Cognitive Orthotics for Students with Cognitive Disabilities

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COGNITIVE ORTHOTICS FOR STUDENTS WITH COGNITIVE DISABILITIES

by

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CHAPTER I

STATEMENT OF THE PROBLEM

Individuals with cognitive impairments often show significant difficulty with independence skills, such as vocational skills and activities of daily living. Individuals with mild mental retardation generally acquire sufficient skills to become independent. However, those classified as moderately mentally retarded rarely achieve this level of independence. As a result, they are relegated to a life where supervision must be maintained to ensure that the tasks are performed in a safe and effective way. This deprives them of a significant measure of autonomy, and it also places a burden on society to provide the supervision. Some individuals with moderate mental retardation remain living with family members, where the logistics of maintaining supervision can be a daunting task. Others will pay to live in group homes, where maintaining sufficient supervision is expensive. Tradeoffs may have to occur between maintaining adequate supervision and improving the quality of the home environment for the residents.

Training programs for individuals with moderate mental retardation have been the traditional method for teaching and maintaining independent living skills. However, theses programs have met with differing degrees of success. Individuals with moderate mental retardation have a very difficult time learning independence skills. Because some individuals in this category do not read, daily living aids, such as cookbooks, cannot be used. These individuals learn very slowly, requiring many learning trials to master a task. In addition, they have a particularly difficult time with generalization. For example, skills learned in one context will not readily carry over to another similar task. Finally, individuals with moderate mental retardation have a particularly difficult time recognizing when a task must be initiated. Even though an individual might have mastered the skills of a particular task, it is very unlikely that he or she will discriminate the proper time to engage in those activities.

Many daily living tasks are comprised of a chain of steps. Even if these steps are simple, their sheer numbers can render the chain very difficult. To add to this, the steps often need to be accomplished in a particular order. A mistake in one step, or an error in the order of the steps, can render the entire chain unacceptable.

Microcomputer technology shows promise to improve the independence skills of individuals having moderate mental retardation. Research suggests that microcomputer-based devices are effective in cuing and supporting individuals with cognitive disabilities as they carry out complex vocational and daily living tasks. However, the majority of this research has been carried out with individuals having traumatic brain injuries. Although these populations share some characteristics, they are distinctly different.

Little research has been conducted with individuals having mental retardation. Research is needed to examine whether microcomputer-based devices can be used to cue and assist individuals with mental retardation as they carry out complex vocational and daily living tasks. It is also important to examine whether this technology shows the potential to provide this support as well or better than that provided by a human supervisor.

CHAPTER II

REVIEW OF THE LITERATURE

Despite over 20 years of schooling, most students with moderate mental retardation will not possess the skills necessary to live and work independently. Despite the best teaching technology, they will not retain many learned skills. Additionally, they will have a difficult time generalizing learned skills to other contexts. For example, proficiency in cooking a particular recipe may not generalize to a similar recipe. Generalization also suffers if task details, such as utensils, measuring devices, appliances, or setting are varied. Finally, poor reading skills preclude the following of written directions. While task directions, consisting of symbols, icons, and other forms of non-textual cues, have been used in an attempt to circumvent reading problems, they are usually too abstract.

It may be more effective to compensate for cognitive deficits rather than attempt to remediate them; for example, the environment may be structured in a way that the target behavior is elicited. Actual physical entities in the individual's environment may be manipulated to occasion this behavior. For example, a series of pictures was used to cue students with multiple disabilities through a complex task (Roberson, 1992). This memory aide was essentially a series of descriptive pictures, developed from an analysis, leading to an intended outcome. Individuals with cognitive impairments used the pictures to sequentially cue their behavior as they completed the task.

Environmental support has been used for many years to occasion appropriate behavior. For example, by displaying relevant pictures at the door to her room, an elderly person with dementia was assisted in remembering family information (Calkins, 1988). Elderly people with dementia have also been assisted in remembering factual information through the use of "memory books," consisting of simple compilations of written sentences and pictures. Bourgeois (1990, 1993), Hoerster, Hickey, & Bourgeois (2001), and Mcpherson, Furniss, Sdogati, Cesaroni, Tartaglini, & Lindesay (2001) stated that these simple devices were capable of increasing the number of factual conversational statements. At the other end of the continuum, sophisticated, wearable microcomputer-based devices have been used to assist individuals with learning disabilities as they completed complex vocational tasks (Cavalier & Ferretti, 1993).

The majority of cognitive orthotic research was done with either geriatric individuals exhibiting dementia, or with individuals who have suffered brain injuries. It is intriguing to postulate that the same techniques may generalize to a population with mental retardation because the groups often appear similar. For example, individuals with mental retardation and individuals with traumatic brain injuries often have poor memory skills. Intelligence tests often yield similar full-scale scores.

However, these groups are often distinctly different. Individuals with mental retardation often show an impairment of skills across many areas frequently thought to comprise "intelligence," whereas individuals with dementia or traumatic brain injuries may continue to exhibit areas of residual strength. The extent to which these residually high areas assist individuals with dementia or traumatic brain injuries as they complete complex tasks is unknown. However, sufficient similarity exists that examination is warranted.

For persons with head injuries, technological innovations have evolved to the point where the "therapeutic environment" is provided by microcomputer-based devices. Several authors suggest that such devices might be used to replace or enhance poorly functioning memory skills (Cole & Bergman, 1987; Levine, Kirsch, Fellon-Krueger, & Jaros, 1984; Parente, Stapleton, & Wheatley, 1991). In this capacity, the computer was seen as the cognitive analog to an orthopedic prosthetic or orthotic. Prosthetics are artificial devices used to replace a missing part of the body (Biology Online.org, 2005), and are often associated with orthopedics. They constitute a class of devices that replace, rather than attempt to rehabilitate, a missing or faulty limb. This term is closely related to "orthotic" which is a support for a limb (Advanced Orthotic Designs, Inc., 2004). Several authors began referring to these aides as "cognitive orthotics" (Kirsch, Levine, Fellon-Krueger, & Jaros, 1987; Parente et al., 1991). An orthotic or prosthetic approach may be more effective than attempting to train or retrain an already dysfunctional memory (Wagner, 1986). This could be achieved by restructuring features of an individual's environment to facilitate the completion of complex tasks.

This review will first clarify some of the nomenclature related to cognitive orthotics. It will then discuss a range of devices that have been used as cognitive "orthotics," and a summary of the associated research will be briefly discussed. The history of cognitive orthotics, from simple non-electronic approaches to sophisticated microcomputer-based devices, will then be explained. Finally, efficacy studies will be described. Many of the devices used in these studies contain features that may be important to the development of effective cognitive orthotics for persons with mental retardation, and these will be highlighted.

Nomenclature

The "cognitive orthotic" term describes a divergent set of devices with an equally divergent set of names. No specific nomenclature has been developed in this emerging field, and the literature contains several other terms for essentially the same process, including "Cognitive Prosthetic" (Calvanio, Levine, & Petrone, 1993; Lynch, 1990; Parente & Stapleton, 1993), "Interactive Task Guidance" (Kirsch, Levine, Lajiness-O'Neill, & Schnyder, 1992), "Task Guidance System" (Levine, Borenstein, Raschke, Pilutti, Koren, BeMent, & Kirsch, 1989), "Cognitive Orthotic Shell" (Napper & Narayan, 1994), and " Computer Aided Visual Communication System" (Steele, Weinrich, & Carlson, 1989). All of these devices provide stimuli designed to cue an individual with a disability through the steps of a complex task. For the purposes of this paper, the term "cognitive orthotic" will be used to describe this class of microcomputer controlled assistive devices.

Cognitive Orthotic Usage

Cognitive orthotics are relatively new to the field of mental retardation. Most have been used with people who have acquired memory problems resulting from traumatic brain injuries (Bergman, 1991a, 1991b), dementia in elderly people (Bourgeois, 1990; Hoerster et al., 2001; McPherson et al., 2001; Wagner, 1986), stroke (Calvanio et al., 1993), severe learning disability (Cavalier & Ferretti, 1993), and aphasia (Chute, Conn, DiPasquale, & Hoag, 1988).

To date, most cognitive orthotics have been used to cue individuals with traumatic brain injuries through complex tasks. They have been deemed most appropriate for individuals who do not respond well to instruction, or for those who respond too slowly (Kirsch et al., 1992). Cognitive orthotics have also been used as a bridging technique until learning could occur, or as an evaluative device used to determine an appropriate amount of environmental cueing.

Examples of Cognitive Orthotics

A cognitive orthotic, developed on a Macintosh computer, was used to guide an individual with aphasia through a cooking task (Steele et al., 1989). It cued the preparation of a commercial box of food mix through a series of animated icons, which were used to circumvent the user's inability to comprehend written materials. The icons represented ingredients, equipment, and specific actions. The animated features of some of the icons, such as a hand turning one of the knobs on a stove, assisted in making the icons more salient. The orthotic was found to be effective in helping the user prepare six different commercial box mixes.

One woman with a traumatic brain injury was assisted through a cooking task (Kirsch et al., 1987). The cognitive orthotic was a microcomputer using a proprietary software program named COGORTH (from COGnitive ORTHosis). The author first broke the tasks of baking cookies and preparing icing into a series of steps. Then the orthotic was programmed to present the series. A single subject ABA study evaluated the efficacy of the orthotic. This experimental design alternated two conditions. In the "A" conditions, the subject was allowed to complete the recipes with the following assistance from a human supervisor:

(a) The subject was first oriented to the kitchen.

(b) Directions for the task were reviewed orally.

(c) Written directions were provided.

(d) An index card was provided which outlined the activity.

During the "B" conditions, the subjects received assistance from the cognitive orthotic. Although not well described by the authors, the orthotic displayed the steps of the task, in text form, on the monitor. The orthotic also provided timing when appropriate. The authors found that errors were significantly higher in both "A" conditions.

Another individual, who suffered from a head injury, was assisted in managing her finances (Bergman, 1998). The orthotic consisted of a microcomputer software application that provided a series of aides, such as an appointment reminder system, a simplified text writer, and a simplified system that allowed the user to organize finances and print checks. The software was similar to that seen in commercial software. However, modifications were made that rendered the software more useable by individuals with head injuries. For example, the appointment book provided advance notice of an appointment. It also provided repeated reminders.

Prior to using this system, the individual used a commercially available finance program that she believed was the simplest available, but was unable to effectively use it. The orthotic proved successful to the extent that the woman used it to effectively manage her money for 11 years.

Another individual with a brain injury was assisted in word processing (Bergman, 1991a). The adapted word processing software was designed to assist the user in turning on the hardware, entering the text writer program, maintaining awareness of the purpose and content of the writing, typing and making corrections, loading the printer with paper, printing and removing the printed copy, and exiting the text writer program. Following training, the subject was noted to use the device frequently and effectively.

Two students with severe learning disabilities were assisted in wiring switch boxes (Cavalier & Ferretti, 1993). This study used a dedicated microprocessor unit which was worn on the subjects' belts. Instructions were provided to the user via speech output.

The students were initially trained by the teacher. They were first taught to identify the different components of the wiring task. The teacher then taught them to perform the 17 steps that comprised the switch box assembly. Training continued, using the system of least prompts, until each subject could perform each of the 17 component steps independently (even though he or she could not necessarily complete the entire sequence of 17 steps independently).

During the second phase, the cognitive orthotic was used to maintain performance in completing the entire task by orally prompting each step of the task. When a student correctly responded to a step, the orthotic replied by presenting the next step. Feedback to the orthotic was supplied either electronically, via switch closures within the circuit being worked on, or via input from a human observer. If a step (occasioned by the orthotic's oral prompt) was completed incorrectly, the step was demonstrated and/or physically prompted by a human assistant.

Results showed that the cognitive orthotic was effective in increasing subject independence and accuracy. During the orthotic-lead condition, subject one correctly performed 11% of the steps independently, and successfully completed all of the remaining steps with only the verbal cue supplied by the orthotic. Subject two independently completed 19% of the steps independently. All of the other steps were successfully completed with only the verbal cues supplied by the orthotic.

A cognitive orthotic can also remind the user when to engage in an activity. For example, the NeuroPage system utilized a standard paging network to remind the user of important activities (Hersch & Treadgold, 1994). A palmtop computer was also used to increase the time management skills of head injured patients (Kim, Burke, Dowds, & George, 1999). This study simply used the calendar function of a standard palmtop computer to improve the punctuality, of an individual with a head injury, in attending therapy sessions. It used the same device to prompt medication compliance. From the first day of the study, the subject arrived punctually, at all appointments, without cues from the staff. Similarly, from the first day of the study, the subject independently asked for all of his medications on schedule.

Wright, Rogers, Hall, Wilson, Evans, Emslie, & Bartram, (2001) also examined the utility of a small hand-held computer as a cognitive orthotic. However, this study employed proprietary cognitive orthotic software designed for individuals with head injuries. It included an appointment book and a notebook. A second study (Wright, Rogers, Hall, Wilson, Evans, & Emslie, 2001) extended the proprietary cognitive orthotic software to include a "to do" list. Apparently, the same subjects were used in both studies. The authors found that all subjects learned to use the hardware and software, and actually chose to use them. However, no data were supplied demonstrating efficacy in improving real-life performance.

Aside from the improvement in task completion, Cognitive orthotics may improve the quality of life for users. However, little actual research has been conducted examining these secondary benefits. Most suggestions were the result of secondary observations. For example, Bergman & Kemmerer, (1991) observed the reactions of a subject using a computerized cognitive orthotic that assisted her in writing text documents. This orthotic assisted her in writing a variety of documents including:

(a) "to do" lists

(b) Lists of things to purchase

(c) Lists of things to remember

(d) Written instructions to her companion

(e) Requests for her companion

(f) Notes of telephone conversations

(g) Letters and essays about her feelings

Several emotional benefits were noted, including:

(a) lowered frustration,

(b) improved emotional lability,

(c) the ability to regain "emotional equanimity" more easily,

(d) reduced cognitive strain, and

(e) improved concentration.

Applications such as these may result in a user who appears noticeably calmer. In addition, they suggest that use of an orthotic might result in an individual who feels empowered. Computer enhanced self-sufficiency in the performance of routine activities may improve user self-esteem, mood and emotional adjustment (Bergman & Kemmerer, 1991; Harris, 1978). It can lessen frustration and provide a sense of mastery and self-control (Matthews, Hartley, & Malec, 1991).

History of Cognitive Orthotics

Early Uses

The notion of improving performance through the restructuring of the environment has been researched for many years. Lindsley (1964) examined the use of cognitive prosthetics with geriatric individuals. He noted the existence of a variety of prosthetic aids for geriatric individuals such as eye glasses, hearing aides, and dentures. Expanding this notion into the cognitive area, Lindsey suggests that we can engineer the environment to make it less debilitating. Fowler, Hart, and Sheehan (1972) described the development of a "prosthetic memory" for a 28 year old man who had suffered a head trauma as a result of an automobile accident. Following rehabilitation, he remained unable to transition from one activity to another, but, would engage in random behaviors, such as wandering aimlessly. The authors supplied the man with a written schedule and an audible timer. At the end of an activity, the timer cued the user to refer to the schedule, which directed him to the next activity. Not only was this procedure effective in eliciting appropriate transitioning behavior, but the man spontaneously and independently applied the technique to construct new schedules. Similarly, Jones and Adam (1979) discussed the notion of using a tape recorder to guide an individual through a task. They also suggested that a microprocessor might control its operation and invoke other functions. For example, hitting a "panic button" would provide the user with crucial orienting information such as the day and time, the location, and the task currently being worked on.

Calkins (1988) described the design of assisted living environments for persons with Alzheimer's disease. She noted that simple alterations, such as displaying personally familiar objects or photographs at the door to an individual's room, could facilitate memory recall.

Simple Non-Electronic Devices

Non-electronic cognitive "prosthetics" have been successfully used with a variety of individuals. Several studies have examined the efficacy of memory aids on geriatric individuals suffering from dementia. Four studies used a "memory aid," in the form of pictures and/or written sentences, to assist geriatric individuals, suffering from dementia, as they conversed with a partner (Bourgeois, 1990, 1993; Hoerster et al., 2001; McPherson et al., 2001). The memory books contained a list of facts that was relevant for each speaker, and were constructed by soliciting input generally from family members. In addition, the sentences also included specific information that the individual was having difficulty remembering. All studies showed that individuals using these memory devices exhibited increased statements of fact and fewer ambiguous utterances.

Environmental modifications can take many different forms. Following a right hemisphere stroke, a patient was no longer able to perceive objects on the left side of her visual field. A rotating food dish was developed, and the subject was to be trained to rotate the dish, as she ate, to bring food objects on the left side of the plate into view. However, it was discovered that just the regular contact of the subject's fork with the dish caused it to rotate sufficiently that all food was eventually discovered (Calvanio, et al., 1993).

In another experiment, a series of descriptive pictures was used to guide individuals with multiple disabilities through a variety of tasks (Roberson, et al., 1992). Subjects in this study included students with moderate and severe intellectual disabilities. The picture series was first developed via analysis, to identify the task's critical steps. The size of each step, and the number of steps, was customized to each individual. The steps were ordered into a logical sequence, and presented via foreword or backward chains. Examples of tasks included cooking, grooming and grocery shopping.

Several authors have noted that cognitive "prosthetics" were successfully used in everyday life by almost everyone, with or without disabilities. Writing prosthetics include spell checkers, word predictors, talking word processors, and an electronic thesaurus

(Edyburn & Gardner, 1999). Additionally, warning bells and instrument lights on cars direct drivers to attend to important matters (Herrmann & Petro, 1990). Colored key jackets, cueing cards and appointment calendars help to identify important objects, information and events (Parente & Stapleton, 1993).

Early Microprocessor-Based Cognitive Orthotic Systems

In 1979, a paper by Jones and Adam anticipated the relatively recent development of the microprocessor. They anticipated the potential that this emerging technology could have in controlling a cognitive prosthetic.

Several features contributed to the functionality of early microcomputer-based cognitive orthotics, including their capacity to detect errors, branch on the basis of a correct or incorrect response, interrupt tasks for higher priority ones, and operate other devices in the environment (Levine & Kirsch, 1985). The ability to detect errors is especially important. If a user deviates from a routine at any point, the entire chain of behaviors may be rendered useless. For example, a cake will be ruined if an essential ingredient is omitted, even though the rest of the preparatory steps were correctly performed. Early cognitive orthotics relied on single switch or keyboard inputs to signal step completion. However, they lacked reliable verification. For example, a microcomputer using the proprietary COGORTH cognitive orthotic software was developed to assist a head injured individual through a vocational task (Kirsch et al., 1992). At the end of each step, the user was simply instructed to "Press the letter C to continue." More sophisticated systems used techniques to decrease errors. For example, after taking medication, a user might be required to enter the number of pills remaining in a pill bottle. If the orthotic knew the number of pills in the bottle previously, it could determine whether the correct number of pills had been taken. If not, some type of remedial action could be initiated (Levine & Kirsch, 1985). Error checking was further improved via more sophisticated input hardware located either in the environment or strategically attached to key components of a task. These enabled the orthotic to accurately monitor either the user's location or accuracy. For example during the wiring of a switch box by individuals with severe learning disabilities, certain electronic switches in the box were closed. These closures produced electronic feedback to a proprietary microprocessor-based cognitive orthotic indicating that a particular step in the task had been performed correctly (Cavalier & Ferretti, 1993).

An orthotic might also differentially respond based on user performance. This may be necessary to correct errors or to limit the amount of time spent on a step. For example, a wearable computer was developed that differentially responded to the wearer depending on his or her location (Friedman, 1993). The device relied upon small transponders, located at strategic points in the environment, to provide location feedback. The computer prompted the user through a pre-programmed schedule, using the transponder information to verify that the user was in the proper location at each step. If not, the computer provided speech feedback to redirect the user to the proper location.

It may also be necessary to interrupt a task for one with a higher priority. Interruptions may be either of two types: absolute or relative (Levine & Kirsch, 1985). Absolute interruptions occur at regular intervals. For example, Kim et al. (1999), used a microcomputer to prompt an individual with a head injury to attend therapy sessions or to take medication at fixed times.

Relative interruptions occur only in relation to certain tasks. For example, Kirsch et al. (1987) used a microcomputer-based cognitive orthotic to assist a brain injured woman as she completed two simultaneous cooking tasks: baking cookies and preparing icing. The computer presented a series of text-based prompts. The prompts differed little from a written set of instructions. However, it did have the ability to time events. In this case it recorded the amount of time that the cookies were in the oven. The orthotic was pre-programmed, ostensibly by the researchers, to time the exact interval needed to bake the cookies. A relative interruption would occur when, while preparing the icing, it became necessary to remove the cookies from the oven.

Finally, orthotics may need to operate other devices within the environment. For example, Friedman, (1993) discussed the development of a microprocessor-based, wearable, cognitive orthotic. This device responded to transponders located in the environment which provided feedback on the orthotic's location. The orthotic was able to provide vocal prompts to the user based on the location of the user in relation to the task at hand. If the user strayed from the appropriate area the orthotic would prompt the user to return. If this was unsuccessful, the orthotic had the capability of radioing an automatic telephone dialer so that a supervisor could be informed.

An example of a system using these features is the COGORTH system (Levine & Kirsch, 1985). COGORTH is a programming language that was developed by a research team (Levine & Kirsch) in the early 1980's. The program was run on a standard DOS-based microcomputer. A supervisor used this authoring language to create the cognitive orthotic's task steps.

The program's authors viewed tasks as constructed of "processes," "stages" and "options." A complex task was divided into several processes. For example, the task of writing this chapter could be divided into the three processes of outlining, writing, and revising. Each process was further broken into stages, or individual components. There are several available behavioral options within each stage. The function of the COGORTH system was to guide the user through the behavioral options needed to complete the stages and processes.

The COGORTH programming language was used in several studies to examine the efficacy of the software and hardware to assist individuals, with head injuries, as they completed baking tasks (Kirsch, Levine, Lajiness, Mossaro, Schneider, & Donders, 1988; Levine et al., 1984), janitorial tasks (Kirsch et al., 1988; Kirsch, et al., 1992), and regulated incontinence (Kirsch et al., 1988).

Users differed and, regardless of the hardware or software used, it was important that the orthotic be customized to meet individual needs. Several program features needed to be modified including: system startup, menu structure, menu content, screen layout, screen complexity, keyboard layout, the number of functions available to the user, the amount of guidance provided, and whether audio and/or visual cues are used (Lynch, 1990). Over 100 modifications to a particular application may have been necessary before the orthotic became maximally effective (Cole, Dehdashti, Petti, & Angert, 1993).

Advanced Devices

Several improvements were made to the earliest cognitive orthotics. First, early systems ran on a standard desktop microcomputer, making portability an issue. However, technological advances led to computers were that could easily be worn (Cavalier & Ferretti, 1993; Friedman, 1993). Second, specialized input devices located in the environment replaced user input in some devices as a way of signaling completion of a task. Finally, output was improved. Initially, a user had to read text on a computer monitor to understand the prompts, and the only sound available was a crude series of beeps and tones (Kirsch et al., 1992). Later applications featured speech output (Napper & Narayan, 1994).

In 1989 (Levine et al.), a mobile robot system was developed to act as a base for a microcomputer-based cognitive orthotic. The robotic base (a Denning 1W Mobile Robot) was programmed to guide the user to specific locations and prompt the individual to perform complex tasks. The robotic base featured an infrared positioning beacon system, a remote radio link, and ultrasonic sensors to locate obstacles in the environment. The robot was capable of following a programmed path. Hardware and software allowed it to avoid obstacles. The robot was also capable of forming a wireless link with the user. Thus, it was able to determine whether the user was staying close to it.

Efficacy Research

Microprocessor-based cognitive orthotics seem to offer several advantages over other types of cognitive orthotics. Several studies were conducted with these devices, using the features noted above, as well as with several other important features. These important features, as well as the research on their efficacy, will be discussed below.

Taken as a whole, the research suggests that computerized cognitive orthotics might be effective with individuals having mental retardation. However, none of these studies produced compelling evidence. Many of the studies were conducted over five years ago. The technology at that time was much less powerful in terms of memory, processing power, input options, and audio and video output. This could potentially have limited its effectiveness compared to the technology available today. Aside from using different subject populations, the type of methodology used also limited the generalization of the results. Many of the studies were simply case studies, often with a single subject. Descriptions of the computerized cognitive orthotics were often vague. Little attempt was made to experimentally examine the features of the orthotic. Finally, there was little attempt to replicate the experiments or to validate the results of the previous studies.

Cognitive Orthotic Control of Cues vs. Written Directions

Superficially, some microprocessor-based cognitive orthotics may not appear appreciably different from more conventional cuing systems. However, several studies suggested the efficacy of the cognitive orthotics over written directions. Many of these early studies used cognitive orthotics based on microcomputers. However, at the time, computer output was limited. Visual output was limited to written text on the computer monitor. Audible output was limited to beeps and tones. Thus, it appeared that the cognitive orthotic did not offer significantly more guidance than did prompts written on paper. However, the computerized cognitive orthotics did allow some timing functions as well as the ability to change to the proper stimulus screen, thereby avoiding page turning errors made possible by traditional written directions. The utility of the devices seemed supported by the research, as follows.

Expanding on their earlier work demonstrating efficacy with a single subject, Kirsch et al. (1992) examined the effectiveness of an orthotic to assist four head-injured individuals as they completed janitorial tasks associated with cleaning a bathroom, and a waiting room, at a university clinic. Although complete psychometric information was not reported on any of the subjects, data showed that all four subjects showed full-scale IQ scores in the range of 66 to 74. Reading achievement scores were not given, but the assumption was made that all four individuals had some ability to read written directions. All four resided in long-term treatment facilities and all were judged to have difficulty completing complex tasks.

