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THE RELATIONSHIP BETWEEN SOFTWARE INTERFACE
INSTRUCTIONAL STYLE AND THE ENGAGEMENT OF
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THE RELATIONSHIP BETWEEN SOFTWARE INTERFACE INSTRUCTIONAL STYLE AND THE ENGAGEMENT OF YOUNG CHILDREN

By

Warren Buckleitner

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ABSTRACT

THE RELATIONSHIP BETWEEN SOFTWARE INTERFACE INSTRUCTIONAL STYLE AND THE ENGAGEMENT OF YOUNG CHILDREN

By

Warren Buckleitner

This study examined the relationship between software interface design and child engagement by exposing 38 preschool-age children to two computer sorting activities. These activities were identical except for design characteristics that could be associated with two common teaching styles. In one of the conditions, called "high computer control" (HICOMP), children were prompted and reinforced with each task, resulting in a less responsive experience. The other condition, called "high child control" (HICHILD) provided minimal instructions and reinforcements. The outcome variables were the number of tasks attempted, tasks correct, time with the activity, mouse clicks and a child rating of the experience. In addition, anecdotal observations documented child reactions to both settings.

Children in the high child control treatment were more active, completing more tasks (mean = 64 vs. 20; $p < .05$),

clicking the mouse more times (mean = 129 vs. 73; $p < .05$), and getting more tasks correct (mean = 41 vs. 16; $p < .05$). Children rated both experiences highly, and spent about the same amount of time with each condition.

In the high computer control setting, there were more clicks per task (mean = 4.07 vs. 2.09; $p < .05$), and children had a higher accuracy level (mean = 85% vs. 68% respectively). In addition, ANOVA procedures suggested that younger choose to stay with the HICOMP experience longer than the older group of children.

This study helps connect the established principles of human/child interaction to computer/child interaction, including the role of external reinforcements and the level of responsivity of the interaction. The results of this study suggest that designers and evaluators of interactive media products for children should pay careful attention to the degree to which the implementation of control mechanisms such as reinforcements can have substantial effects on children's interaction with the software.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

There is an established body of research that has examined the interaction style between adults and children. Some studies measured behavioral outcomes, such as various aspects of the educational effectiveness of the interaction. In the "wait-time" study, Mary Budd Rowe (1974) observed that the average time teachers waited between asking a question and taking further action to elicit a response is about one second. When a student responds to the question, teachers wait, on the average, less than one second before reacting to the response. Rowe called these two time periods-- the period between asking the question and acting further, and the period between the student's response and the teacher's reaction-- wait time. By asking teachers to increase their wait time to between three and five seconds, she observed a 300% increase in the length of students' explanations (Rowe, 1974).

Teacher/child interactions have been documented in intrinsic motivation literature (see Ames, 1990; Brophy, 1981; Lepper, 1985; Smilanski, 1968; Stipek, 1988 to name a few).

Directly related to the study described in this dissertation is the literature that considers the quality and quantity of a child's engagement with a given task, as influenced by an adult/child interaction style. This relationship has been documented by Gerald Mahoney and James MacDonald (2003) with a population of young children with and/or at-risk for developmental problems. When children and parents or caregivers participated in two types of interactions (didactic and responsive), a positive relationship was identified between a responsive interaction style and children's social and linguistic development (Mahoney & MacDonald, 2003; Wolock, 1990; McWilliam et al., 2003).

This doctoral dissertation examined these types of relationships in an interactive media context. A computer classification activity was created that was modified to simulate two contrasting teaching styles, similar to the Mahoney & MacDonald technique. The first style, called "high computer control" (HICOMP) attempted to simulate a teaching style where the teacher carefully introduced each problem, and provided frequent praise and encouragement throughout the experience. As a result, the child had less control over the flow of events, making the experience less responsive. The second style, called "high child control"

(HICHILD) presented the identical sorting experience with the instructions, praise and encouragement turned off. As a result, a child experienced more control over the events, resulting in a more responsive overall experience.

Control, which was varied by changing the quantity of instructions and reinforcements, served as the independent variable in the study. The dependent variable, the engagement of the child, was measured by counting observable child behaviors that were recorded on videotape. These included 1) the number of tasks completed, 2) the number of clicks, or attempts to influence the instruction flow, and 3) the length of time the child chose to spend with each condition.

The study population was 38 preschool-aged children. In addition to discrete continuous measures, anecdotes during data collection provided additional insights. What children said and how they behaved throughout the experience was also documented, specifically children's competency with the input device (a mouse), the ways in which they responded to the software interface, and any other observations that could possibly be related to their engagement with the activity.

Background Literature

The increase in the power of microprocessor-related technologies has made it possible for an increase in the number of interactive media (IM) products designed specifically for young children. These products have also diversified in form (Buckleitner, 1999; Buckleitner, Orr & Wolock, 2002). The pace of this change was predicted in 1965 by computer scientist Gordan Moore. Known today as "Moore's Law," he stated that there would be an exponential growth in the number of transistors per integrated circuit, a trend that is expected to continue through the end of this decade. The Moore's Law phenomenon started affecting teachers and students in 1980, when new computers such as the Apple II and later the IBM PC (1984) created new opportunities for educational publishers in the form of software marketed to the parents and teachers of young children. This increase in software led to an associated wave of research surrounding the use of technology with young children (Lathrop & Goodson, 1983; Rucker, 1985; Jones & Vaughan, 1983; Mead, 1983). A general search of the ERIC database using the key words "software" and "evaluation" for the year 1984 brings up 419 results, as one example. A glance at the results reveals dissertations, papers, studies, and software-design related articles, many dealing with the use of the programming language LOGO with children, discussed extensively in "Mindstorms" (Papert, 1980).

Two decades later (2002), the same ERIC search yields just 22 entries. Despite this decrease in formal intellectual discourse, the number of commercial software products sold to children aged birth to 12 has increased, from 42 per year in 1984 to 550 per year, from 1996-2002 (Buckleitner, Orr & Wolock, 2002).

Microcomputers and microprocessor-related technologies have dramatically changed form since the 1980s. Today's preschool-age child today can access interactive media experiences by way of devices that bear no resemblance to the Apple II, IBM PC or Macintosh of two decades ago. Molding their form around their function, some of today's interactive media choices for young children include interactive book readers such as the LeapPad (LeapFrog) and the PowerTouch Learning System (Fisher-Price) and handheld platforms such as the Game Boy Advance (Nintendo). In addition, portable computing platforms include the Pixter Color (Fisher-Price), the Palm (Palm), the AlphaSmart (AlphaSmart) and the Leapster (Leapfrog) further expand how a child can interact with various types of software. Besides being easy to use, these devices are also easy to find; with distribution channels that include toy stores. Over time, their interactive capabilities have increased, to include touch screens, clear speech, voice input and the ability to save progress over time.

Over time, interactive media products have become more prevalent in the lives of US preschoolers. According to a 2003 survey of 1,065 United States families, seven out of ten (70%) of children in the 4-to 6-year age range have used a computer, and for 27% of these children, the use is daily (Wartella, Rideout & Vanderwater; 2003). Those who use a computer spend an average of just over an hour at the keyboard (1:04), per session. The survey indicated that parents have faith in the educational value of electronic media, with 72% reporting that a computer "mostly helps" a child's learning, compared to 96% for books and 40% for videogames. Given these new and diverse forms of interactive media, it is important to explore technology's impact on young children as well as how to optimize the experiences.

Research on Young Children and Computers

Examinations of the effectiveness of interactive educational applications in K-12 settings start in the mid-1960s, with the advent of mainframe-based Computer Assisted

Instruction (e.g., see Suppes, 1966); and later with microcomputers (Goldberg & Suppes, 1972; Searle, 1974; Papert, 1980; Dwyer, 1980 and Lepper, 1985). Recent efforts to consider the interactive qualities of software interfaces have taken place at the University of Maryland (Druin, Benderson, Boltman, Miura, Knotts-Callahan & Platt; 2002) where children helped design interfaces that would give them their own "interaction paths", or opportunities to create their own way in a new program. After observing children using various interfaces, the researchers concluded, "When IM offers children limited paths of interaction, children easily become bored and uninterested. When technology offered options for varied interaction, children spent a considerable amount of time exploring and actively engaged."

Other research initiatives come from software publishers, whose stake in keeping a child's engagement at an elevated level is associated with the commercial success of a product. Over the past ten years, most testing of this type has come from the usability labs at Knowledge Adventure, The Learning Company, LeapFrog and Microsoft. Unfortunately, the proprietary nature of the product development process has limited the amount of published research results.

One product that was the subject of published research came from Microsoft's Actimate's initiative-- a result of the development of a line of robotic toys that started around 1998. The effort was attributed to Eric Strommen (1998), who described how the children became frustrated when they could not interrupt the toy's musical routines, tending to move on to another activity as a result. Kristin Alexander, who worked with Strommen on the Actimates interface, further suggested that these types of interface design decisions could affect a child's emotional attachment to the experience (Alexandar, 1999).

In another interface study, Debra Lieberman (1995) tested the interface of a software activity designed to teach children about asthma. She described several characteristics of engaging products. "Youngsters liked to have control over a main character, immediate action and feedback, and the challenge of succeeding in increasingly difficult situations." While these conclusions are consistent with human/child interaction research, they offer little in the way of specific outcomes or the processes associated with why one interface "works" and another does not.

Older but useful studies of computer use in early childhood settings have been conducted by Daniel Shade and others at the University of Delaware, who have examined a young children's verbal and facial expressions, their use of the mouse, their body movement, and their attitudes toward software as well as their teachers' comments. They concluded that computer-based technology, with its use of video, audio, and graphics could "engage children for a longer period of time." The results also indicated that allowing children to have control of the program is an important factor in keeping them interested (Shade, D., Nida, R., Lipinski, J., & Watson, J.; 1986).

While these studies have provided general observations about the importance of giving children an interface that is high in child control, the quickly changing technology, combined with the number of variables that could potentially affect children's experience has resulted in few firm conclusions for interface designers.

The most recent, relatively comprehensive literature review on interactive media and children summarized that "little is actually known about the role of interactive media in children's lives, and there are far more questions than there are answers about what computer and video games and Internet use mean to the social, intellectual and physical development of children growing up today" (see Wartella, E., O'Keefe, B. and Scantilin, R., 2001.)

Adult/Child Interactive Style Research

A young child's developmental attainments are considered to be the result of the child's own action on the environment as well as the child's physical maturation (Bruner, 1972; Piaget, 1952). The child utilizes the environment to explore and nurture his own developmental competencies, while these competencies are concurrently restructured and modified as the child accommodates new information (Elkind & Weiss, 1967). Underlying the young child's interaction with the environment is a desire to control, understand and master his or her surroundings (Weiner et al, 1980; White, 1959; Yarrow et al., 1975). This "mastery" motivation is thought to be reflected in the extent to which children persist during activities, the intensity with which the child attend to tasks and in the demonstration of positive affect.

