results were received for questions 34 and 35. Q34 was intended to be a no question, and the vast majority of participants replied negatively to the question whether yellow shirts are part of science. The only group that showed a reply pattern that is more ambiguous is the young girls' subgroup. Older children were more distinct in their reply than younger children (1.90; 1.73). Lastly, the majority of participants replied that science is not only for girls. All the girls from the older group replied no to this question. The subgroup of younger girl was, again, less clear than the other groups; however, these girls tended to answer no to the question. No distinct differences were found among children from different schools.

Table 22

Means Comparison of Video 3 Replies

AGE4_5		Q31	Q32	Q33	Q34	Q35
Boys (4)	Mean (yes=1,no=2)	1.58	1.47	1.52	1.82	1.95
	N	19	17	21	17	19
Boys (5)	Mean (yes=1,no=2)	1.46	1.38	1.43	1.92	1.93
	N	13	13	14	12	15
Girls (4)	Mean (yes=1,no=2)	1.40	1.64	1.36	1.67	1.72
	N	25	22	22	24	25
Girls (5)	Mean (yes=1,no=2)	1.50	1.45	1.16	1.89	2.00
	N	16	20	19	18	20
Boys	Mean (yes=1,no=2)	1.53	1.43	1.49	1.86	1.94
	N	32	30	35	29	34
Girls	Mean (yes=1,no=2)	1.44	1.55	1.27	1.76	1.84
	N	41	42	41	42	45
Age 4	Mean (yes=1,no=2)	1.48	1.56	1.44	1.73	1.82
	N	44	39	43	41	44
Age 5	Mean (yes=1,no=2)	1.48	1.42	1.27	1.90	1.97
	N	29	33	33	30	35
Total	Mean (yes=1,no=2)	1.48	1.50	1.37	1.80	1.89
	N	73	72	76	71	79

Video no. 4: A group of children examine salt crystals

The fourth video clip presented a group of children observing salt crystals using a magnifying glass. The group's teacher was guiding the children and reminded the children to record their observation in their journal. Five questions were presented following the video:

Q41 Does this movie show science activity?

Q42 The children in the movie observed salt crystals. Is observing part of science?

Q43 Later, the children will draw salt crystals in their journals. Are journals science objects?

Q44 Are salt crystals part of science?

Q45 Have you ever looked at salt crystals with a magnifying glass?

Binomial tests conducted on the replies to video 4 questions found the distribution of results to be statistically different than chance (Table 23).

Table 23

Binomial Test Results for Q41-Q45

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Q41	Yes	60	.80	.50	.000(a)
	No	15	.20		
Total		75	1.00		
Q42	Yes	53	.80	.50	.000(a)
	No	13	.20		
Total		66	1.00		

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Q43		Yes	45	.66	.50	.010(a)
		No	23	.34		
	Total		68	1.00		
Q44		Yes	45	.64	.50	.022(a)
		No	25	.36		
	Total		70	1.00		
Q45		No	48	.72	.50	.001(a)
		Yes	19	.28		
	Total		67	1.00		

a Based on Z Approximation.

The majority of the children thought that video clip 4 presented a scientific activity. The group of older girls was the most distinct in their reply pattern. The group was in agreement that observation is a part of science. Older children replied affirmatively to this question more than younger children (1.13; 1.26) and girls more than boys (1.11; 1.30). The group tended to support the assertion that journals are science objects, yet the subgroup of younger boys was divided on this question. The group tended to agree that salt crystals are part of science, with the exception of the young girls' subgroup, which was divided on this question. Lastly, the group tended to reply negatively to the question whether they have observed salt crystals in the past. No significant difference was found among the subgroups as well as among schools.

Table 24

Means Comparison of Video 4 Replies

AGE4_5		Q41	Q42	Q43	Q44	Q45
Boys (4)	Mean	1.16	1.35	1.53	1.33	1.75
	N	19	17	15	15	16
Boys (5)	Mean	1.21	1.23	1.29	1.33	1.67
	N	14	13	14	15	12

AGE4_5		Q41	Q42	Q43	Q44	Q45
Girls (4)	Mean	1.32	1.17	1.33	1.50	1.70
	N	25	18	24	20	20
Girls (5)	Mean	1.06	1.06	1.20	1.25	1.74
	N	17	18	15	20	19
Boys	Mean	1.18	1.30	1.41	1.33	1.71
	N	33	30	29	30	28
Girls	Mean	1.21	1.11	1.28	1.38	1.72
	N	42	36	39	40	39
Age 4	Mean	1.25	1.26	1.41	1.43	1.72
	N	44	35	39	35	36
Age 5	Mean	1.13	1.13	1.24	1.29	1.71
	N	31	31	29	35	31
Total	Mean	1.20	1.20	1.34	1.36	1.72
	N	75	66	68	70	67

Chapter Five: Discussion

When does the concept of science first develop? How do young children conceptualize science? This study was set up to answer these fundamental questions by targeting preschool children (ages 4−5 years), a population that is rarely studied in the field of science education. Since most preschool children do not yet read or write, conventional research tools are ineffective. Therefore, a research tool in the form of a computer game was developed. The instrument was used to study 98 children from five locations in Minnesota.

This chapter discusses the results of the study, its implications, as well as its limitations. The chapter also raises new questions brought up by the findings and outlines possible follow-up studies.

Discussion of Results

The discussion section opens with discussion of the instrument as a research tool and later discusses the findings in order to answer the research questions.

The Instrument

The instrument was designed to solve the problem of engaging preschool children in the research. In its current form, the instrument was demonstrated to be an effective and functional tool. The children enjoyed the game-like format, with many children asking to “play again,” which helped in accomplishing a relatively high response and completion rate. The tasks were easy to follow, and the training sessions provided sufficient practice prior to the beginning of the task. The majority of children completed all the tasks; only a few children (about 4%) quit prior to the end of the sessions. The instrument has the potential to be self-administered due to its data recording function. This may be an advantageous property for researchers, since young children may be shy or intimidated by strangers. Some programming errors caused the instrument to fail during data recording or shut down. A future version of the instrument should address these problems. One remaining limitation is the considerably large percentage of missing data. A combination of computer and experimenter errors combined with participants' choice to avoid some of the sessions resulted in missing data ranging from 8% to 23%. Further studies would have to be done in order to determine if this is a limitation of the instrument, application, or sample.

Instrument's reliability and validity. In order to assess the reliability of the tool, during the pilot phase, several participants were asked to repeat the task they had done on the computer and point at the same pictures on the experimenter's sheet. Some differences were found, which indicated that the tool may not be reliable in gauging children's views. Subsequently, the recorded instructions were modified until the results in the two sessions were matched. An example in support of the reliability of the measurement is given by a case of Set 4 revision. The position of the pictures in Set 4 was changed between the pilot and large-scale study. However, the same images, space and beakers, were chosen as the representation of science in this set. Still, the developmental stage of preschool children may affect the reliability. Glauert (2005) who studied 4-to-5-year-old children noted that work with young children often reveals differences between responses given in different situations.

Face validity. The vast majority of the instrument's items (pictures, videos, and questions) were clear and recognized by participants. A few items could not be labeled by a sample of the participants or carried some ambiguity (see further discussion of these items under the limitation section). The consistency in answers to the majority of movie task questions, as well as consistency in distinguishing science from NS pictures in the picture task, suggests that the items and tasks were understood by the children.

Concurrent validity. The instrument was successful in detecting subgroup differences among children of different ages, genders, and schools. Analysis of the picture task shows that boys and girls may have different preferences and choice pattern when voting for science pictures. For example, when asked to touch a picture showing a science object, the majority of boys touched a picture showing magnets, while the majority of girls touched a picture showing a magnifying glass. Moreover, girls were more likely to fail the task when the NS picture was a doll, while boys were more likely to fail when the NS picture presented a soccer ball. The next section presents additional subgroup differences.

Preschool Children's Views of Science

Do Sample Group Children Hold Views About Science?

The results suggest that the majority of participants do. Eighty-seven percent of the study's sessions were successful − success was determined by the child touching a science picture. This number is significantly higher than the 75% expected by chance, had participants not been able to distinguish between science and NS pictures. Thirty-eight percent of participants who completed all 11 sets did answer correctly in all sets, compared to an expected 4% of those answering correctly by chance. These findings suggest that the majority of the group have started to develop a concept of science and are familiar with the stereotypical views of science, which guided their choice about what constitutes science. Another support for this claim comes from the analysis of less familiar images. Following their participation, random children were asked to label the instrument's images. The children had difficulty labeling three images featuring a seed, a chemical reaction, and magnets (Figure 31). Despite the fact that many of the children could not label these pictures, two of the three, the pictures of chemical reaction and seed, were chosen by the majority of the children (reaction) and boys (seed) as representing science. These findings support findings from research on children's conceptual development. As presented in Chapter Two, many researchers have studied young children's distinction between animate and inanimate objects (Inagaki & Hanato, 2006; Gelman, 1990; Gelman & Wellman; Simons & Keil, 1994). In one featured study, Massey and Gelman (1988) tested preschoolers' conceptions of movement and animate/inanimate objects distinction by presenting them with pictures of novel objects and asking them to predict whether they can move uphill or downhill. They found that the children used their prior knowledge about animate/inanimate classification to guide their decisions. Preschool children successfully determined that sloth and echidna, animals they have never seen before, could go uphill on their own, while a picture showing a statue of a quadruped animal could not go uphill. The children ignored the similarity between the quadruped animal and other known animals and used their conceptions of animacy to guide their decision. Likewise, the findings of the current study suggest that the majority of the participants already possess an emerging view or emerging theory of what constitutes science and use this emerging theory to guide them when approached with a novel picture. A careful hypothesis can be made according to these findings, stating that these children assumed that the concept of science contains nature, and therefore natural objects are part of science. Also, the stereotypical view of science as “chemical science” leads children to associate chemical reaction with science.

Figure 31. Images that most participants found difficult to label

The movie task results show that the group identified three of the videos as presenting science activities. Two boys examining tree bark while asking questions, a volcano experiment, and a group of children examining salt crystals were all considered science by the group of participants, while a video of a girl picking up caterpillars in the playground received ambiguous responses, with half of the responses identifying it as science and half of the responses marking it as a non-science activity.

The findings from both tasks suggest that the participants in this study (98 participants of the large-scale study and 30 participants of the pilot study) were familiar with the stereotypical and non-stereotypical conception of science, as early as age 4.

What Do Sample Group Children Perceive as Science?

Concept. What do young children conceptualize as “science”? As the concept of science is multidimensional and abstract (superordinate concept) and includes concrete items and activities, but also ideas and theories, the study was designed to capture children’s views in three subcategories of the science concept: science, science objects, and science activities. This division was done in order to draw on children’s experience with science. As noted by Ausubel (1968), children’s concepts and cognitive structures developed based on their experience. Repeated experiences help the children develop scripts which may be used to understand, process, and predict events and event-related information (Levy & Fivush, 1993; Nelson & Gruendel, 1981). Fleer and Robbins (2003) rely on Rogoff (1998) when they call for researchers to consider all three planes of children’s experience in science education (the individual child, their classroom, and school or culture). Preschoolers’ science experience combines both content (concepts) and process (activities). They learn new topics, ask questions, make predictions, and investigate and report their findings. Children also learn about science implicitly, as they interact with the objects in the science center, watch a movie that makes connection to science, or listen to an older sibling share his/her thoughts about science. Finally, Perez-Granados and Callanan (1997) claim that when young children are given specific instructions regarding the generality of the category requested, they are more likely to show evidence of understanding the superordinate level of categorization. Thus, it was important to specify and draw on varied experiences with the different constructs of science. Examination of the pattern of picture choice by group participants, although limited by pictures content and grouping, provides a window into children's views and conceptions of science.