Three subjects underwent a single subject ABABA design. One subject was unable to complete the entire experiment, and completed only an ABA design. The "A" condition used a written set of prompts, while the "B" condition used the cognitive orthotic. The cognitive orthotic was a microcomputer using the GOGORTH authoring program. The cognitive orthotic used text output, which was displayed on the computer's monitor. In addition, audible alerts, presumably beeps or tones, were used to signal the user to reorient to the device.

Two subjects showed significant improvements in accuracy when using the orthotic; however performance deteriorated each time written directions (written on paper) were used. One subject failed to show consistent performance over successive trials using the orthotic, and one showed no difference.

This study used subjects exhibiting intelligence test scores in the mentally retarded, to low average range. However, subject performance across all of the intelligence tests' subtests was not provided. The subjects showed reading skills above those seen in individuals with cognitive impairments.

Two of the four subjects showed performance suggesting that the orthotic was effective. Given that both the written directions and the orthotic's output were text based, it seems likely that the improvement in performance was due to the task analysis and structured presentation of stimuli. No subject showed perfect performance using the orthotic. This would support the assertion made by several authors that several iterations of design and modification of several features of the orthotic may be necessary for optimum performance (Bergman, 1991a; Chute & Bliss, 1994; Chute et al., 1988; Cole, 1999; Cole et al., 1993).

Several factors weaken the researchers' conclusions. As noted above, the complete profiles of the subjects were not given. Although full-scale scores were at approximately a level indicative of mental retardation, it is still questionable to what extent these individuals showed overall performance similar to an individual with mental retardation. The authors themselves caution extrapolation of the results to individuals with differing psychological profiles. They state "…careful consideration must be given to the range and severity of cognitive deficits that the patient experiences, because these may be pervasive or severe enough to preclude any benefit" (Page 23). However, little attempt was made to examine how differing profiles affected performance.

Of the seven subjects that began the study, three dropped out sufficiently early so that no data could be reported. One subject dropped out due to transportation difficulties. The other two dropped out due to dissatisfaction with the janitorial task

Two of the remaining four subjects appeared to profit from the computerized cognitive orthotic, while one did not. The fourth began by showing a positive response. However, her response changed during the course of the study. The authors suggest motivational reasons for the change. It appears that the study suffered from some experimental control as far as the subjects were concerned.

Finally, there was not a great deal of attempt made to control potentially important variables related to the computerized cognitive orthotic itself. The authors note that the task steps were presented one by one, while the written directions were presented as a single list. It is difficult to conclude whether the improved performance, of the two subjects who showed improved performance, was due to the stated benefits of the computerized cognitive orthotic.

Other studies examined the effects of a cognitive orthotic on self-care and other adaptive behavior skills of head injured patients. One used an ABA design in which written directions, consisting of a set of index cards arranged in a binder, were compared to an orthotic in the context of a complex cooking task (Kirsch et al., 1988). In this case the cognitive orthotic was a microcomputer, again using the COGORTH software system.

In many ways the cognitive orthotic mirrored the cards. One step was written on each card. Following the direction written on the card, the subject was cued, again via a written prompt on that card, to turn to the next. One of the steps in the cooking task (preparing applesauce muffins) required the subject to time the baking process. This was accomplished by prompting the subject to set a timer.

The orthotic also provided cooking step prompts, in text form, which were displayed on the computer's monitor. In addition, the orthotic's monitor also displayed text that prompted the user to advance to the next step. The orthotic's user "flipped the card" by pressing a key on the keyboard. Thus, the two cuing systems were very similar.

However, the orthotic did have a timer built into the software. Thus, the orthotic was able to handle the timing process rather than relegating it to the subject.

During the first (index card direction) phase, the subject made many errors. Errors dropped significantly during the second, orthotic directed, condition. After completing the first orthotic directed phase, the subject showed better performance when returning to the index cards during the third phase. During the fourth phase the subject was allowed to complete the task without assistance from the index cards or the orthotic. Performance again deteriorated dramatically. However, performance again improved during the final, index card directed, condition.

The authors suggested that the orthotic facilitated learning, allowing the subject to maintain task accuracy with the help of only index cards. However, they also considered the possibility that the subject became more proficient as a result of practice. Thus, the cognitive orthotic directions may have been superfluous to the improvement. In addition, it is impossible to generalize the results of the study because it employed only one subject. The authors describe this subject as having suffered a "mental decline" as the result of anoxia associated with an accident. However, little further information was presented which would have allowed a comparison of cognitive performance with that of a person having moderate mental retardation.

Audible Timers

One advantage of the early microcomputer-based cognitive orthotics over written directions was their ability to measure time. One study did use a standard timer in conjunction with written directions (Fowler et al., 1972), and the combination was found successful in prompting the user to initiate activities. This success may have been due, at least in part, to that audible timer's ability to attract the user's attention to the written cues. It is unlikely that all users would possess the skills needed to independently and accurately set the timer for the next interval. Here, the computer's ability to set the timed interval automatically may offer another degree of usefulness.

A cognitive orthotic was used to remediate a head-injured patient's incontinence (Kirsch et al., 1988). The cognitive orthotic in this study was a microcomputer placed at the subject's bedside. Every two hours it signaled the patient audibly, and via text information on the computer monitor, and the patient was directed to use the urinal. Following the use of the urinal, the subject pressed a key, and the computer began counting another two hour interval. The patient's incontinence immediately ceased. After four days, the system was discontinued and the patient maintained his performance.

While this is a simple application of the technology, it is unclear whether the computerized orthotic was of more benefit than a less technical approach. The authors describe no previous attempt to train the subject to initiate urination in a toilet. It is possible that the subject could have been told to use the bathroom when a conventional timer sounded, and then to reset it when finished. The study also lacks generalization because it utilized only a single subject. The authors again provide little information about his cognitive performance other than to state that he showed a "mental decline."

Speech Output

Early cognitive orthotics relied on text cues. Audible cues consisted of beeps or tones, and were generally used to simply orient the user to the text output. Later, however, hardware and software innovations extended the audio capability of cognitive orthotics to include spoken cues.

A cognitive orthotic was used to improve the shaving skills of a head injured man (Napper & Narayan, 1994). The study utilized a microcomputer with a software program developed to allow caregivers to author task guidance systems. Computer output consisted of text and synthesized speech. Input was from a single switch operated by the subject.

Baseline data were taken via video and audio recordings. Data were taken on several variables including: total time spent on the shaving task, the total number of cues that needed to be presented by an attendant, the duration of time during which the attendant needed to be present, the number of physical interventions presented by the attendant, and the number of shaving errors (the definition of which was unclear). In addition, several other variables were studied including: the total number of cues from the cognitive orthotic, the time required to analyze the shaving task and enter the instructions into the cognitive orthotic, and the degree to which the patient accepted the system.

The results, also obtained via video and audio recordings, revealed that the number of subtasks needed to complete the shaving task decreased while using the orthotic. Both the number of cues needed from the attendant and from the cognitive orthotic dropped as a function of time. The duration of the time in which the attendant was needed also dropped. There was no need for physical intervention from the attendant while the orthotic was being used. The number of errors made by the patient dropped to none. Finally, the total time spent shaving each day dropped as a result of using the orthotic.

Although this study suggests that the orthotic was successful in making the patient independent, there was little quantification or specification of the variables themselves. The author explained that the orthotic used text output on the computer screen as well as synthesized speech. However, there was really no specification of exactly what prompts were used, nor was there an analysis of the shaving task itself. In addition, the criteria for successfully shaving at each step were not identified.

This study was, again, limited due to its use of only a single subject. In addition, the subject's cognitive characteristics are again unknown. The authors note that the subject received a severe traumatic brain injury as the result of a car accident that reportedly left him with "severe cognitive deficits" that "interfered with his independence in activities of daily living" (Page 424). However, little additional information is provided.

The study also used synthesized speech output. The authors state that the particular synthesizer was used because it rendered the best audio output. However, the author provides no information regarding the intelligibility of the audio to the subject.

Animated Graphic Output

Early cognitive orthotics were generally limited to text output. Later, as storage capacities increased and output systems became capable of displaying higher resolutions, graphic output became possible. Pictorial cuing systems showed promise though to cue individuals through complex tasks (Roberson et al., 1992). However, animation may extend this utility.

The use of a cognitive orthotic, using animated or graphic output, was studied with an aphasic individual who could not follow written directions of any kind (Steele et al., 1989). This individual sustained a head injury as the result of a motorcycle accident, and was subsequently required to undergo a partial frontal lobectomy. Consequently, he performed in approximately the seventh percentile on a test of verbal ability. He showed minimal oral or written expressive skills, and no comprehension of written material.

An orthotic system was developed on a Macintosh computer system. This orthotic was termed the "Computer-Aided Visual Communication (C-VIC) system. It did not use text or auditory output, but instead a series of dynamic, animated icons and pictographs.

The orthotic was used to assist in the preparation of six different commercial box food mixes, of varying in complexity. Fourteen trials were run with the subject, using the six different recipes. The subject accurately prepared the food during 11 of the 14 trials. He was able to correctly follow the procedures for several different recipes. He added all necessary ingredients, and he added them in appropriate amounts, and the foods were cooked at the proper temperatures.

Some system weaknesses were noted by the authors. If procedural deviations occurred that differed from the user's expectations, he had a tendency to ignore them. He also tended to ignore incomprehensible directions. The authors found that, at times, the subject needed to see a more global representation of the task because all of the individual steps made the task too difficult for him

The orthotic used only visual output to assist the user. It was the only orthotic found that used animation. It is unknown whether pictures and animation could cue a cognitively impaired individual, with little or no functional reading skills, through a complex task. It is possible that they may be too abstract. The line art pictures and icons used for this study would add to this degree of abstraction. However, actual photographs or very short video clips might make the cue concrete enough to occasion the proper response.

Generalization is again affected by the study's use of only a single subject. The authors state that he was aphasic, and they offer some quantification of his verbal skills. However, they also fail to provide a complete psychometric profile which makes it impossible to compare him to individuals with mental retardation.

Portability

Most studies used orthotics controlled by a microcomputer. This certainly imposed some limitations due to its size. The limitation would have been addressed through the use of a portable computer such as that used in the Napper and Narayan (1994) study. However, size would still pose a limiting factor for many applications. A further reduction in size, and potential improvement in portability, may possibly be achieved through the use of hand-held computers.

Hand-held computers have become ubiquitous. As the name implies, these are microcomputer-based devices that are literally capable of being held in the palm of one's hand. Processor speeds and storage capacities of these devices rival the capabilities of desktop computers considered state of the art only a short time ago. Aside from visual output, via a small screen, these devices are capable of auditory output. Sufficient memory is available that digitized speech, high resolution graphics, animations, and short video clips are all possible. Input is generally achieved via a touch sensitive screen which is activated by a small stylus. Battery power obviates the limitations imposed by an electrical cord.

These devices usually offer several types of built-in software, including a date book, a "to do" list, and a phone/contact directory. These features constitute cognitive orthotics themselves, and they are utilized by many people with and without disabilities every day. The devices are capable of running third party software. Thus, they will run specialized software used to create customized cognitive orthotics.

Several studies utilized hand held computers (Wright et al., 2001a, 2001b). Two different devices were used. The first was a Hewlett Packard HP 360 LX hand-held computer, featuring a separate keyboard. The second was a Casio E10 hand-held computer. This device differed from the first in that an on-screen keyboard was used to enter information. The devices were considerably smaller than the microcomputer-based machines, and had screens measuring 154 cm X 62 Cm for the Hewlett Packard, and 80 cm X 60 cm for the Casio. Both used proprietary interfaces containing a diary, notebook, and "to do" list.

Twelve individuals served as subjects. Nine were described as having suffered traumatic brain injuries. Two suffered a subarachnoid hemorrhage that often results in performance similar to that seen in head injured individuals (Kazzi & Ellis, 2003). The etiology of one was not described.

The specific cognitive skills of the subjects were not described. However, from the complexity of the tasks completed by them, it is assumed that they were functioning approximately in the average range of intelligence.

On a ten point Likert-type scale, with ten being the most useful, seven of the ten subjects rated the personal usefulness of at least one of the devices as seven or higher. All subjects successfully demonstrated how to use all features of the orthotic. Slightly more satisfaction, across all of the main features, was expressed for the computer that used the external keyboard over the one that used the on-screen keyboard. However, it is impossible to say that this was the feature that caused the preference. The preferred computer also had a larger screen. All that can be concluded is that the computer with the separate keyboard and the larger screen had higher ratings for "ease of text entry" and "overall ease of use." Unfortunately, the authors did not investigate this further.

The second study was similar to the first. It utilized twelve subjects, all of whom had suffered closed head injuries. Pre-morbid IQ scores were all in the average to above average ranges of intelligence (averages of 91 to 115).

All subjects were allowed to use each of the two orthotics mentioned above. All demonstrated the ability to use all of the features on both orthotics. On a Likert-type scale of one to ten, with ten being the most useful, the average report of the usefulness of the devices was 7.6, compared to 4.8 for a standard notebook computer. The subjects in this study showed more of a preference for the computer without the keyboard when asked to rate "ease of text entry" and "overall ease of use." The authors suggested that low frequency users were put off by the computer with the physical keyboard while those who tended to enter more text found it more useful.

These studies primarily examined the extent to which users tended to use the two devices, and how various features of the devices affected use. User attitudes and preferences were also studied. However, the studies did not attempt to evaluate the effectiveness of the devices in assisting these individuals. The specifics of the orthotic software were not articulated, nor was there any attempt to assess just how the software was used. It is unknown whether the cognitive orthotic made the subjects more functional or independent.

Kim et al. (1999) used the alarm function of a palmtop computer to increase the ability of a head injured individual to attend therapy sessions and request his medication according to schedule. In this study the palmtop computer was a Psion Series 3a, manufactured by Psion LLC of London. The cognitive orthotic was simply the alarm function built into the device. Following introduction of the device, the subject immediately began attending every therapy session on time. He also immediately began asking for appropriate medications on schedule.

The authors stated that the subject first attempted to use a memory book for information on orientation and scheduled appointments, but found the system ineffective. The memory book was not described. However, it is assumed that it was simply a written compilation of information that could be referred to when needed. This device was then replaced by the computerized orthotic, and the subject showed greatly improved performance. The most significant difference between the computerized cognitive orthotic and the memory book was that the former had an audible signal to orient the user to the information. The computerized orthotic may have functioned simply as a high tech timer.

Again, the study was only a single subject case study. The subject showed intelligence test scores in the mentally retarded range. However, the subject could apparently read, so he apparently showed overall performance different from that of a person with moderate mental retardation.

One study examined the effects of a cognitive orthotic on two high school students with severe learning disabilities. One student exhibited a full-scale intelligence score of 80, while the other showed 85. Both had significant academic achievement deficits.

The subjects were taught to wire an electrical switch box first with the assistance of a human supervisor, and then with the aid of an orthotic (Cavalier & Ferretti, 1993). The task was relatively complex, composed of 47 steps.

The supervisor first taught the subjects to wire the boxes using the System of Least Prompts. Under this procedure, a subject was first allowed to complete each step in the task independently. If an error occurred, the student was given a verbal prompt. If this prompt was not successful, the step was modeled by the teacher. If the model was not sufficient, the student was physically prompted to correctly perform the step. Thus, the minimally intrusive prompt, or series of prompts, was used to correct student performance.

In the second phase, the orthotic guided the student's performance. The orthotic was a portable, proprietary, microprocessor-based device developed by AugmenTec, Inc. of Pittsburg, Pennsylvania. It consisted of a belt-worn microprocessor unit that contained a miniature radio transmitter, ultrasonic sensors, and speech output. According to the authors, the device was able to:

(a) guide the user to specific locations,

(b) cue the user at predetermined times,

(c) orally instruct the user about the task step to be performed,

(d) remind the student about the goal of the task,

(e) in some situations, monitor the user's compliance with the prompts, and

(f) create an electronic record of the user's movements.

Monitoring was done via special interfaces that informed the orthotic whether or not a step had been performed correctly. For those steps in which this was not possible, an observer judged performance and provided feedback to the orthotic. If the student correctly completed the step, the orthotic orally prompted the student to begin the next step. If the step was incorrectly performed, the computer orally corrected the student. If the student failed to correct his or her performance after the computer's oral prompt, the teacher provided the model and, if necessary, the physical prompt.

During the teacher-led acquisition condition, the first subject self-initiated correct steps 6% of the time. Oral prompts were required 89% of the time, and modeling was required 4% of the time. During the maintenance condition, when the orthotic was used, the student self-initiated 11% of the steps. Oral prompts, from the orthotic, were required for the remaining 89% of the steps, and no teacher prompts were required.

During the acquisition condition, the second student self-initiated 13% of the steps. Oral prompts were required on 85% of the steps, and modeling was necessary for 2% of the steps. During the maintenance condition, the student self-initiated 19% of the steps, and needed oral prompts for the remaining 81% of the steps.

The study suggested that the orthotic could substitute for a human supervisor to maintain performance after the acquisition phase. It is interesting that modeling was not needed under the guidance from the cognitive orthotic. However, it is a stretch to attribute this only to the orthotic. Other variables, such as practice effects, might account for the performance.

This study was significant because it extended the range of orthotic users to include students with severe learning disabilities. It also utilized the orthotic in a slightly different way in that the device was used in the maintenance condition following training by a human supervisor. This study was unique in that a significant portion of the feedback to the cognitive orthotic was provided from transponders located in the environment. Feedback could also be obtained directly from the user's performance. For example, wiring a component of the switch box correctly resulted in a feedback signal being sent from the box to the cognitive orthotic. This is a valuable feature because it seems to add a degree of validity over the self-reporting that generated the orthotic's feedback in most other studies. However, the nature of the task lead to the orthotic's ability to receive direct feedback. It may be easier to derive electronic feedback in a task involving the wiring of an electronic device. It is doubtful that this degree of feedback could be achieved in many tasks.

Generalization of the results is again hindered by the small set of subjects. They also appeared to function higher than moderately cognitively impaired individuals. In addition, it is very difficult to understand the nature of the task. The authors explained that the task involved wiring an electronic device. However, it is unknown how complex the task is, or specifically what the subjects were required to do to wire the device.

Subject Acceptance of Cognitive Orthotics

A follow-up study examined the efficacy of a cognitive orthotic to assist twelve subjects, who suffered brain injuries, up to four years after the device was introduced (Kim et al., 2000). Nine of the subjects considered the orthotics to be useful during the initial supervised usage trials. More interesting is the report that seven of the nine continued to use the orthotics independently after the usage trials. It was disappointing that no data were provided regarding the length of time that the seven continuing users had been using the device, nor is there a great deal of information relative to the efficacy of the devices.

Another case study reported the success of a head injured woman in using a cognitive orthotic for eleven years (Bergman, 1998). Development of the orthotic initially began in 1988 (Bergman, 1991b). It was developed for a woman with a doctoral degree who sustained a head injury as the result of a motor vehicle accident in 1984.

Following rehabilitation the woman exhibited many memory and attention deficits.

This woman's cognitive orthotic was a microcomputer-based device. It contained an appointment scheduling feature and a text writer. The text writer was a simplified piece of software used to correspond with others, make notes, and gather data for important decisions. The software was developed via an iterative process in which modifications were made as the result of error analysis.

Bergman (1998) reported similar outcomes, after six years, for a head injured individual. This man used an orthotic to write checks and balance his checking account.

Generalization across cognitive orthotic tasks was reportedly facilitated by consistency of orthotic design features (Bergman, 2000). A microcomputer-based cognitive orthotic, featuring six activity modules, was initially developed. Modules included an electronic journal, directory of names, addresses and phone number database, telephone log, savings deposit/withdrawal organizer, check writing assistant, and appointment scheduler.

The six modules were constructed using a consistent interface. Although little elaboration of the software was reported, the author stated that it was developed based on principles from neuropsychology and learning theory. It reportedly facilitated error-free learning, ease of mastery of the system and the task, and rapid generalization. The device also facilitated active participation of the user.

The subjects included 41 individuals with documented traumatic brain injuries resulting from various etiologies. Each subject displayed difficulty with time management, money management, remembering, and the consistent and reliable completion of routine tasks. Each subject was initially trained to use the journal module. When proficient, another module was introduced. Of the 41 subjects, 36 achieved mastery of four or more modules. Mastery of successive modules was described as rapid.

The authors conclude that rapid mastery of successive modules was facilitated through consistency in interface design. They note that most subjects achieved the generalization with relative ease. However, the authors do describe some individual characteristics that may preclude successful generalization. Of particular interest to the present study was the author's contention that below-average general intellectual functioning may contraindicate success. However, it is important to note that the interface and tasks addressed were relatively sophisticated. It would be inappropriate to conclude that this contention would apply to all orthotics.

Summary

All of the studies involved the use of microcomputer-based cognitive orthotics to assist individuals, with some type of cognitive impairment, in completing complex tasks. The studies primarily examined the use of cognitive orthotics to assist individuals with head injuries. However one study extended the research to a subject with severe aphasia. Another was conducted with students having learning disabilities. All subjects shared the inability to complete a complex task. However, the etiology of each of their disabilities varied considerably, and so did the details of their cognitive performance.

Some individuals with head injuries showed overall intellectual skills in the mentally retarded range of intelligence, raising the question whether cognitive orthotics might also be effective with that population. However, many individuals with head injuries show residual skills that may have assisted them in profiting from the orthotic. For example, many of the subjects had relatively good reading skills. These individuals varied considerably in their pre-morbid cognitive skills. Therefore some may have had very good skills in some areas following their head injury. Individuals with mental retardation often have areas of relative strength and weakness. However, their profiles tended to be much more consistent.

Many of the studies discussed the imperfections of the orthotics used, and the need to improve these devices. Some described the development of their device as an iterative process. An examination of error patterns, and an adjustment based upon that analysis, was seen as important. There is every reason to believe that similar adjustment would need to be made when developing a cognitive orthotic for an individual with mental retardation.

Input methods varied across devices. Some consisted of only a switch. Others used a keyboard. More advanced systems, such as the palmtop devices, used miniaturized keyboards located on the device itself. Others used on-screen keyboards located on the palmtop device's miniature display. All types of input systems showed utility for the user. Miniaturized inputs were effectively used. This suggests that the improvements in portability provided by a miniature system need not necessarily be limited by difficulty in operating the system.

Output was often text, which was displayed on the computer's monitor. However, one system used dynamic icons. This departure from text output may have the potential to extend the usefulness of the device to users without functional reading skills. Animation also has the potential to convey essential information about a component of the task not possible with a static image. However, again, the possibility exists that this type of display would be too abstract for the user with a moderate cognitive impairment.

It was interesting to note that digitized photographs were not used as visual output. This may have been partially due to the state of technology at the time that the devices were developed. More recent advances in storage media make the use of actual photographs practical in even the hand-held devices. Video was also not used, presumably for the same reasons. Today microcomputers could incorporate this output easily. However, hand-held devices would still have difficulty storing much of it.

Some form of audio stimulus was used by several devices. This has ranged from a simple beep or tone to speech output. Speech output has progressed from synthesized speech to more understandable digitized speech. One of the advantages of the former is less memory requirement. However, like video output, storage has increased to the point where digitized speech can be used on even the smallest devices.

Earlier orthotics generally relied on proprietary software dedicated to the creation of orthotics. This made cross platform use difficult. The acquisition of the appropriate software would have also been more difficult and, most likely, more expensive. However, there is software currently available that is ubiquitous, inexpensive, and often already on a user's machine.

Examples include Microsoft's PowerPoint or Internet Explorer software. PowerPoint is present on many Windows-based machines. It is very easy to author programs using it, and the resulting programs could incorporate almost all of the orthotic features noted above. Internet Explorer is a standard Web browser that is capable of reading programs written in the Hypertext Markup Language (HTML). Again, almost all orthotic features could be created using this software.

Most studies reported an increase in accuracy over what the user could achieve on his or her own. The orthotic was often superior to conventional memory aides such as written notes. Maintenance of skills was possible without the reliance on human intervention. Some studies suggest that cognitive orthotics improve task efficiency. Some also suggest that the orthotic might help a subject learn to perform the task so that he or she is eventually able to perform it with only a written aide. It has even been suggested that a cognitive orthotic might help teach the generic skill of interacting with a cueing system in general (Kirsch et al., 1988). Finally, several studies suggest that microcomputer-based cognitive orthotics are sufficiently effective that users are motivated to continue using them on a long-term basis.

Some cognitive orthotics were shown to be effective "right out of the box." Others required some degree of training to operate effectively. However, once the user was capable of operating the device, he or she was able to use it to perform a complex task without receiving instruction on the task itself. Still others were used after training had occurred on both operating the orthotic and on completing the task. Finally, there is some evidence suggesting that by keeping the interface consistent, a developer may be able to create a cognitive orthotic to assist an individual to complete a new task with little or no training.

Applicability of Previous Research to Current Research

When considering the body of literature as a whole, cognitive orthotics seem effective with individuals suffering traumatic brain injuries. To differing degrees, these individuals often show several impairments in cognition including: attention problems, difficulty with spatial orientation, difficulty with short and long-term memory skills, an impairment of reasoning skills, and an impairment of higher-order integration of functions (Levine & Kirsch, 1985). In addition, they often have difficulty with stimulus discrimination, organization skills, the ability to generate appropriate responses, and the ability to solve problems in logical steps (Napper & Narayan, 1994). Many have a very difficult time resuming competitive employment and independent activities of daily living, even after the actual brain trauma has healed (Levine & Kirsch, 1985). This disruption in skills may result in secondary problems such as low self-esteem and affect (Kirsch et al., 1987, Parente & Stapleton, 1993).