In early childhood classroom settings, particular teacher/child interaction styles have been identified as having positive and negative influences on the quality of children's engagement. Learning settings where teachers or caregivers are characterized as responsive have been associated with higher levels of engagement (Clarke-Stewart, 1973; Phillips et al., 1987; Roupp, 1979). In special education settings, teaching styles that have been characterized as responsive have also been associated with high levels of child engagement (Mahoney, Powell 1988; Wolock, 1990; MacDonald, 2003). The use of a didactic teaching style, in which the adult focuses on the achievement of specific skills by controlling and directing the child's behavior according to the adult's agenda, has been found to have a negative influence on children's involvement in both home and preschool environments (Ainsworth & Bell, 1973; Clarke-Stewart, 1973; Farnham-Diggory & Ramsey, 1971; Hunt, 1961; Huston-Stein et al., 1977; Stern et al., 1969; Vlietstra, 1979).

Human Attributes in Software Interfaces

As interactive media activities have become prevalent in mainstream culture (Wartella, O'Keefe & Scantlin; 2000) the interaction between children and technology has been compared to human interactions (Turkle, 1984; Reeves & Nass, 1996; Crawford, 2003).

Like a teacher/child relationship, the software/child relationship is created by individuals who make decisions and assumptions about how children learn, how much say they should have in the learning process, the interaction style, and the way that they like to be spoken to (Druin, et al., 1999; Lieberman & Brown, 1995; Malone & Lepper, 1987).

In "The Computer as a Second Self" (1984), Sherry Turkle described her informal observations of children as they played with robotic turtles used for programming in the computer language LOGO, noting that the children gave objects within the software life, or "animism". "Children play with and manipulate objects to get a sense of control over their powers. They want it to seem alive so they can be in a position to bring it under control. The more contact children have with computational objects, the more nuanced and elaborated this psychological language becomes. As the world of traditional objects serves as material for a child's construction of the physical, the computer serves as a stimulus to the construction of the psychological. "These observations were written prior to the development of graphical user interfaces, at a time when most research surrounding children and computers revolved around LOGO (e.g., Papert, 1980; Clements, 1987).

In 1986, Clifford Nass and Byron Reeves conducted a series of quantitative studies at Stanford's Department of Communications in which the attributes of human/human and computer/human interactions were directly associated. Using both adults and children as a test population, they recorded the behaviors of their human subjects using different computer interfaces that varied in complexity and graphic features. They concluded that humans treat computers as real people and places, and provided examples that their subjects were rude or polite to different interfaces, treated computers with female narration differently than male-voiced interfaces, and reacted to large faces on a screen in a way that suggested that the images could invade a person's culturally mitigated body space. They note "the human brain evolved over 200,000 years in a world in which only humans exhibited rich social behaviors, and a world in which all perceived objects were real physical objects, and now modern media engages old brains." Their resulting book "The Media Equation" (See Reeves and Nass, 1996; Gilbert, 1991) influenced the design of commercial products such as Microsoft Bob (Microsoft, 1998) and the help wizard found in Microsoft Office, which takes the form of a humanized talking paper clip.

Research Methods on Interface Design

The challenges associated with the examination of how children use varying software interfaces were minimized in a study by Thomas Malone (1987), who measured factors related to engagement by exposing children to a number line game called Darts, an activity first designed for the Plato CAI system at the University of Illinois. Malone gradually removed, or subtracted features from the existing software experience to see what effect the changes would have on the child's interest in the activity.

For the purposes of the study described in this paper, Malone's technique of subtracting features was modified, so that the results of changes could be studied in two directions instead of one. This required the addition of a preferences menu that allowed the narration and reinforcers to be switched on/off easily.

From a research methods perspective, this technique proved to be useful for quickly alternating between high child control and high child control conditions. This was essential in order to better explore the differences between the two types of experiences.

Research Question and Hypothesis

The following research question is examined in this study: Are there observable differences in child behaviors in two versions of the same software sorting activity, one with a high level of instruction and reinforcement (high computer control), the other with relatively few instructions and reinforcements (high child control)?

It is hypothesized that similar patterns observed in contrasting adult/child interactions by Rowe, Clarke-Stewart, Phillips, Mahoney, Powell, Wolock, MacDonald, Ainsworth, Farnham-Diggory, Ramsey, Hunt, Huston-Stein and Vlietstra will also be observed in computer/child interactions. More specifically, the high computer control condition will result in less activity by the child, and less time with the activity, and the high child control condition will result is more activity by child, and more time with the activity.

CHAPTER 2

METHOD

This section contains a description of the research setting followed by the characteristics of the subjects who participated in the study. Next, the subject recruitment and data collection methods and associated coding procedures are discussed and described. Finally, the two experimental conditions: HICHILD (high child control) and HICOMP (high computer control) are defined and explained, along with the types of measurements that were collected for each outcome variable.

The Research Setting

The data was collected in two sessions at the Michigan State University Child Development Laboratory in East Lansing, Michigan. The center provides services primarily to the faculty and students of the university, and is administered by the Department of Family and Child Ecology. At the time of the study, 326 children were enrolled in the school, with mostly Caucasian (66%) and Asian (18%) students (Table 1). The study subjects were recruited by asking the parents to sign and return human subject permission forms prior to the data collection period.

The Subjects

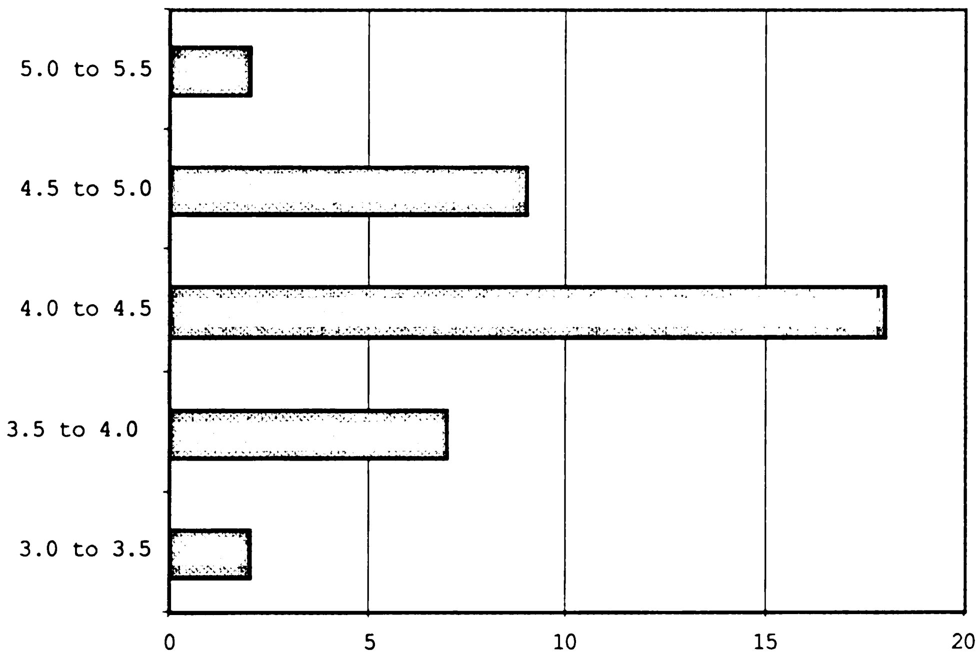
A total of 38 preschool-age subjects are represented in the data set. These children ranged from 3.4 to 5.1 years of age. There were 19 males, 19 females, and the mean age was 4.3 years. Initially, 42 children participated in the study. Of these, 34 were taped for both HICHILD and HICOMP sessions. Four were taped for just one session, three were absent for the second session, and one ended her second session prematurely, voiding her session data. Two younger children were eliminated from the data set because of their inability to successfully complete more than three problems for either the HICHILD and HICOMP sessions. There were a total of 72 sessions coded (36 HICHILD and 36 HICOMP), averaging 8.5 minutes in length. Table 1 presents the background characteristics of the children who participated in the study.

Table 1: Frequencies for Selected Child Characteristics (N = 38)

Gender	N	Percent
Male	20	52.6
Female	18	47.4
Ethnicity		
Arabic	1	2.6
Asian	6	15.8
Caucasian	30	78.9
Hispanic	1	2.6
Age Ranges (years)		
3.0 to 3.5	2	5.3
3.5 to 4.0	7	18.4
4.0 to 4.5	18	47.4
4.5 to 5.0	9	23.7
5.0 to 5.5	2	5.3

Minimum age: 40.37 months
Maximum age: 60.50 months
Mean age: 51.42 months or 4.29 years

Figure 1: Number of Children, by Age (N = 38)



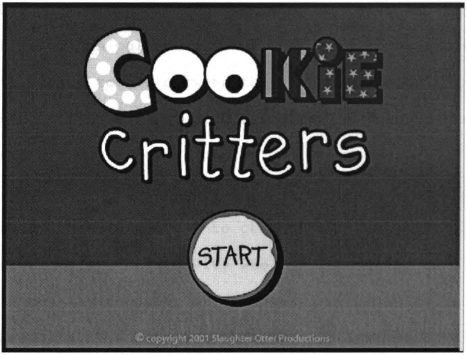
Procedures

The following section describes the procedures that were use for gathering the data. In an effort to simulate two contrasting instruction styles at the computer while keeping other variables constant, a custom software activity was created with preferences that allowed the quantity of reinforcements and narration to be easily adjusted.

The activity was designed to be familiar to preschool-age children in an early childhood classroom. It was also similar to sorting activities found in popular preschool software packages, such as JumpStart Preschool, Millie's Math House, Reader Rabbit Preschool, My First LEGO, and many others. Despite the familiar nature of the task, there were no commercial characters used in the program to ensure that the experience would be equally novel to every child.

In both HICHILD and HICOMP situations, children were asked to feed the Cookie Critters by dragging the appropriately shaped cookie to its matching critter. With each correct response, a points tracking strip appeared across the bottom of the screen (this feature was not used in the later data collection session). Specific design features are described below.

Figure 2: Cookie Critters Opening Screen



Cookie Critters Activity Design Constraints

1. Developmentally appropriate. The activity was designed to start at a developmental level of approximately 2 1/2 years.
2. A straightforward, simple activity. The sorting activity was designed to be typical of many early childhood curriculum activities, with a theme that typical preschool-age children can understand.
3. No prior exposure to activity content. While the task was designed to be easy to use, it was also created from scratch, using original characters and

narration that would be entirely novel to the subjects.