Picture task. The picture task provides us with multileveled data. The pictures that were chosen first are suggested to represent the shared stereotypical view of science (or the subcategory), while the pictures that got the majority of votes after three choices are suggested to represent alterative views. This assumption is an interpretation of Maoldomhnaigh and Hunt's (1989) and Matthews' (1994) criticism of the DAST method. These researchers claim that when asked to "draw a scientist," participants drew an image based on the expectations of the examiner. When asked to draw another scientist, participants drew images that were less stereotypical. Therefore the discussion of the findings will address the chosen pictures and the order of their choice. The stereotypical view of science as viewed from the first chosen science pictures includes a volcano, the human body, and chemicals. Dinosaurs (51% of boys) and a plant (37% of the girls) complete the list of first chosen pictures (discussion about gender differences under the "Gender" section below). The pictures that got more than 70% of the votes after three attempts include the first three pictures (volcano, chemicals, and human body) but also the pictures featuring space, colors, and chemical reaction. The picture of plant got 74% of the girls' vote. Interestingly, the picture featuring dinosaurs did not pass the 70% threshold.

There was much more variability with regard to the science-object pictures. A balancing scale and a picture featuring liquids (with measuring cups) were the only two pictures chosen by the majority of the group. However, the rest of the pictures were chosen by subgroups: magnets, spider, and leaves by the boys; magnifying glass and globe by the girls. These differences may not stem from gender differences per se but rather from interaction of the age, school, and classroom variables. It is expected to have a larger variety, as different schools and classrooms possess different objects. The familiarity of children with the objects (e.g., magnets) will affect children's choice and conception. Following three attempts, these pictures do not change much. A scale, liquids (with measuring cups), and binoculars were chosen by the entire group as representing science objects. These images represent measurement and observation and may shed light on the concept of science as investigative in nature. Leaves, spider, seed, and globe were chosen by more than 70% of boys, while the magnifying glass was chosen by 78% of the girls. A gender difference that is opposite to the data about gender preferences (boys chose the nature-themed pictures) is discussed under the "Gender" section.

The results regarding the subcategory of science activity are more unified than the results for the science object subcategory. Following the first touch, the chosen pictures were those which feature a boy using a scale, a girl looking at butterfly, and three girls conducting an experiment indoors. One gender and age diversion was detected: Boys and young children chose the picture showing girls examining tree bark with magnifying glass, and girls and older children chose a more stereotypical picture of a boy with goggles and a test tube. Following three attempts, a small shift is detected: Four pictures were chosen by the entire group: a boy weighs with scale, a boy with goggles, girls examining tree bark with a magnifying glass, and a group of children conducting an investigation at a small pool. Interestingly, these are all very stereotypical images of science. Gender and age difference was detected: Boys chose the image of a girl with a butterfly, young children voted for the picture featuring a girl writing on a tree bark, and girls and older children chose a picture of girls conducting an experiment in the classroom.

Finally, analysis of the NS pictures hints at an “active” factor in science. Pictures presenting static objects (baby bottle, sofa, pizza, rack of clothes) were chosen significantly less than the science pictures in these sets. Pictures showing more active objects (soccer ball, playground, toy truck) were chosen more frequently on the first try, but less than the science pictures following the third choice. This difference may be due to the latter group being more attractive to children, and not necessarily because of their dynamic nature; however, this point, what is NOT considered science, is worth further examination. The motif of action with regard to science may present some parallels to the findings that children use the theme of self-movement to distinguish between animate and inanimate objects (Massey & Gelman, 1988). Learning about the reasons for exclusion items from the “science” category may contribute to the understanding of the boundaries of the category itself. Therefore, using pictures that represent action but may seem unattractive to young children might shed some light on the current data.

Movie task. From the movie task, we learned that the group considered volcanoes (79%, $p<0.01$) and tree trunks (68%, $p<0.01$) as part of science. Salt crystals (64%, $p<0.05$; 71% of older children) and caterpillars (63%, $p<0.05$; 73% of older children) were considered science by a smaller majority of the group. Interestingly, a magnifying glass was considered a science object by 86% ($p<0.01$) of the group, while during the picture task only girls chose this picture more than 70%. The focal point of the movie task was obviously the science activity subcategory, as all the video clips presented children in action. Examination of a tree trunk while asking questions was considered a science activity (81%, $p<0.01$), as were the volcano experiment (87%, $p<0.01$) and salt crystal observations (80%, $p<0.01$). Asking questions (64%, $p<0.05$), mixing things (80%, $p<0.01$), and observing (80%, $p<0.01$) are considered science activities, while "picking up" is not part of science.

The distinction between the videos is quite remarkable and may suggest that the purpose of the activity, and not the object upon which the activity is done, determines whether the activity is considered science. The children did not consider picking up caterpillars to be a science activity and did not consider the picking up to be part of science. The children did, however, consider caterpillars as belonging to the science category. One hypothesis may be that "picking up" does not carry any investigative value, and therefore the entire activity (even if performed with science items like caterpillars) is not considered science. An alternative explanation may be that the activity does not fall within the stereotypical science experiments and therefore was not chosen as science. Further interviews are needed in order to determine the reasons for the exclusion of the video. Support for the latter explanation comes from the analysis of the pictures that were indicated as science (chosen more frequently than the NS picture in the set) but with fewer votes compared to other science pictures in the same set. These pictures show natural objects and topics − rocks, shells, pinecone, weather, and animals as well as watching with binoculars and observing a rock − were not chosen as frequently as more stereotypical or well-known topics. Similar results were found during the pilot session, which lead to question whether the reason for the exclusion is a low association of this items with science (they may be associated with nature) or simply that these are less stereotypical images. Further studies would have to address this question. The other two pictures in this group, featuring the breaking of light and electricity, may not have been chosen due to the fact that these topics are not addressed in many preschools.

Overall, it seems that the majority of the group held a clear concept of science. It appears that participants were well aware of the stereotypical views about science, however it seem that their concept of science was not superficial but rather deep and elaborated. The group of participants showed signs of knowledge of alternative conceptions of science as well as distinction between scientific and non scientific behaviors. The variability of pictures chosen for the science object subcategory is understandable, as children probably choose an image that represents his of hers experience or familiarity with the object. However, since the children came from different classroom, each classroom may have different science artifacts or objects, and the children chose what was familiar to them.

Beliefs. The movie task included a few questions that tap into children's beliefs about science. Video 2 presented a boy conducting a volcano experiment. One of the questions following this clip was whether "science is only for boys." Video 3 featured a girl picking caterpillars in the playground. One of the questions following this clip was whether "science is only for girls." These questions tap into children's beliefs about who is entitled to "do science." The results may represent participants' own beliefs or their perception of the public belief. Eighty percent of the group (boys 84%; girls 77%) replied "no" to the first question (if science is only for boys), while 89% of participants (boys 94%; girls 84%) replied "no" to the second question (if science is only for girls). Older children replied negatively to both questions in higher percentage than younger children. Interestingly, boys tended to answer negatively more than girls, but that may be due to interaction between age and gender. Despite the unequivocal "no" vote to both of these questions, more children believed that science is NOT only for boys than for girls. This suggests that the association of science with boys, which is evident from studying beliefs of older students, may have started during the preschool years. The public shared stereotype, associating science with boys, may have affected the views and beliefs of very young children, and therefore more children replied negatively to the first question. Further studies should follow up on this finding and examine it more thoroughly.

Are There Differences Between the Perception of Science Among Subgroups (Gender, Age, School)?

Age. Age was associated with better success in all tasks. Success/failure analysis of all sessions shows that 9% of 5-year-old children failed on the first attempt, compared with 16% of children who were 4 years old. Eighteen percent of the older children failed following a second attempt, compared with 28% of younger children. Additionally, 24% of older children touched a NS picture as their third choice, compared with 39% of the younger children who did so (see Table 6: Cross-tabulation of task success count and age, in Chapter Four). The average age of the top-performing (TP) group was 60 months, compared to an average age of 56 months of the bottom-performing (BP) group. Results from the movie task show that the replies of the younger group were more varied than those of the older children, although still significantly different than chance. For example, to the question of whether a magnifying glass is a science object, 93% of the older children answered positively, compared to 80% of the younger children. Clearly, some of the younger children have used their perception of science, as well as their previous knowledge, to answer this question affirmatively. Therefore, the findings of this study support the notion that children as young as 4 years old are in the process of developing views about science. This claim aligns with findings about children's conceptions in other areas. Conceptual development research shows that infants and toddlers categorize novel words and objects while learning about their environment (Gelman, 1999; Markman, 1990, to name two). Not surprisingly, children who have been exposed to science in their classrooms, or have learned about science through media or at home, have developed views about what constitutes as science. The older the children get, the more stereotypical views they present.

Gender. No gender differences were found with regard to the success/failure proportion across the entire study, meaning that the majority of the study's boys and girls were able to distinguish science from NS pictures, regardless of their gender. However, gender differences were found with regard to success/failure proportion of specific sets, and with different choice patterns and science picture preferences.

On the subject of task success/failure, the subgroup of young girls failed more than other subgroups in choosing the picture showing clothes (33% vs. 26% after three attempts, Set 4); more girls than boys chose the NS picture showing a baby bottle (28%

vs. 16% after three attempts, Set 6); and girls, especially young girls, failed significantly more than boys by choosing the NS picture showing a doll (40% vs. 29% following three attempts, Set 7). In contrast, more boys than girls failed by choosing the NS picture featuring a red sofa (26% vs. 16% after three attempts, Set 3); more boys than girls chose the NS picture featuring a soccer ball (52% vs. 32% after three attempts, Set 5); boys chose the NS picture of a boy tying shoes more than girls (35% vs. 29% after three attempts, Set 9); and boys failed more than girls by touching the picture featuring the "patty-cake" game (44% vs. 26% after three attempts, Set 10). The selection of NS pictures depends on the content of the picture itself as well as the content of the science pictures in the set. Some NS pictures fit with preschoolers gendered interests (Alexander, Johnson, Leibham & Kelley, 2008; DeLoache, Simcock & Macari, 2007), such as a doll and baby bottle for girls and a soccer ball for boys. The NS picture showing children playing the "patty-cake" game may carry a female stereotype due to the social nature of the game; however, it was chosen more by boys. The results suggest that other factors may have affected the choice of a NS picture. These factors may be related to the individual child, classroom events, or cultural background (Fleer & Robbins, 2003; Rogoff, 1998).

Evidence for gender differences was also found in the picture choice pattern of boys and girls; however, these differences are somewhat ambiguous when compared with gendered preferences as presented in the literature. For example, with regard to pictures showing "science," there was an agreement between boys and girls on the pictures showing human body volcano and chemicals. However, the picture featuring dinosaurs was chosen mostly by boys (following the first attempt), and the picture showing a plant was chosen by the majority of the girls (following the first, second, and third attempts). This choice pattern aligns with the findings of prior research. Alexander et al. (2008) and DeLoache et al. (2007) studied the development of conceptual interests in young children and found that boys' top conceptual interests focused on conceptual interests, such as dinosaurs, airplanes, and horses, while girls' top interests were sociodramatic play and creative arts. Gender differences with regard to science education have been noted by many researchers (Coulson, 1991; Farenga & Joyce, 1997, 1999; Jones et al. 2000; Ormerod & Wood, 1983; Zoldosova & Prokop, 2006, to name a few). According to this body of research, from an early age, boys and girls report on different preferences with regard to science, with boys favoring physical science and girls favoring natural science, colors, and aesthetics.