When one examines the deficits noted above, it is easy to note similarities between this group and individuals with mental retardation. Although little research suggests it, it seems compelling to think that the technology might generalize to individuals with mental retardation. However, although the groups share some common characteristics, they are actually very dissimilar. Persons having suffered a traumatic brain injury frequently regain high functioning in a number of cognitive areas. These higher areas may assist the individual in responding to the compensatory assistance provided by the cognitive orthotic. The results of one study support this contention. In this study the characteristics of the subjects were compared with their success using the cognitive orthotic system. It was noted that many of the variables seen in people with mental retardation, versus people with traumatic brain injury, predicted poor performance in using the orthotic (Bergman, 2000). In addition, people having traumatic brain injuries are often high enough cognitively that they can respond to more abstract orthotic output, such as text.

However, some studies suggested that cognitive orthotics might benefit individuals with other types of cognitive disabilities. Recent research has just begun to examine the effectiveness of this technology with persons identified as mentally retarded. The Able Link Technologies Company has produced a cognitive orthotic referred to as the "Visual Assistant" designed to work with persons having mental retardation. Pilot study results reveal that subjects using the system significantly increased their accuracy and independence while engaged in a software packaging and pizza box assembly task (Able Link Technologies, 2005).

The difficulty of using a cognitive orthotic with persons having mental retardation may be due to limitations in the early technology. Most of the computers used in previous research contained now obsolete processors. The more powerful processors available today may render new cognitive orthotics much more sophisticated. Second, auditory output often consisted of crude beeps. Improvements in speech synthesis technology may make orthotics much more understandable, and thus usable, by a globally lower cognitively functioning population.

Visual output in the early systems was typically text-based. Color monitors, more powerful processors, and larger storage devices may significantly improve the visual information presented to the user. For example, it is now possible to see a step of a complex task demonstrated on a monitor via multimedia, rather than only receiving verbal or text directions.

Recent advances in input options may also make these devices much more powerful. Older systems generally depended on keyboard or switch inputs. However, newer systems could conceivably use speech recognition, a potentially easier response for the user.

Along with improved processor, input, and output features, each generation of computers becomes more economical. Most of the early cognitive orthotic systems described would most likely not be cost-effective for many users. However, technology has become much more economical, making it reasonable to expect that a home or work setting could have the hardware.

Summary

Cognitive orthotic devices have been shown to assist some users with traumatic brain injuries in completing complex tasks independently. The use of these systems with mentally retarded individuals has received surprisingly little attention. The studies noted above support, but fail to convince, a reader that computerized cognitive orthotics will be effective with persons having moderate mental retardation for the following reasons:

1. No study used moderately mentally retarded subjects.

2. Most technology used is dated. More current technology may prove more effective with this population that is unable to read or understand more abstract computer output.

3. The reported subjects are often not well described. Many seem to have characteristics similar to

individuals with moderate mental retardation. However, it is unclear to what extent there is a similarity.

4. The output from the orthotics is often poorly described.

5. The task analysis of the steps is often not described.

6. Most studies used only one to a few subjects. This makes it difficult to replicate and generalize results.

7. Some studies focused on attitudes from the users, while failing to examine the impact that the device had on the user's performance.

8. Devices were often examined as a whole without comparing them to a similar intervention using a lower-tech alternative.

9. Few studies provided data quantifying their results.

Research on the use of cognitive orthotics for people with moderate mental retardation is important. Despite over two decades of training in our schools, people with moderate mental retardation still have an extremely difficult time living independently or earning a living. Already limited, and shrinking, funding make independent living and work almost impossible.

A cognitive orthotic has the potential to support a person with mental retardation in the everyday endeavors that people without cognitive disabilities take for granted, and they can do it in a cost-effective way. This technology has the potential to significantly improve the quality of life for this large population of deserving individuals.

CHAPTER III

OBJECTIVES AND HYPOTHESES

Experimental Question

The purpose of the this study was to examine whether the prompts provided by a cognitive orthotic, in the form of a hand-held "Pocket PC" computer, could guide an individual with mental retardation through a multi-step task equally as well as a human supervisor.

Null Hypothesis

There will be no difference in the accuracy of task completion between subjects in the human supervisor-led and orthotic-led conditions.

CHAPTER IV

METHOD

The Experimental Task

A cooking task was chosen for the experimental task. It was chosen for three reasons. First, it is a task that is essential to an individual with a cognitive disability's success in living independently. Second, it is a task that contains different types of features, as follows:

(a) Measurement of Volume- For example, the subjects were required to measure a variety of liquids.

(b) Visual Discrimination - Subjects were required to discriminate a variety of ingredients of the recipe. They were also required to discriminate numbers, such as when setting the temperature control on the oven.

(c) Sequential Processing - Subjects were required to complete the task in a sequence.

(d) Estimation - Subjects were required to estimate ½ of the batter.

Third, the task was judged to be difficult for the subjects to complete. An alternate recipe, which was printed on the box (See Appendix A) was used for several reasons. First, it required more ingredients than the original box recipe. The original recipe required only three main ingredients, the mix, milk, cooking oil and an egg. The alternate recipe used these as well as sugar, raspberry preserves, and cream cheese.

Fourth, the alternate recipe contained more steps. The original recipe required the subject to mix the four ingredients and then pour them into muffin cups. The alternate recipe called for the same mixing. However, it also called for splitting the batter into two halves, applying them with a layer of preserves in the middle, and mixing and spreading a separate topping.

Fifth, the alternate recipe had more difficult steps. For example, the subjects were required to estimate half of the mix. They were required to evenly spread the alternating layers. They also had to reserve parts of the ingredients for use in later steps.

Subjects

Subjects were selected from students attending the moderately cognitively impaired program at Van Buren Intermediate School District's Bert Goens Learning Center, in Lawrence, Michigan. The subject pool included students from 16 to 26 years of age.

The moderately cognitively impaired program primarily includes students identified as cognitively impaired according to the Michigan Special Education Rules and Regulations. The rules are as follows:

> R 340.1705 Cognitive impairment; determination.
> Rule 5. (1) Cognitive impairment shall be manifested during the developmental period and be determined through the demonstration of all of the following behavioral characteristics:
>
> (a) Development at a rate at or below approximately 2 standard deviations below the mean as determined through intellectual assessment.
>
> (b) Scores approximately within the lowest 6 percentiles on a standardized test in reading and arithmetic. This requirement will not apply if the student is not of an age, grade, or mental age appropriate for formal or standardized achievement tests.
>
> (c) Lack of development primarily in the cognitive domain.
>
> (d) Impairment of adaptive behavior.
>
> (e) Adversely affects a student's educational performance.
>
> (2) A determination of impairment shall be based upon a comprehensive evaluation by a multidisciplinary evaluation team, which shall include a psychologist.

The subject pool was comprised primarily of students showing intellectual development approximately three standard deviations below the mean. As a group they had a very difficult time learning new information. Further, skills learned in one setting did often not easily generalize to other settings. Finally, higher order concepts were difficult for them. Language tended to be concrete, and abstract concepts were often beyond their comprehension. Academics were very difficult for them, and most will leave school with only a small sight word vocabulary, at generally an early elementary reading level (Bierne-Smith, Patton, & Ittenbach, 1994; Snell, 1993).

Graduation from the moderately cognitively impaired program will not yield a high school diploma, but rather a certificate of completion. Most students will not be able to live or work completely independently. Many home-living tasks, such as cooking, will be very difficult for the population. Low reading levels will make reading cookbooks or instructions on food packages difficult to impossible.

Subjects for this study were selected from a pool of 37 students. This pool consisted of all students participating in a classroom for students with moderate cognitive impairments at the Bert Goens Learning Center. A list of all students aged 16 years or greater was first compiled, and each student on the list was assigned a sequential number. Successive strings of two-digit numbers were obtained from a table of random numbers (Hopkins & Glass, 1978). Numbers greater than 37 were discarded as were duplicates of already drawn numbers. The first nine numbers drawn were used to select the initial pool of potential subjects. For example, if the first random number drawn was "09," the ninth student on the list was selected. After the initial group of nine was selected, another pool was selected, in the same way, to comprise a list of alternates. If for some reason a member of the original pool of nine was rejected as a subject, the first subject on the alternate list would fill that slot.

The students' classroom teachers were then consulted to ascertain the appropriateness of the subject for the study. The subjects needed to meet the following criteria:

1. The subject's physical capability of performing the task was considered. For example, severe motor disabilities or blindness would render the subject incapable of successfully completing the task under either experimental condition.

2. The student's behavior and attention span must have been such that it could be reasonably expected that the student could maintain participation in the task for the duration of the sessions (approximately one hour) and for the duration of the study (approximately eight weeks).

Of the first nine potential subjects chosen, one was eliminated following consultation. This young woman suffered from cerebral palsy, making her arm and hand motor movements laborious and very slow. It was felt that she did not fit criteria one. The first alternate was then selected to increase the subject pool to nine. She was found to meet both criteria.

The parents and guardians were then contacted by phone. The purpose of the study was described, and the parents and guardians were told how their student would participate. Questions were answered. Following the telephone conversation, permission slips were sent to the parent or guardian for signature (See Appendix B). All were returned with signatures of assent. The subjects were also asked to sign a different permission form (See Appendix C). This form was written in a manner easier for them to understand, and was read to them by the author. Each subject was asked to sign if they wanted to participate in the study. All subjects signed permission slips.

While meeting all of the above criteria, the subjects constituted a relatively heterogeneous group. Individuals differed in cognitive skills. Intelligence test scores showed a variability from approximately the low 40's to the high 60's.

All subjects were relatively homogeneous in regard to academic skills. All showed reading skills no higher than approximately the mid second grade level. Subjects ranged from having almost no functional reading skills, to individuals having low elementary-level sight word and reading comprehension levels.

Sensory acuity was generally good for most subjects. Four used glasses to correct vision, but none had serious vision problems. One student had a severe hearing impairment, and he wore hearing aides. However the amplification provided by his aides and the use of the amplified speakers attached to the orthotic proved adequate. Prior to the beginning of the sessions he was allowed to hear the output from the orthotic, and he stated that he could hear the device well. In addition, he performed accurately on many of the steps of the task, further supporting his assertion that he could hear the output well.

Two subjects had medical problems that could potentially affect their performance. One subject suffered grand mal seizures. Petit mal seizures have not been documented or suspected. The latter condition would have been potentially confounding to the study in that the subject's performance could have been unknowingly affected by seizure activity. However, this was not the case. Grand mal seizures would have been easily noted during a session. However, they did not occur during any sessions. The other subject had very limited use of his right arm and hand due to a stroke suffered at birth. This necessitated some assistance from the supervisor. For example, he required assistance to pour the batter from a large bowl into the baking pan. Prior to the sessions, this experimenter discussed allowable assistance to ensure that the supervisor did not inadvertently cue the subject as a result of her assistance.

Two subjects had histories of significant behavioral problems. This examiner had a great deal of experience with the subjects and believed that behavior problems will most likely not be seen primarily due to the highly reinforcing nature of the activity. It was decided, prior to the beginning of the sessions, that if a subject seemed to be having a bad day, his or her session would be postponed until the next day. This delay was never needed. The nine subjects averaged 21 years of age. Intelligence test scores averaged 52. Reading achievement test scores showed the group to have an average of first grade reading skills.

As a group, the subject pool was diverse across several dimensions. The following table summarizes their characteristics.

Subject	Age	Intelligence Test Score	Reading Achievement Test Scores
JM	23	42	K.9 to 1.4
TT	24	69	1.7 to 2.3
MI	21	46	K.6 to K.8
LK	23	58	1.7 to 2.4
JP	20	45	k.7
TC	17	47	PK
RM	22	55	1.3 to 2.1
RL	21	57	K.4
BZ	17	53	1.5 to 1.7

Table 1: Subject Test Summary

Subject	Sensory Problems	Motor Problems	Behavioral Issues	Medical Issues
JM	Hearing Aides Correct Bilateral Hearing Loss	None	None	None
TT	None	None	ADHD Impulsivity	Medication for Behavior
MI	None	None	Distractibility	None
LK	Glasses Correct Vision	None	None	Down Syndrome
JP	Glasses Correct Vision	None	Oppositional Distractible	Medication for Behavior
TC	Glasses Correct Vision	No Use of Left Arm or Hand	None	Stroke at Birth
RM	None	None	None	Down Syndrome
RL	None	None	None	None
BZ	Glasses Correct Vision	None	None	Seizure Disorder

Table 2: Subject Characteristics

Subject:	JM
Age:	22-6
Intellectual Test Results:	WISC-III administered in July of 1998 yielded a full scale score of 42.
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of 1.4, a Reading Fluency grade equivalent of < K.9, and a Passage Comprehension grade equivalent of 1.0.
Sensory Problems:	Moderate bilateral hearing loss corrected with amplification.
Motor Problems:	None
Behavior:	No significant problems.
Medical Issues:	None
Subject:	TT
Age:	24-9

Intellectual Test Results:	WAIS-R, administered in March of 1998 yielded a full scale score of 69.
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of 2.1, a Reading Fluency grade equivalent of 2.3, and a Passage Comprehension grade equivalent of 1.7.
Sensory Problems:	None
Motor Problems:	None
Behavior:	Although much higher functioning than most in the population, subjects two has a history of hyperactivity, impulsiveness and behavioral difficulties. However, over the years his behavior has improved to the point where it is no longer a significant

	limiting factor to his education.
Medical Issues:	Currently reserves medication to modulate hyperactivity and mood.
Subject:	MI
Age:	21-0
Intellectual Test Results:	WAIS-R administered in 2002 yielded a full scale score of 46.
Reading Achievement:	WIAT reading test scores, administered in October of 2004, show a Letter-Word Identification grade equivalent of K.8, a Reading Fluency grade equivalent of < K.9, and a Passage Comprehension grade equivalent of K.6.
Sensory Problems:	None
Motor Problems:	None

Behavior:	No significant problems. Periodic inattention to task requires some redirection.
Medical Issues:	None

Subject:	LK
Age:	24-3
Intellectual Test Results:	WAIS-R administered in November of 1998 yielded a full scale score of 58.
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of 2.4, a Reading Fluency grade equivalent of 2.1, and a Passage Comprehension grade equivalent of 1.7.
Sensory Problems:	Wears Glasses
Motor Problems:	None
Behavior:	No significant problems.
Medical Issues:	Down Syndrome

Subject:	JP
Age:	23-6
Intellectual Test Results:	WISC-III administered in 1996 yielded a full scale score of 45
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of K.7, a Reading Fluency grade equivalent of < K.9, and a Passage Comprehension grade equivalent of K.7.
Sensory Problems:	Wears Glasses
Motor Problems:	None
Behavior:	Periodic strong oppositional behavior. Periodic aggression toward others. Subject five requires a one-on-one classroom aide. However, JP's behavior is known well enough that behavior problems were not

	anticipated with this subject.
Medical Issues:	Currently takes medication to modulate his behavior and mood. Medication is noted to periodically affect attention.
Subject:	TC
Age:	17-5
Intellectual Test Results:	WISC-III administered in January of 1997 yielded a full scale score of 47.
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Broad Reading standard score below 55 and a grade equivalent at the PK level.
Sensory Problems:	Wears Glasses
Motor Problems:	Limited use of his left arm due to stroke at birth.
Behavior:	Excellent
Medical Issues:	None

Subject:	RM
Age:	24-2
Intellectual Test Results:	WISC-III administered in 1998 yielded a full scale score of 55
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of 2.1, a Reading Fluency grade equivalent of < 1.9, and a Passage Comprehension grade equivalent of 1.3.
Sensory Problems:	None
Motor Problems:	None
Behavior:	Excellent
Medical Issues:	Down Syndrome

Subject:	RL
Age:	19-9
Intellectual Test Results:	WAIS-III administered in January of 2004 yielded a full scale score of 57.

Reading Achievement:	WIAT reading test scores administered in January of 2004 show a Broad Reading grade equivalent of K.4.
Sensory Problems:	None
Motor Problems:	None
Behavior:	No problems noted.
Medical:	None

Subject:	BZ
Age:	18-1
Intellectual Test Results:	Parts of WISC-III administered in 1999 yielded a full scale score estimate in low 50's.
Reading Achievement:	WIAT reading test scores administered in October of 2004 show a Letter-Word Identification grade equivalent of 1.5, a Reading Fluency grade equivalent of 1.7, and a Passage Comprehension grade equivalent of 1.0.

Sensory Problems:	None
Motor Problems:	None
Behavior:	Excellent
Medical Issues:	Subject to grand mal seizures. Currently takes medication to control them. Vagal nerve stimulator surgically implanted during course of study.

Setting

The study was conducted in the home living classroom at the Bert Goens Learning Center, at Van Buren Intermediate School District, in Lawrence, Michigan. This classroom is large, and is used to teach students daily living skills such as cooking, cleaning, bed making, clothes washing, etc. The room's setup is similar to that of an apartment. A bathroom is centrally located in the classroom, and it is surrounded by areas resembling a living room, a bedroom, and a kitchen. The kitchen area contains a long island which holds a sink, a dishwasher, a stove, an oven and a 32 by 38 inch countertop. A refrigerator, washer and dryer are located behind the island as are cupboards and additional counter space.

This room is not dedicated to any given class. Teachers sign out the room as needed. Thus this examiner was able to secure the room for periods of uninterrupted sessions. In addition, a sign was placed on the door requesting that the subject and supervisor not be disturbed. The subjects completed the experimental cooking tasks on the island.

A camcorder was mounted on a tripod and placed approximately ten feet from the countertop. The subject stood behind the island containing the countertop, facing the camera. At the onset of the study, a few subjects expressed some apprehension at being video recorded. However, when it was explained that the tape would only be used for the experimenter to refer to if additional information or confirmation was needed about how they did the task, all seemed to become at ease with the camera, and no one seemed distracted by it. A couple used the occasion to simulate a cooking show, which they seemed to enjoy.

Each day, the tapes were taken home and transferred to the hard drive of a computer. These digital records were then reviewed for reliability purposes, and to check a response if a rating was unclear or missing on a protocol. The digital format made it easy to scan the session to find the proper event. These data were also backed up onto three DVD disks.

Supervisors

Six supervisors were recruited to supervise the orthotic-led sessions. The experimenter ran all supervisor-led sessions due to the need for consistency in supervisor responses to incorrect steps initiated by the subjects. The supervisors were all aides at the Bert Goens Learning Center. They were all volunteers, and permission from their classroom teachers was obtained prior to the beginning of the study.

The supervisors were trained in two sessions. Session one began with an overview of the study. The supervisors were then each given a handout that briefly explained the details of their participation in the study (See appendix D) and the handout was reviewed with them. A sample protocol was then distributed and they were acquainted with the parts of it.

Finally, the supervisors were shown the orthotic. The orthotic's display was projected on the wall, and the supervisors were shown the entire orthotic led session. The subjects were then shown the materials and equipment. The first training was ended with a question/answer period.

During the second session, the supervisors were given the actual protocol for the supervisor-led phase (See Appendix E). The experimenter then completed the entire recipe preparation process, referring to the protocol as he went. Questions were again answered.

The experimenter participated with each supervisor during her first session. The supervisors were first re-oriented to the protocols. The session was then run, with the experimenter assisting the supervisor. Scoring conventions were clarified, and the supervisors were shown how to correct potential problems with the orthotic.

The experimenter was present in the building during all sessions when a supervisor ran a session. On two occasions he was called down to the classroom to correct problems with the orthotic. The problems consisted of the subject inadvertently leaving the Internet Explorer program.

Apparatus

Initial Probe and Human-Supervisor-Led Condition

The majority of the apparatus consisted of standard kitchen tools and ingredients. The following were used in the probe session as well as in the human supervisor sessions.

(a) Electric Oven - Due to the fact that the oven in the home living classroom was more difficult to use, and was an unconventional unit with digital controls, the oven in a neighboring classroom was used to bake the product. In case that oven was in use, or if there was already a product in that oven from another subject, a very similar oven in a second classroom was substituted. Both ovens were electric. Their upper front faces both featured four knobs used to control the stove's heating elements as well as the temperature control for the oven. The stove controls had no functional use in the study. Rather, they served as distracters to the centrally located oven temperature control. Each oven had a single temperature control. The oven temperature was selected by rotating the knob counterclockwise until the temperature, as indicated on the face of the dial, aligned with a reference mark.

(b) Two Mixing Bowls

(c) Six Baking Pans

(d) Two Standard Wind-up Mechanical Kitchen Timers

(e) An Array of Wooden and Metal Spoons and Spatulas

(f) A Pair of Scissors Used to Open he Bag of Mix or the Cream Cheese

(g) The Box Mix. This was a Pillsbury Lemon Poppy Seed Muffin Mix.

(h) A Gallon of Milk

(i) A Bottle of Cooking Oil

(j) Individual Packets of Cream Cheese

(k) A Bag of Sugar

(l) A Can of PAM Cooking Spray

(m) A Container of Egg Beaters Egg Substitute. It was decided to substitute "Egg Beaters" in place of the called-for egg. Egg beaters are pasteurized, this avoiding the possibility of salmonella contamination. Second, the use of this pourable egg substitute avoided having to teach each subject how to successfully crack an egg. It is felt that this, and other, egg substitutes are readily available and may serve as an aide when cooking.

(n) A Jar of Raspberry Preserves

(o) Several Clear Plastic One-Cup Measuring Cups Graded for Measuring Liquids

(p) A modified photocopy of the ingredients on the side of the box mix (See Appendix F). This was done for two reasons. First, one component of the recipe was simplified. One step of the original recipe called for retaining 2/3 of the batter. It was felt that estimation of this type of volume was not necessary for successful completion of the recipe and possibly too difficult for the subjects or the supervisors to estimate. This was changed to ½. The altered recipe also substituted Egg Beaters for the egg. The modified directions were developed by photocopying the mix's alternate instructions from the side of the box. The photocopier was used to enlarge the directions to make them easier to read. The lines specifying the amount of batter to reserve and the egg were removed, and new lines inserted using a similar font and type size. A new copy of these directions was given to each subject at the beginning of the probe session and at the beginning of each human supervisor session. They were told that they could use a pencil and the directions as they wished.

Orthotic-Led Condition

This condition also used most of the apparatus as listed above. However, it used four modifications. First, a set of 8, 10 inch by 10 inch colored squares were placed at the upper edge of the countertop at the beginning of each session. They were used as visual cues to locate the various ingredients used during the cooking task.

Second, a set of modified measuring cups replaced the ones described above. These were standard one-cup measuring cups identical to the ones above. However, these had colored lines drawn over the various fractional measurements used during the task. The colored lines designated the following measurements:

Yellow = ¼ Cup

Blue = 1/3 Cup

Green = ½ Cup

Orange = ¾ Cup

Red = One Cup

The colored lines were used in conjunction with the computer orthotic to simplify, via correspondence, the measurement task.

Third, the instruction form was omitted. This was done to ensure that cues were taken only from the orthotic.

Finally, and most importantly, this condition relied upon a microcomputer-based cognitive orthotic. The orthotic was a standard Hewlett Packard iPAQ Pocket PC computer. This device contained a two inch by three inch color screen. It also had a 400 megahertz processor and 128 megabytes of RAM. The orthotic program itself was located on a 32 megabyte secure digital card inserted into one of the computer's memory slots. Overall, the device measures three inches by five inches, and was operated via an internal battery. Subjects used a small stylus to navigate within the device by tapping on "hot spots' located on the device's screen.

The device had audio output. However, because of concerns about one of the subject's ability to hear the device, a set of amplified external speakers was plugged into the device. It was decided at the onset of the study to use the amplified speakers for consistency and to assist the supervisors in hearing the output. This was important because the audible output cued the supervisors as to the specific step being performed on the protocol.

The orthotic program was developed in HTML and read via the standard Internet Explorer program built into the Pocket PC device. Thus, the orthotic program was essentially a set of 45 linked web pages. The web pages utilized a simple and standard interface (See Appendix G). Each page consisted of three components. The majority of the screen (approximately 2 inches by 2 inches) contained a picture. These were generally static JPEG photos of ingredients, equipment or steps in the process. However two pages displayed animated GIF pictures used to animate portions of the cake preparation processes. The processes were: (a) spraying the entire bottom of the cooking pan with cooking spray, and (b) chopping the cream cheese with a spoon.

The other visual features consisted of a standard interface to either advance the orthotic to the next step, or to replay the current step. Those were the only two functions available to the user. A back-up button was not included because it was feared that the subject would become lost in the process by using it. The web browser itself contained some small icons to (a) back up to the previous page, (b) enter a home page, and (c) open a screen for bookmarked pages. The users were instructed not to use those icons, and none attempted to do so. Supervisors were instructed to use the back button to return the browser to a previous page if the subject inadvertently advanced two screens. Auditory output was also used. This generally took the form of the examiner's voice guiding the subject through each step. An auditory signal was also used to time events, such as stirring.

At the beginning of each session, the experimenter attached the device to the external speakers, turned the device on, and started the web browser program. He also tapped the "home" icon which brought the browser to the first step of the task. At that point the subject was given the stylus and allowed to progress through the orthotic's steps by tapping on either the "next" icon or the "repeat" icon. Holding the stylus on the screen for a slightly longer time resulted in a menu popping up on the screen. This menu was superfluous to the orthotic task. The subjects were taught to tap somewhere on the picture, but off the menu, to remove it.