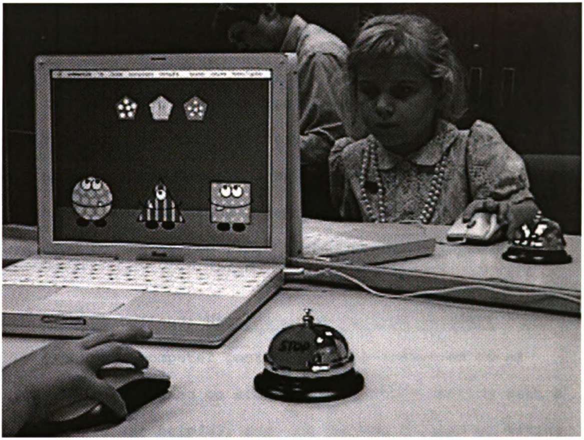
4. Design preferences. The activity was designed to have hidden pull-down menus that make it possible to easily toggle between the two experimental conditions while keeping all other aspects of the experience constant.
5. Generalizable. In order for the results of the study to have meaning to commercial software developers, the activity was designed to be similar in quality to other existing mainstream software products. The software activity was created by a commercial software designer (Daren Carstens of Carstens Studios, Inc.).

Data Collection

The data was collected in two visits to the Michigan State University Child Development Laboratory; the first during the first the week of October 21, 2002 and the second the week of June 22, 2003. Both child sessions were taped in the same visit. The experiment was conducted in a parent lounge located on the same floor as the classrooms.

The Counting Critter activity was installed on an Apple Macintosh laptop computer, using a Logitech USB optical mouse that is typical of any Macintosh or Windows computer. All of the sessions were videotaped, and a written script was followed to keep the experience the same for each session (Table 2).

Figure 3: The Research Setting



After the first session was coded in October of 2002 (N = 21), a second visit was scheduled in June of 2003 with 17 new subjects. The procedure was modified in four ways for the second group, with 1) a better defined exit procedure, using a hotel desk bell labeled with a red stop sign to enable the child to terminate the activity, instead of being required to ask to stop. This was to minimize the amount of researcher interaction with the child during the testing period, and to determine if researcher interactions might be interacting in some way with the other measures, 2) the ability to toggle off the points tracking feature, consisting of a series of symbols that appeared on the bottom of the screen for each problem solved, in order to see if this feature was influencing the outcome, 3) the addition of a mirror to better view the child's facial expressions for anecdotal data collection, and 4) a slightly modified rating Likert-style child rating system was used to see if the first method could be improved.

Condition 1 Defined: High Computer Control (HICOMP)

The high computer control setting (referred to as HICOMP) was designed to simulate a teaching setting with a teacher who was helpful, encouraging and focused on making sure that the child was guided toward the correct answer. Each problem was first introduced, and additional help was provided for incorrect answers. This condition is commonly used in commercial preschool software activities, when the designer assumes that a younger child needs additional support and encouragement. As a result of the extra narration and instructions, the responsivity is less than the HICHILD setting. In the second administration, the points tracking feature was toggled off.

Table 2: HICOMP Setting and Scripts

<u>Cookie Critters, HICOMP Treatment Setting</u>
Volume = 8/10

Instructions = 4/4
- 1 = no instructions
- 2 = brief instructions
- 3 = long instructions
- 4 = extensive instructions

Verbal Feedback = 4/4
- 1 = no feedback
- 2 = brief feedback
- 3 = long instructions
- 4 = extensive instructions

Points Tracker = OFF (shown ON in Figure 4)
Sticky mouse = OFF
Problem sets = Infinity

<u>Researcher Script, HICOMP Treatment</u>
"Hello (child name)". (If the second trial, say: "We're going to play (the same) computer game that we played before."

<Help child get seated. Position the bell and the mouse in front of the screen. Ask the child to ring the bell to make sure he/she is comfortable with the process. Say "When you want to stop, ring this bell like this." (Demonstrate).

<Let child ring bell.>

Say: "Click here to start"

<Point to the "start" button on the screen.>

<Go to a nearby table and quietly read and observe, out of site of the child. Let the child play as long as he/she wants. Do not interact with the child or initiate conversation. If the child asks for help, make a suggestion or fix the problem, then resume quietly working/observing.>

Software Dialog, HICOMP Treatment
"Welcome to Cookie Critters, the game where we look for things in common. Let's meet the Cookie Critters. Our first Cookie Critter is in the shape of a circle, has the color yellow, and has spots for a pattern. The second cookie critter is in the shape of a triangle, is colored red, and has stripes for a pattern; and finely, the third cookie critter is in the shape of a square, it is the color blue, and has stars for a pattern."

"In this game we want to feed the cookies to the critters below. First click on a cookie and then click on the critter you want to feed it to."

<Child selects cookie>

"You chose the (circle cookie). Can you click on the critter that is a (circle)?"

<Correct response>

"Way to go! Circle cookie, circle critter!"

<Sound effect and visual: bells ring and critter crunches the cookie>

<Bell rings, applause>

<Intermittent effect: 1 out of 10 times at random, the critter who just ate the cookie burps>

"All right, click on the (next/last) cookie. You picked the (square) cookie. Can you click on the critter that is a (square)?"

<Incorrect response.>

<Bonk, critter makes crazy face.>

"No, this is a (circle) critter. We're looking for a (square) critter."

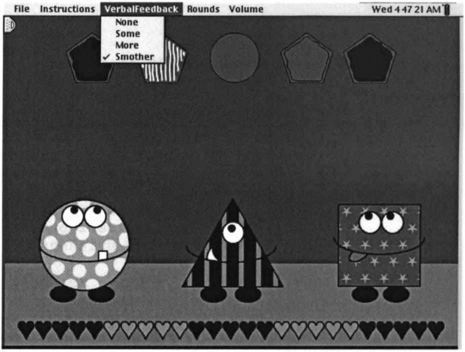
<Repeat in context sensitive manner if it is a repeated incorrect response>

"Yeah! (Square) cookie, (square) critter!"

[Ending sequence]. Child rings bell.
Researcher: "All done. Can you show me you felt about this game?" (present Likert-type smile face scale to child)

<If second try, add> "Did you notice any differences from the first time?"

Figure 4: Screen-- Setting the Verbal Feedback on the Highest Setting for the HICOMP Treatment



Condition 2 Defined: High Child Control (HICHILD)

The high child control setting (HICHILD) was designed to simulate a less invasive teacher/child interaction, while keeping other aspects of the experience identical to the HICOMP treatment. Using the pull down menus, the verbal feedback following each correct or incorrect answer was toggled off, and the initial instructions were reduced to one sentence. As a result, the treatment was more responsive and controlled by the child.

Performance feedback was left on - correct answers resulting in a bell ringing and crunching critter, incorrect answers resulting in a bonk and a crazy face on the critter. In the second administration, the points tracking feature was toggled off.

Table 3: HICHILD Setting and Scripts

<u>Cookie Critters, HICHILD Treatment Setting</u>
Volume = 8/10

Instructions = 1/4
- 1 = no instructions
- 2 = brief instructions
- 3 = long instructions
- 4 = extensive instructions

Verbal Feedback = 1/4
- 1 = no feedback
- 2 = brief feedback
- 3 = long instructions
- 4 = extensive instructions

Points tracker = OFF (shown ON in Figure 5)
Sticky mouse = OFF
Problems = Infinity

<u>Researcher Script, HICHILD Treatment</u>
"Hello (child name). We're going to play (the same) game (that we played yesterday/earlier)."

<Help child get seated.>

<Say "When you want to stop, ring this bell like this. Let the child try it. Ready? Click here to start. Point to the Start button on the screen."

<Go to a nearby table and quietly read and observe, out of site of the child. Let the child play as long as he/she wants. Do not interact with the child or initiate conversation. If the child asks for help, make a suggestion or fix the problem, then resume quietly working/observing.>

<u>Software Dialog, HICHILD Treatment</u>
"In this game we want to feed the cookies to the critters below."

<Child selects cookie and makes correct match.>

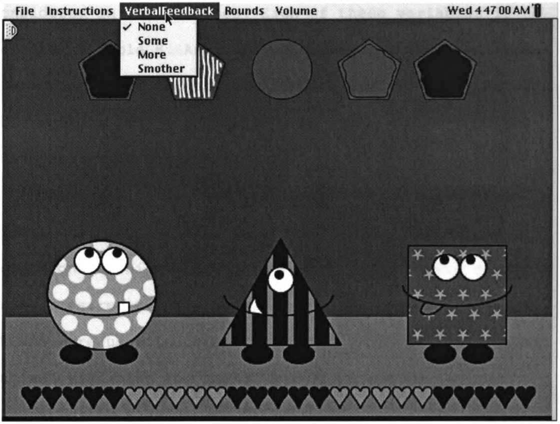
<Sound: bell rings, critter crunches.>

<Intermittent effect: critter burps from 1 to 10 times>

<Child selects cookie and makes incorrect match>

<Sound and visual -- BOINK and crazy face>

Figure 5: Screen-- Setting the Verbal Feedback on the Lowest Setting for the HICHILD Treatment



Data Collection, Analysis, and Inter-Rater Reliability Results

Videotape was used to collect both anecdotal and quantitative information related to each child's reaction to the software activity. Quantitative measures included mouse clicks, number of problems attempted vs. solved, number of seconds on the task, and the child's rating of the task. The gender of child and session order were also considered in the analyses. Each of these variables is defined in Table 8. Anecdotal observations included verbal statements about the program, facial expressions, posture, observations of how the child used the mouse or keyboard, and other child behaviors.

The quantitative analysis was a two-step procedure. First, the means of each dependent variable under the conditions of high and high computer control were compared using a paired t-test. Next, a series of repeated measure ANOVAs were used to detect interactions between the within subject variables and the dependent variables. Statistically significant findings of $p \leq .05$ are reported.

Inter-rater reliability procedures were conducted by randomly selecting 1/3 of the 38 cases using the "Select Cases" feature in SPSS. A third year undergraduate college student was asked to code these cases. Reliability was conducted on four measures, as follows: mouse clicks, number of tasks, number of correct tasks, and time in seconds. These results, referred to as "2" in Table 4, were tested for significance with the first set "1" of data using Pearson correlations. In all cases, the means of the two data sets were correlated at a level of .85 or greater (sig. < .05).