The ambiguity of the results is revealed by the analysis of children's chosen pictures for "science object" and "science activity." In the former category (science object), the pictures featuring natural objects (leaves, seed, spider) were chosen by a majority of the boys (following the first, second, and third attempts). In contrast, the picture showing a magnifying glass was chosen by a majority of the girls (following the first, second, and third attempts). This pattern contradicts prior findings. Interestingly, during the pilot study, the picture of the seed was replaced with a picture of butterfly, which got the majority of the girls' votes. The aesthetic butterfly was replaced with a picture of a seed, and the results changed. It can be argued, that other factors may have played a role in this case. A spider, which is taxonomically categorized as a natural object, is also scary and some of the girls may fear or be disgusted by it. The image of the seed is unattractive as well. The only “pretty” natural picture would be the colorful leaves, and the fact that it was chosen by the boys (and less by the girls) contradicts previous data. In the science activity category, the results are again ambiguous. Following the first attempt, the majority of girls chose a picture showing a very stereotypical image featuring a boy with goggles holding a test tube. The boys, on the other hand, chose a picture showing girls observing a tree bark with magnifying glass. Following the third attempt, a majority of the girls chose a picture showing girls conducting an experiment, and the boys chose a girl observing a butterfly. This is again a reverse of the expectations based on other researchers’ reports. A possible explanation may be that the gender choice interacted with age, and so older girls preferred stereotypical images of science object and activity such as a magnifying glass or test tube, while a group of younger boys preferred natural items. Additional hypothesis may be that girls are more aware of the stereotypes (that are manmade, social definitions) associated with science and expressed them in order to pick pictures that show “real” science. Future research may be able to explain the results.

School and classroom. Determining school differences is difficult, because out of the five locations, three of the locations had very few participants (fewer than 10). Some school differences were detected in specific sets, mostly relating to science objects and science activities, that go beyond age or gender differences. These differences in picture choice may relate directly to the presence of some items in the classroom or experience with specific science activity that was done in the classroom. However, a whole study analysis found that children's performance in the different schools was due to age differences, with two exceptions: Classroom E and School 5. The data show that 40% of the 15 children who were considered top performers (TP; children who completed all 11 sets without choosing any NS picture) came from one classroom: Classroom E. This class is one of three classrooms from the University of Minnesota's Lab School that participated at the study. The majority of the children in this class belong to the younger age group (4 years), so it is assumed that the high success level does not relate to age alone. The children in this school have intense science experience, and some of the children participated in a small group called the "super scientists." Another variable might be the time of day. While classrooms D and F take place in the morning, Classroom E meets in the afternoon. Since the testing sessions took place during school hours, it might be that during the afternoon children were able to concentrate better.

School 5 is a Head Start classroom located in a Native American reservation. This group of children tended to fail (by choosing the NS pictures) more often than groups from other schools, regardless of the children's age. These findings align with previous data about Native American children's perception of science and scientists. Monhardt (2003) studied Navajo elementary school students' images of scientists and found that they presented a less stereotypical view of scientists compared with a comparison group of US students. Follow-up interviews revealed that some of the children did not have any conception of science or scientists and other students had a vague concept of scientists. There are several possible explanations for the findings of the current study: First, children might not have fully understood the task. This explanation is very unlikely since all the children completed the training sessions successfully. Second, the children did not have a concept of science. This may be due to minimal exposure to the word *science* and related concepts during the school and at home, compared with children from other schools. Based on personal experience, the children in this classroom participate in science activities, but these may have not been labeled as “science.” The home experience of children in this school (afterschool activities, reading books, family discussions) is quite different from the home experience of children in other schools. Altogether, the children in this school may have received a low exposure, both explicit and implicit, to science. Ausubel’s (1968) theory of meaningful learning determines that concepts are formed and developed through experience and connection to the learner’s prior knowledge. If children’s everyday experience does not include any relation to science, they would not have any cognitive structure to serve as foundation for future modification and expansion of this concept. Aikenhead (1997) posited that differences between the culture of science and the Native American culture might distance those students from science:

> “If the subculture of science is generally at odds with a student’s everyday world, as it can be with First Nations students, then science instruction can disrupt the student’s view of the world by forcing that student to abandon or marginalize his or her indigenous way of knowing and reconstruct in its place a new (scientific) way of knowing” (p. 222).

Third, it might be that School 5 children’s concept of science is different than the stereotypical views of science, as tested in the current study. They may perceive science differently, and their concept was not represented by the pictures presented to them. Monhardt (2003) found also that the sample of Navajo students made references to science that included local, environmental, and geological images, different from the comparison group. Lastly, the children may have categorized the items in a different manner (thematically, not taxonomically), and despite their familiarity with the stereotypes of science, a different way of thinking and classification led them to choose a relatively large number of the NS pictures. Researchers in the field of cognitive development have noted that preschool children tend to classify based on thematic or idiosyncratic relations in contrast with adults that classify objects taxonomically (Markman & Hutchinson ,1984; Waxman & Gelman, 1986). These researchers have found that when presented a label ("touch a picture showing science"), children as young as 3 years of age will classify items taxonomically. Rogoff (1998, 2003) stresses the need to consider children's culture during comparative studies, as culture and contexts affects the way children think, and warns against using European-American Western lenses when studying indigenous cultures. Correa-Chávez and Rogoff (2005) assert that "thinking depends on features of the context, not just on the mental activity of brains" (p. 7). Hence, School 5 children may have been choosing the pictures based on other criterion than the label "science."

Considering the four possibilities, it must be noted that School 5 had a small number of participants, who may not be representing of the entire group. Future studies with interview components would have to be conducted in order to determine the reason for the data gathered in this study.

Implications

The current study presents several contributions for early childhood science education research and teaching. The following section presents implications that stem directly from the findings of the current study as well as the author's suggestions for possible applications of the findings by researchers and teachers.

The study has found that the majority of participants (preschool children as young as 4 years of age) were familiar with the stereotypic views of science and were capable of conceptualizing and making inferences about the concept and practice of science. Children's views about science go beyond their firsthand experience with science activities. The majority of participants were able to classify unfamiliar objects as "science" based on some features (natural objects, chemical reaction). The study supports other scholars' assertions that preschool children **are** capable of learning and thinking about science (Bowman, Donovan & Burns, 2001; Eshach, 2006; French, 2004; Metz, 1995). Unfortunately, science is often missing from the early childhood classrooms (Greenfield et al., 2009; New, 1999). Hence, considering the findings of the current study, the author believes that further research should be designed in order to understand the origin of the preschoolers' concept of science, its sources, and possible ways to enhance and expand the stereotypical views of science.

As Eshach (2006) noted, ideas which take shape in early childhood do not readily disappear with age, but rather prove to be disconcertingly robust (p. 4). The current study shows that some of the children were not familiar with the concept of science. Since preschoolers are capable to learn and think about science, the author believes it is important for the early preschool science curriculum to be developed and taught in preschool so that children's conception of science will not rely on shallow stereotypic presentation of science, but rather on true firsthand experiences.

Cognitive and conceptual development is tightly related to children's early experiences and culture (Bowman et al., 2001; Rogoff, 2003). Gaps between populations begin during the early years (Heckman & Masterov, 2007). Children who grow up in poor socioeconomic environments are likely to suffer from a poverty of scientific concepts and skills (Eshach, 2006). Monhardt (2003) asserts that "of all minority populations, American Indians are least likely to enter scientific careers and are underrepresented in careers that require high-level scientific knowledge" (p. 26). The current study found that preschool children from a Head Start classroom located on an American Indian reservation failed on the tasks in large percentages compared with children from other schools. Future studies would have to target the population of American Indian children in order to answer the question of how they view science and what their concept of science includes. The skewed performance of this group on the task emphasizes the need to invest in early childhood science interventions for minority children, in order to pave the road for their later participation in the science community.

Gender differences and perceptions of gender-role stereotypes in science are well documented (Kahle & Lakes, 1983; Jones et al. 2000; Ormerod & Wood, 1983). Preschoolers' gendered interests were documented in several studies (Alexander et al., 2008; DeLoache et al., 2007). The current study did not find evidence for gender differences in performance (task success); however, it did note some choice differences between boys and girls. The findings do not fully align with previous research. In one case, girls chose the picture featuring a plant, while boys chose a picture showing a dinosaur (when asked about science pictures); in another case, the girls chose the picture showing a magnifying glass, while boys picked the nature-themed pictures, such as leaves, spider, and seed (when asked about science object pictures), which is in contrast to previous data associating girls' interests with natural themes. Further research would have to look into the contradictory findings.

Finally, the developed instrument was demonstrated to be a good tool for studying science concepts in preschool children. Children enjoyed the gamelike format and were able to follow the instructions. Since the developed instrument does not rely on expressive language, it may be adapted and used with populations of young children, children with special needs, and children who are whose expressive language is not proficient (such as English learners). Further development is needed in order to enlarge and randomize the variety of pictures and videos. Findings of this study also support the need to go beyond stereotype when assessing children's views (Boylan et al., 1992). Observed differences in picture selection following the first and third choices stress the need to provide a variety of images and multiple-choice opportunity in order to gauge children's true concept. Following on some other researchers studying young children (Boylan, et al., 1992; Fleer & Hardy, 1993; Fleer & Robbins, 2003; Monhardt, 2003), an interview component is necessary in order to complement and understand children's reasoning and thought.

Implications for Teachers

The author draws on the data gathered in the current study, as well as her experience as a science educator, to compile this set of implication for teachers.

1. **Support children's conceptualization of science.** As it was shown that preschool children are capable of developing views and conceptualizing science, early childhood teachers can help children develop an elaborate concept of science (that go beyond the stereotypical view) by establishing a science center with different science objects in the classroom. The center will allow children to conceptualize the objects as "science objects" and also to interact with science objects during their free play time.

2. **Go beyond the stereotype.** The study shows young children are familiar with the stereotypical images of science, even those with which they do not have firsthand experience. Assuming that they learn about those stereotypical images in other places than school (media, family, siblings), the author believes it is important to emphasize how science relates and affects everyday life and the fact that everything around us can relate to science. By designing small inquiry investigations with topics that are taken from children's life (e.g., baking cookies, looking at and studying the frogs in the backyard, investigating the songbirds on the tree or the worms underneath), teachers can help children develop a round and inclusive concept about science.

3. **Model "science skills."** Teachers can also support children's understanding of science as they model science as a way of thinking and solving problem, not just a content area. Teachers can model and practice with their children the

different steps of scientific inquiry such as asking questions, making predictions, investigating, recording, and sharing their findings with their friends. The study has suggested that preschool children understand the investigative nature of science activities. By modeling and practicing “science skills,” teachers can help their students get to the essence of what science is. Repeating the sequence of steps again and again will help the children create a script, a mental model of events, and help children “think like scientists.” In other words the children will be able to internalize and apply critical thinking and problem-solving skills when needed.

4. **Engage both genders.** The current study has found some gender differences with regard to interests and conceptualizing of science. Although this finding does not fully align with previous data, gender differences were detected. Data from previous studies tells us that from an early age, boys and girls have different preferences and interests. The author believes it is important that teachers will design and conduct science activities that will appeal to and engage both genders. Additionally, it is the author’s opinion that early childhood professionals (as well as parents and other caregivers) must explicitly reject the public belief that perceives science as more suitable for boys.

5. **Develop culturally based science activities.** The current study has pointed at some possible differences in response pattern between children from a Native American reservation and children who come from middle-class families

living in the suburbs. The National Association for the Education of Young Children calls for early-childhood teachers to consider each child's culture prior to making decisions about developmentally appropriate and instructional practices for each child (NAEYC, 2009). In the author's opinion, it is important that early childhood educators design science activities on themes related to the culture of their students so that students can easily engage in a familiar topic. In doing so, the teachers will bridge a possible gap between the home culture of the students and the culture schooling, and culture of science, and make science more accessible for these children.