Some subjects were able to use the stylus effectively to progress through the steps of the orthotic. However, others had difficulty doing so. When this occurred frequently, the supervisor was instructed to operate the interface under the verbal direction of the subject.

During the orthotic-led phase, each subject navigated through the series of pages. These pages are shown in Appendix H. Two screens were animated, and thus could not be appropriately shown. The output for these screens is a static image which samples the entire animation.

Design

The study was developed as a series of single-subject designs. Nine subjects were used in the study. Conventional preparation of the recipe was first demonstrated to all nine subjects. During the succeeding 8 days each subject was given the opportunity to prepare the recipe as it was presented to them. Latency of the probe from the demonstration is as follows.

Subject	**Probe Latency in Days**
BZ	6
MI	2
RL	6
JP	3
JM	2
TC	8
LK	3
TT	2
RM	7

Table 3: Latency Period Between Initial Demonstration and Probe Session

Following this initial probe the nine subjects were broken into three groups. Group one completed the recipe conventionally, being assisted by a human supervisor, over six sessions. Group two completed six sessions using only the orthotic. Group three first completed three sessions with the assistance of a human supervisor, followed by three sessions assisted by the orthotic.

Initial Training

Groups one, two and three initially met as a group with this examiner. The purpose of the study and the specifics of their participation were first explained. The subjects were then asked if they wanted to participate in the study, and all responded in the affirmative. The entire conventional cooking task was then demonstrated to the group.

Following the cooking task demonstration, each member of the group was briefly shown how to measure liquids to the fraction of a cup. The subjects were first shown a measuring cup, and their attention was drawn to the fractional measurements on the side. Each subject was then individually shown a series of three fractions on the board. Given a particular fraction on the board, each was required to point to the corresponding fraction on the side of their cup. If the subject indicated the incorrect fraction he or she was shown the correct matching fraction and he or she was asked to point to it. The subject was then shown that the fraction on the board and the indicated one on the cup were the same. This procedure was repeated for all three fractions.

All subjects were then shown how to operate the orthotic. An external amplified speaker was attached to the orthotic, and the subjects were first shown how the device would speak directions. The orthotic was them circulated between the subjects and they were allowed to see the display.

The subjects were then showed the orthotic's interface. It was explained that there were only two buttons on the device. They were first shown the forward arrow, and it was explained that tapping this button would take them to the next step in the task. They were then shown the redo button, and it was explained that this button would allow them to see and hear the current step again.

Finally, each subject was allowed to try the orthotic. They were first asked to show what they would do to move to the next step in the task. If they responded correctly, they were asked to show how they would repeat the current step. If a subject made an error he or she was asked to repeat the procedure until a correct response was obtained.

Two issues emerged from the orthotic training. First, some subjects did not tap the screen hard enough to occasion the correct function. When this occurred, subjects were encouraged to practice the tapping several times until the got the feel of the device. Other times they held the press too long, which resulted in the orthotic displaying an unwanted menu. Subjects were instructed to tap anywhere on the screen's picture to remove the menu, and then try the tap again. Following training, subjects seemed comfortable with the device and its use.

All subjects were then run through an initial probe. The purpose of the probe was to determine whether the subjects were able to independently complete the task after only watching the demonstration. Subjects were given the photocopied, and modified, directions from the box. They were also given a pencil, and they were told that they could use the directions and the pencil as they wished. They were then reminded of the demonstration and asked to complete the task independently. Subjects were told that the examiner could answer no questions, and was only going to watch and see how they did. Actually the examiner did answer one type of question. If a subject asked where an object or ingredient was located, he or she was told the general area (refrigerator or cupboard). Sometimes the subject requested a particular utensil. If that occurred he or she was directed to it.

Subjects were assured that the task would be difficult. This was done in order to keep spirits and motivation high. The examiner started by warning each subject that the task was difficult, for a purpose. The subject was told that good performance was not expected, but would come later. General praise and reassurance was provided during the course of the task to retain positive performance.

Task Steps

Supervisor-Led

(a) Preheat the oven to 350 Degrees.

(b) Spray pan with PAM.

(c) Reserve ½ cup of mix.

(d) In another bowl combine (in any order).

- Remaining Mix
- Milk
- Oil
- Egg Beaters

(e) Stir 50 to 75 strokes.

(f) Spread 1/2 of batter into the pan.

(g) Spoon jam evenly over batter and spread to within ½ inch of edge of pan.

(h) Drop remaining 1/2 of batter, by spoons full, over the preserves.

(i) Carefully spread out piles to within ½ inch of edge of pan.

(j) Add sugar to reserved ½ cup of bread mix.

(k) Cut in cream cheese until uniformly mixed.

(l) Spread over batter in pan.

(m) Bake 50 minutes.

Orthotic-Led

(a) Locate the cream cheese.

(b) Locate the flower.

(c) Locate the cooking spray.

(d) Locate the baking pan.

(e) Locate the milk.

(f) Locate the cooking oil.

(g) Locate the Egg Beaters.

(h) Locate the jam.

(i) Locate the sugar.

(j) Fill the measuring cup to the red (3/4 Cup) line with milk.

(k) Put it on the red square.

(l) Fill another measuring cup to the blue (1/3 Cup) line with oil.

(m) Put it on the blue square.

(n) Fill another measuring cup with raspberry preserves to the green (1/2 Cup) line.

(o) Put it on the yellow square.

(p) Preheat the oven to 350 degrees.

(q) Spray the bottom and sides of the baking pan with the PAM cooking spray.

(r) Fill another measuring cup to the green (1/2 Cup) mark with the bread mix.

(s) Put the measuring cup on the green square.

(t) Put the remaining mix in the bag on the orange square.

(u) Fill another measuring cup to the yellow (1/4 Cup) lie with Egg Beaters.

(v) Pour the cup into bowl one.

(w) Pour the oil on the blue square into bowl one.

(x) Pour the milk on the red square into bowl one.

(y) Pour the mix on the orange square into bowl one.

(z) Stir until the orthotic beeps.

(aa) Fill another measuring cup to the orange (2/3 Cup) line with part of the batter.

(bb) Put the measuring cup on the black square.

(cc) Put the bowl of batter on the pink square.

(dd) Pour the cup of batter on the black square into the baking pan.

(ee) Spread it out evenly and all the way to the side of the pan.

(ff) Put the cup of jam on the yellow square on top of the batter in the baking pan.

(gg) Spread it out evenly and all the way to the side of the pan.

(hh) Drop spoons full of the batter on the pink square on top of the jam in the baking pan.

(ii) Spread it out evenly and all the way to the side of the pan.

(jj) Fill another measuring cup to the yellow (1/4 Cup) line with sugar.

(kk) Put the sugar into bowl two.

(ll) Put the reserved mix on the green square into bowl two.

(mm) Add the cream cheese into bowl two.

(nn) Chop the cream cheese with a spoon until it is in small pieces and mixed with the sugar and flower mix.

(oo) Put this mixture over the batter in the baking pan.

(pp) Spread it out evenly and all the way to the side of the pan.

(qq) Put the baking pan into the preheated oven.

(rr) Set the timer for 50 minutes.

Task Protocols

Appendices E and I contain the protocols used in the study. A separate protocol was used for each of the conditions. Column one in each protocol contained the step of the task. In the supervisor-led task it was a general statement of the step. In the orthotic-led task it was the auditory output from the orthotic.

Column two in each protocol was an operational definition of the acceptable step criteria. In the orthotic-led phase, the raters were told to simply judge whether that particular criterion was met or not. The raters were told not to worry about any other variables.

Column three contained a blank for recording whether the step was performed to criteria. Raters placed a "+" or a "-" in the space. They were told to ensure that all spaces were marked before they left the classroom.

Finally, column four contained notes about marking performance. For example, one note advised raters that the next series of ingredients could be added in any order.

The orthotic-led phase protocol was scored using the scoring criteria in the exact order listed on the protocol. This protocol was relatively easy to score because all steps were cued by the orthotic. The supervisor needed only score the correct step. As noted above, this was easy to do because the audible output from the orthotic cued the supervisor as to what step was being worked on.

The supervisor-led protocol was shared by the supervisor-led phase and the initial probe. The protocol was scored by generally following the steps as enumerated by the protocol. Some deviation from the steps was allowed. For example, subjects could put the batter ingredients into the bowl in any order. When a deviation from the prescribed order was appropriate, it was stated on the protocol.

During the initial probe phase, the protocol was used more liberally. During the initial probe, subjects could complete steps in any order that they wished. However, the experimenter still rated all of the items on the protocol as specified.

Items were selected for the protocol from an analysis of the recipe preparation process. Most items were simply the next sequential step in the preparation process. However, additional criteria were added to the step if they were felt to be important to the overall success of the process, or if they contributed to the overall quality of the product. For example, item three of the supervisor-led protocol required that the baking pan be sprayed with nonstick cooking spray. This is specified in the recipe. However, an additional criteria of spraying at least 75 % of the bottom of the baking pan was also included because it would be important to the overall outcome of the recipe. That is, the cake must be removable from the pan. Similarly, step seven specified that milk must be added to the mix to make the batter. Additionally, the next item specified that the milk must be correctly measured to within 1/8 cup. Thus, partial credit could be obtained (one point) for simply adding the milk. However, additional credit (one additional point) would be given for adding it in the correct quantity.

Items were also included if they represented steps that could be potentially confused by the subject. For example, the recipe is made more difficult because it required the subject to reserve portions of some ingredient to be used at a later stage. Thus, points were given for reserving the correct ingredient as well as using the entire ingredient when it was necessary to do so.

The orthotic-led protocol contained significantly more items than did the supervisor-led. This was done because the task was broken down into finer components that could be cued by the orthotic, hopefully occasioning more accurate preparation. For example, subjects were instructed to place items on colored squares located on the countertop. The colored squares served as cues to assist the subject in finding the correct ingredient when told to do so. Thus, additional items measured whether these cues were used correctly. When comparing performance with supervisor-led phases these items were excluded to give the protocol a more coarse measurement which was commensurate with that of the supervisor-led protocol.

Sessions

Supervisor-Led Sessions

Prior to the beginning of the sessions the experimenter prepared the classroom. He ensured that all ingredients and equipment were present. A tape was placed into the camcorder and rewound.

The subject was then brought to the classroom. He or she was given an instruction sheet and a pencil. The subject was told that the instruction sheet and pencil could be used in any way that the subject wished. A bag of mix was removed from the box and opened for the subject. This was done for the subject because the bags were very difficult to open and it was feared that spillage would occur. The box itself was immediately discarded so that the subject could follow the directions only on the modified instruction sheet.

The subject was then told to complete the mix exactly as it was specified in the instructions. Some parts of the instructions could be done in different orders. For example, one sentence specified which ingredients were to be put into the bowl to make the batter. The subject was allowed to add these ingredients in any order. However, most steps were to be completed in exactly the order presented. While some of the steps could have been successfully completed in other orders, it was felt that completing them in the specified order was important because allowable deviations could not always be discriminated in the real world.

As the subject proceeded through the task, the experimenter recorded whether each step was completed accurately and in the proper order. If a subject lagged after completion of a step, the experimenter asked "what's next?" Care was taken to avoid questions that would prompt the subject. The subject was allowed to continue independently until an error was made. When this occurred, the error was recorded on the protocol, and the subject was prompted to correct the step by a verbal reminder and, at times, a demonstration. Oral reminders were made when the subject failed to initiate the correct step of the task. Demonstrations were made for measurement errors, or for errors more easily corrected by observation. An example would be chopping the cream cheese into sufficiently small pieces, or setting the temperature knob on the oven. The subject was also frequently referred back to the written directions when being corrected.

Orthotic-Led Sessions

Prior to the beginning of the orthotic- sessions, the experimenter again prepared the classroom as described for the supervisor-led sessions. The subject and supervisor were then called to the room and the orthotic was prepared as described above. The experimenter then left the classroom in the care of the supervisor.

The supervisors then observed the subject as he or she completed the task with the assistance of the orthotic. No interaction, related to the completion of the task, was allowed. Supervisors were allowed to assist the subject with such general things as opening the bag, carrying the pan to the oven, inserting the pan in the oven, cleaning up a mess, etc. The supervisor was allowed to provide general encouragement, but no feedback that would affect the completion of the task.

Supervisors recorded the completion of each step on the protocol. Column one of the protocol was keyed to the auditory output from the orthotic, and this helped ensure that the correct data were taken for each step. A column on the protocol contained the criteria for judging the completion of a step, and supervisors were instructed to only rate the criteria as noted for that step.

Several authors noted that customization to individual users was necessary to construct effective orthotics (Bergman, 1991a; Cole, 1999; Lynch, 1990). Several considered the development an iterative task based upon examination of error patterns (Chute & Bliss, 1994; Chute et al., 1988). As the first few subjects completed the task, with the assistance of the orthotic, it was discovered that three broad types of errors were being noted.

First, some subjects failed to complete only what the orthotic told them to do, but continued on to other steps. Second, many users failed to discriminate the colored "lines" on the measuring cups from the colored "squares" where things were placed. Third, several failed to understand that when all of the initial ingredients were mixed, they formed a new item with a different name, the "batter."

To emulate the iterative orthotic development process, subject performance was observed by both the experimenter and the supervisor. When a subject was found to have difficulty because of one of these three classes of errors, he or she was prompted at the beginning of the next session. For example, if a subject failed to identify the batter during a session, he or she was told, at the beginning of the next session, "When you add all the ingredients into the bowl and stir them up they become something that is called the batter." Subjects that tended to go beyond the orthotic-prompted step of a task were told "Remember to do only what the computer tells you." Subjects that confused "lines" and "squares were shown the lines of the side of the measuring cup and were told "These are lines." They were then shown the squares and were told "These are squares." These prompts were noted on the subject's protocols, and they will be discussed in the Results section below.

Spacing of Sessions

Sessions were conducted on approximately a rotating basis. Some adjustment had to be done due to the fact that one subject attended school on Tuesdays, Thursdays and Fridays. Another attended Wednesdays, Thursdays and Fridays. Other sessions had to be adjusted for days when the student was not in attendance due to illness. Conflicts with other scheduled activities also necessitated some changes. All sessions took place over approximately six weeks. Session dates for each subject are listed below. All sessions were conducted in 2004.

Con-dition	**Subject**	**Probe**	**1**	**2**	**3**	**4**	**5**	**6**
1	BZ	10/18	10/27	11/1	11/8	11/12	11/17	11/19
	MI	10/14	10/21	10/29	11/2	11/5	11/11	11/18
	RL	10/18	10/22	10/25	11/3	11/11	11/17	11/22
2	JP	10/15	10/25	10/29	11/5	11/10	11/16	11/18
	JM	10/14	10/26	11/1	11/10	11/16	11/18	11/22
	TC	10/20	10/27	11/3	11/5	11/10	11/17	11/19
3	LK	10/15	10/21	10/28	11/3	11/12	11/17	11/22
	TT	10/14	10/26	11/1	11/5	11/8	11/16	11/18
	RM	10/19	10/22	10/27	11/2	11/12	11/19	11/23

Table 4: Session Dates for Each Subject

All subjects showed average days between sessions in the range of approximately four and one half to six and one half days. Latencies of consecutive sessions and average latencies are listed below.

Subject	**1 to 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**Total Days**	**Average**
BZ	5	7	4	5	2	23	4.6
MI	8	4	3	6	7	28	5.6
RL	3	9	8	6	5	31	6.2
JP	4	7	5	6	2	24	4.8
JM	6	9	6	2	4	27	5.4
TC	7	2	5	7	2	23	4.6
LK	7	6	9	5	5	32	6.4
TT	6	4	3	8	2	23	4.6
RM	5	6	10	7	4	32	6.4

Table 5: Consecutive Session Latency in Days

CHAPTER V

RESULTS

Supervisor-Led Sessions Only

BZ

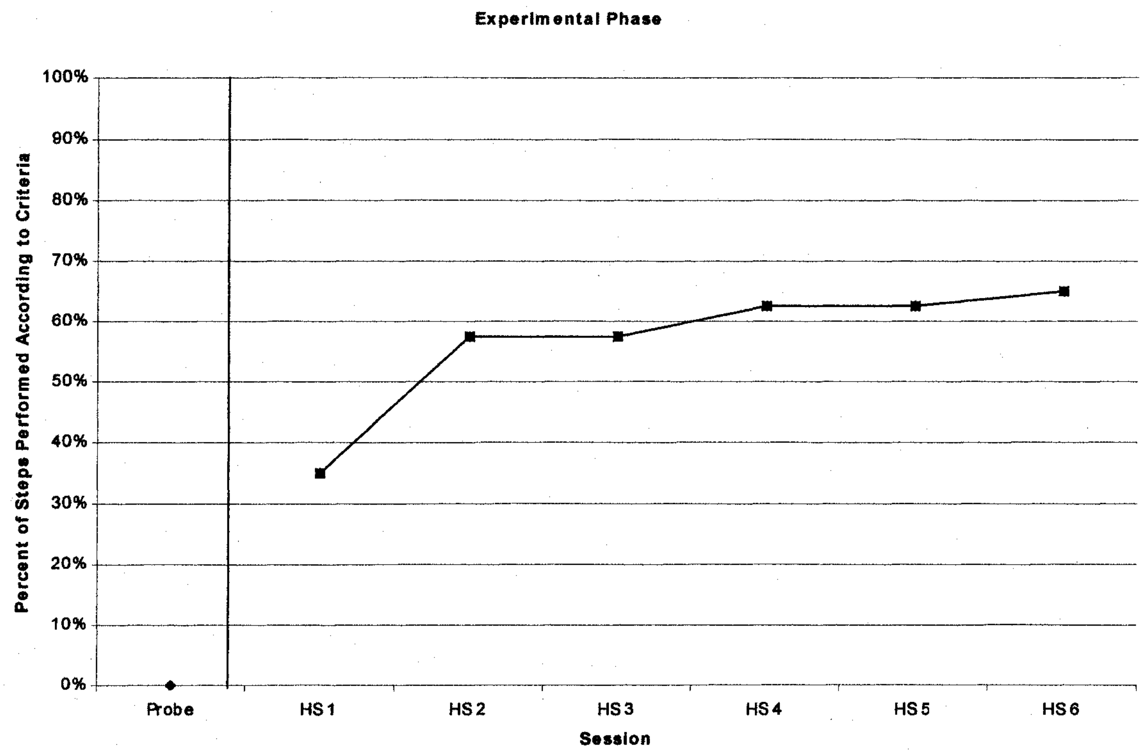

Figure 1: BZ, Supervisor-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Human Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

Initial Probe

BZ completed no steps of the initial probe correctly. She secured the box mix, the mixing bowl, two measuring cups, and several utensils at the beginning of the probe. She opened the bag of mix, but then became confused as to what to do. BZ appeared to try to read the directions in order to ascertain the procedure, but was evidently unable to do so. She expressed some discomfort at not being able to complete the process. The experimenter attempted to allay those concerns by stating that this session was more of a "test" and that she was not expected to be able to complete it independently.

Supervisor-Led Sessions

BZ was in the group that received the supervisor-Led sessions only. She completed all six sessions. BZ completed the six experimental sessions in 23 days, with an average session spacing of 4.6 days. The longest interval between sessions was seven days, and the smallest was two.

BZ very reluctantly came to session one. She was very anxious at the prospect of completing another session like the initial probe. She relaxed considerably when it was explained that she would have help from then on. After that, she was very relaxed and happy during the experimental sessions.

BZ showed a significant increase in performance once the supervisor assistance was initiated. She completed 40% of the protocol items correctly during the first session, and this number increased to almost 60% during the second. BZ's performance leveled off quickly past that point. She showed only a 7% improvement in performance between session two and session six. She ended the study completing approximately 65% of the protocol steps correctly.

Session Observations

BZ's overall session behavior was unremarkable. She attended well and showed good motivation throughout the approximately 40 minute sessions. She was quite proud of correct performance and she frequently referred to herself as "smart." BZ appeared to consider her responses before making them. Most errors seemed to result from forgetting steps of the task. Her reading skills were insufficient to provide guidance through the task. She appeared unable to refer to any parts of the recipe. Measurement was very difficult for her even following repeated measurement models.

MI

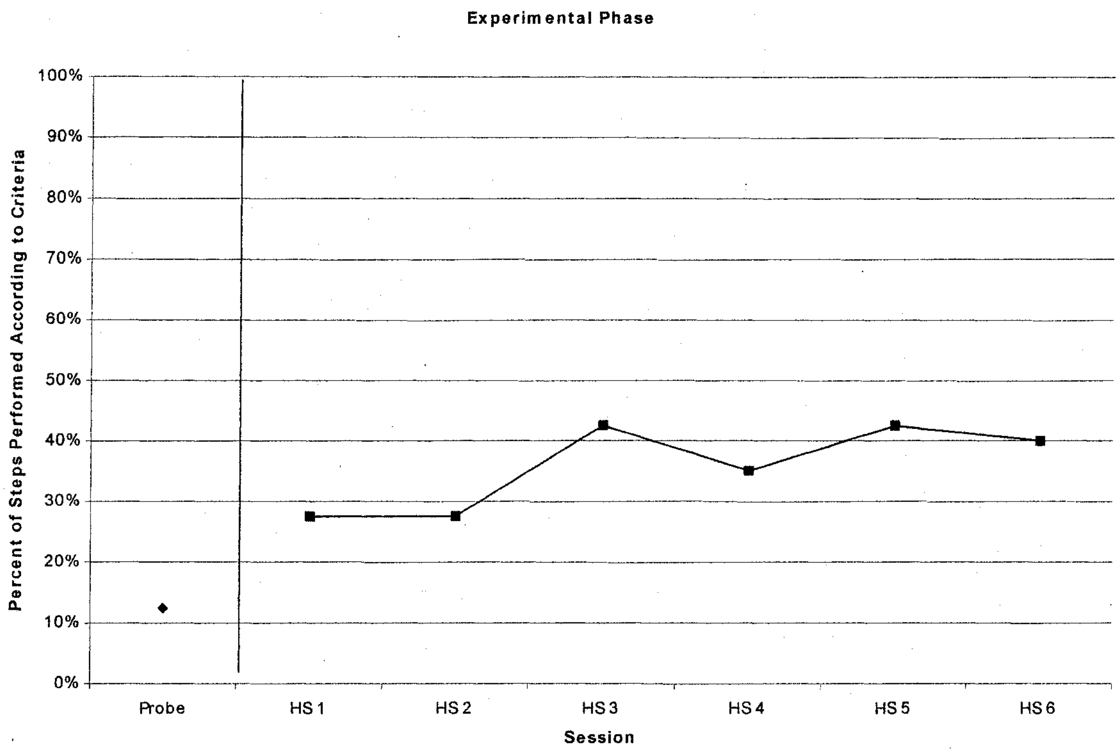

Figure 2: MI, Supervisor-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Human Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

Initial Probe

MI completed approximately 13% of the initial probe steps accurately. He poured the mix into a bowl and remembered to add milk and Egg Beaters. However, he made no attempt to measure them. After stirring the mixture he poured it into a baking pan and placed it in the oven.

Supervisor-Led Sessions

MI was in the group that received the supervisor-Led sessions only. He completed all six sessions. MI completed the six experimental sessions in 28 days, with an average session spacing of 5.6 days. The longest interval between sessions was eight days, and the smallest was three.

MI completed just over 10% of the steps during the initial probe. During the first examiner-assisted session his performance rose to approximately 28%. From that point on MI showed only small and inconsistent gains. On two sessions his performance rose to a high of approximately 43%. However, both sessions were followed by ones showing slight decreases. During his last session he completed 40% of the protocol items correctly.

Session Observations

MI showed one of the lower series of performances across all of the subjects. His reading skills were assessed at only a mid kindergarten level, and he paid little attention to the printed materials before him. His overall performance was rather impulsive. MI appeared to attempt to rely on his memory to complete steps rather than refer to some external source, such as his instructions. Although he began to use the measuring cups to attempt measurement of the ingredients, he was unable to measure accurately, nor did he show any attempt to find the measurement called for by the recipe.

MI tended to lack focus on the steps of the task. He frequently needed redirecting to either the recipe or to the features of the cake itself.

RL

Initial Probe

RL performed the initial probe relatively well in comparison with most other subjects, correctly completing 50% of the items. She showed some memory of the steps across the entirety of the task. RL referred to the printed directions several times during the probe. Although she could read very few words, it is possible that she was able to read some of the ingredients and note the associated measurement. However, most of her actual measurements were incorrect.