Table 4: Inter-Rater Reliability Pearson Correlation Statistics

Variable Pair Names	Correlation	N	Sig.
HICHILD Correct Answers 1 HICHILD Correct Answers 2	.992	9	.000
HICOMP Correct Answers 1 HICOMP Correct Answers 2	.998	8	.000
HICHILD Tasks 1 HICHILD Tasks 2	.998	8	.000
HICOMP Tasks 1 HICOMP Tasks 2	.958	8	.001
HICHILD Time 1 HICHILD Time 2	.982	9	.000
HICOMP Time 1 HICOMP Time 2	.982	8	.000
HICHILD Clicks 1 HICHILD Clicks 2	.954	9	.000
HICOMP Clicks 1 HICOMP Clicks 2	.852	8	.015

Intraclass Correlations

In order to avoid potential errors that can occur with Pearson correlations, an ANOVA was conducted, further insuring that the first and second data sets could be combined. Table 5 lists the results. In all cases, significance was reached ($p < .05$).

Table 5: Inter-Rater Reliability Intraclass Correlations

Variable Pair Names	Correlation	F	N	Sig.
HICHILD Correct	.9896	188.5	9	.0000
HICOMP Correct	.9750	79.10	8	.0000
HICHILD Tasks	.9969	645.9	9	.0000
HICOMP Tasks	.9578	46.40	7	.0000
HICHILD Seconds	.9659	57.60	10	.0000
HICOMP Seconds	.9899	98.80	8	.0000
HICHILD Clicks	.9430	34.10	8	.0000
HICOMP Clicks	.8151	9.80	7	.0031

The Combination of the Two Administration Sessions

Both the individual samples t-test and the Chi-square procedures indicated no significant differences between the first and second administration sessions, considering both between-subject and within-subject factors. It was consequently determined that data from the two sessions could be combined, thereby increasing the overall statistical power of the sample. See Table 6 for details.

The lack of significance between the measurements of each variable between the two administrations is important to note (p values ranged from .082 to .609), particularly because there were some intentional design differences in the second administration. These consisted of the turning off of the points tracking feature, a better defined child exit strategy, a slightly different Likert-style child rating sheet to see if the results could be improved (they were not) and the use of a mirror to better observe the child's facial expressions during each treatment.

Table 6: Independent Samples T-test for the Two Administrations for Each Continuous Variable

Variable	Administration Session	N	Mean	Std. Deviation	Std. Error Mean	p
HICHILD Time	first	21	470.33	227.30	49.60	.326
	second	15	559.60	311.03	80.30	
HICOMP Time	first	21	546.04	314.78	68.69	.571
	second	15	602.86	260.16	67.17	
HICHILD Clicks	first	21	115.61	58.61	12.79	.101
	second	15	172.53	138.76	35.83	
HICOMP Clicks	first	21	71.19	55.81	12.17	.455
	second	15	83.33	32.32	8.34	
HICHILD Tasks	first	21	59.14	35.82	7.81	.231
	second	15	76.93	51.78	13.37	
HICOMP Tasks	first	21	20.42	12.38	2.70	.596
	second	15	22.73	13.23	3.41	
HICHILD Correct	first	21	35.00	12.74	2.78	.086
	second	15	55.80	52.07	13.44	
HICOMP Correct	first	21	15.95	10.61	2.31	.433
	second	15	18.46	7.20	1.86	
HICHILD Rating	first	21	4.57	1.07	.23	.496
	second	16	4.78	.65	.16	
HICOMP Rating	first	21	4.66	.96	.21	.606
	second	16	4.50	.96	.24	
Age	first	21	50.11	5.47	1.19	.082
	second	17	53.04	4.38	1.06	

Table 7: Chi-square Statistics for Gender and Order of Treatments

Gender	N (Session 1)	N (Session 2)	Total
Male	11	9	20
Female	10	8	18

Chi-square value = 2.374, p = .0499

Order	N (Session 1)	N (Session 2)	Total
HICHILD to HICOMP	11	7	18
HICOMP to HICHILD	10	6	16

Chi-square value = 5.529, p = .137

Table 8: Variable Names, Descriptions, and Values

ID#: Every child was assigned a number, from 1 to 38, in the order they were tested. This number was used instead of the child's name in reporting the results. Measurement Level: Nominal.

GENDER: Male or female. Measurement Level: Nominal

Value	Label
1.00	Male
2.00	Female

AGE: age in months and days, from birth to date of treatment. Measurement Level: Scale.

ORDER: The order the treatment was administered. Measurement Level: Nominal

Value	Label
1.00	high-low
2.00	low-high

ADMINNUM: Indicates whether the videotaping took place during the September 2002 (first) or the June 2003 (second) session. Chi-squared correlations were used to insure that the two data sessions could be combined into one.

Value	Label
1.00	first
2.00	second

<u>High Child Control Variables</u>

HICHILDTIME: The time, measured in seconds, of the high child control treatment, measured from the child's first click to the child's exit request. Measurement Level: Scale

HICHILDCLICKS: The number of mouse clicks a child made during the high child control treatment. Measurement Level: Scale

HICHILDTASKS: The number of tasks the child attempted, either correct or incorrect, during the high child control treatment.

HICHILDCORREC: The number of correct responses made during the high child control treatment. Measurement Level: Scale

HICHILDRATING: A child's rating of the high child control experience, on a scale of 1 (frown face) to 5 (smile face). Measurement Level: Scale.

HICHILDRATIO: The number of clicks per task during the high child control treatment. Measurement Level: Scale

HICHILDACC: The percent of tasks correct during the high child control treatment. Measurement Level: Scale

High Computer Control Variables
HICOMPTIME: The time, measured in seconds, of the high computer control treatment, measured from the child's first click to the child's exit request. Measurement Level: Scale

HICOMPCLICKS: The number of mouse clicks a child made during the high computer control treatment. Measurement Level: Scale

HICOMPTASKS: The number of tasks the child attempted, either correct or incorrect, during the high computer control treatment.

HICOMPCORREC: The number of correct responses made during the high child control treatment. Measurement Level: Scale

HICOMPRATING: A child's rating of the high computer control experience, on a scale of 1 (frown face) to 5 (smile face). Measurement Level: Scale.

HICOMPRATIO: The number of clicks per task during the high computer control treatment. Measurement Level: Scale

HICOMPACC: The percent of tasks correct during the high computer control treatment. Measurement Level: Scale

CHAPTER 3

QUANTITATIVE FINDINGS

The purpose of this study was to examine the relationship of teaching style in a typical preschool software sorting activity to the engagement of preschool-age children. The following research question was addressed:

> Are there observable differences in child behaviors in a high child control software interface setting versus a high computer control software interface setting?

This relationship was explored both quantitatively and through the collection of anecdotes. In this section, the quantitative measures are described and discussed. The means of each variable were first analyzed with a paired-samples t-test to determine whether there were statistically significant differences between the two experimental conditions; HICOMP (high computer control) and HICHILD (high child control), both described in Chapter 2. The t-values and their associated statistical significances are shown in Tables 9 through 15 in this chapter, as well as the means and standard deviations.

The next step was to conduct a series of repeated measure ANOVAs to determine a) whether there was a statistically significant interaction between four between-subject factors; age, gender, order, and administration (1st or 2nd) and the experimental conditions and b) whether there was a main effect of each between subject factor on the behavioral variables. The findings of the paired t-test and repeated measures ANOVA are presented and discussed below.

Statistical Results, by Variable

Time

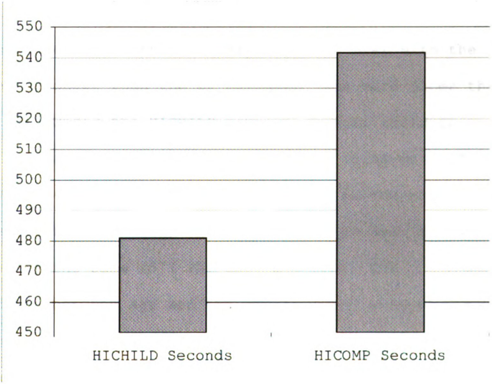
1. Results of the Paired T-test for Time. Children did not spend significantly different amounts of time in either of the two conditions. The means for time of the two conditions were close (HICHILD = 480.0 seconds, HICOMP = 541.0 seconds), and paired t-test analysis results for time show that the difference was not significant ($p < .05$), as shown in Table 9.

Table 9: Paired Samples Statistics for Time

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Seconds	480.97	34	207.17	35.5
HICOMP Seconds	541.53	34	269.18	46.1

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Con. Interval of the Dif. Lower	Upper	t	Df	Sig. (2-tailed)
HICHILD Seconds HICOMP Seconds	-60.56	306.43	52.55	-167.47	46.36	-1.15	33	.257

Figure 6: Comparison of Mean Scores for Time



2. Results of Repeated Measures ANOVA for Time. The repeated measures analysis showed that the differences between the experimental conditions of high and high computer control were not significant. Furthermore, there were no significant interactions among age, gender, order of task, or administration number and the time.

When the whole group was divided into two groups by their age, however, there was a significant and interesting effect on the time that the two groups (one < 50 months, the other > 50 months) chose to stay with the activity. Regardless of the experimental condition, the 14 younger children, aged 50 months or less, chose to stay with the experience longer than the 22 children (who were older than 50 months). Under the HICHILD setting younger children wanted to stay much longer than the older children (610 seconds vs. 442 seconds, $p < .05$) whereas in the high computer control setting, the differences in mean times were nearly the same (573 vs. 567, $p < .05$). The interaction between age and the experimental condition was not statistically significant. Possible reasons for this difference are discussed in Chapter 5.

Table 10: Differences in Time, by Age

	Grouping by age	N	Mean	Std. Deviation	Std. Error Mean
HICHILD Time (seconds)	50 months or younger	14	610.35	215.45	57.58
	over 50 months	22	442.09	277.04	59.06
HICOMP Time (seconds)	50 months or younger	14	573.35	299.89	80.14
	over 50 months	22	567.40	291.80	62.21

Mouse Clicks

A second behavioral measure was the number of times a child clicked the mouse, which was counted from the first child-initiated click at the start of the session to the last click before the child opted out of the session for both conditions. Because the ability to move the mouse/cursor to a target on the screen was a prerequisite skill for using the activity, two children were dropped from the data set after demonstrating that they were unable to successfully click the mouse.

The number of mouse clicks was possible to record from the videotapes due to the audible feedback associated with each click event; often also associated with some screen event.

1. Results of the Paired T-test for Clicks. As shown in Table 11, children in the high child control setting clicked more times (mean = 129.09) than when they were in the high computer control setting (mean = 73.68, $p < .05$).

Table 11: Paired Samples Statistics for Number of Clicks

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Clicks	129.08	34	77.99	13.37
HICOMP Clicks	73.68	34	47.18	8.09

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	T	df	Sig. (2-tailed)
HICHILD Clicks/ HICOMP Clicks	55.41	84.30	14.46	25.99	84.83	3.83	33	.001

2. Results of the Repeated Measures ANOVA for Clicks. The repeated measures analysis, as with the paired T-test, showed a statistically significant relationship between the number of clicks for the high child control condition (mean = 129.01) and the high computer control condition (mean = 73.68). Repeated Measures ANOVA revealed a significant interaction between age grouping and numbers of clicks ($p < .05$). No significant interaction was found among gender, order of task or administration number.