Limitations

Two major limitations are interwoven in this study. The first is item selection addressing both pictures and videos. The second is the nature of the instrument, which reports on children's choices without providing the reasoning for the selection.

Although the items were chosen following a thorough review of preschool curricula and classroom observations, the specific pictures and their grouping in four picture sets had an effect on children's choices. The fixed sets, intended to control for items and order they are presented, have affected children's decision and results. The picture showing dinosaurs that did not get enough votes to be included in the final presentation of "science pictures" may have been chosen if presented within a different set, hence compared to other pictures. Therefore, a comparison of all science pictures may be erroneous, since the children voted for each picture in relation to the other pictures in the set and not the entire pool of pictures.

Picture Recognition. A picture recognition test was conducted with half of the participants. The test was conducted with random participants and was conducted following their participation. The test presented to participants a page with all the pictures they saw during the study and asked them to name each picture. If they were not able to name it, they were asked to guess what it is or what it is used for. Three pictures were marked as questionable: a picture showing colorful magnets, a picture showing a seed, and a picture showing a chemical reaction. Interestingly, children were able to answer or “guess” the essence of the pictures showing the seed and the chemical reaction. The picture showing magnets was not familiar to children who do not have the magnets in their classroom. Their appearance does not hint on their use and may be confusing to children. Unfortunately, the identity of the responders to the picture recognition test was not saved and therefore could not be correlated with their results. Future versions of the instrument should replace these pictures (or at least the picture showing magnets).

Finally, some specific items (pictures and questions) carried ambiguity in the way they were presented. Movie task questions asking whether sitting or talking are part of science, and intended to serve as a “no” question, can actually be correct. Some science activities do require talking or sitting at a table, and although this is not a necessity for all science activities, it may be true for some.

Some of the pictures created an ambiguity as well. As discussed in the previous chapter, the picture showing children reading may be associated with science, since preschool science involves books that allow children to explore the topic. Other pictures may have been confusing to children. The picture showing the breaking of light through a prism, which is a specific process in the eyes of people who are familiar with the properties of light, may be confusing for preschool children. This picture may seem to them as having two separate objects, prism and rainbow, without any familiarity with the properties of light. If this picture was chosen, it would be impossible to tell what the children consider as science – the rainbow or the clear triangle object. Another problematic item may be the picture showing a truck. This picture features a single object in a set of collections (shells, bottles, and rocks), which may hint to the child that this is an exception, making it easy to "guess" and touch other pictures regardless of science views.

The second major limitation is the lack of depth and reasoning of the results. The study provides data on children's choices of pictures or videos that represent science, without the reasoning of why some items are NOT science, or what experiences they draw on when choosing a science picture. Future versions of the instrument may include a follow-up interview component to deepen the understanding of the factors affecting the views and perceptions of science.

Future Studies

Several directions for future studies stem from the current research.

1. Expanding the current study in order to deepen our understanding of the way preschool children perceive science. The expansion should include more pictures and videos, possibly in a randomized order, and target diverse preschool-age populations. This larger study may confirm the findings of the

current study or point at new trends that could not be detected in the current research population size.

2. What affects the formation of science views? Another possible follow-up research may look into the causes and factors which contribute to the formation of the science concept. That type of study will focus on children's reasoning for labeling a picture as science or non-science, as well as compare children's views with home and school science activities.

3. Connecting the dots. A third possible follow-up study will use the current instrument with older children, students of early elementary school grades, in order to learn whether subgroup differences that were detected in the current study continue as children get older. This proposed study may also provide the missing link between the abundance of data of upper-elementary students and the current research findings regarding preschool children.

Conclusion

This study attempted to explore preschool children's views of science. Since this population is rarely studied within the field of science education, a computer-based instrument was designed. The study enrolled more than 120 children ages 4 to 5 years and asked them to point at pictures that represented science, science objects, and science activities. In addition, participants were asked yes/no questions following short video clips that featured preschool children engaged in variety of activities. The study found that the majority of the participants had a conception of science and the children were aware of stereotypical images related to science. Some images got a large number of votes from children following the first, second, and third choices (for example, images featuring a volcano, a human body, and chemicals). Other images got fewer votes after the first choice but more votes during the second and third choices (for example, images featuring space, colors, binoculars, and a boy looking at a test tube). Gender differences were found but were somewhat ambiguous. In addition, both boys and girls believed that science is for both genders, although a small bias favoring boys was detected. Children from a classroom on an American Indian reservation "failed" more often on the tasks compared with the rest of the group, suggesting a low familiarity with the stereotypical views of science. However, due to the low number of participants from this classroom, no clear statements can be made and further studies are needed in order to explore what American Indian preschoolers consider as science.

The instrument developed for this study was found to be a good and reliable tool for studying preschool children. The children were engaged and interested in both picture and movie tasks, and most children were able to complete the training sessions without any assistance. Future development of the instrument will include larger and randomized sets of pictures in order to further explore children's conceptions of science.

In addition to its significance for science education researchers, this study provides some useful implications for teachers. Labeling science activities as "science" would help preschool children expand their concept of science. It is important to conduct a variety of science activities that will interest both boys and girls. Finally, the author includes a suggestion of establishing a science center in the classroom in order to provide preschoolers with the opportunity to interact firsthand with science-related artifacts and, by doing so, enhance their concept of science.

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Appendix A: Focus Group Protocol

(Estimated time: 10-15 minutes)

Experimenter and group of 3-4 preschool children sit around a small table. Next to the experimenter sits Froggy, a frog puppet.

Experimenter (to the children): Thanks so much for coming to talk with me. My friend Froggy and I would like to ask you some questions about science. First, have you heard the word science or scientist before?

Experimenter (to Froggy): How about you Froggy? Do you know what science means? You don't?! (surprised) Well, you are very lucky, because these children are very very smart and they can tell you a lot about science, would you like that? (Froggy nods).

Experimenter (to the children): Could you tell Froggy what is science?

(follow up their answers and asking "why is that science?")

Experimenter (to Froggy): Wow, these children really know a lot about science. Now that you heard so many things about science, let's play a game, I need your help Froggy. I will put on the table pictures of children doing all kind of activities. Some of the children are doing science activities. Can you show me where the children that are doing science are?

Experimenter arranges the pictures on the table.

Experimenter (to Froggy): OK Froggy, are you ready? (Froggy signs 'no' and whisper something the in experimenter ear) Oh, Froggy, is that too hard for you? Maybe we can ask the children to help.

Experimenter (to the children): Can you help Froggy and point at the pictures that show children doing science? (After each child point at a picture ask him/her why is that science).

Repeat the process two more times with different pictures and thank the children for their help.

Experimenter (to the children): Did you know? A scientist is a person who does science. Have you met a scientist before?

Experimenter (to the children): What I'd like you to do now, is to close your eyes and imagine that you see a real scientist (wait for 30 seconds) OK, you can open your eyes now. Can you describe the scientist that you pictured in your mind?

Experimenter (to the children): Take a look at these pictures (arrange pictures of scientists). Is one of these pictures looks like the scientist that you pictured in your head? Do you see any other scientists in the pictures?

Appendix B: Picture and Video Tasks Training Protocol Flow Model

0. Only arrow presented. Child is asked to touch the arrow. If task completed successfully, move to (1); if arrow is not touched, play audio file again. If the arrow is too small, children may miss it, so maybe put it in a box or make the area around it “count” as if the arrow was touched. Also, can the arrow flash when touched?
1. One picture and arrow presented; audio file asks the child to “touch the picture of the dog when you are done, touch the arrow button.” If task completed, move to (3).
2. If the task is not completed within a certain time (~ 10 sec):
    a. Participant did not touch picture or arrow? Repeat (1) with a different picture. Repeat 2 more times (and end session).
    b. Participant touched picture but not arrow? Arrow flashes and audio file reminds to touch the arrow.
3. 2 pictures (one dog and one non-dog) and arrow on the screen; audio file asks the child to “touch a picture of a dog; when you are done – touch the arrow button.” If task completed, move to (5).
4. If the task is not completed within a certain time (~ 10 sec):
    a. Participant did not touch anything. Repeat (3) with a different set of pictures. Repeat 2 more times and end session.
    b. Participant touched the non-dog picture and touched the arrow repeat (3) with a different set of pictures. Repeat 2 more times (and end session).
    c. Participant touched the dog picture but not the arrow? Dog picture fades; Arrow flashes and audio file reminds to touch the arrow.
5. When the child touched the picture it dims, and an audio file asks “touch another dog, if there aren’t any dogs, touch the arrow.” If successful, move to (7).
6. If the task is not completed within a certain time (~ 10 sec), repeat audio file; if still no reply, go back to (3).

7. 4 pictures (2 dogs and 2 non-dogs) presented with the arrow button; audio file asks the child to "touch a picture of a dog. When you are done, touch the arrow." If task completed, move to (9).
8. If the task is not completed within a certain time (~ 10 sec):
    a. Participant did not touch anything: repeat (7) with a different set of pictures. Repeat 2 more times (and end session).
    b. Participant touched a wrong picture and arrow: repeat (7) with a different set of pictures. Repeat 2 more times (and end session).
    c. Participant touched a dog picture but did not touch the arrow→ Dog picture fades; Arrow flashes and audio file reminds to touch the arrow.
9. The chosen picture is dimmed, and an audio file asks to "touch all the dogs you see, if there aren't any dogs, touch the arrow." If task completed – move to 11.
10. If the task is not completed within a certain time (~ 10 sec), repeat audio file, and if still no reply, go back to (7) with a different set of pictures.
11. 4 pictures (3 dogs and 1 non-dog) presented with the arrow button; audio file asks the child to "touch a picture of a dog. When you are done, touch the arrow." If task completed – move to (13).
12. If the task is not completed within a certain time (~ 10 sec):
    a. Participant did not touch anything: repeat (11) with a different set of pictures. Repeat 2 more times (and end session).
    b. Participant touched a wrong picture and arrow: repeat (11) with a different set of pictures. Repeat 2 more times (and end session).
    c. Participant touched a dog picture but did not touch the arrow→ Dog picture fades; Arrow flashes and audio file reminds to touch the arrow.
13. The chosen picture is dimmed, and an audio file asks to "touch all the dogs you see, if there aren't any dogs, touch the arrow." If task completed, training session ends and <u>move to first picture test.</u>

    If task not completed, repeat (11) two more times and end training session.

Video Task Training Protocol

(1) In this game you are going to watch short videos. After the video, I will ask you few questions and you can reply by touching one of the doggy-figures below. Let's practice, Ready? Watch the first video carefully.

[Participants watch a 10-second video clip of a girl sliding down a slide]

That was a fun video. Now listen carefully to my questions:*

1. Was the girl in the movie sliding? Yes she was! Touch the doggy that signs yes
2. Did the girl in the movie eat pizza? No she didn't! Touch the doggy that signs no
3. What is the girl's name? Hmm, we don't know. Touch the doggy that signs I don't know.

*During the first step of video training only the correct doggie is active and moving.

(2) Great job! Let's practice one more time. Watch the next short movie:

[Participants watch a 15-second video clip of a boy washing hands]

Thanks for watching so nicely. Now, listen to my questions:**

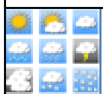
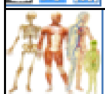
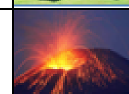
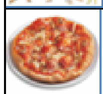
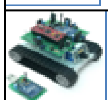
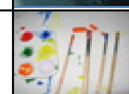
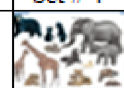
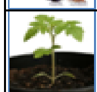
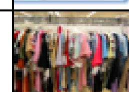
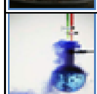
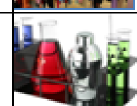
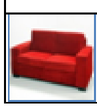
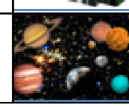
1. Was the boy in the movie sliding down the slide?
2. How old is the boy in the movie?
3. The boy in the movie washed his hands. Do you wash your hands at school?