Supervisor-Led Sessions

RL was in the group that received the supervisor-Led sessions only. She completed all six sessions. RL completed the six experimental sessions in 31 days, with an

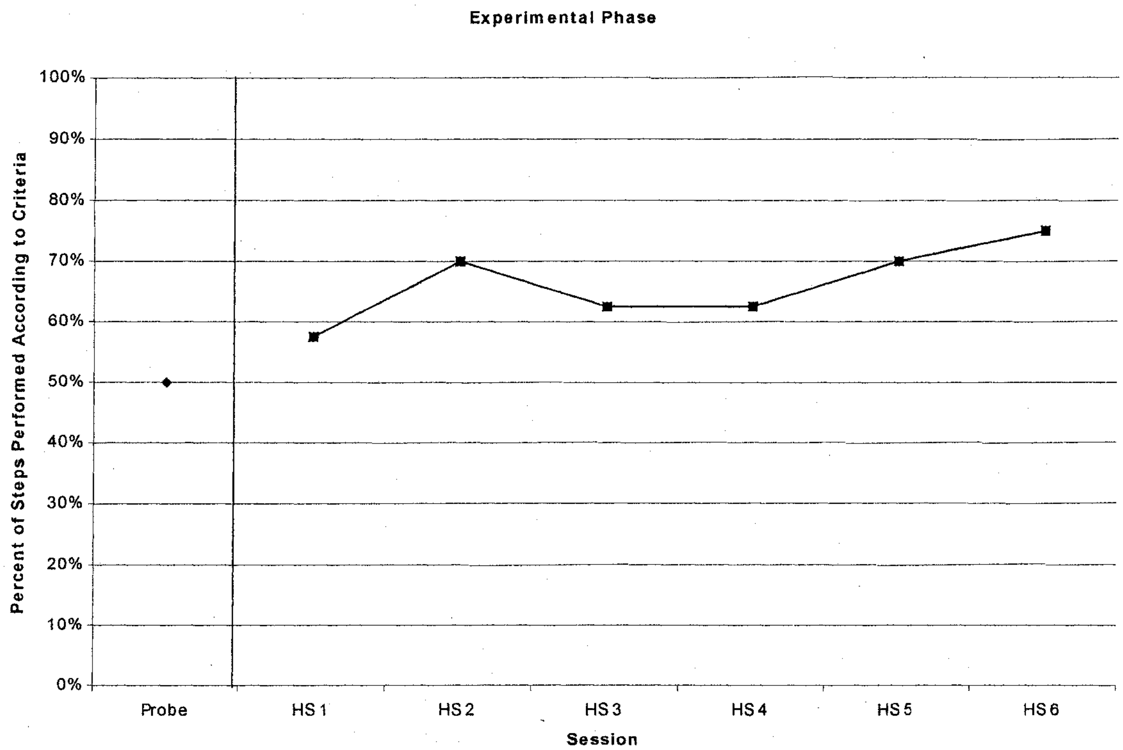

Figure 3: RL, Supervisor-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Human Supervisor Sessions

Probe = Initial Student Probe (No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

average session spacing of 6.2 days. The longest interval between sessions was nine days, and the smallest was three

During the first supervisor-led session RL's performance increased to approximately 58%. Her performance then tended to level out. During sessions two and five, RL achieved 70%, while sessions three and four were at 63%. RL completed the sessions by achieving a score of 75%.

Session Observations

RL completed the sessions happily and very cooperatively. She interacted well with this examiner and appeared quite at ease with the venue. As noted during the probe, RL referred back to the recipe frequently. Although reading was very difficult for her, she was able to correctly locate some of the ingredients and note their respective measurements.

Orthotic-Led Sessions Only

JM

Initial Probe

JM has a bilateral hearing loss, which is corrected with hearing aides. Thus, JM's ability to clearly hear the auditory output was a concern. The amplified speakers were turned to almost complete volume. Ambient noise in the room was not a concern. JM indicated that he could hear the orthotic well. His performance on the initial items supported his assertion.

JM showed extremely good performance on the initial probe, completing 85% of the items correctly. He performed

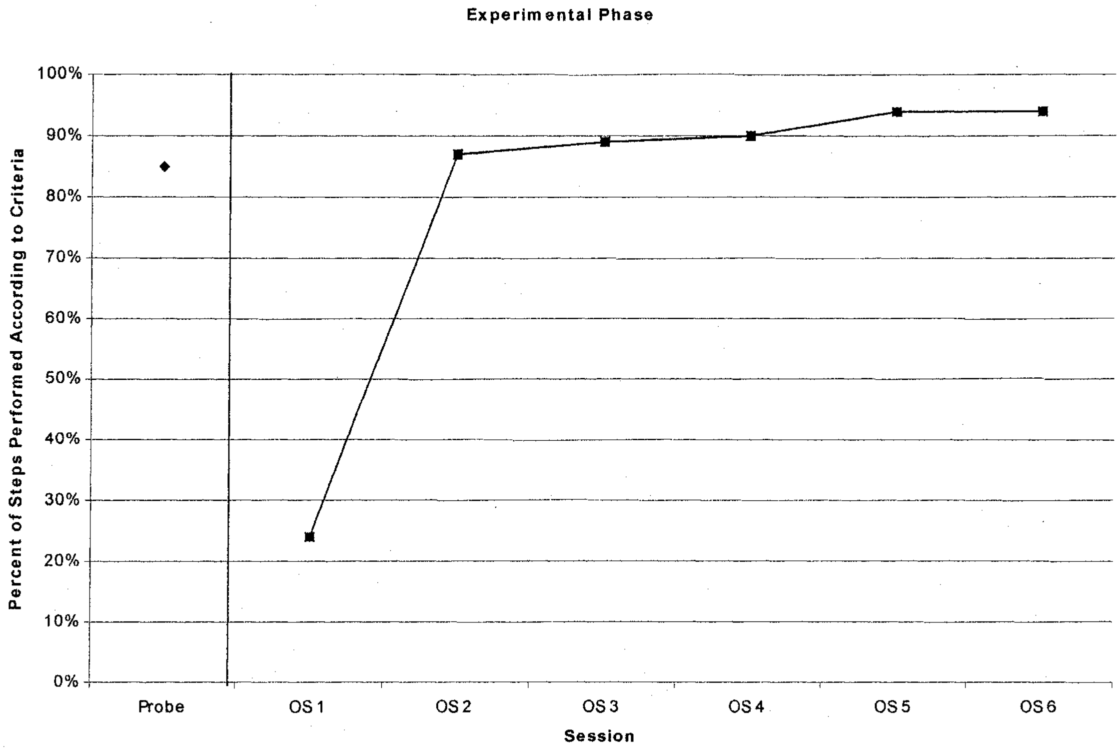

Figure 4: JM, Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

OS (x) = Orthotic Supervisor-Led Sessions

relatively quickly and confidently, appearing as though he had watched the initial demonstration closely.

<u>Orthotic-Led Sessions</u>

JM was in the group that received the orthotic-Led sessions only. He completed all six sessions. JM completed the six experimental sessions in 27 days, with an average session spacing of 5.4 days. The longest interval between sessions was nine days, and the smallest was two. JM's first orthotic-Led session was initially perplexing. He began by correctly getting out all of the items as specified by the orthotic. When asked to fill a measuring cup with milk, he obtained a measuring cup, but made no attempt to fill it with milk. When asked to place the cup on a colored square, he selected another measuring cup and nested it in the first. JM's performance remained extremely poor past that point. The session was ended early due to his complete confusion about the task.

This experimenter and his supervisor, who has worked with JM for several years, discussed his performance. It was suggested by this experimenter that his hearing impairment may have rendered his auditory comprehension skills sufficiently delayed that he was unable to comprehend the instructions. This was considered unlikely by the supervisor. She posed the idea that JM did not really understand that the orthotic was going to assist JM in making a cake, just like the one in the demonstration. After considerable discussion and debate, it was decided to progress according to the supervisor's hypothesis.

At the beginning of the second orthotic-led session the nature of the task was clarified. It was explained that the nature of the task was to make a cake like the one in the demonstration. It was also explained that this would be accomplished by closely following the instructions presented by the orthotic.

Subsequently, JM's performance immediately climbed to 87%. Successive sessions showed small improvements in accuracy. During his final two sessions he achieved scores of approximately 94%.

Session Observations

JM's teachers describe him as an astute observer. This observation was supported by his performance on the initial probe. As noted above, he apparently did not understand that the orthotic was to be used to complete the same baking task as he had seen in the demonstration, and attempted during the initial probe. Once this was clarified, his performance improved dramatically.

JM also had a difficult time understanding that when all of the initial ingredients were mixed in the bowl, they became an item with a new name, the "batter." The orthotic briefly mentioned this transformation. However, it was apparently not explained clearly enough to be understood by him.

JM also became very confused about the colored prompts used in the orthotic phase. Colored lines substituted for the standard measures on the measuring cups. For example, the orthotic instructed the user to "fill the measuring cup with milk to the orange line." Colored squares were used to identify ingredients after they were measured. For example, the user might be told to "Place the cup of oil on the red square." JM was obviously confused with the two prompts. In one instance he correctly filled a measuring cup to the specified colored line. However, when told to place the measuring cup on a colored square he obtained another measuring cup and searched for the colored line.

TC

Initial Probe

TC added many of the ingredients for the batter; approximately half of the measurements were correct. Beyond that, few steps were completed correctly. TC referred to the printed instructions occasionally. And he appeared able to read a few of the words. Overall, TC correctly completed approximately 11% of the steps.

Orthotic-Led Sessions

TC was in the group that received the orthotic-led sessions only. He completed all six sessions. TC completed the six experimental sessions in 23 days, with an

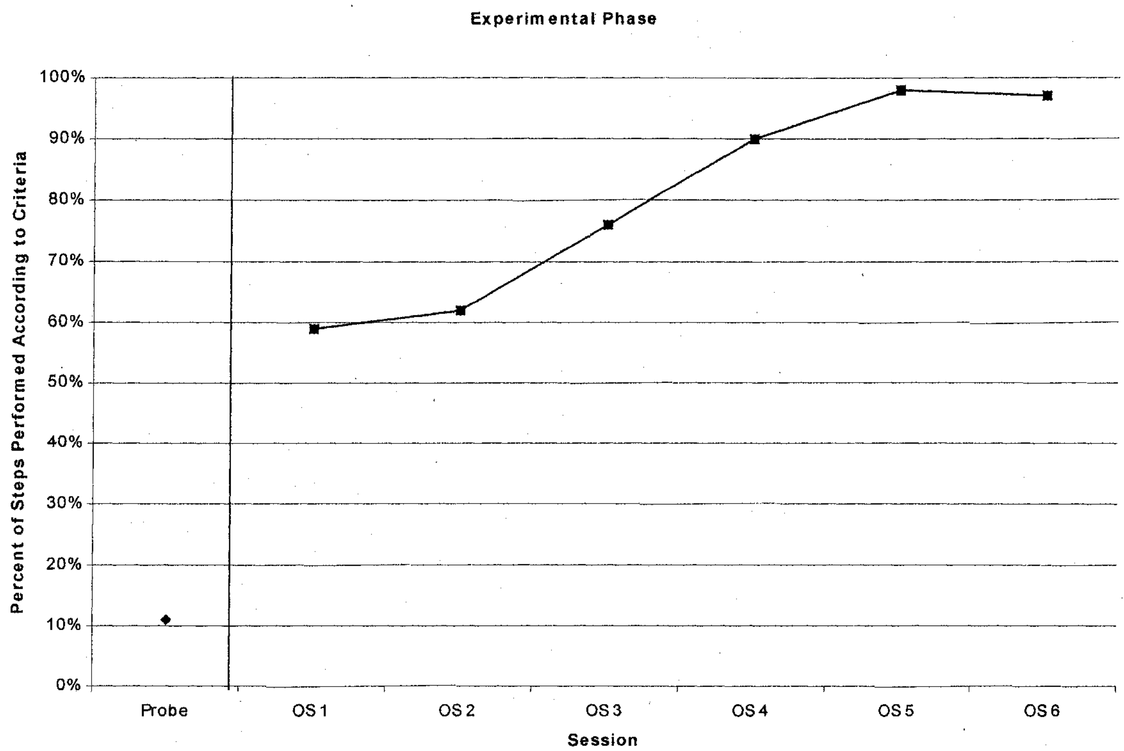

Figure 5: TC, Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

OS (x) = Orthotic Supervisor-Led Sessions

average session spacing of 4.6 days. The longest interval between sessions was seven days, and the smallest was two.

TC began the orthotic-Led sessions with an accuracy of approximately 59%. His performance on successive sessions continued to rise steadily. His last two sessions approached 100% accuracy.

TC was reminded once to do only what told by the orthotic. During one session, the concept of the batter was explained.

<u>Session Observations</u>

TC had limited use of his right arm and hand due to a stroke that he suffered as an infant. Assistance with some of the tasks was necessary. TC had a difficult time learning to use the stylus to navigate his way through the orthotic. Assistance from the supervisor facilitated this significantly.

<u>JP</u>

<u>Initial Probe</u>

JP poured some of the ingredients into a bowl. Most ingredients were added without measurement. He poured sugar into a measuring cup without reference to the fractional measurements. This "batter" was poured into the baking pan.

<u>Orthotic-Led Sessions</u>

JP was in the group that received the orthotic-Led sessions only. He completed all six sessions. JP completed the six experimental sessions in 24 days, with an average session spacing of 4.8 days. The longest interval between sessions was seven days, and the smallest was two.

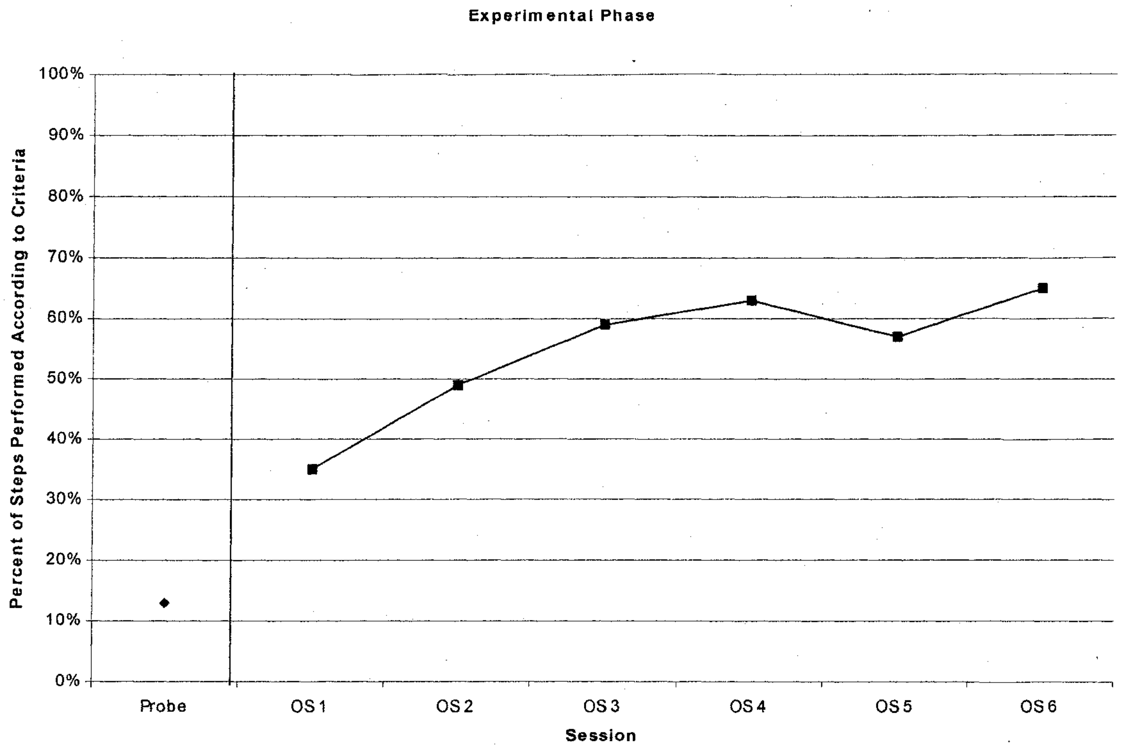

Figure 6: JP, Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

OS (x) = Orthotic Supervisor-Led Sessions

JP began the orthotic-Led sessions with approximately 35% performance. He showed steady improvement in performance during the next three sessions, but appeared to level out for the final two. During his last session, he achieved a score of approximately 65%.

Session Observations

JP had a difficult time keeping his responses to only what the orthotic specified. He tended to complete a step as instructed, but then continue well beyond what he was told to do. At that time JP appeared to become very confused, typically concluding the session with many missed steps. JP was reminded to "do only what the computer tells you," but consistently showed this behavior across all of the sessions.

JP also had difficulty discriminating colored "lines" on the measuring cups from the colored "squares" used to identify ingredients. Explaining these differences resulted in minimal improvement.

JP started almost every session accurately. However, when the tasks became more difficult, the orthotic lost its ability to maintain his performance. Measurement was particularly difficult for him. He tended to attempt use of the printed instructions very infrequently, and then only briefly.

Combined Supervisor-Led and Orthotic-Led Sessions

TT

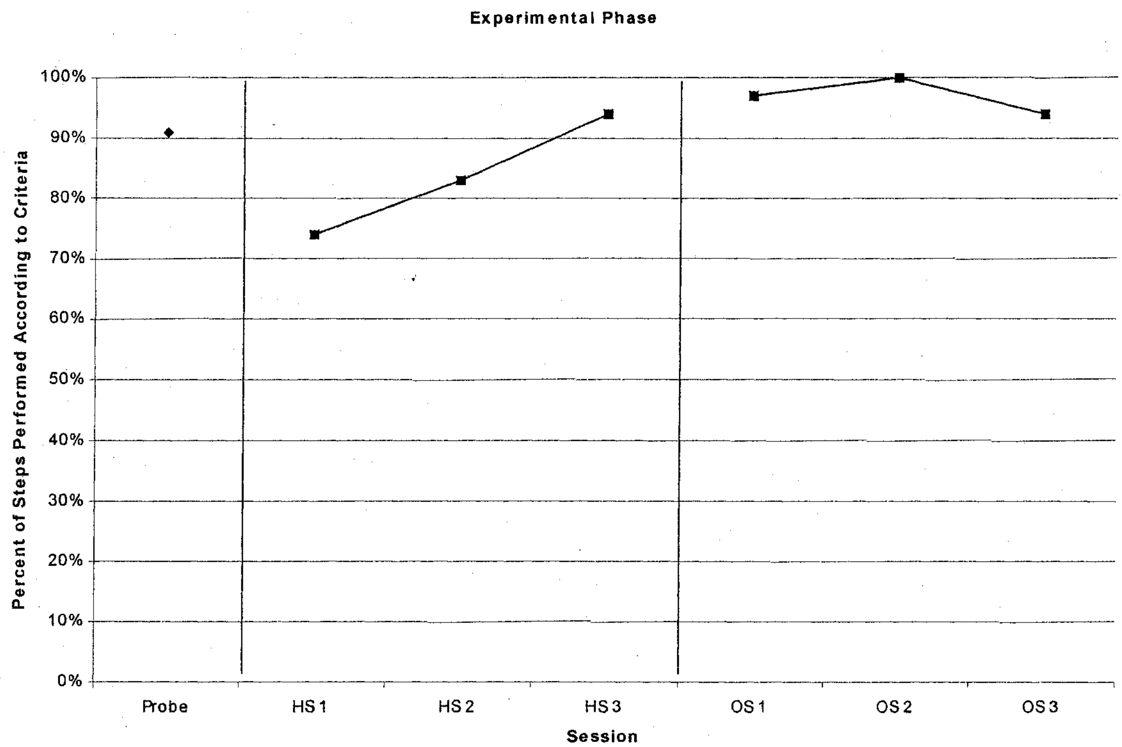

Figure 7: TT, Combined Supervisor-Led and Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

Initial Probe

TT showed one of the best performances on the initial probe, correctly completing approximately 91% of the probe items correctly. Unlike most of the other subjects, he correctly measured ingredients.

Supervisor-Led Sessions

TT was in the group that received the supervisor-led sessions for the first three sessions, and the orthotic-led sessions for the last three. He completed all six sessions. TT completed the six experimental sessions in 23 days, with an average session spacing of 4.6 days. The longest interval between sessions was eight days, and the smallest was two.

TT 's performance dropped during his first supervisor-Led session. This was most likely due to the fact that during the latter session he was required to follow the recipe in a prescribed order, which was not the case during the initial probe. TT showed progressively better performance during the second and third supervisor-Led sessions, achieving approximately 95% accuracy during the third.

Orthotic-Led Sessions

TT maintained his accurate responding throughout the three orthotic-led sessions. He achieved a high score of 100% correct on the second orthotic-Led session, and finished with an accuracy of approximately 95%.

Comparison of Orthotic-Led and Supervisor-Led Sessions

Comparison of the conditions on the graph above is somewhat problematic because the number of items varied between protocols. The orthotic-Led protocol contained approximately 20 additional steps. These steps were "helper" steps designed to break down the main steps, or in some way aide the completion of the main steps. For example, one step entailed placing a measuring cup on a colored square as a means to accurately locate it for another step.

These steps were omitted from the orthotic-Led protocol in order to allow direct comparison of the two tasks. The following graph summarizes the results.

Session Observations

TT showed the highest intelligence test scores of all the subjects. However, his reading scores were not significantly higher. TT utilized the instructions to accurately complete the task in the supervisor-led phase. He required none of the prompts (e.g. Identification of the batter, discrimination of colored lines and squares) necessary for most.

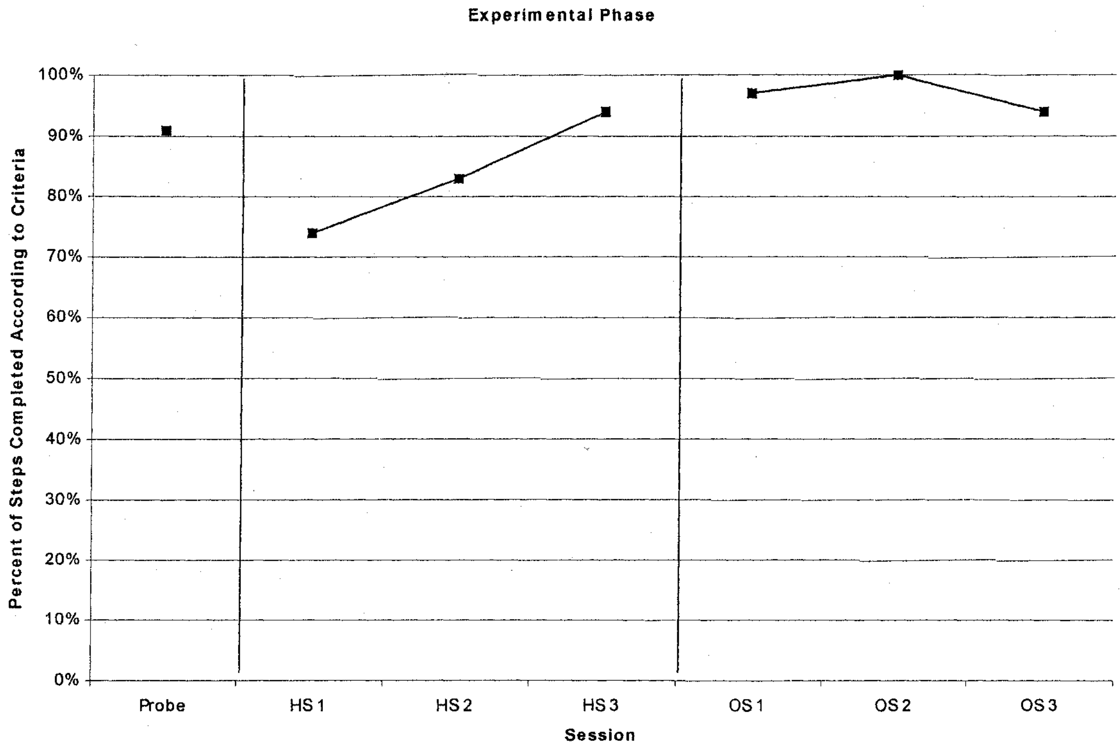

Figure 8: TT, Comparison Data

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

These results are very consistent with those seen on the first graph.

LK

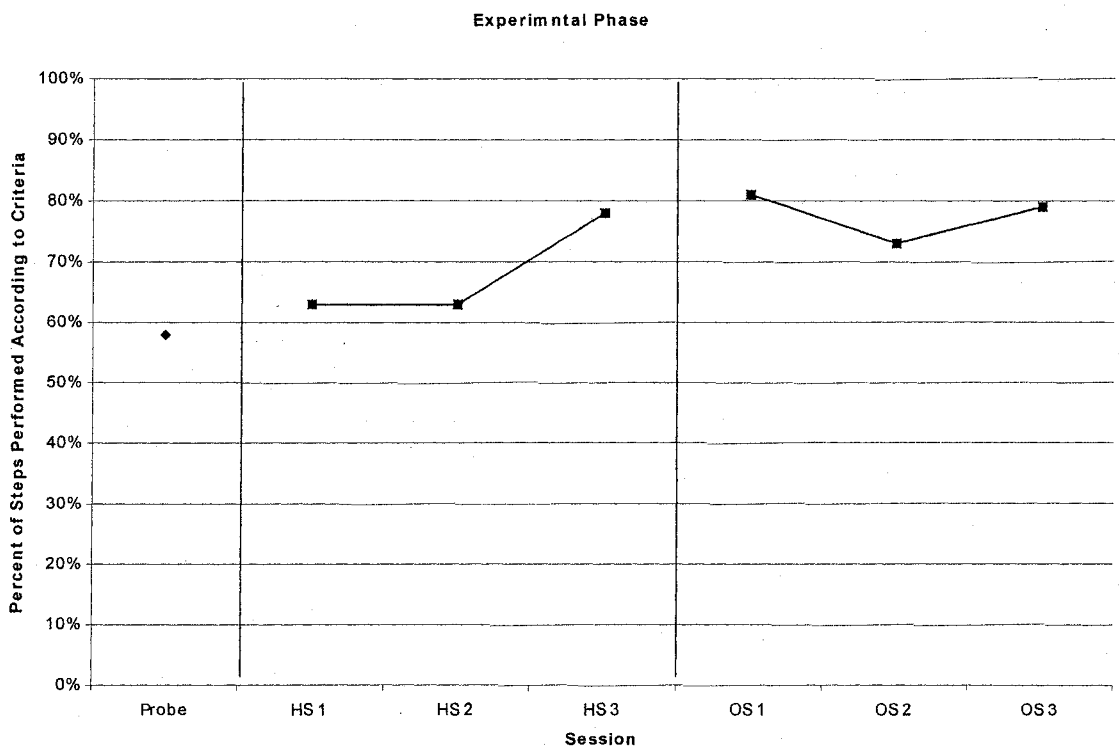

Figure 9: LK, Combined Supervisor-Led and Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

Initial Probe

LK completed approximately 58% of the probe steps correctly. He consulted the directions, and he measured correctly.