As with the time measurement, when in the HICHILD condition, the group of younger children (< 50 months) clicked a greater number of times than older children (166.35 vs. 122.14), but under the condition of HICOMP, younger children clicked fewer times than older children (65.07 vs. 83.36). The differences between the number of clicks for younger and older children, regardless of experimental condition, was not significant ($p = .154$).

Number of Tasks

Another key measure of a child's activity in both conditions was the number of tasks the child attempted, regardless of whether correct or incorrect.

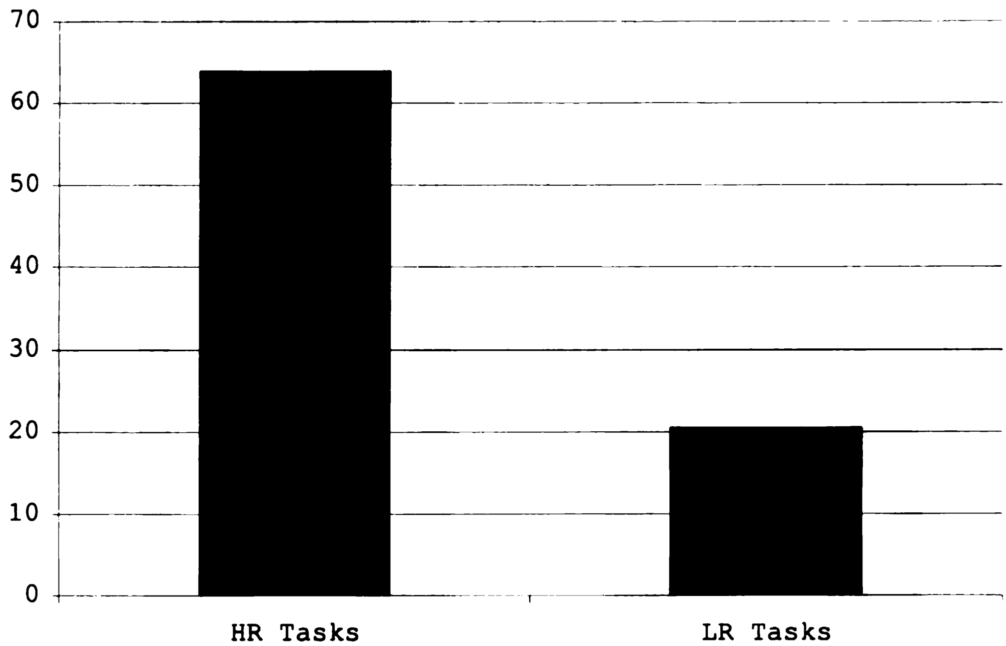
1. Results of the Paired T-test for Tasks. There was a significant difference between the two conditions, in terms of the number of tasks attempted. As presented in Table 12, children attempted significantly more tasks (mean = 63.8 vs. 20.4; $p < .05$) in the HICHILD situation than in the HICOMP situation.

Table 12: Paired Samples Statistics for Tasks

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Tasks	63.82	34	38.12	6.54
HICOMP Tasks	20.38	34	12.14	2.08

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	T	df	Sig. (2-tailed)
HICHILD Tasks/ HICOMP tasks	43.44	37.01	6.35	30.53	56.35	6.85	33	.000

Figure 7: Comparison of Mean Scores for Tasks



2. Results of the Repeated Measures ANOVA for Tasks.

The repeated measures analysis, as with the paired t-test, showed that there were significant differences between the HICHILD and HICOMP conditions (63.82 vs. 20.38; $p <. 05$). Like several of the other behavioral measures, interactions did not emerge for gender ($p = .134$), order ($p = .820$), or administration session ($p = .352$); but did emerge when the children were divided into two age groups. Under HICHILD, the mean number of tasks attempted was greater for younger children than for older children (mean = 80.57 vs. 52.10). Under the HICOMP condition, the mean number of tasks attempted was nearly the same for younger and older children (mean = 20.64 vs. 20.20). Within-subjects analyses show this difference to be statistically significant ($p < .05$).

It is interesting to note that age, regardless of experimental condition, has a nearly significant relationship ($p = .051$) to number of tasks attempted. The mean number of tasks completed by younger children exceeds that of older children (50.607 vs. 36.150 respectively).

Click/Task Ratio

In order to better understand the click phenomenon, a value was created by dividing the number of clicks by the number of tasks. This "click/task ratio" represents the degree to which each child's clicks were productive.

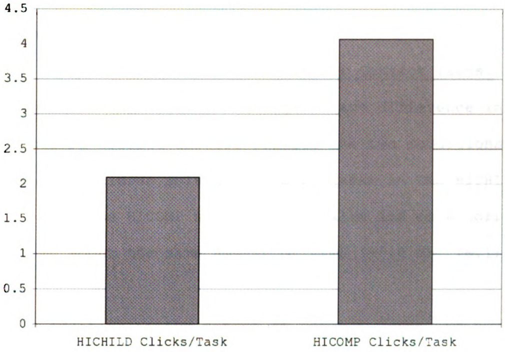
1. Results of Paired T-test for Click/Task Ratio. As shown in Table 13 and Figure 8, results of a t-test indicate a significant difference in the number of clicks per task in the two experimental conditions. Children in the HICOMP setting click almost twice as many times per problem as children in the HICHILD setting (4.070 vs. 2.095, $p < .05$).

Table 13: Paired Samples Statistics for Click/Task Ratio

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Clicks/Task	2.095	34	0.37	.06
HICOMP Clicks/Task	4.070	34	2.06	.35

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
HICHILD Clicks/Task HICOMP Clicks/Task	-1.98	2.00	.34	-2.6744	-1.2756	-5.745	33	.000

Figure 8: Comparison of Mean Scores for Clicks/Task



2. Results of the Repeated Measures ANOVA for Click/Task Ratio. Interaction of this variable with age grouping was not significant ($p > .05$). Similar checks for other between subjects measures were also not significant, as follows: Administration Session ($p = .690$), Order of Task ($p = .397$) and Gender ($p = .269$). There was no main effect for Age.

Correct Tasks

Another interesting variable was the number of correct answers, especially in light of the similar lengths of time for both the HICHILD and HICOMP sessions. Task-oriented educators who are wondering if greater structure pays off in terms of higher accuracy will be interested in this relationship.

1. Results of the Paired T-test for Correct Tasks. As shown in Table 12, there was a significant difference in the number of correct answers between the two conditions. Because the children solved many more tasks in the HICHILD setting than the HICOMP setting, they also had more correct answers in about the same amount of time (41.0 vs. 16.1; $p < .05$).

In addition to the number of correct tasks, an accuracy measure, percent correct, was created by dividing the total number of correct answers by the total number of tasks completed. The paired t-test showed that children in the HICOMP condition were significantly more accurate than children in the HICHILD condition (84.95% vs. 67.97%, $p < .05$). This illustrates an interesting tradeoff. In the HICOMP condition the child solves fewer problems accurately, while in the HICHILD condition, children try more problems with many more correct solutions, but also more errors.

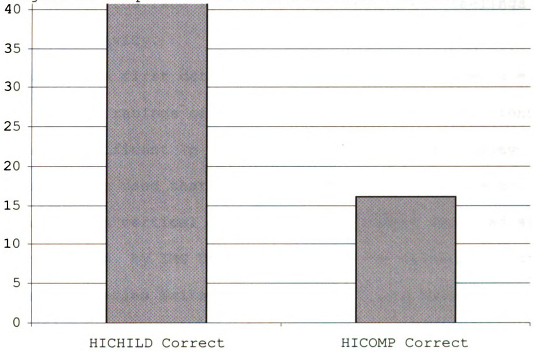
Table 14: Paired Samples Statistics for Correct Tasks

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Correct	41.00	34	29.69	5.09
HICOMP Correct	16.15	34	8.82	1.51

Paired Samples Tests: Correct Tasks

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Conf. Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
HICHILD Correct HICOMP Correct	24.85	30.47	5.22	14.22	35.49	4.76	33	.000

Figure 9: Comparison of Mean Scores for Correct Tasks



2. Results of the Repeated Measures ANOVA for Correct Tasks and Accuracy. Interaction of correct tasks and accuracy with the between-subject variables were not significant ($p > .05$) for Age, Gender, Order and

Administration Session. There were also no main effects of the between-subjects variables.

Rating

Two attempts were made to measure each child's general satisfaction with the treatment immediately after completion of a session. In the first administration (Fall 2002, N = 22), children were shown a horizontal row of five smiley faces, arranged from frown to smile, and asked to put a mark on the face that best explained their feelings about the activity.

After the first data session was coded (1 = low, 5 = high) and the ratings of the HICHILD and HICOMP conditions were not significant ($p > .05$), a second, similar survey instrument was used that also used smile and frown faces, but based on a vertical scale. This instrument was used at Microsoft Corp. by IMG Usability during the development of Microsoft Creative Writer (Risden, Hanna, and Kanerva, 1997). Again, the ratings results were not significant, for both the first and second administration ($p > .05$) and the HICHILD and HICOMP conditions ($p > .05$). Children tended to give both conditions the highest rating, regardless of the instrument.

More information about the preschool children's positive or negative reaction about each condition came from the less systematic anecdotal observations, which are described and explained in Chapter 4.

<u>1. Results of the Paired T-test for Ratings.</u> As shown in Table 15, no significant differences ($p > .05$) between the HICHILD and HICOMP conditions for child rating were identified.

Table 15: Paired Samples Statistics for Rating

	Mean	N	Std. Deviation	Std. Error Mean
HICHILD Rating	4.68	36	.92	.15
HICOMP Rating	4.58	36	.96	.16

	Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	Df	Sig. (2-tailed)
HICHILD Rating HICOMP Rating	.06	1.39	.23	-.40	.54	.29	35	.76

2. Results of the Repeated Measures ANOVA for Ratings.

Interaction of child ratings with the other within-subject variables were not significant for age ($p > .05$), gender ($p > .05$), order ($p > .05$) and administration session ($p > .05$).

CHAPTER 4

ANECDOTES

The 38 children that participated in this study ranged in age from 40.37 months to 60.74 months. In addition to age, there were many other developmental, environmental, and cultural factors at play. Written anecdotal observations were made during the data collection and the videotape coding process to highlight some of these (see Table 16: Qualitative Data Codes).

These observations are useful for better understanding the types of behaviors that were not captured by quantitative methods. These are impressions and subjective observations only.