** During the second step of the training all three doggies are active. If a child touches the wrong doggie figure s/he will hear the same question again.

Appendix C: Pilot Study Picture Test Items and Raw Data

Question: “Touch a picture showing science.”

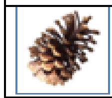
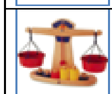
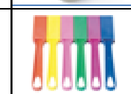
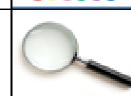
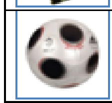
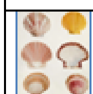
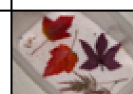
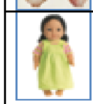
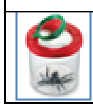
Prompt question: “Are there any more? Touch all pictures showing science. When you are done, touch the blue arrow.”

Set # 1	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 2	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Weather	4	11	14	14		Playground Set*	4	5	6	8
	Human Body	15	22	22	23		Volcano	13	21	24	24
	Pizza*	1	2	5	5		Snow Flake	0	8	10	11
	Electronics	7	13	17	18		Paints & paintbrush	13	20	22	23
Set # 3						Set # 4					
	Dinosaurs	11	20	23	23		Animals	9	12	16	17
	Plant	8	18	21	21		Rack of clothes*	1	7	7	8
	Bubbling liquid/gas	11	18	22	24		Test tubes and beaker	8	15	21	21
	Sofa*	0	1	2	4		Space; Solar system	12	22	23	26

* denotes a non-science picture

Picture Test Sets 5-8: Science Object

Question: “Touch a picture showing a science object.”
Prompt question: “Are there any more? Touch all pictures showing science objects. When you are done, touch the blue arrow.”

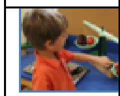
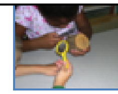
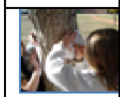
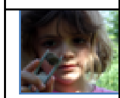
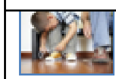
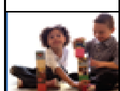
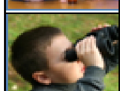
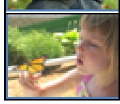
Set # 5	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 6	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Pinecone	5	12	16	18		Baby bottle*	1	5	6	8
	Scale	12	21	24	25		Play Magnets	12	19	23	23
	Binoculars	9	18	24	24		Magnifying Glass	12	20	24	26
	Soccer Ball*	4	6	6	10		Butterfly	5	12	17	20
Set # 7						Set # 8					
	Shells	5	12	17	19		Leaves	9	17	18	19
	Doll*	5	9	9	10		Colored liquids in different containers	12	19	20	21
	Spider in a bug cup	11	18	24	25		Toy truck*	3	4	9	10
	Globe	9	18	22	25		Rocks	6	14	18	21

* denotes a non-science picture

Picture Test Sets 9-11: Science Activity

Question: “Touch a picture showing a science activity.”

Prompt question: “Are there any more? Touch all pictures showing science activities. When you are done, touch the blue arrow.”

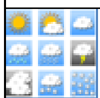
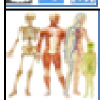
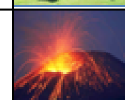
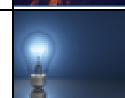
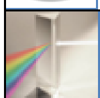
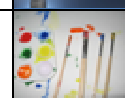
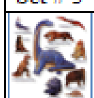
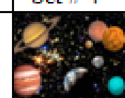
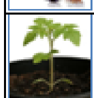
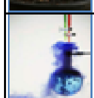
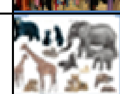
Set # 9	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 10	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Boy measures with scale	13	24	24	25		Girl observes with magnifying glass	8	17	22	24
	Girl records a tree bark	4	13	21	21		Group of children and teacher study a pond	6	17	21	22
	Girl observes a rock held by tweezers	10	15	20	22		Children play ‘pattycake’ (clapping game)	2	4	8	9
	Boy ties his shoelaces	3	6	8	12		A boy with goggles observes a test tube	14	19	20	24
Set # 11											
	Children build with blocks	5	8	10	11						
	Girls conduct an experiment	10	21	22	23						
	Boy looks through binoculars	8	15	22	23						
	Girl holds and observes a butterfly	7	14	17	21						

* denotes a non-science picture

Appendix D: Large Scale Study Picture Test Items and Raw Data

Question: “Touch a picture showing science.”

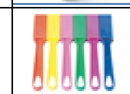
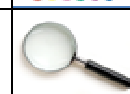
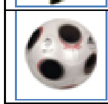
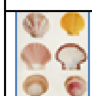
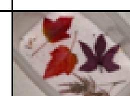
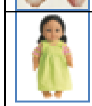
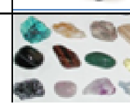
Prompt question: “Are there any more? Touch all pictures showing science. When you are done, touch the blue arrow.”

Set # 1	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 2	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Weather	18	33	37	42		Playground Set*	12	19	25	36
	Human Body	13	52	54	56		Volcano	37	49	54	57
	Pizza*	4	8	14	20		Light Bulb	6	25	35	40
	Prism & Rainbow	14	14	40	44		Paints & paintbrush	19	41	55	59
Set # 3						Set # 4					
	Dinosaurs	32	49	54	61		Space; Solar system	28	52	59	65
	Plant	21	42	55	57		Rack of clothes*	8	20	26	33
	Bubbling liquid/gas	24	43	57	60		Animals	11	28	46	54
	Sofa*	4	13	17	23		Chemicals in bottles	34	52	62	67

* denotes a non-science picture

LS Picture Test Sets 5-8: Science Object

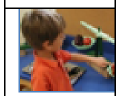
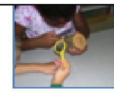
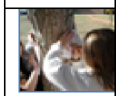
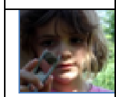
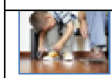
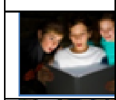
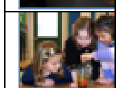
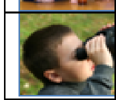
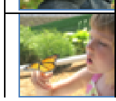
Question: "Touch a picture showing a science object."
Prompt question: "Are there any more? Touch all pictures showing science objects. When you are done, touch the blue arrow."

Set # 5	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 6	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Pinecone	12	26	37	47		Baby bottle*	6	16	19	31
	Scale	38	54	65	70		Play Magnets	21	37	50	52
	Binoculars	19	45	57	63		Magnifying Glass	31	46	58	65
	Soccer Ball*	12	24	33	42		Seed	20	45	55	61
Set # 7						Set # 8					
	Shells	14	33	47	54		Leaves	24	44	56	62
	Doll*	17	24	29	36		Colored liquids in different containers	33	58	65	71
	Spider in a bug cup	25	48	58	63		Toy truck*	12	18	26	36
	Globe	26	49	61	67		Rocks	12	33	49	57

* denotes a non-science picture

LS Picture Test Sets 9-11: Science Activity

Question: "Touch a picture showing a science activity."
Prompt question: "Are there any more? Touch all pictures showing science activities. When you are done, touch the blue arrow."

Set # 9	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries	Set # 10	Description	Number of touches after 1 try	Number of touches after 2 tries	Number of touches after 3 tries	Number of touches after 4 tries
	Boy measures with scale	33	55	65	69		Girl observes with magnifying glass	22	43	57	65
	Girl records a tree bark	14	33	53	55		Group of children and teacher study a pond	22	44	55	62
	Girl observes a rock held by tweezers	19	39	52	62		Children play 'pattycake' (clapping game)	4	16	28	38
	Boy ties his showlaces	15	23	27	43		A boy with goggles observes a test tube	31	50	64	71
Set # 11											
	Children read a book	19	30	44	52						
	Girls conduct an experiment	25	48	60	72						
	Boy looks through binoculars	12	37	50	60						
	Girl holds and observes a butterfly	28	43	56	59						

* denotes a non-science picture

Appendix E: Pilot study Follow-up Interview Protocol

A. Observation of participants during the study

1. Is the child engaged (concentrated, interacting with the program) Y N IDK

2. Does the child enjoy the activity (smiling, excited) Y N IDK

3. Was the child hesitant at touching the screen Y N IDK

4. Does the child look distressed Y N IDK

5. Reaction time too short good enough too long

6. Other observations:

Follow-up Interview:

Use the participant's data of the pilot trial and print out slides of the test. Explain to the child that I want to learn if the program works fine, if the pictures are good and how can I change it so it is more fun for other children. For that reason I need the child's help to explain to me his/her choices. Go over each slide, ask the original question and see what the child chooses (test-retest reliability). If the child points at a different picture than the one he chose in the test, say "oops, I think you actually chose that picture, can you tell me why did you pick it?"

Ask about chosen pictures and non-chosen pictures.

Appendix F: Chapter Four Tables

Set 1

Table 1-1: Set 1 Participants' Demographics

		AGE4_5		Total
		4	5	4
GEN	Boys	19	14	33
	Girls	18	20	38
Total		37	34	71

Table 1-2: Set 1 - First Choice Distribution

	Observed N	Expected N	Residual
WEATHER	20	17.8	2.3
HUMAN BODY	33	17.8	15.3
PIZZA	4	17.8	-13.8
PRISM	14	17.8	-3.8
Total	71		

Table 1-3: Test Statistics

	VOTE_1
Chi-Square(a)	24.831
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.

The minimum expected cell frequency is 17.8.

Table 1-4: Set 1 - Binomial Test for Successful Choice following First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	67	.94	.75	.000(a)
	0	4	.06		
Total		71	1.00		

a Based on Z Approximation.

Table 1-5: Set 1 - Binomial Test for Successful Choice following Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	63	.9	.56	.000(a)
	0	8	.1		
Total		71	1.0		

a Based on Z Approximation.

Table 1-6: Set 1 - Binomial Test for Successful Choice following Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	58	.82	.38	.000(a)
	0	13	.18		
Total		71	1.00		

a Based on Z Approximation.

Table 1-7: Set 1 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success		AGE (years)		Total
		4	5	
0	Boys	5	2	7
	Girls	4	2	6
Total		9	4	13
1	Boys	14	12	26
	Girls	14	18	32
Total		28	30	58

Table 1-8: Logistic Regression Variables Information

			N	Percent			
Dependent Variable	S_F_13	0	13	18.3%			
		1	58	81.7%			
		Total	71	100.0%			
Factor	GEN	0	33	46.5%			
		1	38	53.5%			
		Total	71	100.0%			
	SCH	1	6	8.5%			
		2	20	28.2%			
		3	31	43.7%			
		4	4	5.6%			
		5	10	14.1%			
		Total	71	100.0%			
			N	Minimum	Maximum	Mean	Std. Deviation
Covariate	AGE		71	45	69	58.58	6.686

Table 1-9: Set 1 - Logistic Regression Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
	Lower	Upper	Wald Chi-Square	Df	Sig.	Lower	Upper
(Intercept)	-5.726	3.1021	-11.806	.354	3.407	1	.065
[GEN=0]	-.277	.6515	-1.553	1.000	.180	1	.671
[GEN=1]	0(a)	.	.	.	.	.	.
[SCH=1]	22.547	.9386	20.707	24.387	577.096	1	.000
[SCH=2]	2.160	.9749	.249	4.071	4.909	1	.027
[SCH=3]	1.480	.8815	-.248	3.207	2.817	1	.093
[SCH=4]	22.263	.9747	20.352	24.173	521.693	1	.000
[SCH=5]	0(a)	.	.	.	.	.	.
AGE	.102	.0474	.009	.195	4.632	1	.031
(Scale)	1(b)						

Dependent Variable: S_F_13
Model: (Intercept), GEN, SCH, AGE

a Set to zero because this parameter is redundant.

b Fixed at the displayed value.