Supervisor-Led Sessions

LK was in the group that received the supervisor-led sessions for the first three sessions, and the orthotic-led sessions for the last three. He completed all six sessions. TT completed the six experimental sessions in 32 days, with an average session spacing of 6.9 days. The longest interval between sessions was nine days, and the smallest was five.

LK's performance stayed stable following the probe. In the first two sessions he completed approximately 63% of the steps correctly. However, during the third supervisor-led session he completed approximately 78% of the steps correctly.

Orthotic-Led Sessions

LK's performance during the three orthotic-led sessions remained approximately commensurate with his final performance during the supervisor-led condition. During his first session he showed approximately 80% accuracy. This dropped to approximately 73% during the second session, and finished with approximately 80% accuracy.

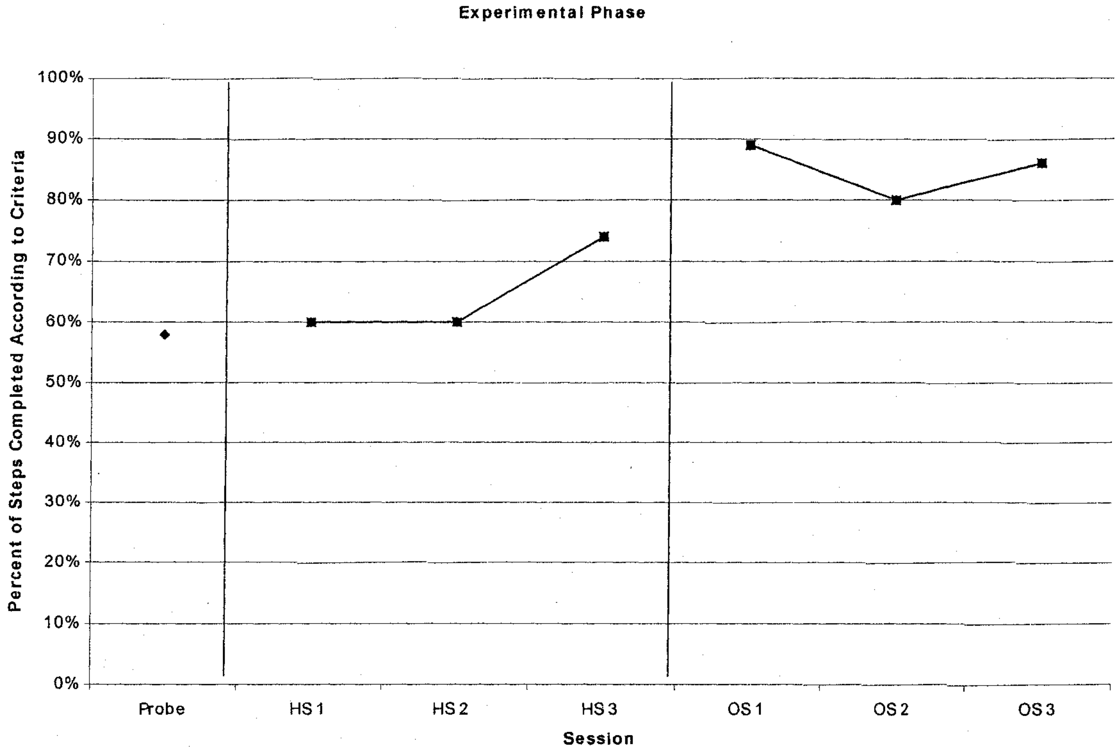

Figure 10: LK, Comparison Data

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

Comparison of Orthotic-Led and Supervisor-Led Sessions

When factoring out the "helper" steps, LK showed slightly higher performance. During his initial session in the orthotic-Led phase he showed approximately 89% accuracy. This fell to 80% during the second session, but finished at approximately 86%. This suggests that LK relied on previous learning to either skip the helper steps or to recover from errors made during the helper steps.

Session Observations

LK enjoyed his participation in the study. He frequently made the sessions into a "cooking show." LK completed the steps in both conditions carefully. He attended to directions and appeared to consult the written directions.

LK showed some good decision-making skills. For example, during one orthotic-led session he discovered that he omitted the cooking oil. He added the oil, as another layer, on top of the already poured batter. LK later examined his product, decided that the layer of oil would not work, and drained off the oil before continuing.

LK used the touch screen interface fairly well. Occasional problems were noted, however he competed the entire exercise without assistance.

RM

Initial Probe

RM showed 22% accuracy during the initial probe. She consulted the written directions, but made few accurate measurements.

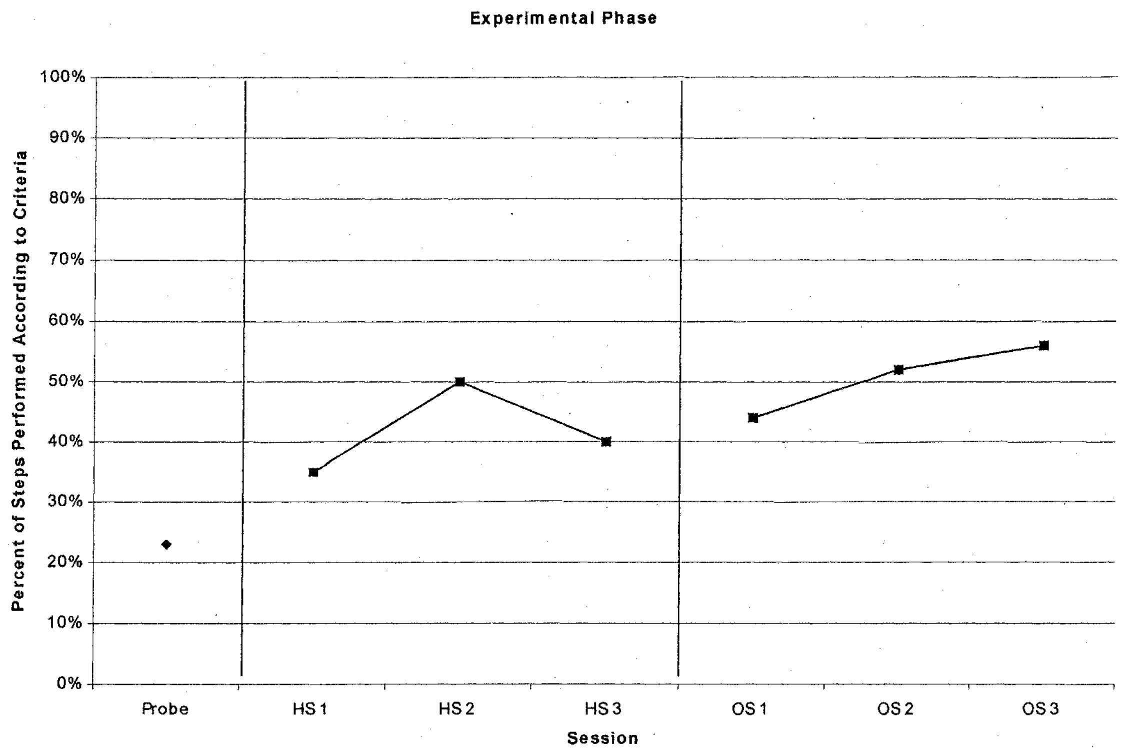

Figure 11: RM, Combined Supervisor-Led and Orthotic-Led Sessions

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

Supervisor-Led Sessions

RM was in the group that received the supervisor-led sessions for the first three sessions, and the orthotic-led sessions for the last three. She completed all six sessions. RM completed the six experimental sessions in 32 days, with an average session spacing of 6.4 days. The longest interval between sessions was ten days, and the smallest was four.

RM made some small gains during the supervisor-led sessions. During her first session she achieved approximately 35% of the items. This increased to 50% during the second session, but dropped back to approximately 40% during the third.

Orthotic-Led Sessions

RM showed slightly better performance during the orthotic-led condition. During her first session in the orthotic-led condition, she correctly completed 44% of the steps. This was roughly commensurate with her performance during the last session of the supervisor-led condition. Her performance increased slowly during the second and third sessions, ending in a score of approximately 56%.

Comparison of Orthotic-Led and Supervisor-Led Sessions

Roughly equivalent results are noted. However, her orthotic-led condition scores are all lower. This suggests that she may have completed more of the helper steps correctly, while missing some of the more crucial steps.

Session Observations

RM consistently worked hard. She consulted the written directions, and attended to the orthotic. RM had difficulty with the touch screen. The supervisor assisted her by operating the device under RM's verbal control.

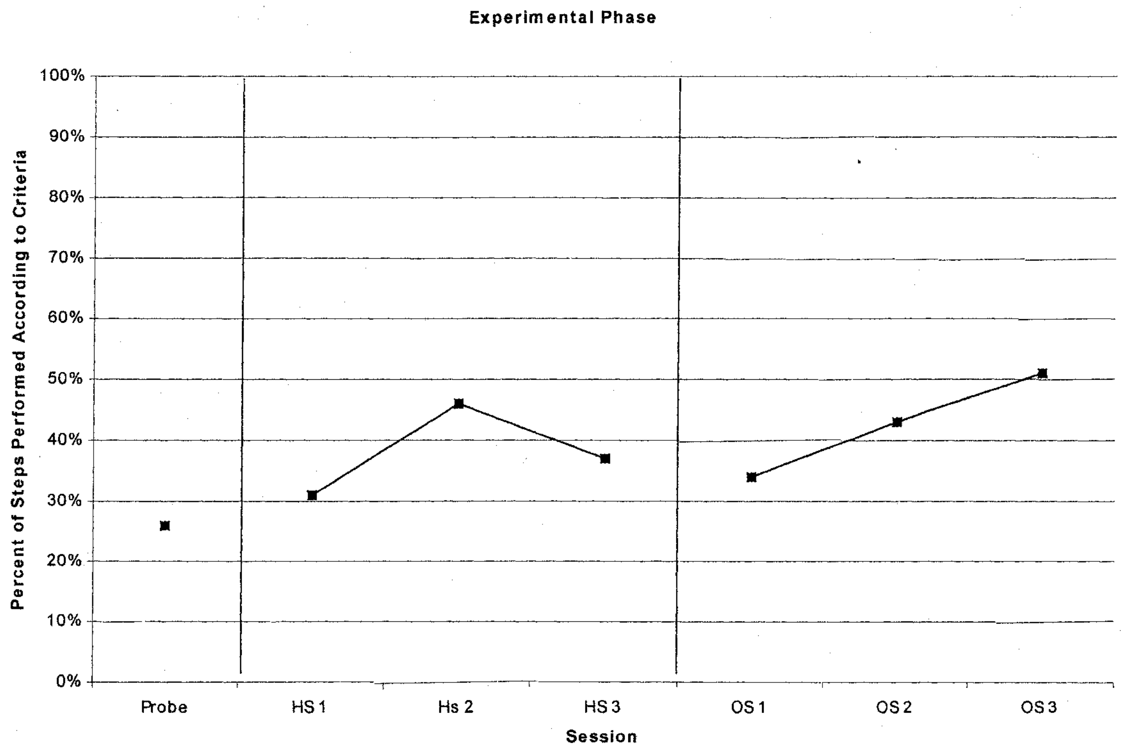

Figure 12: RM, Comparison Data

Percent of Steps Performed According to Criteria Across Probe, Human Supervisor and Orthotic Supervisor Sessions

Probe = Initial Student Probe
(No Human Supervisor Assistance)

HS (x) = Human Supervisor-Led Sessions

OS (x) = Orthotic Supervisor-Led Sessions

Experimental Hypotheses

Examination of the slopes of the lines of best fit for the orthotic-led versus the human supervisor-led conditions supports the experimental hypothesis.

Human-Led/Orthotic-Led Sessions

All three subjects maintained or improved performance as they transitioned from the human supervisor-led condition to the orthotic-led.

CHAPTER VI

DISCUSSION

This study examined the performance of nine subjects, in three different experimental conditions, as they completed a complex cooking task. Three subjects completed the task with the assistance of a human supervisor. Three completed the task with the assistance of a computerized cognitive orthotic. Three completed the task first with the assistance of a human supervisor (first three sessions) and then with the assistance of the orthotic (last three sessions). Appendix J shows a comparison of all nine subjects' performance.

Due to the small number of subjects, the study was designed without the use of inferential statistics. However, even in their absence, the results offer some interesting information. This discussion will begin by presenting suggestions from the data. Often these suggestions pose further questions, and these will be discussed as possible topics for additional studies. This chapter will then discuss some general observations made during the study.

Overall Subject Performance

Subject performance on the probe varied considerably, ranging from a low of 0% of criterion items completed successfully, to a high of 80%. This suggests that none of the subjects were capable of completing the experimental task prior to the human or orthotic-led sessions. Also, as predicted by their reading test achievement scores, none of the subjects completed the task solely by reading the recipe. Casual observations made during the human supervisor-lead sessions revealed that the subjects again varied considerably in their ability to profit from the written instructions. On one end, some subjects appeared to gain no information from the text. At the other extreme, some subjects were able to gain some information from the written directions. Most of this was limited to matching a measurement with an ingredient. With the exception of, perhaps, one student, none were able to use the written materials to complete the steps in the correct order. In fact, some of the written directions appeared to confuse them.

The Cognitive Orthotic

Consistent with the observations of several authors (Bergman, 1991a; Bergman, 1991b; Chute et al., 1988; Cole, 1999; Lynch, 1990) adjustments were necessary to make the orthotic effective. During this study, two problems emerged as consistent hindrances to successful task completion. First, some subjects had the tendency to want to go beyond what the orthotic instructed them to do. During the human supervisor-led phase this was not a problem because the supervisor always corrected the subject when this began to occur. However, during the orthotic-led phase, this could become problematic. Minor deviations simply meant that the subject got a bit ahead of the orthotic, causing them to skim through the screens to make the orthotic "catch up." In more serious deviations the subject significantly deviated from the task steps. This often resulted in the baked product being ruined or seriously degraded. When a subject was noted to make procedural deviations during a session, he or she was told, at the beginning of the next session, to "do only what the computer tells you to do."

The second consistent problem involved the use of colored prompts during the orthotic-lead sessions. As described above, the orthotic-lead sessions used modified measuring cups. To avoid the discrimination problems anticipated when attempting to use a measuring cup, the various measurement index marks were color coded. Thus, a subject was not told to fill the measuring cup to the ½ cup mark. Instead, he or she was instructed to fill the cup to the blue line.

The other prompt was a series of colored squares. These were devised to give the subject an easier way to locate an item. For example, the recipe called for reserving a portion of the bread mix for use in a later step. Instead of requiring the subject to discriminate the reserved mix from the main mix, at a later time, the subject was instructed to place the main mix on the orange square and the reserved mix on the pink square. Later, the subject could be directed to the appropriate square to retrieve the item.

The problem arose as some subjects attempted to discriminate colored "lines" and colored "squares." Frequently, a subject correctly measured an ingredient to the correct colored line. However, when asked to place that cup on a colored square, the subject tended to attempt another measurement. When this occurred, the subject was shown, during the beginning of the next session, the difference between colored "lines" and colored "squares."

A customized interface might have produced better performance. This study used the Pocket PC version of the Internet Explorer program to present the steps of the task. At each step, the subject had the option of only advancing to the next step, or replaying the current step. This was accomplished by tapping the touch sensitive screen with a small plastic stylus.

The computer responded differently depending on how hard the stylus was pressed against the screen, and for how long it remained pressed. Pressing the screen too lightly, or for too short a duration, produced no response from the orthotic. However, pressing the stylus for too long resulted in an unwanted secondary menu being displayed. When this occurred, subjects were taught to press anywhere on the screen, but off the secondary menu, to make it disappear.

Some subjects had little problem using the stylus. However, others did. When it occurred, the correction process appeared distracting to the subjects.

Two subjects tapped on the screen in such a way as to leave the program altogether. Although also easily remediable, this too served as a distraction to the subjects. A customized interface would have solved both these problems.

Observations during the orthotic-lead sessions suggest that subjects attended to both the visual stimuli on the screen as well as the auditory prompts. Some subjects used the repeat function on the orthotic. However, no subject appeared to scrutinize the visual display. It is also unknown to what extent the subjects derived any additional information from the animation. This would be an excellent topic for future research.

Another interesting area for research would be to examine the properties of the static visual output. "Iconicity" refers to the continuum that describes symbols by ease of recognition (Beukelman & Mirenda, 1992). This study used actual photographs, objects easily identified. However, it would be interesting to examine visual output with other levels of iconicity. For example, line drawings would have the advantage of requiring far less memory, but may convey far less information to an individual with a moderate cognitive impairment.

Items were pulled from the orthotic-lead protocol, that measured steps requiring some judgment of the quality of performance, to examine the degree to which the visual information may have aided performance. For example, steps were examined that judges whether the subject:

(a) spread the batter so that the thickest area was not more than twice the thinnest,

(b) spread the batter so that it was within one half inch of the side of the pan all the way around, and

(c) chopped the cream cheese into pieces no more than ½ inch square.

These items were summed for each subject in the human-led condition and the orthotic-led condition, and the sums were examined across the six experimental sessions. A line of best fit was calculated on this performance, and regression coefficients were generated as a way to characterize the slope of this line. The coefficients averaged .205 for the human-lead subjects, while a value of .446 was noted for the orthotic-lead subjects.

Emotional Responses

Two authors (Bergman & Kemmerer, 1991; Harris, 1978) discussed the improvements to mood and motivation that may arise from the success occasioned by a cognitive orthotic. The inverse was vividly demonstrated by one subject. BZ began the study with a frustrating experience, achieving none of the criterion steps during the initial probe. When this examiner went to get her in her classroom to participate in the first experimental session she was very reluctant to participate. This was somewhat perplexing in that participation in the study was generally considered a privilege by her peers. Discussion with BZ revealed that her reluctance stemmed from her poor probe performance. Even though it was explained to her that the probe was purposefully hard, she was very reluctant to attempt the task again. It was finally explained to her that future sessions would all be assisted by a supervisor. She then happily completed all of the experimental sessions. To what extent does our educational system foster student dependency to the extent that they are fearful to attempt tasks that have been difficult for them? To what extent could we improve their quality of life by empowering them?

Consistent with an observation made by Steele, et al. (1989) one subject required a more global view of the experimental task. JM started the study showing very good performance (85%) on the initial probe. On the basis of this performance it was expected that he would perform very well on the first orthotic-led task. However, while completing the first session JM appeared very confused. His performance was significantly lower than predicted

(24%). JM's supervisor was also very perplexed. During a discussion, following the session, it was speculated that JM may not have understood that the task was the same one that he performed during the probe. The orthotic-led process may have been sufficiently different that JM thought the task different.

At the beginning of the second session it was explained that the orthotic-led process would result in the same cake that was produced during the initial probe. JM's accuracy during this session rose to 87% and he maintained or improved performance on all successive trials.

The interface also proved problematic in that timed steps assumed that the subject already had all of the necessary equipment and ingredients at his or her disposal. The orthotic did not wait for a confirmation from the subject that he or she was ready to begin, but instead automatically began counting. For example, some subjects searched for an appropriate spoon while the orthotic counted a stirring interval. This could have been easily corrected by modifying the orthotic to require confirmation that the subject was ready to begin stirring before that actual timing began.

Study-Related Observations

Each subject began the study by watching as the experimenter demonstrated making the cake in the manner that it would be made during the supervisor-led condition. This was done, in part, to demonstrate that the subjects could not simply make the cake after a demonstration, and this assertion was indeed supported. However, this step may have obscured the effects of the orthotic in that the orthotic was never given the chance to guide a completely naïve subject through the process. It would have been interesting to begin with a subject who only knew the goal of the task, and then see how effective the orthotic was "right out of the box." Although not necessary for this study, such a method would be interesting for further research.

It is important to understand that success, as defined by the criteria in this study, might not have translated into success in baking this cake in the real world. Some steps may have been completed differently, or some steps may have been completed in a different order, and the cake may have turned out acceptable for consumption. However, the purpose of the study was not to examine the effectiveness of the orthotic versus a human supervisor in making this particular cake. Rather, it was to examine the effectiveness of these two systems in guiding an individual with a cognitive impairment through the completion of a complex task. It is possible that a different task might have much more stringent accuracy requirements.

Human-Led vs. Orthotic-Led

Regardless of experimental condition, all subjects improved performance as they proceeded through the study. As noted above, only two general modifications to the process were necessary to significantly improve performance. These were: A) directing the subject to only do what she was told to by the orthotic, and B) helping the subject to discriminate colored "lines" on the measuring cups with colored "squares" on the countertop.

It was anticipated that the human-supervisor condition might offer some advantage to the subjects because subjects were corrected on a step when they were either not performing the step to criteria or when they attempted to complete an incorrect step. Thus, each subject in a human-led phase started the next step from a correctly completed base. This effect was noted to a minimal extent. Some subjects in the orthotic-led phase (JP especially) responded far differently than prompted. This, at times, resulted in a catastrophic error that led the subject on a path that produced only more serious deviations from the steps of the task.

However, when examining the data chart compilation (See Appendix J) it can be seen that the performance of the subjects in the orthotic-led condition was very similar to those noted in the human-led condition. Lines of best fit were calculated for the subjects in the orthotic-led condition and the supervisor-led condition, and regression coefficients were again calculated as a way to examine the slope of these lines. The average coefficient for each group was .27 for the orthotic-led subjects versus .34 for the human-lead.

Human-Led/Orthotic-Led

Those subjects who began the study in the human-led condition, followed by the orthotic-lead condition showed performance very similar to that seen in the other two conditions. When they entered the orthotic-led sessions, all three subjects were able to generally maintain performance, to slightly improve performance over that seen in the human-lead sessions. The largest increases in performance for this group were in the human-lead sessions.

However, it is possible that some ceiling effect could have taken place.

In a real-life application starting with human-supervisor assistance and then transitioning to orthotic-lead assistance might actually be the most practical. Several authors talk about feedback mechanisms for the orthotic (Cavalier & Ferretti, 1993; Friedman, 1993; Levine & Kirsch, 1985). However, in real-life, automatic feedback mechanisms may be very difficult to establish. For example, Cavalier & Ferretti's (1993) switch wiring orthotic made use of the electronic circuitry to supply feedback to the orthotic relative to whether a step had been correctly completed or not. However, this study also relied on human observers to provide some of the feedback. Starting a subject with human supervision would allow the orthotic to be fine tuned to the needs of the specific user. While not addressing the experimental hypothesis, the results for the subjects in this condition suggest that a cognitive orthotic might maintain a skill that was previously taught by a human supervisor. Considering the potential cost of constructing orthotics with automatic feedback mechanisms, this approach might actually be the most practical and cost effective.

Summary

An individual's independence skills will have a direct bearing on the quality of his or her life. Individuals independent in their life skills will be able to live in less restrictive settings. For example, students with these skills may be able to live independent of the constant supervision provided in a group home. An individual's independence also affects the environment in which they function. Human resources are, by far, the most expensive part of any program that provides housing and employment for individuals with cognitive disabilities. An independent individual does not require as much training and supervision. This frees scarce and vital resources so that other individuals can receive more attention.

In this study, the human-supervisor condition represented what was essentially the state of the current system for assisting individuals with moderate cognitive disabilities in home or vocational settings. It is even possible that an individual is given little or no training or support to function independently. Under these conditions almost everything is done for the individual. Vocational opportunities are often not present, and the individual spends most of his or her day watching television.

The other two conditions, namely the orthotic-led condition and the human/orthotic-led condition, allow considerably more independence for the individual. The results of this study suggest that they may be viable alternatives.

Future Research

The present study examined the ability of a computerized cognitive orthotic to guide a student with a cognitive ability through a complex task. This study was not concerned with whether the subject learned to complete the task independently. However, Kirsch et al. (1988, 1992) suggested that use of an orthotic resulted in learning. It would be interesting to examine whether continued use of the cognitive orthotic would result in learning.

Two authors (Bergman, 2000; Chute & Bliss, 1994) recommend the use of a consistent interface in orthotic design. It would be interesting to present different tasks, using the same interface, and study the ability of the orthotic to generalize performance across these different tasks.

Finally, this study examined the ability of a computerized cognitive orthotic, in the form of a hand-held computer. This device presents significant benefits to a user due to its portability. However, the device also may have some limitations due to its:

(a) small visual output,

(b) limited volume,

(c) troublesome input method (as described above), and

(d) limited memory.

Although not as portable, a notebook computer would offer a larger screen, louder auditory output, keyboard or mouse input, and memory capacity to present much richer audio and video content. It would be interesting to examine each of these features and their contribution to the orthotic process so that the benefits of portability could be balanced against these other features.

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APPENDIX A

Box Mix Directions

Pillsbury Bake-Off Winning Recipe

LEMON-POPPY SEED-RASPBERRY COFFEE CAKE

A favorite recipe from Bake-Off® Contest 38.