Table 16: Anecdotal Data Codes

HICOMP = High Computer Control
HICHILD = High Computer Control
10 = Order of test, from 1 (first) to 41 (last)
F = Female
M = Male
50 = Age in Months

In order to protect the identity of each child, codes (for example, HICOMP10F50) were designed. The first two digits tell which treatment the child was in: either HICHILD or HICOMP. The second numeral gives the child's assigned ID number, from 1 to 41, which tells the order in which they were given the first trial. Any number greater than 21 represents the second data collection session. The next character indicates if the child is a male (M) or female (F). The final number tells the age of the child in months.

Behaviors Unique to the High Computer Control Setting

Nearly all of the children who participated in this study could be described as active, curious learners, regardless of the experimental condition. However, during the HICOMP condition, there were more periods of uninterruptible narration, during which some children would keep themselves entertained by moving, singing, and trying to talk to the researcher.

These behaviors were observed less frequently during the high child control treatment, which appeared to be better at keeping children on the task of sorting the shapes (63.8 vs. 20.4 for HICHILD and HICOMP, respectively).

Time-filling behaviors included playing with the optical mouse-- the children seemed fascinated with the red light-- looking around the parent's lounge, playing with hair, and playing with clothing. Some children tried to engage the researcher in conversation, or would talk to themselves in the mirror or the narrator in the computer. It was striking how persistent some children were, however, patiently sticking staying with the HICOMP experience despite what appeared to be excruciatingly long narrated sequences.

An initial hypothesis of this study was that children in the HICOMP session would choose to end their session sooner than in the HICHILD setting, providing that they understood that they could terminate the activity at any point. However, this did not happen-- there was no statistically significant difference between the HICOMP and HICHILD times.

When considering children's general body activity (posture, head movements, hand activity, wiggling, and so on), it was clear that children in the HICOMP condition were more restless, while children in HICHILD situation were more alert. They sat up straighter, and tuned into the screen events rather than slump. It was noted that they were less likely to yawn, or rest their head in their hands during the narration sequences for both sessions.

The following are researcher notes that were related to child distraction. The key to understanding the subject codes, the starting string of letters and numbers, can be found in Table 16.

> HICOMP18F44. In her first HICOMP trial, she is very involved with the critters. She kept track of which critters burped, and makes up games to stay entertained during the narration. After 60 seconds, she starts to lose interest. First she starts looking at the red light under the optical mouse. Then she plays with her fingernail, twirling it on the table. Toward the end of the session, she starts looking around the room, and suddenly looses her balance, slipping out of her chair. After this event, her pacing slows dramatically. We are both very nearly asleep she asks to stop (much to my relief).

HICOMP1M52. He starts trying to remember which critters burped, and which ones didn't. Toward the end, he started looking around the room, and at one point got out of his chair, and looked through the camera viewfinder.

HICOMP5M45. Right in the middle of the HICOMP session, he turns and says "SPARTY!" (seeing the MSU Mascot icon on my nametag). This distracts him, and slows his progress.

HICOMP11M48 appears to be very interested in how many hearts he has filled in and how many he hearts to go. Now he starts getting very bored; making mouth sounds and the gets very slow, slumping toward the end of the session.

The Social Nature of Preschoolers

The study took place in parent's lounge located on the same floor as the children's classrooms. When it was time for a child's turn, he or she was taken away from the classroom, at times interrupting an activity.

The research room was a quiet setting, and there was no person present other than the researcher, who was following a script designed to minimize interaction with the children. While some of the children were quiet, others were social. Following are some of these observations related to these observed social behaviors.

HICOMP10F55 is a very verbal, competitive girl who seems task oriented. She was worried about getting back in time for lunch, which seemed to increase her eagerness to finish. She also asked about her friends and wanted to know "how many did Kristin do?"

HICHILD13M56 spends a lot of time describing the things on the screen, but he isn't sure what to do. He does a lot of talking, rather than the computer. He wants to feed each critter, and talks to each one.

HICOMP10F55 does not like to work alone. She talks about her friends, and wants to go back to her classroom to see what they are doing.

Children would sometimes initiate social dialog with game elements, which has also been noted by others (Turkle, 1984; Reeves & Nass, 1996). Children would sometimes assign human attributes to the critters, such as hunger or emotion.

In two of the sessions, children were more concerned with whether the critters had a chance to eat ("it's your turn now" or "hey, you already ate!") than worrying about making the correct match. These children responded positively to the intermittent critter burps, which occurred in both the HICHILD and HICOMP settings.

> HICHILD7F46 is insisting on feeding every critter a cookie equally. "You already ate." In his view, the cookies were fighting for food, and he was the feeder. "Hey, I'm feeding you!" he would scold, as he clicked on the critter who opened his mouth."
>
> HICOMP34M53 kept nodding yes every time the narrator would ask a question. "Can you click on the critter with stripes?" (nod).
>
> HICHILD1M52 and HICOMP1M52 "I want him to Burp!" Children thought the critter burping, happened for both HICHILD and HICOMP settings at intermittent intervals, was very funny. They also laughed at the expression on the critter's face when it didn't like the cookie (in both HICHILD and HICOMP settings), prompting some children to intentionally make incorrect answers.

Children's Response to Praise

The HICOMP treatment narration contained comments such as "Way to go! Circle cookie, circle critter!" and "Yeah! (Square) cookie, (square) critter!" and the HICHILD narration did not use praise. Children's responses to each situation in relation to the presence of praise were recorded. Children in the HICHILD setting consistently displayed behaviors associated with intrinsic motivation, such as praising themselves and celebrating accomplishments. In the HICOMP treatment, the acknowledgement of achievement came from the software.

> HICHILD2M54 This was his second treatment (LC was his first). He takes off very quickly in the HICHILD, solving many problems, and then seems to notice that this treatment has been changed. "How come they're not clapping?" "They must have hurt their hands." Later he enthusiastically proclaimed "I'm fast at this now" and became very interested in the tracking indicators at the bottom of the screen. "Look...stars now!
>
> HICHILD3M54 "I did it!" (repeats many times, with each correct answers).
>
> HICHILD24M43 "I'm doing a great job!" (HICHILD, trial 1)
>
> HICOMP27F58 "This is so easy!" (after one HICOMP trial)
>
> HICHILD25M48 "He ate the square!" (after first HICHILD trial). He had an interesting reaction to the second HICOMP trial… turned the mouse sideways and did a lot of "hurry up" clicks).

Prior research on the relationship between praise and engagement in elementary (e.g., Brophy 1981; Hitz, Driscoll, 1988; Kohn, 1993) and preschool classrooms (Green & Lepper, 1974) has shown that extrinsic reinforcers can interfere with children's engagement during play and learning tasks.

<u>Children's Evaluative Comments During the Two Treatments</u>

Methods for measuring children's opinions of the experience did not reveal significant differences between the two treatments ($p > .05$). Anecdotes collected during the procedure, however, were useful for gaining a general sense of children's feelings.

Children were eager to volunteer for their second trial, regardless of whether the first treatment was high or low in responsivity. Their comments (below) indicated that they seemed to enjoy feeding the critters, and expressed a positive connection to entire process. In addition, the challenge of the sorting tasks helped to maintain interest. Because the task started easy and gradually became more challenging, children were observed trying to find out how far they could go before the challenge became too difficult.

Most of the "challenge seekers" were older and more verbal (the last two digits of the code reflect age in months), which should be considered when making conclusions from these observations. Following are the set of anecdotes from children who indicated they remembered the previous treatment.

> HICHILD10F55, after finishing the second HICHILD treatment said, "It made it better because I did more than yesterday." Researcher, "More problems? Child, "Yes."
>
> HICHILD16F52 "It was more fun when it was faster." This statement was made after spending 475 seconds in HICHILD treatment, vs. 212 in HICOMP treatment).
>
> HICHILD13F56 said "I liked it better yesterday" after finishing the HICHILD treatment. She meant that she preferred yesterday's HICOMP treatment more than today's HICHILD session. This was an

interesting case, because she did many more problems in the HICHILD treatment (142 vs. 23) and also spent far more time in the HICHILD treatment (721 seconds vs. 375 seconds). It is unclear why she said this.

HICHILD18F44 "It doesn't make noise. The other day it made noise." (After finishing second HC treatment).

HICHILD7F46 "I liked that game a lot." (After first HC treatment).

HICOMP37F49 "I didn't like the game," after the first HICOMP treatment, solving 14/14 problems in 5.0 minutes before ringing the bell. Later in the day, with some coaxing, she came back for the HC treatment and completed the second highest number of problems attempted (169), and the highest number of correct problems (168). After the record-setting session, she said "I liked the frosting" referring to the white patterns on the critters.

HICHILD18F44 "I liked it better today," referring to the HICHILD session she had just finished. "I liked it here too. It didn't make any sound when you get it right today."

HICHILD19M61 "I liked the first one better" (referring to the HICOMP setting). "The shape didn't dance because I don't like it that way. Also the critter would dance. I liked the first one better. Put in more critters and more shapes. I'm so smart because I played Millie's Math House."

HICHILD22M49 shows how much enjoyment is increased when control is increased. He has a huge smile on his face throughout the second HICHILD taping. He seems developmentally below the cognitive sorting task, and seems to find the experimentation liberating because he knows he can 'trial-and-error' his way to the correct solution.

These observations provide some indication that in most cases children preferred the HICHILD experience over the HICOMP experience. However, the selection process for observations was not systematic, reducing the validity of this conclusion.

Use of the Mouse as an Input Device

The ability to use a mouse was a prerequisite skill for this activity, regardless of age. A closer examination of this skill found that it consisted of a coordination of two simultaneous movements: a fine motor movement (clicking) and a gross motor movement (moving an arm). A positive correlation between a child's maturation level and mouse proficiency has been identified in general terms (Liu, 1996; Strommen, 1993), although prior computer use, which was not measured in this study, must certainly also play a role.

Because preschool-age children have developing motor skills, and the age range of the study population was over 24 months, it was expected that there would be wide variation among the children in their mouse abilities. The anecdotal evidence supported this conclusion.

> HICHILD11M48 uses an interesting "machine gun" style of clicking. Rather than sending a discrete click or event to the computer, he keeps clicking until the computer responds. He was concerned about the pattern that the critters ate, over correct or incorrect answers. "That one didn't get to eat, that one didn't get to eat." At various times, he would try to drag cookies. Obviously, he's used a mouse before and is interested in controlling the screen events.

> HICOMP1M52. On his second HICOMP trial, he began playing with the mouse wheel, and also discovered the computer's track pad. He started to use the pad to move the cursor, while using the mouse buttons to enter his clicks.

> HICHILD14F44. She starts trying to shake the cookie from the cursor, after she changes her mind about which cookie should get to eat. The software should "let her off the hook" more easily.