Table 1-10: Crosstab of Schools by Success/Failure Proportion Following Third Choice

		Task Success		Total
		0	1	
School	1	0	6	6
	2	2	18	20
	3	7	24	31
	4	0	4	4
	5	4	6	10
Total		13	58	71

Table 1-11: Set 1 First Choice by Age & Gender

			VOTE_1				
			Weather N=20	Human Body N=33	Pizza N=4	Prism/Rainbow N=14	Total N=71
Boys	AGE	4	5	11	1	2	19
		5	5	6	1	2	14
	Total		10	17	2	4	33
Girls	AGE	4	5	8	1	4	18
		5	5	8	1	6	20

Total	10	16	2	10	38

Table 1-12: Set 1 First Choice by School

		VOTE_1				Total
		Weather	Human Body	Pizza	Prism/Rainbow	Weather
SCHOOL	1	2	2	0	2	6
	2	5	11	0	4	20
	3	11	13	2	5	31
	4	0	3	0	1	4
	5	2	4	2	2	10
Total		20	33	4	14	71

Set 2

Table 2-1: Set 2 Participants' Demographics

		AGE (years)		Total		
		4	5			
GEN	Boys	19	14	33		
	Girls	22	20	42		
Total		41	34	75		
		N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)		75	45	71	58.11	6.837

Table 2-2: Set 2 - First Choice Distribution

	Observed N	Expected N	Residual
Playground	12	18.8	-6.8
Volcano	37	18.8	18.3
Light-bulb	6	18.8	-12.8
Colors	20	18.8	1.3
Total	75		

Table 2-3: Set 2 First Choice Chi-Squared Test Statistics

	VOTE_2
Chi-Square(a)	28.947
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.

The minimum expected cell frequency is 18.8.

Table 2-4: Set 2 - Binomial Test for Successful Choice Following First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	63	.84	.75	.043(a)
	0	12	.16		
Total		75	1.00		

a Based on Z Approximation; significant at the 0.05 level.

Table 2-5: Set 2 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	56	.7	.56	.001(a)
	0	19	.3		
Total		75	1.0		

a Based on Z Approximation.

Table 2-6: Set 2 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	50	.67	.38	.000(a)
	0	25	.33		
Total		75	1.00		

a Based on Z Approximation.

Table 2-7: Set 2 Cross-Tabulation of Success/Failure Following Third Choice Based on Gender and Age

Task Success		AGE (years)		Total
		4	5	
0	Boys	6	5	11
	Girls	12	2	14

	Total	18	7	25
1	Boys	13	9	22
	Girls	10	18	28
	Total	23	27	50

Table 2-8: Set 2 Logistic Regression Variable Information

			N	Percent
Dependent Variable	S_F_23	0	25	33.3%
		1	50	66.7%
		Total	75	100.0%
Factor	GEN	Boys	33	44.0%
		Girls	42	56.0%
		Total	75	100.0%
	SCH	1	6	8.0%
		2	23	30.7%
		3	31	41.3%
		4	5	6.7%
		5	10	13.3%
		Total	75	100.0%

		N	Minimum	Maximum	Mean	Std. Deviation
Covariate	AGE	75	45	71	58.11	6.837

Table 2-9: Set 2 - Logistic Regression Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-6.411	2.8141	-11.926	-.895	5.189	1	.023
[GEN=0]	.047	.5982	-1.126	1.219	.006	1	.938
[GEN=1]	0[a]	.	.	.	.	.	.
[SCH=1]	1.087	1.5343	-1.920	4.094	.502	1	.479
[SCH=2]	.177	.8768	-1.542	1.895	.041	1	.840
[SCH=3]	.379	.8664	-1.319	2.077	.191	1	.662
[SCH=4]	.716	1.6592	-2.536	3.968	.186	1	.666
[SCH=5]	0[a]	.	.	.	.	.	.
AGE	.118	.0434	.033	.203	7.379	1	.007
(Scale)	1[b]						

Dependent Variable: S_F_23
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 2-10: Set 2 First Choice by Age and Gender

			VOTE_2				Total
			Playground	Volcano	Light Bulb	Colors	
Boys	AGE (yr)	4	2	11	0	6	19
		5	3	6	3	2	14
	Total		5	17	3	8	33
Girls	AGE (yr)	4	6	6	1	9	22
		5	1	14	2	3	20
	Total		7	20	3	12	42

Table 2-11: Set 2 First Choice by School

		VOTE_2				Total
		Playground	Volcano	Light Bulb	Colors	
SCH	1	0	3	0	3	6
	2	2	11	2	8	23
	3	7	15	3	6	31
	4	1	3	0	1	5
	5	2	5	1	2	10

Total	12	37	6	20	75

Set 3

Table 3-1: Set 3 Participants' Demographics

	AGE (years)		
	4	5	Total
Boys	20	15	35
Girls	24	21	45
Total	44	36	80

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	80	45	71	58.33	6.737

Table 3-2: Set 3 - First Choice Distribution

	Observed N	Expected N	Residual
Dinosaurs	32	20.0	12.0
Plant	20	20.0	.0
Reaction	24	20.0	4.0
Sofa	4	20.0	-16.0
Total	80		

Table 3-3: Set 3 - First Choice Chi-Squared Test Statistics

	VOTE_3
Chi-Square(a)	20.800
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 20.0.

Table 3-4: Set 3 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)

Task Success	1	76	.95	.75	.000(a)
	0	4	.05		
Total		80	1.00		

a Based on Z Approximation.

Table 3-5: Set 3 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	68	.85	.56	.000(a)
	0	12	.15		
Total		80	1.0		

a Based on Z Approximation.

Table 3-6: Set 3 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	64	.80	.38	.000(a)
	0	16	.20		
Total		80	1.00		

a Based on Z Approximation.

Table 3-7: Set 3 Cross-Tabulation of Success/Failure Following Third Choice Based on Gender and Age

Task Success			GEN		Total
			Boys	Girls	
0	AGE (yr)	4	6	5	11
		5	3	2	5
	Total		9	7	16
1	AGE (yr)	4	14	19	33
		5	12	19	31
	Total		26	38	64

Table 3-10: Set 3 First Choice by Age and Gender

			VOTE_3				Total
			Dinosaurs	Plant	Reaction	Sofa	
Boys	AGE (yr)	4	11	1	7	1	20
		5	7	3	4	1	15
	Total		18	4	11	2	35
Girls	AGE (yr)	4	6	8	8	2	24
		5	8	8	5	0	21
	Total		14	16	13	2	45

Table 3-11: Set 3 First Choice by School

		VOTE_3				Total
		Dinosaurs	Plant	Reaction	Sofa	
School	1	1	3	2	0	6
	2	9	10	8	1	28
	3	17	4	11	2	34
	4	1	0	1	0	2
	5	4	3	2	1	10
Total		32	20	24	4	80

Table 3-12: Set 3 Cross-tabulation of School and Gender

		SCHOOL					Total
		1	2	3	4	5	
	boys	4	9	17	0	5	35
	Girls	2	19	17	2	5	45
Total		6	28	34	2	10	80

Set 4

Table 4-1: Set 4 Participants' Demographics

	AGE (years)		Total
	4	5	
Boys	17	17	34

Girls	25	21	46		
Total	42	38	80		
	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	80	45	71	58.48	6.745

Table 4-2: Set 4 - First Choice Distribution

	Observed N	Expected N	Residual
Space	27	20.0	7.0
Clothes	7	20.0	-13.0
Animals	11	20.0	-9.0
Chemicals	35	20.0	15.0
Total	80		

Table 4-3: Set 4 - First Choice Chi Squared Test Statistics

	VOTE_4
Chi-Square(a)	26.200
df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 20.0.

Table 4-4: Set 4 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	73	.91	.75	.000(a)
	0	7	.09		
Total		80	1.00		

a Based on Z Approximation.

Table 4-5: Set 4 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	61	.8	.56	.000(a)
	0	19	.2		

Total		80	1.0		

a Based on Z Approximation.

Table 4-6: Set 4 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	56	.70	.38	.000(a)
	0	24	.30		
Total		80	1.00		

a Based on Z Approximation.

Table 4-7: Set 4 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success			AGE (years)		Total
			4	5	
0	GEN	Boys	4	5	9
		Girls	10	5	15
	Total		14	10	24
1	GEN	Boys	13	12	25
		Girls	15	16	31
	Total		28	28	56

Table 4-8: Set 4 Cross-Tabulation of Success/Failure Based on School

		SCHOOL					Total
		1	2	3	4	5	
Task Success	0	1	8	10	0	5	24
	1	5	20	22	5	4	56
Total		6	28	32	5	9	80

Table 4-9: Set 4 Logistic Regression Variable Information

			N	Percent
Dependent Variable	S_F_43	0	24	30.0%
		1	56	70.0%
		Total	80	100.0%
Factor	GEN	Boys	34	42.5%

		N	Percent
	Girls	46	57.5%
	Total	80	100.0%
SCH	1	6	7.5%
	2	28	35.0%
	3	32	40.0%
	4	5	6.3%
	5	9	11.3%
	Total	80	100.0%

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	80	45	71	58.48	6.745

Table 4-10: Set 4 - Logistic Regression Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-5.920	2.7103	-11.232	-.608	4.772	1	.029
[GEN=0]	.487	.5353	-.562	1.536	.827	1	.363
[GEN=1]	0[a]	.	.	.	.	.	.
[SCH=1]	1.988	1.5295	-1.010	4.986	1.690	1	.194
[SCH=2]	1.542	.9091	-.240	3.324	2.877	1	.090
[SCH=3]	1.512	.8823	-.218	3.241	2.936	1	.087
[SCH=4]	23.331	.9779	21.414	25.248	569.242	1	.000
[SCH=5]	0[a]	.	.	.	.	.	.
AGE	.089	.0408	.009	.169	4.710	1	.030
(Scale)	1[b]						

Dependent Variable: S_F_43
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 4-11: Set 4 First Choice by Age and Gender

AGE (years)		VOTE_4 Space	Clothes	Animals	Chemicals	Total
4	Boys	5	2	2	8	17
	Girls	11	2	3	9	25
	Total	16	4	5	17	42
5	Boys	5	0	4	8	17
	Girls	6	3	2	10	21
	Total	11	3	6	18	38

Table 4-12: Set 4 First Choice by School

SCHOOL			VOTE_4 Space	Clothes	Animals	Chemicals	Total
1	AGE4_5	4	1	0	0	2	3
		5	2	0	0	1	3
	Total		3			3	6
2	AGE4_5	4	4	2	2	7	15
		5	1	1	2	9	13
	Total		5	3	4	16	28
3	AGE4_5	4	10	2	2	6	20
		5	5	0	2	5	12
	Total		15	2	4	11	32
4	AGE (yr)	4	1	0	0	1	2
		5	1	0	0	2	3
	Total		2			3	5
5	AGE (yr)	4	0	0	1	1	2
		5	2	2	2	1	7
	Total		2	2	3	2	9

Set 5

Table 5-1: Set 5 Participants' Demographics

	AGE (years)		Total
	4	5	4
Boys	18	15	33
Girls	24	23	47
Total	42	38	80

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	80	45	71	58.68	6.741

Table 5-2: Set 5 - First Choice Distribution

	Observed N	Expected N	Residual
Pinecone	11	20.0	-9.0

Scale	38	20.0	18.0
Binoculars	19	20.0	-1.0
Soccer Ball	12	20.0	-8.0
Total	80		

Table 5-3: Set 5 - First Choice Chi-Squared Test Statistics

	VOTE_5
Chi-Square(a)	23.500
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 20.0.