Prep Time: 15 minutes
(Ready in 1 hour 45 minutes)

1 (15.6-oz.) pkg. Pillsbury® Lemon PoppySeed Quick Bread & Muffin Mix
3/4 cup milk
1/3 cup oil
1 egg
1/2 cup raspberry preserves
1/4 cup sugar
1 (3-oz.) pkg. cream cheese

1. Heat oven to 350°F. Spray 9 or 10-inch springform pan with nonstick cooking spray. Reserve 1/2 cup of the quick bread mix in small bowl for topping.

2. In large bowl, combine remaining quick bread mix, milk, oil and egg. Stir 50 to 75 strokes until mix is moistened. Spread 2/3 of batter in bottom of sprayed pan. Spoon preserves over batter; spread carefully to within 1/2 inch of edge of pan. Drop remaining batter by spoonfuls over preserves; carefully spread. (Some preserves may show through.)

3. Add sugar to reserved 1/2 cup quick bread mix. With pastry blender or fork, cut in cream cheese until mixture resembles coarse crumbs. Sprinkle mixture over batter.

4. Bake at 350°F. for 45 to 55 minutes or until edges are golden brown. Cool 45 minutes. Serve warm or cool.

10 servings

HIGH ALTITUDE (ABOVE 3500 FEET): Add 1/4 cup flour to dry quick bread mix; mix well. Reserve 1/2 cup. Bake at 375°F. for 40 to 45 minutes.

APPENDIX B

Subject Guardian Consent Form

Western Michigan University
Department of Educational Studies
Special Education Program

James Yanna – Investigator
Dr. George Haus – Dissertation Chair

Subject Guardian Dissertation Consent Form

January 2, 2003

Guardian
Street
City/State/Zip

Dear ______________________,

I would like [student] to take part in a study, which will be my doctoral dissertation. This study will examine whether a computer can be used to help students with cognitive disabilities complete difficult independence or vocational tasks. This system has been effectively used with individuals having head injuries, and I am hopeful that it might work with students with cognitive impairments, enabling them to be more independent and successful.

During the study I will ask [student] to complete a task either by memory, with the help of written directions, or from directions provided by a computer. [student] will complete approximately eleven 30 minute sessions, one session per week. All tasks will be done at school, and will be staggered during the day to minimize disruption.

A staff person will supervise the task and record [student's] performance. There is no danger to the task. The task will be videotaped to ensure that the records are reliable.

[Student] will not participate if you or [student] doesn't want to. You or [student] can also quit the study at any time. Your student's decision to participate in an individual session or not, or quit, will have no effect on his schooling. No one but me and the session supervisor will know the results. No information will be put in the student file or even kept at school. All information will be kept in Dr. Haus' office at Western Michigan University during a mandatory three-year retention period. No student will be identifiable from reading the dissertation.

There are few potential risks to [student]. They may include:

A) disruption to their daily schedule,
B) loss of class time,
C) frustration over attempting to complete difficult tasks, and
D) feeling pressured to participate because a school authority has asked them to do so.

All efforts will be made to avoid these problems.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I am very optimistic that computer technology will allow our students to become much more independent. I hope that this study will be a small step toward this goal. If you have any questions please feel free to call either me (674-8096 school, 668-3216 home) or my advisor Dr. George Haus (387-5935). You may also contact the Chair, Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) if questions or problems arise during the course of the study.

_____ I allow [student] to participate in the study.

_____ I do **not** want to participate in the study.

Parent/Guardian Signature ________________________________

Date ______________________

APPENDIX C

Subject Consent Form

Western Michigan University
Department of Educational Studies
Special Education Program

James Yanna – Investigator
Dr. George Haus – Dissertation Chair

Dissertation Subject Consent Form

September 2, 2003

Student
Street
City/State/Zip

Dear ______________________,

I would like you to take part in a study. This study will examine whether a computer can be used to help you complete a difficult task such as something that you would need to do at work or at home. During the study I will ask you to complete a task either by memory, or with the help of written directions or directions from a computer. I will ask you to do one task, which will take about 30 minutes, about once per week. You will do a total of about ten tasks, and the entire study will take place over two months. All tasks will be done at school, and I will work out with your teachers when it will be a good time to do them.

A person will watch you do the task and he or she will write down how you do. There is no danger to the task. The only problem is that you will miss some class, and I will schedule this time so that it isn't a problem. Some of the tasks might be hard and you may become frustrated. The results that you and the other people show will help me to decide whether a computer is a good way to help you do things either at work or at home.

You do not have to participate if you don't want.. You can also quit at any time. Your decision to participate or not, or quit, will have no effect on how you do in school. No one but me or the person helping you will know how you did. I will record the study using a video camera, and this will be used to help me know that the person helping you was doing a good job. No one but me and the person helping you will ever know how you did. No information will be put in your student file or even kept at school. There will be no way that anyone will know that you helped in the study, even after reading my paper. It will be kept in Dr. Haus' office. He is my teacher at the university. From what I learn, I hope to make it easier for you to learn how to do many things on your own.

There are few possible risks. They may include:

E) It might disrupt your school schedule.
F) You might lose some time in class.
G) You might get frustrated when you try to do some hard tasks.
H) You might feel pressured to help with this project because I have asked you to do so.

I'll try very hard to avoid these problems.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

If you have any questions please see me. I can also help you contact my teacher, Dr. Haus. His telephone number is 387-5947. You may also call the Chair of the Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) if you have questions during the study.

_____ I would like to help with the study.

_____ I do **not** want to help with the study.

Student Signature _______________________________________

Witness Signature _________________________________

Date ______________________

APPENDIX D

Supervisor Handout

Introduction:

Thank you so much for volunteering to be part of my dissertation study. The dissertation is the last step of my ten year effort to complete my doctoral degree.

This study will examine the effects of using a hand-held computer to assist a person with mental retardation as he or she carries out a complex task. As you undoubtedly know, complex tasks, such as multi-step independent living or vocational tasks are very difficult for our students. This means that they have to be dependent upon supervisors to successfully complete these tasks, which severely limits their ability to live and work independently.

Technology has shown considerable merit to assist individuals with mental retardation. The technique that we will be examining has already proved itself effective with some individuals who have suffered closed-head injuries. My study will attempt to extend these results to people having mental retardation.

The Task:

The complex task that I have chosen is a cooking task. We will be preparing a box coffee cake mix. I've chosen this task because it is fairly complicated. You will assist your subject in one of two ways, depending on the day.

Supervisor-Lead Days

On these days you will help the subject go through the task pretty much the way that the box tells you. Here are the steps:

1. *Preheat the oven to 350 Degrees.*
2. *Spray pan with PAM*
3. *Reserve ½ cup of mix in a bowl.*
4. *In another bowl combine*
    a. *Remaining mix.*
    b. *Milk*
    c. *Oil*
    d. *¼ cup Egg beater*
5. *Stir 50 to 75 strokes.*
6. *Spread 2/3 of batter into the pan.*
7. *Spoon jam evenly over batter and spread to within ½ inch of edge of pan.*
8. *Drop remaining 1/3 of better, by spoon full, over the preserves.*
9. *Carefully spread out piles to within ½ inch of edge of pan.*
10. *Add sugar to reserved ½ cup of bread mix.*
11. *Cut in cream cheese until uniformly mixed.*
12. *Spread over batter in pan.*

13. Bake 50 minutes.

For each step you will first encourage the subject to do the next step. Start by asking the subject "What is next?" If the subject answers correctly, allow him or her to do it.

If he or she does the process correctly praise and continue on.

If he or she answers incorrectly briefly explain the next step and allow him or her to do it.

If he or she answers correctly, but starts to complete the step incorrectly correct verbally, with a model only if necessary.

Computer-Lead Days

On the computer-lead days your basic job will be to record performance. You will not intervene unless the subject is about to create an error on a critical task. These are highlighted in red on your protocol. Please note that the supervisor-lead tasks and the computer-lead tasks use different protocols. In this condition, if an error is made on a critical task, correct just as you would for the supervisor-lead tasks. The only other time you might have to help the subject is if he or she has a problem with the computer itself.

The Protocol

Please fill out the protocol completely. Following the session please return the protocol to my office immediately. You can then pick up the protocol for the next session. Please note that the protocols differ for different phases. I will post the phase that you will be in each time. I will also order the protocols to match the phase. Prior to beginning a session please ensure that the protocol matches the phase on the sheet.

Prompting

During the sessions the subjects may ask questions. You are only allowed to make general praise such as "You're doing fine." Do not answer any specific questions. Also, do not give any type of general feedback such as "You need to work more slowly."

Operating the Orthotic

I will demonstrate operation of the orthotic.

Taping

Each of you will receive a video tape to use during your sessions. Each session will be taped. You will be responsible for loading the camcorder and starting it prior to the session. After each session please return the tape with the protocol. Do not rewind the tape. Just start from the point where it is.

Other Misc Things

1. Please have the subject use the bathroom prior to the session.
2. Please run the dishes through the dishwasher after the session.
3. After the dishes are washed please return them to the cupboard.
4. You and your subject can do what you want with the coffee cake after it is completed. Please put the pan in the dishwasher at the end of the day.

APPENDIX E

Human Supervisor Protocol

Supervisor-Led Protocol V6

Subject Name　　　　　　　　　　　　Supervisor

Date　　　　　　　　　　　　　　　　Session

Steps	Criteria	+ or -	Note
Preheat the oven to 350 Degrees.	Turns on oven.	1	
	Temperature knob set to LESS THAN 25 degrees off.	2	
Spray pan with PAM	Uses PAM	3	
	Pan bottom AT LEAST 75% covered.	4	
Reserve ½ cup of mix.	Reserves Correct Mix	5	
	Less than off by 1/8 cup.	6	
Combine in bowl.		7	Can combine ingredients in any order.
	Adds milk to bowl one.	7	
	3/4 cup to within 1/8 cup.	8	
	Adds oil to bowl one.	9	
	1/3 cup to within 1/8 cup.	10	
	Adds Egg Beaters to bowl one.	11	
	1/4 cup to within 1/8 cup.	12	
	Adds all of remaining mix in bag.	13	If attempt to use reserved score "-"
	Adds no other ingredients to bowl one.	14	
Stir 50 to 75 strokes.	Stir at least 50 strokes.	15	
Spread 1/2 of batter into the pan.	Puts about half of batter in pan.	16	
	Batter spread so thickest area not more than twice the thinnest.	17	Wait until subject finishes step below if correction necessary.
	Batter spread to within 1/2 inch of side of pan all the way around.	18	
Spoon jam evenly over batter and spread to within ½ inch of edge of pan.	Puts preserves on top of first layer of batter in pan.	19	
	Measured 1/2 cup to within 1/8 cup.	20	
	Uses almost all preserves.	21	
	Preserves spread so thickest area not more than twice the thinnest.	22	You will need to watch the next three simultaneously!

	Preserves spread to within 1/2 inch of the side of the pan all the way around.	23	
24	Spoons reserved batter onto preserves.	24	
	Uses almost all reserved batter.	25	
	Drops into more than four piles.	26	
Carefully spread out piles to within ½ inch of edge of pan.	Batter spread so thickest area not more than twice the thinnest.	27	
	Batter spread to within 1/2 inch of side of pan all the way around.	28	
Add sugar to reserved ½ cup of bread mix.	Adds sugar to bowl two.	29	Sugar or mix can be added in any order.
	Measures 1/4 cup sugar to within 1/8 cup.	30	
	Pours reserved mix in bowl two.	31	
	Pours in all of reserved mix.	32	
Cut in cream cheese until uniformly mixed.	Puts cream cheese in bowl two..	33	
	Pieces chopped to less than 1/2 inch square.	34	
	Pieces evenly mixed with mix and sugar.	35	
Spread over batter in pan.	Spoons topping from bowl two onto baking pan.	36	
	Topping spread so thickest area not more than twice the thinnest.	37	
	Topping spread to within 1/2 inch of side of pan all the way around.	38	
Bake 50 minutes.	Puts pan in oven.	39	
	Timer set to within 5 minutes.	40	

Notes

APPENDIX F

Modified Recipe Directions

Pillsbury Bake-Off Winning Recipe

LEMON-POPPY SEED-RASPBERRY COFFEE CAKE

A favorite recipe from Bake-Off® Contest 38.

Prep Time: 15 minutes
(Ready in 1 hour 45 minutes)

1 (15.6-oz.) pkg. Pillsbury® Lemon PoppySeed Quick Bread & Muffin Mix
3/4 cup milk
1/3 cup oil
¼ Cup Egg Beaters
1/2 cup raspberry preserves
1/4 cup sugar
1 (3-oz.) pkg. cream cheese

1. Heat oven to 350°F. Spray 9 or 10-inch springform pan with nonstick cooking spray. Reserve 1/2 cup of the quick bread mix in small bowl for topping.

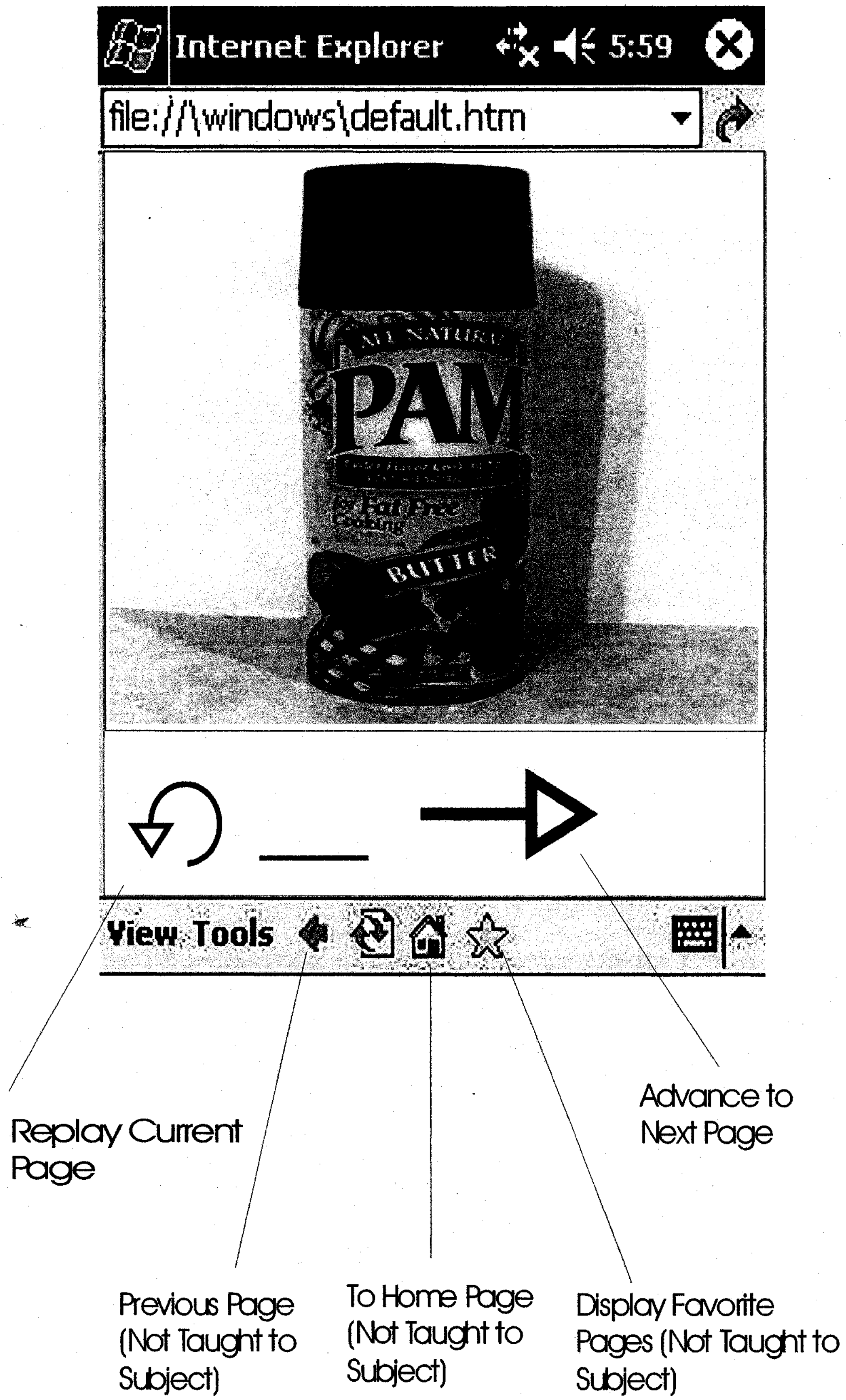
2. In large bowl, combine remaining quick bread mix, milk, oil and egg. Stir 50 to 75 strokes until mix is moistened. Spread ½ of batter in bottom of sprayed pan. Spoon preserves over batter; spread carefully to within 1/2 inch of edge of pan. Drop remaining batter by spoonfuls over preserves; carefully spread. (Some preserves may show through.)

3. Add sugar to reserved 1/2 cup quick bread mix. With pastry blender or fork, cut in cream cheese until mixture resembles coarse crumbs. Sprinkle mixture over batter.

4. Bake at 350°F. for 45 to 55 minutes or until edges are golden brown. Cool 45 minutes. Serve warm or cool.

APPENDIX G

Orthotic Display


Internet Explorer
5:59
file://\windows\default.htm
PAM
BUTTER
View Tools
Replay Current Page
Advance to Next Page
Previous Page (Not Taught to Subject)
To Home Page (Not Taught to Subject)
Display Favorite Pages (Not Taught to Subject)

APPENDIX H

Orthotic Task Sequence

1

Get out the cream cheese. It looks like this.

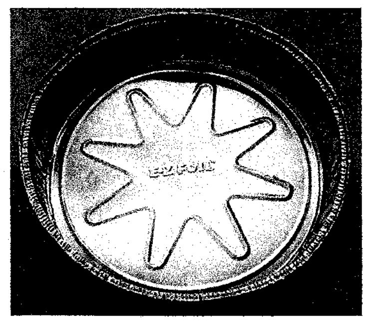
2

Get out the box of flower. It looks like this.

3

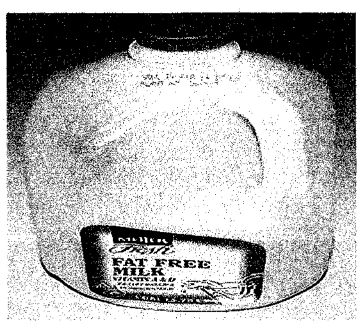
Get out the cooking spray. It looks like this.

4



Get out a pan. It looks like this.

5



Get out the milk. It looks like this.

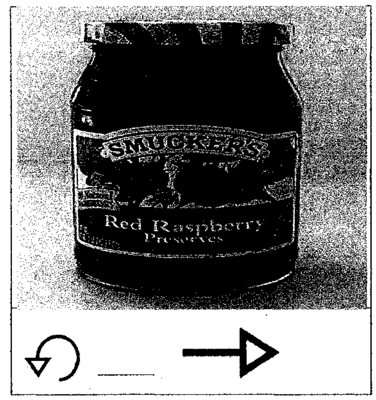
6

Get out the cooking oil. It looks like this.

7

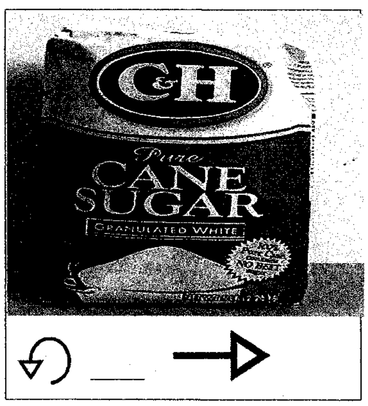
Get out the Egg Beaters. They look like this.

8



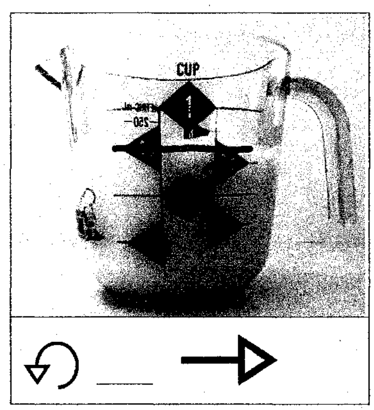
Get out the jam. It looks like this.

9



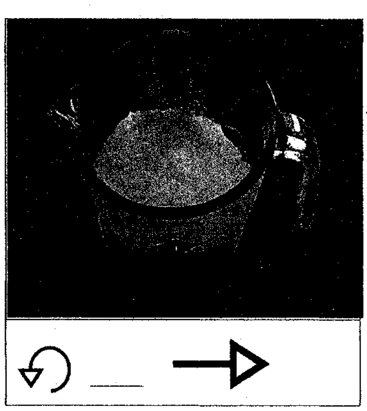
Get out the sugar. It looks like this.

10



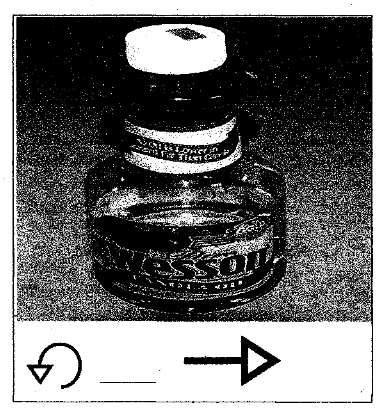
Fill the measuring cup to the red line with milk. It should look like this.

11



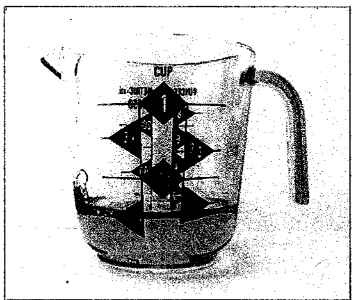
Put it on the red square.

12



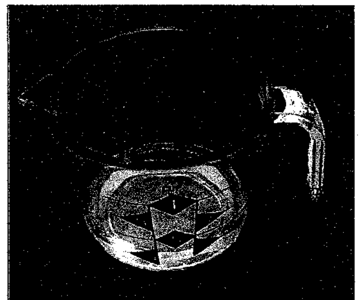
Find the bottle of oil again. It should look like this picture.

13



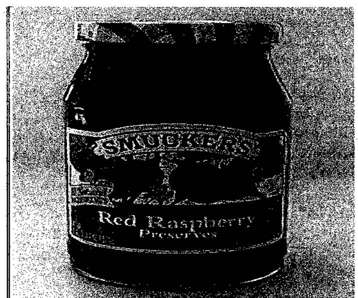
Fill another measuring cup to the blue line with oil.

14



Put it on the blue square.

15



Find the raspberry jam again. It should look like this.

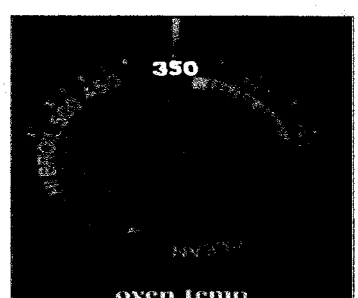
16

Use a spoon to scoop the jam into another measuring cup. Fill the cup to the green line. It should look like this.

17

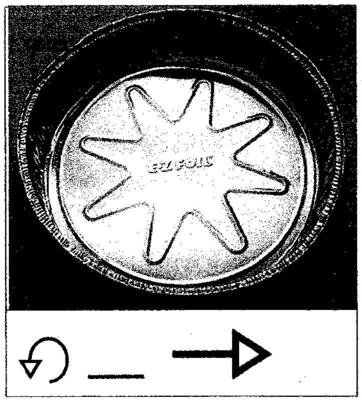
Put it on the yellow square.

18



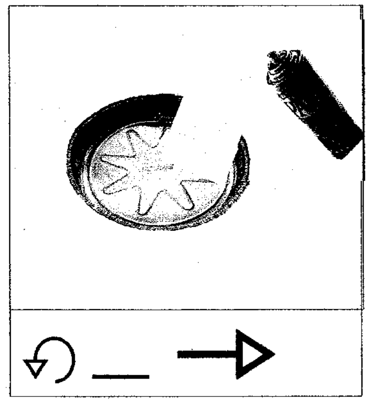
Find the temperature knob on the oven. It's the one with the blue dot. Turn it until it looks like the picture.

19



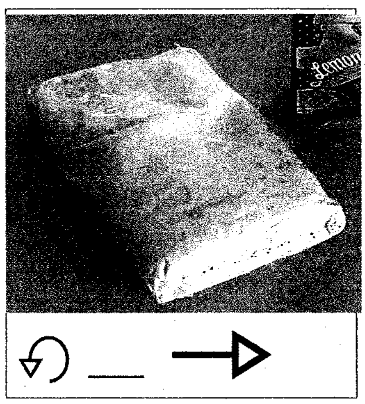
Find the cooking spray and the round pan again.

20



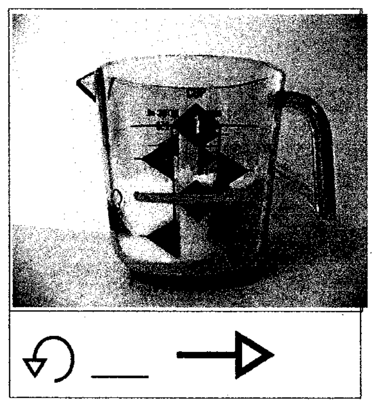
Spray the bottom and sides of the pan until it is all covered.

21



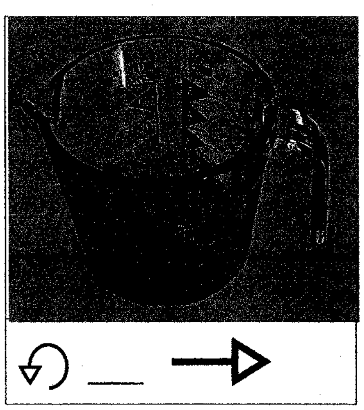
Find the bread mix from the box. It should look like this.