> HICOMP18F44 was a very interesting case. At first she wouldn't click on a critter, which was required in order to enter the answer. She just positioned the selected cookie over the critter and waited. Finally, after about 20 seconds, she became impatient, resulting in a "hurry up" click. This seemed to break the ice and it also taught her the procedure for using the program. She accidentally experienced success. You could tell that she thought that it was the software, not her, that was acting silly. She seemed to be a bit stubborn, e.g., thinking "I can wait this out as long as you can!" In this case, the "hurry up" click saved the session.

The mouse clicks observed in this study could be classified as intended clicks and unintended clicks. Clicks that are unintended, or wasted, are clicks that do not work toward the objective of the activity, in this case, either selecting a cookie or a critter.

Unintended clicks were observed with a greater frequency in the HICOMP setting, as indicated by the significantly different click/task ratio.

Mouse use related behaviors that have been previously documented by Strommen (1994) and others were observed in this study. In times of frustration, some children would lift the mouse straight up, as if trying to directly link their vertical movement with the cursor orientation.

Children were also observed at times having trouble hitting the target with the cursor. In Cookie Critters, the target was any one of three cookies, which were designed to create a large, easy target. However, several children were observed overshooting the cookie.

A third mouse-related behavior that was observed was the click, a fine-motor skill. In recent evolutions of some computer mice, the click has been complicated by the addition of a second button (left and right) and/or a scrolling wheel.

The Cookie Critter activity used a "sticky" cursor, so that children would not need to employ require simultaneous motor movements (holding the mouse button down, while moving the cursor, together at the same time). This technique, sometimes called "drag and drop", was used by a surprising number of children. They seemed to assume that they needed to press and hold the mouse button down to begin movement, which would then be ceased when the mouse button was released.

In usability research that led to the development of a new trackball input device for children called the Microsoft EasyBall (Strommen, 1994), Erik Strommen noted that children had difficulty maintaining pressure on the standard mouse button using what he called the "hold and go" technique. Strommen maintained that because the children had difficulty keeping pressure on the mouse button, they could also not coordinate the movement of the device. In some cases the children used two hands to hold the button down or would pick the mouse up and hold it, squeezing tightly to click. This problem had been observed with adult computer users by usability researchers (Gillan, Holden, Adam, Rudisill, and Magee, 1990). Table 17, "Classification of Mouse Clicks Listed by Frequency During the Cookie Critters Activity" takes a closer look at the types of mouse clicks that occurred with this particular population of children, and attempts to sort them into groups.

Table 17: Classification of Mouse Clicks Listed by Frequency During the Cookie Critters Activity

This is an attempt to classify the types of mouse use observed in this study.

1. Double Stroke, Intentional Clicks. This click consisted of one complete down and up stroke while on the intended target. For example, the child sees a cookie, moves the cursor to it, and clicks. This type of click was more common in the older group of children (>50 months) who were more likely to have prior mouse experience. This type of click was common in both HICOMP and HICHILD settings.

2. Single Stroke, Intentional Clicks. Approximately 1 in 5 children used "drag and drop" or "hold and go" (Strommen) single stroke clicks in both the HICHILD and HICOMP settings, even though the activity used a "sticky mouse" making this technique unnecessary. A child using this type of click would first position the cursor over the target cookie, and then make one downstroke, holding down the mouse button, and not letting it come back up until it was over the target critter. This type of click requires the coordination of both fine motor and gross motor movements simultaneously. It was interesting that some children switched to this strategy in the HICOMP setting, from intentional clicks, after they learned that they could not speed the events along. Perhaps this was out of frustration.

3. "Hurry Up!" Unintentional Clicks. This click resulted when a child attempts to influence the temporal sequence of events on the screen by clicking the mouse. Commercial early childhood software activities that allow children to "click through" introductions or screen events may reinforce this behavior. This clicking behavior was observed only in the HICOMP setting.

4. "Rapid Fire" or "Machine Gun" Unintentional Clicks. This technique refers to when child sends a continuous stream of clicks, sometimes in a short burst and other times for longer sequences. The child's thinking seems to be along the line of "I'll just keep clicking until the computer hears me." It was also a way to keep busy, perhaps creating a simulated feeling of control in the HICOMP setting. This was rare in HICHILD settings, much more common in the HICOMP setting when children did not have as much control.

Child Experimentation

Some children seemed more interested in playing with the activity to see what would happen, which resulted in a much higher frequency of errors.

Such experimenting included a boy who used the mouse and the track pad simultaneously to enter answers, and two older children who found their way into the program preferences and changed the settings. These explorations happened when children appeared to be bored and unengaged with the computer task.

> HICHILD15F56 is a non-verbal female who quietly made 98 simultaneous errors, just to see the critter "boink" and make a silly face. She seemed to want to test the limits of the program or perhaps the researcher. After the 99th problem, she made the correct answer, which she knew all along.
>
> HICHILD21M49 has a smile on his face throughout the second taping, clearly enjoying the experience despite struggling with the challenge. Even though he is developmentally below the level of the sorting task, he seems to find the experimentation liberating as he uses trial-and-error to find his way to the correct solution.

More activity-related experimentation took place in the HICHILD setting than the HICOMP setting, an observation that was supported quantitatively by the number of problems attempted.

Implications for Designers

The following elements of the Cookie Critters experience appeared to make a difference in the quality of the child's time with the Cookie Critter's activity. These non-systematic observations were taken as notes during the each administration session and while coding the tapes.

1. Include a brief, ten second "launching experience." The importance of providing a launching event, or an "anticipatory set" (Hunter, 1982) that could get a child's attention (Gagné, 1977) and then provide a clear path for the child to take the next transaction in the interaction played a key role in a child's initial reaction to the Cookie Critters activity. In both the HICHILD or HICOMP treatment, a short, one sentence phrase such as "click a cookie" that is spoken as the clickable cookie is highlighted on the screen, advertised what was needed to do in order to get started. When the launching instructions were toggled off, or when they were set on the maximum setting, the younger children seemed more likely to become lost or distracted.

2. Insure quick success for every child, regardless of developmental level. Approximately five of the 41 children were resistant to participation. This may have been due to some past unsuccessful experience with a computer activity,

but it is important to note that approximately 12% of this particular sample seemed to feel strongly that computer activities were not something for them. When the first few screens and the introductory sequence were short, clear and easily bypassed, children seemed more likely to experience some degree of "accidental success."

There was one flaw that was identified in the Cookie Critter's activity that affected ease of use for several children. The first screen starts with an inch-wide round target with the printed word "start" on it (Figure 10).

In order to unlock the activity screen, children are required to hit this target, which implies that they will know that the button means start. While this is logical to an adult who can read, a preschool child can't, so there is no indication what to do.

Figure 10: The Cookie Critters First Screen

One way around this bottleneck would be to make the screen so that any click, regardless of where the cursor is, advances the program to the next screen.

3. <u>Incorporate dynamic, or "living" features that are driven by, or respond directly to the child's actions</u>. In the starting screen in Figure 10, for example, children would be more likely to become engaged early on if the eyes in word "Cookie" followed the cursor around the screen. Dynamic animation properties such as these, that follow the initiation of the child, seem to be effective for increasing initial engagement.

4. <u>Use humor carefully and intermittently</u>. Children seemed to respond well to events such as when the critter burped after eating a correct match, and "bonk" sounds when cookie did not match. These small events worked very well to support children's engagement.

5. <u>Opt for context sensitive "roadside assistance" in place of lengthy segments of spoken instructions</u>. Ideally, interactive media products designed for young children could be able to sense outlier behaviors, such as series of errors, and respond appropriately. This assistance cannot disrupt the current activity; for example, by launching a new path with a help sequence. It needs to happen out of the way, while respecting the child's current problem solving space.

6. <u>Put children in the role of being in control</u>. In this case, it was being able to be in charge of feeding the

cookies, determining which cookie was able to eat, and which wasn't.

7. Capitalize on a children's initial motivation. Each child started both HICHILD and HICOMP experiences with some level of motivation. It is up to the designer to determine how this motivation will be spent. This study illustrated that this motivation can be either used for more accurate responses and less activity, or more activity with more correct answers and more mistakes, depending on quantity of the reinforcements and instructions. In the case of an activity like Cookie Critters, it is a question of the instructional design priorities.

8. Provide a meaningful context, from the perspective of the child, not an adult. The first administration session used a version of Cookie Critters with a visual progress tracking feature turned on. This made it possible for children to see how many problems they had solved, and how many more they had to do before the next challenge level. This technique has been used in commercial software products, including Stickybear Math (Optimum Resources) and such as School Zone's "On Track" series of software.

CHAPTER 5

DISCUSSION

This study was designed to explore the relationship between instructional style (high child control and high computer control) and child engagement in an interactive media setting. This relationship was examined using both quantitative data and through the collection of informal anecdotal observations.

The measures revealed some interesting, statistically significant ($p < .05$) relationships. Children in the high child control setting performed more mouse clicks (129 vs. 73) and had lower accuracy rate for problems (68% vs. 85%), in about the same amount of time. However, the most striking finding was that children attempted over three times more problems (64 vs. 20) and more than twice as many correct answers (41 vs. 16) in the high child control condition. While no significant differences were found by gender or session administration, the age of the children did matter in terms of the amount of time spent with the task.

The population's large developmental span (40 to 60 months) led to a high degree of variability in children's performance across the tasks. In addition to the expected differences due to cognitive abilities, some children seemed determined to test the outer limits of the activity.

For example, one child (HICHILD36F61) chose to stay with the HICHILD activity for 25.2 minutes (17.2 minutes longer than the mean time of 8.0 minutes), completing a record number of 195 tasks (131.2 more than the mean of 63.8); in contrast to children like HICOMP12F41 who completed just 11 tasks, or HICHILD10F55 who stayed for just 2.2 minutes. In the high computer control setting, times ranged from a low of 1.8 to 21.4 minutes, with a standard deviation of 4.48 minutes, and the number of tasks attempted ranged from 3 to 56 with a standard deviation of 12.14.

Considering that outliers were not removed from the data set and the population of young children was heterogeneous, especially with regard to developmental level, the resulting standard deviations for time, clicks and tasks were large.

Anecdotal observations were useful for better understanding how children reacted to each treatment, as well as the computer setting in general. They also helped to illustrate the wide degree of variance in how preschoolers approach a novel computer interface.

These findings may be useful for educators or software designers who wish to know more about how preschoolers use computer interfaces. Following are major findings from the study, followed by a discussion of the results. The end of this chapter lists limitations and suggests areas for future research.

Major Findings

1. Children clicked more in the HICHILD setting, but had fewer wasted clicks than in the HICOMP setting. For the purposes of this study, a click is defined as the two part motion (and up and down stroke) when children choose to interact with the software interface. The click was easily counted due to the distinctive sound associated with stroke, as well as the visual clues provided by screen events.