Table 5-4: Set 5 - Binomial Test for Successful Choice after First Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
S_F_5	Group 1	1	68	.85	.75	.022(a)
	Group 2	0	12	.15		
	Total		80	1.00		

a Based on Z Approximation.

Table 5-5: Set 5 - Binomial Test for Successful Choice after Second Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
S_F_52	Group 1	1	56	.7	.56	.007(a)
	Group 2	0	24	.3		
	Total		80	1.0		

a Based on Z Approximation.

Table 5-6: Set 5 - Binomial Test for Successful Choice after Third Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
S_F_53	Group 1	1	48	.60	.38	.000(a)
	Group 2	0	32	.40		
	Total		80	1.00		

a Based on Z Approximation.

Table 5-7: Set 5 Cross-Tabulation of Success/Failure based on Gender and Age

Task	AGE (years)		
Success	4	5	Total

0	Boys	9	8	17
	Girls	12	3	15
Total		21	11	32
1	Boys	9	7	16
	Girls	12	20	32
Total		21	27	48

Table 5-8: Set 5 Cross-Tabulation of Success/Failure based on School

		SCH					Total
		1	2	3	4	5	
Task Success	0	2	13	10	2	5	32
	1	4	15	22	4	3	48
Total		6	28	32	6	8	80

Table 5-9: Set 5 Logistic Regression Variable Information

			N	Percent
Dependent Variable	Task Success	0	32	40.0%
		1	48	60.0%
		Total	80	100.0%
Factor	GEN	Boys	33	41.3%
		Girls	47	58.8%
		Total	80	100.0%
	SCH	1	6	7.5%
		2	28	35.0%
		3	32	40.0%
		4	6	7.5%
		5	8	10.0%
		Total	80	100.0%

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	80	45	71	58.68	6.741

Table 5-10: Set 5 Logistic Regression Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.
(Intercept)	-6.478	2.9844	-12.328	-.629	4.712	1	.030
[GEN=1]	1.144	.5349	.096	2.192	4.573	1	.032
[GEN=0]	0[a]	.	.	.	.	.	.
[SCH=5]	-1.842	1.5041	-4.790	1.106	1.500	1	.221
[SCH=4]	-.613	1.6469	-3.840	2.615	.138	1	.710
[SCH=3]	.308	1.4310	-2.497	3.113	.046	1	.830
[SCH=2]	-.840	1.4254	-3.634	1.954	.347	1	.556
[SCH=1]	0[a]	.	.	.	.	.	.
AGE	.115	.0423	.032	.198	7.347	1	.007
(Scale)	1[b]						

Dependent Variable: S_F_53
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 5-11: Set 5 First Choice by Age and Gender

GEN			VOTE_5 Pinecone	Scale	Binoculars	Soccer Ball	Total
Boys	AGE (yr)	4	6	8	1	3	18
		5	0	4	9	2	15
	Total		6	12	10	5	33
Girls	AGE (yr)	4	2	9	7	6	24
		5	3	17	2	1	23
	Total		5	26	9	7	47

Table 5-12: Set 5 First Choice by School

		VOTE_5 Pinecone	Scale	Binoculars	Soccer Ball	Total
SCH	1	0	5	0	1	6
	2	2	13	9	4	28
	3	8	15	6	3	32
	4	1	3	1	1	6
	5	0	2	3	3	8
Total		11	38	19	12	80

Set 6

Table 6-1: Set 6 Participants' Demographics

	AGE (years)				
	4	5	Total		
Boys	17	14	31		
Girls	24	23	47		
Total	41	37	78		
	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	78	45	71	58.55	6.941

Table 6-2: Set 6 - First Choice Distribution

	Observed N	Expected N	Residual
Baby Bottle	5	19.5	-14.5
Magnets	21	19.5	1.5
Magnifying Glass	32	19.5	12.5
Seed	20	19.5	.5
Total	78		

Table 6-3: Set 6 - First Choice Chi-Squared Test Statistics

	VOTE_6
Chi-Square(a)	18.923
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5;
the minimum expected cell frequency is 19.5.

Table 6-4: Set 6 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	73	.94	.75	.000(a)

	0	5	.06		
Total		78	1.00		

a Based on Z Approximation.

Table 6-5: Set 6 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	63	.8	.6	.000(a)
	0	15	.2		
Total		78	1.0		

a Based on Z Approximation.

Table 6-6: Set 6 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task success	1	60	.77	.50	.000(a)
	0	18	.23		
Total		78	1.00		

a Based on Z Approximation.

Table 6-7: Set 6 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success		AGE (years)		Total
		4	5	
0	Boys	5	0	5
	Girls	8	5	13
Total		13	5	18
1	Boys	12	14	26
	Girls	16	18	34
Total		28	32	60

Table 6-8: Set 6 Cross-Tabulation of Success/Failure based on School

		SCHOOL					Total
		1	2	3	4	5	
Task Success	0	0	6	10	1	1	18
	1	6	22	23	2	7	60
Total		6	28	33	3	8	78

Table 6-9: Set 6 Logistic Regression Variable Information

			N	Percent
Dependent Variable	S_F_63	0	18	23.1%
		1	60	76.9%
		Total	78	100.0%
Factor	GEN	Boys	31	39.7%
		Girls	47	60.3%
		Total	78	100.0%
	SCH	1	6	7.7%
		2	28	35.9%
		3	33	42.3%
		4	3	3.8%
		5	8	10.3%
		Total	78	100.0%

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	78	45	71	58.55	6.941

Table 6-10: Set 6 - Logistic Regression Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.
(Intercept)	-5.967	3.2754	-12.387	.452	3.319	1	.068
[GEN=0]	.879	.6189	-.334	2.092	2.018	1	.155
[GEN=1]	0[a]	.	.	.	.	.	.
[SCH=1]	20.606	1.2819	18.093	23.118	258.407	1	.000
[SCH=2]	-.172	1.2263	-2.575	2.232	.020	1	.889
[SCH=3]	-.595	1.2420	-3.029	1.839	.229	1	.632
[SCH=4]	-.914	1.5136	-3.881	2.052	.365	1	.546
[SCH=5]	0[a]	.	.	.	.	.	.
AGE	.126	.0517	.024	.227	5.923	1	.015
(Scale)	1[b]						

Dependent Variable: S_F_63
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 6-11: Set 6 First Choice by Age and Gender

			VOTE_6 Baby Bottle	Magnets	Magnifying Glass	Seed	Total
Boys	AGE (yr)	4	1	8	4	4	17
		5	0	4	3	7	14
	Total		1	12	7	11	31
Girls	AGE (yr)	4	3	6	12	3	24
		5	1	3	13	6	23
	Total		4	9	25	9	47

Table 6-12: Set 6 First Choice by School

		VOTE_6 Baby Bottle	Magnets	Magnifying Glass	Seed	Total
SCH	1	0	5	1	0	6
	2	1	6	16	5	28
	3	3	7	12	11	33
	4	0	1	0	2	3
	5	1	2	3	2	8
Total		5	21	32	20	78

Set 7

Table 7-1: Set 7 Participants' Demographics

		AGE (years)		
		4	5	Total
GEN	Boys	18	16	34
	Girls	25	22	47
Total		43	38	81

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	81	45	69	58.43	6.663

Table 7-2: Set 7 - First Choice Distribution

	Observed N	Expected N	Residual
Shells	13	20.3	-7.3
Doll	17	20.3	-3.3
Spider	25	20.3	4.8
Globe	26	20.3	5.8
Total	81		

Table 7-3: Set 7 - First Choice Chi Squared Test Statistics

	VOTE_7
Chi-Square(a)	5.864
Df	3
Asymp. Sig.	.118

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 20.3.

Table 7-4: Set 7 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	64	.79	.75	.244(a)
	0	17	.21		
Total		81	1.00		

a Based on Z Approximation.

Table 7-5: Set 7 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)

Task Success	1	57	.7	.56	.006(a)
	0	24	.3		
Total		81	1.0		

a Based on Z Approximation.

Table 7-6: Set 7 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	52	.64	.38	.000(a)
	0	29	.36		
Total		81	1.00		

a Based on Z Approximation.

Table 7-7: Set 7 Cross-Tabulation of Success/Failure based on Gender and Age

Task success following 3 tries		AGE (years)		Total
		4	5	
0	Boys	5	5	10
	Girls	14	5	19
Total		19	10	29
1	Boys	13	11	24
	Girls	11	17	28
Total		24	28	52

Table 7-8: Set 7 Cross-Tabulation of Success/Failure based on School

		SCHOOL					Total
		1	2	3	4	5	
Task	0	3	8	12	2	4	29
Success	1	3	23	19	3	4	52
Total		6	31	31	5	8	81

Table 7-9: Set 7 Logistic Regression Variable Information

			N	Percent
Dependent Variable	S_F_73	0	29	35.8%
		1	52	64.2%
		Total	81	100.0%
Factor	GEN	Boys	34	42.0%

		N	%
	Girls	47	58.0%
	Total	81	100.0%
SCH	1	6	7.4%
	2	31	38.3%
	3	31	38.3%
	4	5	6.2%
	5	8	9.9%
	Total	81	100.0%

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	81	45	69	58.43	6.663

Table 7-10: Set 7 - Logistic Regression Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-6.200	2.9366	-11.955	-.444	4.457	1	.035
[GEN=0]	.727	.5756	-.401	1.855	1.594	1	.207
[GEN=1]	0[a]	.	.	.	.	.	.
[SCH=1]	-.082	1.1270	-2.291	2.127	.005	1	.942
[SCH=2]	1.482	.8960	-.274	3.238	2.737	1	.098
[SCH=3]	.880	.9085	-.901	2.661	.938	1	.333
[SCH=4]	.768	1.4494	-2.073	3.608	.281	1	.596
[SCH=5]	0[a]	.	.	.	.	.	.
AGE	.096	.0442	.010	.183	4.737	1	.030
(Scale)	1[b]						

Dependent Variable: S_F_73
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 7-11: Set 7 First Choice by Gender and Age

AGE (years)		VOTE_7 Shells	Doll	Spider	Globe	Total
4	Boys	2	4	7	5	18
	Girls	5	9	6	5	25
	Total	7	13	13	10	43
5	Boys	3	1	6	6	16
	Girls	3	3	6	10	22
	Total	6	4	12	16	38

Table 7-12: Set 7 First Choice by School

	VOTE_7	Total

		Shells	Doll	Spider	Globe	
SCHOOL	1	0	2	0	4	6
	2	2	5	11	13	31
	3	9	5	12	5	31
	4	0	1	2	2	5
	5	2	4	0	2	8
Total		13	17	25	26	81

Set 8

Table 8-1: Set 8 Participants' Demographics

	AGE (years)		Total		
	4	5			
Boys	17	13	30		
Girls	25	24	49		
Total	42	37	79		
	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	79	45	71	58.52	6.852

Table 8-2: Set 8 - First Choice Distribution

	Observed N	Expected N	Residual
Leaves	22	19.8	2.3
Bottles	33	19.8	13.3
Truck	12	19.8	-7.8
Rocks	12	19.8	-7.8
Total	79		

Table 8-3: Set 8 - First Choice Chi-Squared Test Statistics

	VOTE_8
Chi-Square(a)	15.228
Df	3
Asymp. Sig.	.002

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 19.8.

Table 8-4: Set 8 - Binomial Test for Successful Choice after First Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	Group 1	1	67	.85	.75	.025(a)
	Group 2	0	12	.15		
	Total		79	1.00		

a Based on Z Approximation.