22



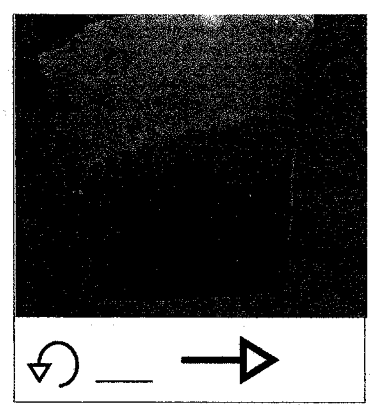
Fill another measuring cup to the greenmark with the bread mix. Leave the rest in the bag.

23



Put the cup on the green square.

24

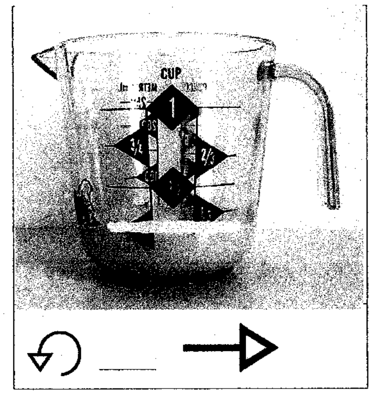


Put the bag on the orange square.

25

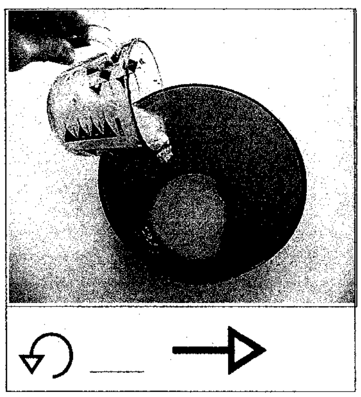
Find the egg beaters. They look like this.

26



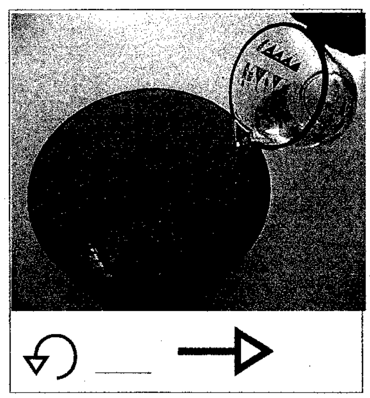
Pour some of the egg beaters into the measuring cup. Fill it to the yellow line. It should look like this.

27



Pour the egg beaters into the bowl.

28

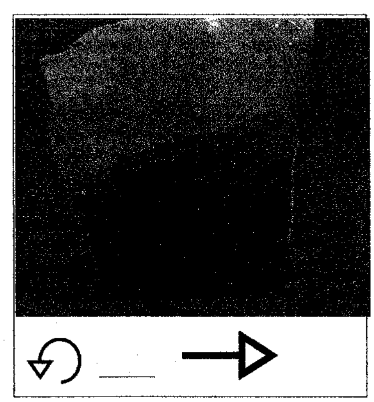


Pour the oil into the bowl. It should be on the blue square.

29

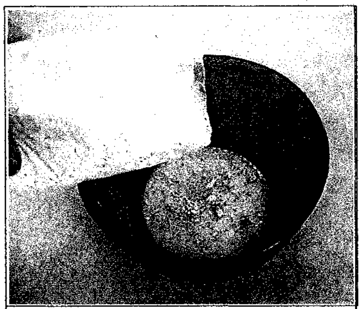
Pour the milk into the bowl. It should be on the red square.

30



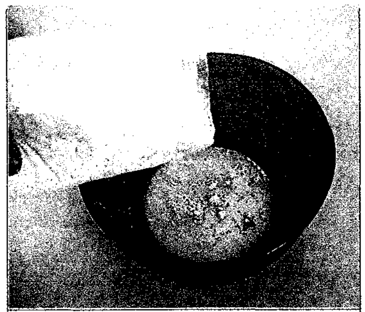
Find the bread mix in the bag. It should be on the orange square.

31



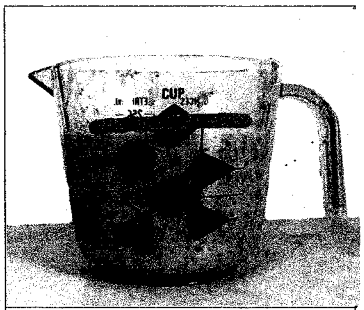
Put the bread mix into the bowl.

32



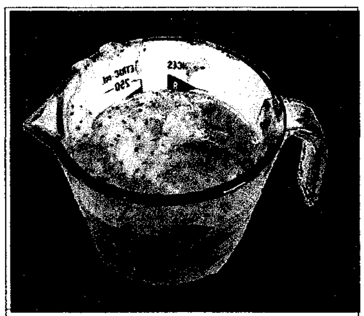
Stir until you hear the beep.

33



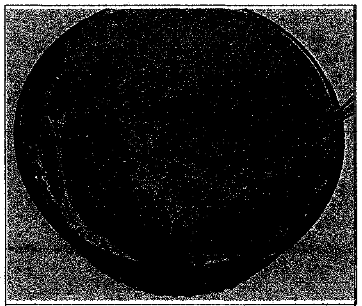
This is now called the batter.Spoon the batter into the measuring cup to the orange line. It should look like this.

34



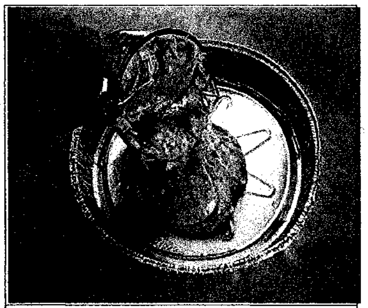
Put the measuring cup of batter on the black square.

35



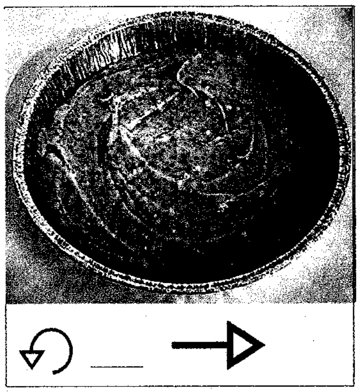
Put the bowl of batter on the pink square.

36



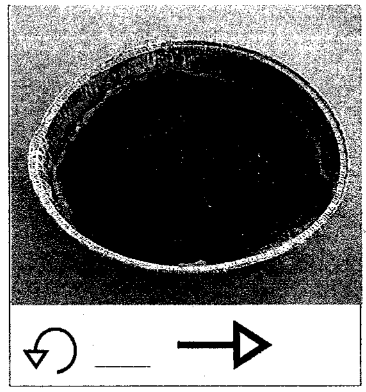
Find the cup of batter on the black square. Pour it into the

37



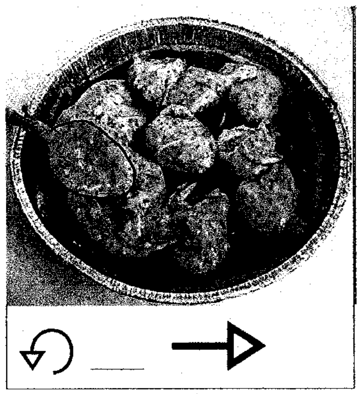
Spread the batter onto the pan evenly, so it looks like this.

38



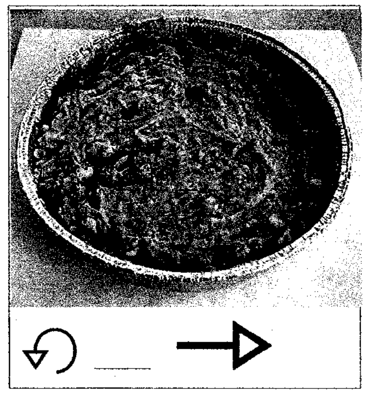
Find the jam on the yellow square.Spread it on the batter in the pan so that it looks like the picture.

39



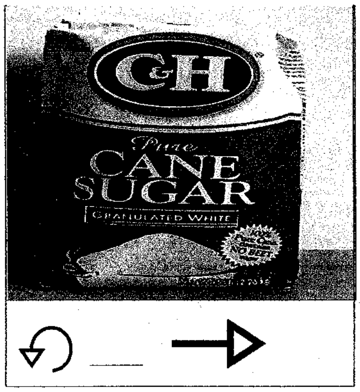
Find the batter on the pink square.Drop spoons full of the batter on top of the jam. It should look like this.

40



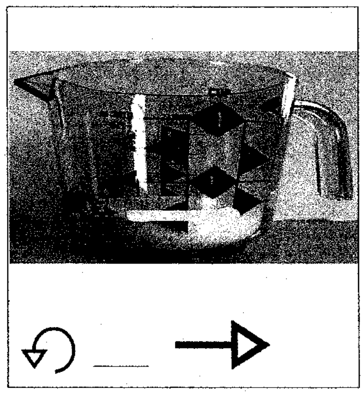
Spread out those piles of batter to make them look like the picture.

41



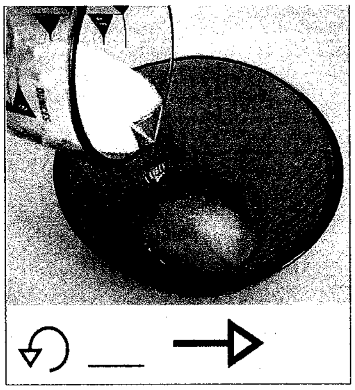
Find the sugar. It should look like this.

42



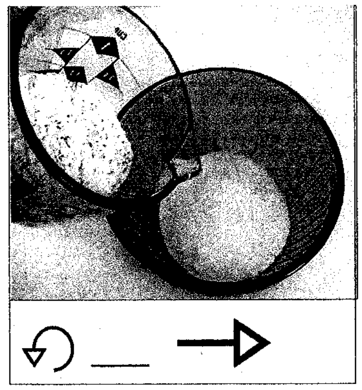
Fill another measuring cup to the yellow line with the sugar. It should look like this.

43



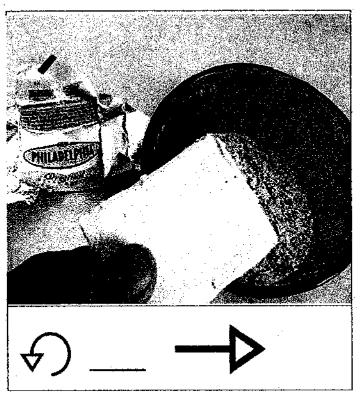
Put the sugar into a different bowl.

44



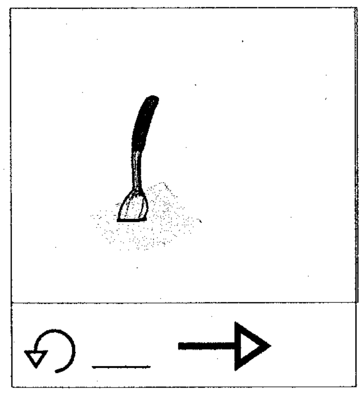
Put the cup of mix on the green square into the bowl.

45



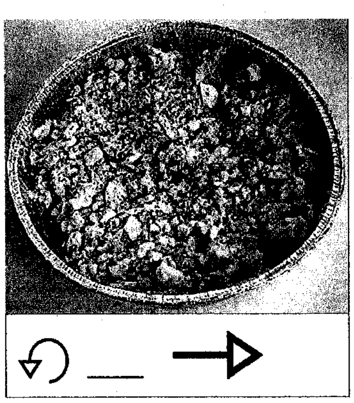
Put the cream cheese into the bowl.

46



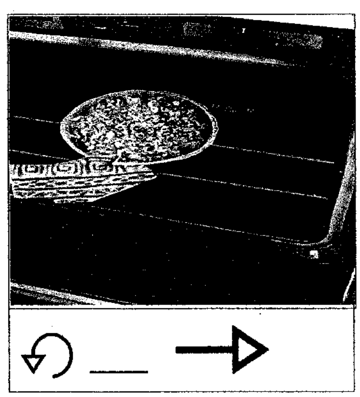
Chop the cheese with the spoon and mix it with the rest of the things in the bowl. Do it until you hear the beep.

47



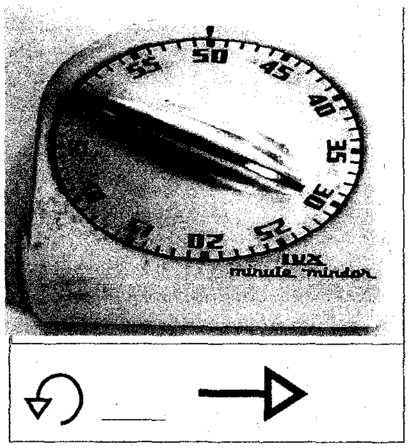
Spoon this bowl over the batter in your pan. Spread it out until it looks like this.

48



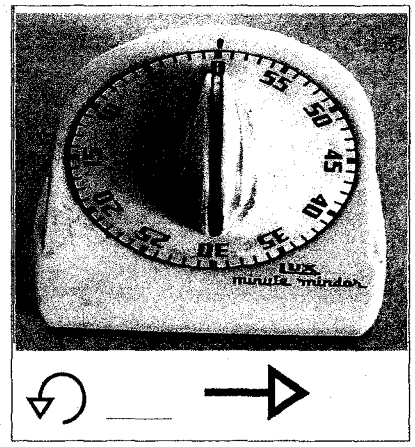
Put the pan in the oven. Don't forget to use your oven mit.

49



Set your timer so it looks like this.

49



Come back when the timer dings. It will look like this.

APPENDIX I

Orthotic-Led Protocol

Subject Name | Supervisor
Date

Pre-Session Instructions (From Jim only!)

Get out the cream cheese. It looks like this.	Gets out cream cheese	1
Get out the box of flower. It looks like this.	Gets out mix.	2
Get out the cooking spray. It looks like this.	Gets out spray.	3
Get out a pan. It looks like this.	Gets out pan.	4
Get out the milk. It looks like this.	Gets out milk.	5
Get out the cooking oil. It looks like this.	Gets out oil.	6
Get out the Egg Beaters. They look like this.	Gets out egg beaters.	7
Get out the jam. It looks like this.	Gets out jam.	8
Get out the sugar. It looks like this.	Gets out sugar.	9
Fill measuring cup to red line with milk. It should look like this.	Fills with milk.	10
	Fills cup so it is off less than 1/8 cup.	11
Put it on the red square.	Puts milk on red square.	12
Find the bottle of oil again. It should look like this picture.	Finds oil.	13
Fill another measuring cup to blue line with the oil.	Fills cup to blue line so it is off less than 1/8 cup.	14
Put it on the blue square.	Puts on blue square.	15
Find the raspberry jam again. It looks like this.	Finds jam.	16
Use a spoon to scoop the jam into another measuring cup. Fill the cup to the green line. It should look like this.	Fills cup to green line so it is off less than 1/8 cup.	17
Put it on the yellow square.	Puts on yellow square.	18

Find the temperature knob on the oven. Its the one with the blue dot. Turn it until it looks like the picture.	Set so off less than 25 degrees.	19
Find the cooking spray and the round pan again.	[redacted]	20
	Finds spray.	21
Spray the bottom and sides of the pan until it is all covered.	Pan bottom greater than 75% covered.	22
Find the bread mix from the box. It should look like this.	Finds bread mix.	23
Fill another measuring cup to the green mark with the bread mix. Leave the rest in the bag.	Fills cup to green line so it is off less than 1/8 cup.	24
Put the cup on the green square.	Puts on green square.	25
Put the bag on the orange square.	Puts bag on orange square.	26
Find the Egg Beaters. They look like this.	Finds egg beaters.	27
Pour some of the Egg Beaters into a measuring cup. Fill it to the yellow line. It should look like this.	Fills cup to yellow line so it is off less than 1/8 cup.	28
Pour the Egg Beaters into the bowl.	Eggs poured in bowl one.	29
Pour the oil into the bowl. It should be on the blue square.	Oil poured in bowl one,	30
Pour the milk into the bowl. It should be on the red square.	Milk poured in bowl one.	31
Find the bread mix in the bag. It should be on the orange square.	Finds mix.	32
Put the bread mix into the bowl.	Mix poured in bowl one.	33
Stir unil hear beep.	Mixes until after beep.	34
This is now called the batter. Spoon batter into measuring cup to the orange line. It should look like this picture.	Fills cup to orange line so it is off less than 1/8 cup.	35
Put the measuring cup of batter on the black square.	Puts on black square.	36
Put the bowl of batter on the pink square.	Puts on pink square.	37
Find the cup of batter on the black square. Pour it into the pan.	Pours correct batter into pan.	38

Spread the batter onto the pan evenly, so it looks like this.	Batter spread so thickest area not more than twice the thinnest.	39
	Batter spread to within 1/2 inch of side of pan all the way around.	40
Find the jam on the yellow square. Spread it on the batter in the pan so that it looks like the picture.	Puts preserves into pan on top of batter.	41
	Preserves spread so thickest area not more than twice the thinnest.	42
	Preserves spread to within 1/2 inch of side of pan all the way around.	43
	Spreads preserves so that MOST not mixed with batter.	44
Find the batter on the pink square. Drop spoons full of the batter on top of the jam. It should look like this.	Spoons reserved batter on top of preserves.	45
	Spoons into more than 4 piles.	47
Spread out those little piles of batter to make them look like the picture.	Batter spread so thickest area not more than twice the thinnest.	47
	Batter spread to within 1/2 inch of side of pan all the way around.	48
	Spreads batter so that MOST not mixed with preserves.	49
Find the sugar. It should look like this.	Finds sugar.	50
Fill another measuring cup to the yellow line with the sugar. It should look like this.	Fills cup to yellow line so it is off less than 1/8 cup.	51
Put the sugar into a different bowl.	Pours sugar into bowl #2.	52
Put in the cup of mix on the green square into the bowl.	Pours reserved mix into bowl two.	53
Put the cream cheese into the bowl.	Puts cream cheese into bowl two.	54
Chop the cheese with a spoon and mix it with the rest of the things in the bowl. Do it until you hear the beep.	Pieces less than 1/2 inch square.	55

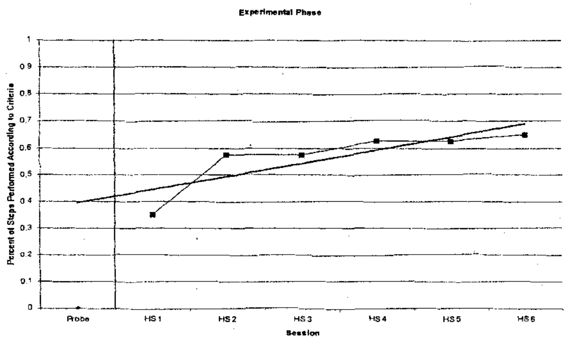
	Pieces evenly mixed.	56
Spoon this bowl over the batter in your pan. Spread it out until it looks like this.	Spoons topping onto second layer of batter in pan.	57
	Topping spread to within 1/2 inch of side of pan all the way around.	58
	Topping spread so that thickest no more than twice the thinnest.	59
Put the pan into the oven. Don't forget to use your oven mitt.	Puts pan in oven.	60
	Uses oven mitt.	61
Set your timer so it looks lke this.	Set so less than 5 minutes off.	62
Come back when the timer dings. It will look like this.	Pan removed within five minutes of end time.	63

Notes

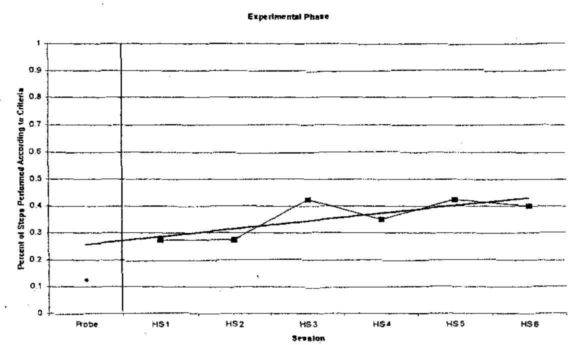
APPENDIX J

Data Chart Compilation

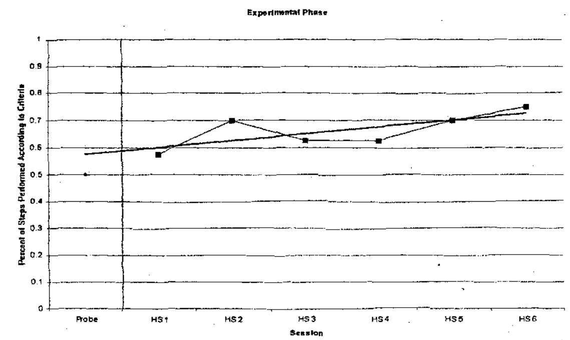
Human-Led



BZ

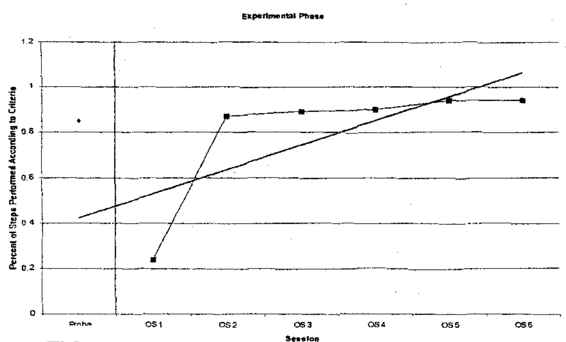


MI



RL

Orthotic-Led



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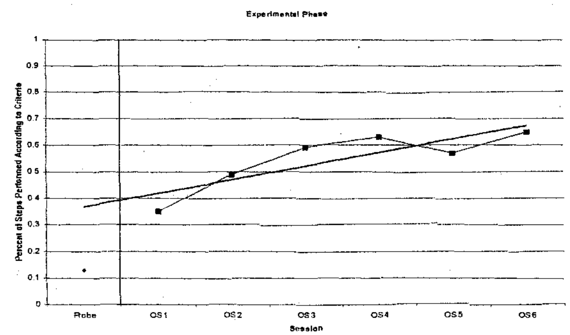
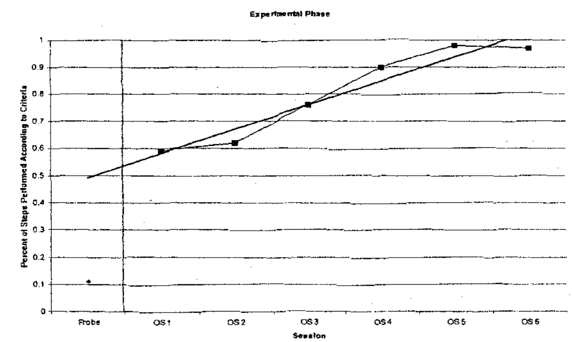
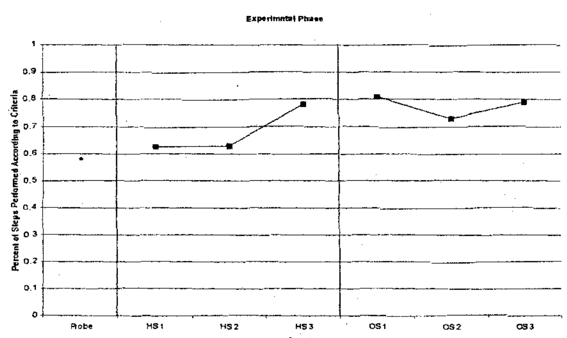


JP

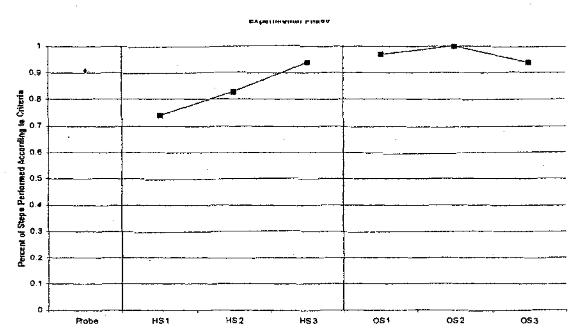


TC

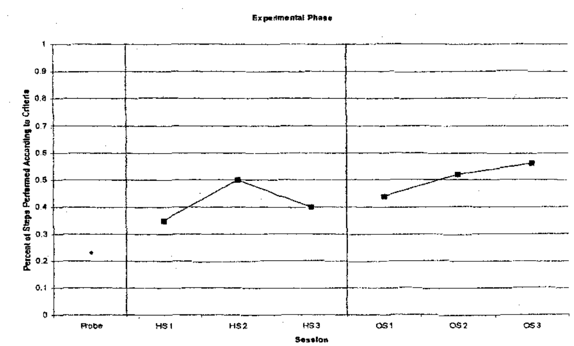
Human/Orthotic-Led



LK



TT



RM

APPENDIX K

Human Subjects Institutional Review Board
Permission Form

WESTERN MICHIGAN UNIVERSITY

Centennial 1903-2003 Celebration

Human Subjects Institutional Review Board

file

Date: December 19, 2003

To: George Haus, Principal Investigator
James Yanna, Student Investigator for dissertation

From: Mary Lagerwey, Ph.D., Chair Mary Lagerwey

Re: HSIRB Project Number: 03-02-32

This letter will serve as confirmation that your research project entitled "The Use of Cognitive Orthotics to Assist with Mental Retardation in Completing Complex Tasks" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: March 19, 2004

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