Mouse clicks were a useful behavioral indicator of a child's motives, interests, ability level and activity level. This meaning of the click depended on the situation. The click could mean something either intended, or non-intended. Intended clicks might have a meaning such as "OK, I'm ready, lets get started", "I'd like to choose that cookie", "Is this cookie the right one?" or an expression of affect such as "hey, hurry along" or "I'm feeling very frustrated!"

In the high child control setting, children clicked more (mean = 129.08 vs. 73.68 respectively; $p < .05$) over the same amount of time as the high computer control setting. This outcome has more meaning when interpreted in the context of the number of problems completed in each setting. In the HICHILD setting, children attempted more than three times (320%) the number of tasks (63.8 vs. 20.4; $p < .05$), resulting in a click per task ratio nearly two times (194%) that of the HICOMP setting (4.07 vs. 2.095; $p < .05$).

To conclude, when responsivity was increased, children were much more active, clicking more frequently; and more of those clicks were related in some way to an intended outcome (from the perspective of the software designer). In the HICOMP treatment, the added narration and reinforcement statements seemed to create a barrier to child's activity and problem solving effort.

<u>2. Children chose to spend about the same amount of time in each trial. But there were interesting interactions for time and age.</u> One initial hypothesis of this study was that the lower the level of responsivity, the less time a child would voluntarily stay with treatment.

Contrary to this prediction, children in the HICOMP setting actually spent a bit more time than when in the HICHILD condition (mean = 480 seconds vs. 540 seconds, respectively) although this relationship was not significant ($p > .05$). The novelty of the sorting experience kept the children in both situations, and children's willingness to comply with the software's instructions might explain the slightly greater time spent in the HICOMP situation. Because both treatments were conducted out of a child's regular play setting in a parent lounge down the hall, it is possible that the novelty effect was magnified. This could be further explored with an additional study that would examine child reactions to each treatment in the context of a free choice period, over the course of a longer period of time, along with a hidden counter in the software to measure the frequency of use. In this study, these questions were not formally addressed.

The ANOVA revealed some notable findings when the entire group of children was divided by younger and older age groups. The 14 younger children, aged < 50 months on average chose to stay with the experience longer than the 22 older children ($p < .05$) regardless of the experimental condition.

An explanation for this may be the challenge level, which started with three objects to sort, based on one attribute, and increased to five objects and three attributes. Because most of the problems were geared toward the middle of the age group (46 to 52 months), the older, more competent children more quickly exhausted the novelty and challenge available in the experience than the younger group, resulting in a loss of interest, and less time on task. For designers, this helps illustrate the importance of having a fluid challenge level that either automatically adapts to the child's ability level, or that lets the child have some control over the challenge setting.

<u>3. Children attempted more problems and experimented more in the HICHILD setting.</u> Another statistically significant relationship was the number of problems that were attempted between the two treatments. In the HICHILD condition, the children were 317% busier, attempting 63 problems in approximately the same amount of time spent in the HICOMP condition with only 20 problems solved ($p < .05$).

When children experienced a more structured and controlled interface with a high level of narration and direction, they showed a decrease in activity, as measured by number of problems attempted. Anecdotal observations supported this observation, with more fidgeting, yawning, and placing head on the table during the HICHILD situation.

Another observation relevant to this topic was that the HICOMP treatment work was more accurate, with a higher percentage of correct answers (84.95% vs. 67.97% respectively; $p < .05$). When there was increased activity, there was a decrease in accuracy. When the sum of correct answers, however, was compared between the two conditions, during the HICHILD condition children ended up with 393% more correct answers -- 41.0 vs. 16.1 ($p < .05$).

Interpreting the significance of this finding is dependent upon the theoretical framework and associated instructional objectives of the software designer. If the end goal is for the learner to solve a higher number of correct answers and increase the amount of experimentation, the HICHILD setting is the preferable design. If higher accuracy regardless of the number of problems is the only goal, the HICOMP setting is the preferable option.

4. The older group of children chose to spend less time in the HICHILD setting than the younger group of children.

When the population was grouped into two parts by age (over 50 months and under 50 months), there was a significant and interesting difference in the amount of time the two groups choose to stay with the activity. Regardless of the experimental condition, the younger group stayed longer than the older children ($p < .05$) although the HICHILD setting held them longer. (610 vs. 442 seconds, whereas the HICOMP setting was 573 vs. 567 seconds).

It may be that the increased responsivity of the HICHILD setting allowed the older, more competent children to use up the challenge sooner, resulting in a shorter session time. The greater number of attempted problems by the older children (80.57 vs. 52.10) supports this observation, particularly when compared with the older children in the HICOMP setting, where the difference narrowed to 20.6 vs. 20.2. The decreased responsivity seemed to be associated with the child's ability to quickly reach their challenge level, which had an affect on the amount of time they chose to stay with the activity.

5. Children rated both experiences highly, but anecdotal observations seemed to indicate that children generally preferred the HICHILD treatment over the HICOMP treatment. A formal measure of the child's feelings about each treatment was attempted using a Likert-type scale. There were no significant differences between the two groups (4.65 for HICHILD, 4.58 for HICOMP; $p > .05$). When children were asked "how did you like it?" immediately after a

treatment, they would say either nothing or that they liked it, by touching one of the smiles faces. It was hypothesized that children would rate the HICOMP experience lower than the HICHILD setting. This was not supported by the survey ratings.

Additional information was gathered less systematically, by observing children's reactions when their turn came up to play the second trial. In general, they would respond enthusiastically to the idea of coming back to the room to play the game some more, regardless of the first condition they experienced; high or high computer control.

Nine of the children, generally older, were able to verbally compare the HICHILD and HICOMP treatments after the second session. From these videotaped conversations, it was possible to determine that these children had more positive things to say about the HICHILD experience. In order to more accurately understand children's reactions to each treatment, additional exposures to both the HICHILD and HICOMP treatments would be necessary, over a longer period of time. It is likely that children would have a more discriminating attitude toward between the two treatments after the novelty of the experience is reduced.

Limitations

Research that examines the effects of software interfaces on young children is subject to a variety of potentially confounding variables that must be identified and controlled for in order to create useful results. The first challenge is the study population itself. The typical group of preschoolers may be diverse, representing different cultures, language abilities, past exposure to technology, problem solving abilities, and age to name a few. The child participants of this study varied in all of these areas. In order to control for these variables, the procedure subjected the same child to both conditions.

Individual children reacted differently to participation in the study for each data collection period. This was influenced by what was happening in the classroom at the time, and how a child was feeling on the particular day of the research. Several children expressed hesitancy in leaving their classroom with a stranger, which may have been reduced in the second trial, after the "stranger" was more familiar to them.

One notable limitation was the age variance. The children in this study ranged from 3.36 years to 5.1 years, representing a significant developmental range.

A second limitation with this type of study is with the computer activity itself, which must be carefully defined in order to make the study generalizable to the outside world. Lepper (1989) acknowledged this challenge.

> "A first potential difficulty in any discussion of the 'effects' of 'computers' on children is that the computer itself is a multifaceted invention. The computer may serve as a tutor, an assistant, a coach, a mentor, or a drill sergeant; it may offer experiential learning opportunities through simulations, microworlds, or hypertext programs; it may also provide tools for word processing, data analysis, music composition, and telecommunications ... many effects of computer use are also likely to vary as a function of individual differences in children's aptitudes, backgrounds, and attitudes. As a result, it simply does not make sense to discuss the effects of exposure to 'the computer' without a specification of the uses to which it is being put and the children with whom it is being used." (Lepper and Gurtner, 1989).

Other technology-related variables include the subject matter, the challenge level, incidental content such as story scripts, formal design features such as animation and sound, and the interpersonal context of computer use. Thus, attention to a wide range of program characteristics and outcome measures are necessary.

Consideration for these variables was addressed by creating a novel software experience that eliminated the possibility of prior exposure, but was similar in function to many commercial software activities. By also building in hidden menus to enable the features to be studied to be adjusted, a usable research tool was created.

A second important procedural characteristic was the use of an alternating paired-sampling technique, where the same child was exposed to both software experiences. This helped to minimize variance.

While many of the within-subject factors were controlled with the alternating paired sample technique, this technique was not enough to compensate for all of the study limitations. Ideally, an additional study would be conducted that would observe children using both the HICHILD and HICOMP experiences as a free-choice item in a preschool classroom over an extended period of time. This would help minimize the following limitations:

1. Novelty effect: How much influence is the novelty of the first few exposures, vs. subsequent sessions? While the novelty effect is present in home or classroom computer environments, the context is not new. In this case, the novelty effect included a new computer, a new mouse, a new room and a new "teacher" (in this case the researcher).

2. The involuntary timing of the treatments. Children had no choice about when to use the software activity, or in many cases if they even wanted to participate in the activity. The formality of the research setting was different than informal home or school software settings.

Implications for Future Research

While this study was effective at addressing the question of how reinforcements and instructions can influence child behaviors, it raised additional questions.

First, the method of toggling design features in a software interface could be further exploited for the exploration of interface design. Additional features could be added or subtracted from the experience to study child reactions, both quantitatively and qualitatively. For example, it would be interesting to toggle on or off the intermittent reinforcements to see if there is an associated change in time on task or mouse clicks. The type of mouse control could be toggled between "drag and drop" and "click and stick." Even features as subtle as a child's preference for a particular narration style or the effectiveness of a hint system could be studied with a relatively small population of children.

Secondly, there are many extension studies that could be conducted to more closely examine the findings from this study, including categorization of clicks or an examination of the correct answers over the course of the HICHILD and HICOMP sessions. This could help to better understand if a child's experimenting, resulting in more wrong answers at the start of a session, leads to more mastery and correct answers later in the session.

Another question not examined in this study is the longevity of the experience. With commercial software, this often leads to a product's success or failure. Based on the results of this study, it is not known how the HICHILD or HICOMP treatments affect long term use.

A formal classification of mouse skills could be helpful to developers of early childhood activities, in light of mouse dependent interfaces, and future pen based interfaces. It is clear that much can be learned about general computer interfaces in general, for all populations, by the way that young children approach typical interactive media interfaces.

Conclusion

This study demonstrated that behavioral differences that have been documented in teacher/child interactions can also be applied to computer/child settings, and when experimental conditions are carefully controlled, statistically significant correlations with outcome variables related to engagement can be illustrated. The similarity between the Cookie Critters activity and many commercial children's CD-ROMs and Internet sites strengthens the ability to generalize the findings.

While the child's developmental level, prior experiences, and personality are all key players in the computer/child interaction; it is the nature of the computer activity, as the more competent partner in the exchange, whose design will ultimately determine the nature of the child’s engagement.

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