Table 8-5: Set 8 - Binomial Test for Successful Choice after Second Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	Group 1	1	63	.8	.56	.000(a)
	Group 2	0	16	.2		
	Total		79	1.0		

a Based on Z Approximation.

Table 8-6: Set 8 - Binomial Test for Successful Choice after Third Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	Group 1	1	55	.70	.38	.000(a)
	Group 2	0	24	.30		
	Total		79	1.00		

a Based on Z Approximation.

Table 8-7: Set 8 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success			AGE (years)		Total
			4	5	
0		Boys	8	2	10
		Girls	8	6	14
	Total		16	8	24
1		Boys	9	11	20
		Girls	17	18	35
	Total		26	29	55

Table 8-8: Set 8 Cross-Tabulation of Success/Failure based on School

	SCHOOL					
	1	2	3	4	5	Total
Task Success 0	1	9	12	0	2	24
1	5	20	21	5	4	55
Total	6	29	33	5	6	79

Table 8-11: Set 8 First Choice by Gender and Age

			VOTE_8				
			Leaves	Bottles	Truck	Rocks	Total
Boys	AGE 4_5	4	5	4	5	3	17
		5	3	6	1	3	13
	Total		8	10	6	6	30
Girls	AGE 4_5	4	9	8	3	5	25
		5	5	15	3	1	24
	Total		14	23	6	6	49

Table 8-12: Set 8 First Choice by School

		VOTE_8				
		Leaves	Bottles	Truck	Rocks	Total
SCH	1	1	4	0	1	6
	2	10	12	4	3	29
	3	8	12	6	7	33
	4	2	3	0	0	5
	5	1	2	2	1	6
Total		22	33	12	12	79

Set 9

Table 9-1: Set 9 Participants' Demographics

		GEN		
		Boys	Girls	Total
AGE (years)	4	17	24	41
	5	14	24	38

Total	31	48	79		
	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	79	45	69	58.51	6.833

Table 9-2: Set 9 - First Choice Distribution

	Observed N	Expected N	Residual
Weigh	31	19.8	11.3
Write on Bark	14	19.8	-5.8
Observe	19	19.8	-.8
Tie Shoe	15	19.8	-4.8
Total	79		

Table 9-3: Set 9 - First Choice Chi-Squared Test Statistics

	VOTE_9
Chi-Square(a)	9.253
Df	3
Asymp. Sig.	.026

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 19.8.

Table 9-4: Set 9 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	64	.81	.75	.133(a)
	0	15	.19		
Total		79	1.00		

a Based on Z Approximation.

Table 9-5: Set 9 - Binomial Test for Successful Choice after Second Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
S_F_92	Group 1	1	56	.7	.56	.005(a)
	Group 2	0	23	.3		
	Total		79	1.0		

a Based on Z Approximation.

Table 9-6: Set 9 - Binomial Test for Successful Choice after Third Touch

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
S_F_93	Group 1	1	54	.68	.38	.000(a)
	Group 2	0	25	.32		
	Total		79	1.00		

a Based on Z Approximation.

Table 9-7: Set 9 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success			AGE4_5		Total
			4	5	
0	GEN	Boys	4	7	11
		Girls	7	7	14
	Total		11	14	25
1	GEN	Boys	13	7	20
		Girls	17	17	34
	Total		30	24	54

Table 9-8: Set 9 Cross-Tabulation of Success/Failure based on School

		Task Success (after 3 tries)		Total
		0	1	
SCHOOL	1	2	4	6
	2	8	19	27
	3	9	24	33
	4	1	5	6
	5	5	2	7
Total		25	54	79

Table 9-10: Set 9 - Logistic Regression Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.
(Intercept)	.061	2.4651	-4.770	4.893	.001	1	.980
[GEN=0]	-.274	.5184	-1.291	.742	.280	1	.597
[GEN=1]	0[a]	.	.	.	.	.	.
[SCH=1]	1.664	1.2111	-.709	4.038	1.889	1	.169
[SCH=2]	1.711	.9495	-.150	3.572	3.247	1	.072
[SCH=3]	1.857	.9486	-.003	3.716	3.830	1	.050
[SCH=4]	2.446	1.3874	-.274	5.165	3.108	1	.078
[SCH=5]	0[a]	.	.	.	.	.	.
AGE	-.014	.0380	-.089	.060	.137	1	.712
(Scale)	1[b]						

Dependent Variable: S_F_93
Model: (Intercept), GEN, SCH, AGE

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table 9-11: Set 9 First Choice by Gender and Age

GEN			VOTE_9 Weigh	Write on Bark	Observe	Tie Shoe	Total
Boys	AGE (yr)	4	7 (41%)	3 (18%)	5 (29%)	2 (12%)	17
		5	4 (29%)	0	3 (21%)	7 (50%)	14
	Total		11	3	8	9	31
Girls	AGE (yr)	4	6 (25%)	8 (33%)	7 (29%)	3 (13%)	24
		5	14 (58%)	3 (13%)	4 (17%)	3 (13%)	24
	Total		20	11	11	6	48

Table 9-12: Set 9 First Choice by School

		VOTE_9 Weigh	Write on Bark	Observe	Tie Shoe	Total
SCHOOL	1	5 (83%)	0	0	1 (17%)	6
	2	9 (33%)	6 (22%)	7 (26%)	5 (18%)	27
	3	11 (33%)	7 (21%)	10 (30%)	5 (15%)	33
	4	4 (67%)	0	2 (33%)	0	6

5	2 (29%)	1 (14%)	0	4 (57%)	7
Total	31	14	19	15	79

Set 10

Table 10-1: Set 10 Participants' Demographics

	AGE (years)		
	4	5	Total
GEN Boys	18	14	32
Girls	24	22	46
Total	42	36	78

	N	Minimum	Maximum	Mean	Std. Deviation
Covariate AGE	78	45	71	58.46	6.707

Table 10-2: Set 10 - First Choice Distribution

	Observed N	Expected N	Residual
Magnifying	20	19.5	.5
Pond	22	19.5	2.5
Game	4	19.5	-15.5
Goggles	32	19.5	12.5
Total	78		

Table 10-3: Set 10 - First Choice Chi-Squared Test Statistics

	VOTE_10
Chi-Square(a)	20.667
Df	3
Asymp. Sig.	.000

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 19.5.

Table 10-4: Set 10 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
S_F_10	1	74	.95	.75	.000(a)

	0	4	.05		
Total		78	1.00		

a Based on Z Approximation.

Table 10-5: Set 10 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	64	.8	.56	.000(a)
	0	14	.2		
Total		78	1.0		

a Based on Z Approximation.

Table 10-6: Set 10 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
S_F_103	1	52	.67	.38	.000(a)
	0	26	.33		
Total		78	1.00		

a Based on Z Approximation.

Table 10-7: Set 10 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success (after 3 tries)			AGE4_5		Total
			4	5	
0	Boys	Count	8	6	14
	Girls	Count	10	2	12
Total			18 (69%)	8 (31%)	26
1	Boys	Count	10	8	18
	Girls	Count	14	20	34
Total			24 (46%)	28 (54%)	52

Table 10-8: Set 10 Cross-Tabulation of Success/Failure based on School

		SCHOOL					Total
		1	2	3	4	5	
Task Success	0	2	7	14	0	3	26
	1	4	23	17	4	4	52
Total		6	30	31	4	7	78

Table 10-11: Set 10 First Choice by Gender and Age

AGE (years)				VOTE_10				Total
				Magnifying	Pond	Game	Goggles	
4		Boys	Count	7 (39%)	4 (22%)	1 (6%)	6 (33%)	18
		Girls	Count	7 (29%)	7 (29%)	2 (8.3%)	8 (33%)	24
	Total		Count	14 (33.5%)	11 (26%)	3 (7%)	14 (33.5%)	42
5		Boys	Count	3 (21%)	6 (43%)	1 (7%)	4 (29%)	14
		Girls	Count	3 (14%)	5 (23%)	0	14 (63%)	22
	Total		Count	6 (17%)	11 (30%)	1 (3%)	18 (50%)	36

Table 10-12: Set 10 First Choice by School

		VOTE_10				Total
		Magnifying	Pond	Game	Goggles	
School	1	0	3 (50%)	0	3 (50%)	6
	2	10 (33%)	6 (20%)	2 (6.7%)	12 (40%)	30
	3	10 (32%)	7 (23%)	2 (7%)	12 (39%)	31
	4	0	1 (25%)	0	3 (75%)	4
	5	0	5 (71.4)	0	2 (29%)	7
Total		20	22	4	32	78

Set 11

Table 11-1: Set 11 Participants' Demographics

	AGE4_5		Total
	4	5	4
Boys	20	16	36
Girls	24	23	47
Total	44	39	83

	N	Minimum	Maximum	Mean	Std. Deviation
AGE (months)	83	45	71	58.57	6.748

Table 11-2: Set 11 - First Choice Distribution

	Observed N	Expected N	Residual
Reading	17	20.8	-3.8
Experimenting	25	20.8	4.3
Binoculars	13	20.8	-7.8
Observing Butterfly	28	20.8	7.3
Total	83		

Table 11-3: Set 11 - First Choice Chi-Squared Test Statistics

	VOTE_11
Chi-Square(a)	6.976
Df	3
Asymp. Sig.	.073

a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 20.8.

Table 11-4: Set 11 - Binomial Test for Successful Choice after First Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	66	.80	.75	.207(a)
	0	17	.20		
Total		83	1.00		

a Based on Z Approximation.

Table 11-5: Set 11 - Binomial Test for Successful Choice after Second Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Task Success	1	55	.66	.56	.037(a)
	0	28	.34		
Total		83	1.0		

a Based on Z Approximation.

Table 11-6: Set 11 - Binomial Test for Successful Choice after Third Touch

	Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (2-tailed)
Task Success	1	41	.49	.38	.022(a)
	0	42	.51		
Total		83	1.00		

a Based on Z Approximation.

Table 11-7: Set 11 – Mean Success Proportion by Age Group

AGE (years)	First Choice (test proportion)	Second Choice (test proportion)	Third Choice (test proportion)

4	Mean	.70 (.75)	.57 (.56)	.34 (.38)
	N	44	44	44
5	Mean	.90 (.75)	.77 (.56)	.67 (.38)
	N	39	39	39
Total	Mean	.80	.66	.49
	N	83	83	83

Table 11-8: Set 11 Cross-Tabulation of Success/Failure based on Gender and Age

Task Success		AGE (years) 4	5	Total
0	Boys	11	6	17
	Girls	18	7	25
	Total	29	13	42
1	Boys	9	10	19
	Girls	6	16	22
	Total	15	26	41

Table 11-9: Set 11 Cross-Tabulation of Success/Failure based on School

		Task Success 0	1	Total
School	1	3	3	6
	2	13	17	30
	3	21	14	35
	4	1	4	5
	5	4	3	7
Total		42	41	83

Table 11-11: Set 11 First Choice by Gender and Age

AGE (years)		VOTE_11 Reading	Experiment	Binoculars	Observing Butterfly	Total
4	Boys	5	5	4	6	20
	Girls	8	5	4	7	24
	Total	13	10	8	13	44
5	Boys	2	6	2	6	16
	Girls	2	9	3	9	23
	Total	4	15	5	15	39

Table 11-12: Set 11 First Choice by School

		VOTE_11				
		Reading	Experiment	Binoculars	Observing Butterfly	Total
SCH	1	3	2	0	1	6
	2	2	10	4	14	30
	3	11	7	7	10	35
	4	0	5	0	0	5
	5	1	1	2	3	7
Total		17	25	13	28	83