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ABSTRACT

The ability of at-risk and handicapped infants and toddlers to interact with microcomputers was studied. One research phase focused on the parameters (motor, language, and cognitive developmental levels) for using the microcomputer. The overall project examines eight levels of use culminating in using a menu driven program for making choices to initiate an interaction. Level 1 objectives begin with assessing the needs of each individual through an information-gathering process. Objectives at level 2 attempt to establish the cause/effect relationship, while level 3 teaches the concept of making choices. The first three levels were implemented with 10 infants and toddlers. Five of the children were functioning at 55-77% of their chronological age. These children were more mildly handicapped and were capable of performing the level 2 task without assistance (i.e, minimal positioning/adaptive equipment). The other five functioned from 6-15% of their chronological age. These children were multihandicapped, including severely motor and sensory impaired. They required a great deal of teaching and assistance to perform the task at level 2. The children appeared to understand the cause/effect relationship between the computer screen and activating a switch. It also appears that their response time can become adequate and consistent in a very short time period. It is concluded that when level 8 is reached, the child will be able to select from a variety of categories, which perhaps will provide the consistent control of the environment necessary for normal concept development. (SEW)

# CRITICAL LEARNING:

# MULTIPLY HANDICAPPED BABIES GET ON-LINE

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Severely physically handicapped infants and toddlers are limited in the amount of interaction they can have with their environment. This may limit the amount they can learn from it, causing secondary handicaps and thus creating an even more handicapped individual. This cycle can possibly be broken by using a microcomputer to give some of the environmental interaction back to the infant.

The early years are vitally important for conceptual and language development. Kephart states that all knowledge is built on the infant's motor experimentation on the world around him (Goldenberg, 1979, p.40). Without that motor information, the child is unable to attach meaning to his world. Similarily, Piaget state "knowledge is derived from action ..." (Goldenberg, 1979, p.41). These indivdiuals are joined by many others in reciting the importance of early motor actions and environmental manipulations to develop knowledge bases. Ruder, Bricker, & Ruder (1975, p.21) show that Bruner, Piaget, and Inhelder reach the same conclusion in reference to language development. Language is a symbol system and the child must know how to manipulate symbols before language is possible. To achieve symbolization, manipulation of the objects these symbols represent is necessary.

The question is raised by Goldenberg (1979, p.47) as to the level of motor interaction necessary to obtain the sensorimotor experiences needed. He points out that some severely motorically handicapped individuals reach high levels of cognitive development and suggests that active control over the environment may not be necessary but that these individuals are receiving feedback from their surroundings in some other form. He proposes that possibility of 'remote control' manipulation as being an adequate experimentation method for conceptual development.

The inability to act upon the environment creates a second handicap for a child because it does not allow normal experiences of the world to build information on (Goldenberg, 1979, p.29). If these secondary handicaps can be prevented it should begin at an early age in order to take advantage of this critical learning period. The prevention of lags in conceptual development will facilitate language development providing a good base to build on. The microcomputer and the related technology can be utilized in this provention process. It can provide a reliable means for an infant to control and manipulate his world and explore as non-handicapped children do (Vanderheiden, 1981, p.55).

TECHNOLOGY FOR LEARNING

The ability to interact with one's environment is probably essential to the learning process. While the process of vicarious learning (Bandura, 1963) has been published in the research literature, to assess learning it is necessary for an interactive behavior to occur on the part of the child.

Microcomputer based technology is now providing the means to maximize children's ability to interact with their environment (ie. respond to or initiate an observable action) as well as provide a means of systematically evaluate the consistency and accuracy of those interactions, even though they may be insignificant to the observer. There are three areas in which technology can significantly effect learning by enhancing environmental interactions of the child: communication, environmental control, and environmental manipulation. These three "domains" must be woven together in order to provide teachers and parents to "teach" these children to function to fullest potential.

Communication . Communication can be considered one of the most basic forms of environmental interaction. Typically it begins within the first year of life for handicapped and nonhandicapped individuals. Defining communication as the transmitting of a message with two necessary components, the intention of the sender to transmit and a receiver who intends to receive and understand that message (Bryen, 1982), the nonhandicapped child soon has an advantage in his or her ability to learn verbal language, the most efficient mode of communication. Many handicapped children are very delayed in their ability to learn verbal language and some never do. Additionally, their ability to interact nonverbally may also be severely limited. The inability to communicate efficiently and rapidly creates setbacks in learning, inhibiting experimentation with their enviroment. The technology is currently available to give these individuals efficient modes of communication that don't rely on their verbal abilities. Thus, a nonverbal child can communicate (and thus interact with the environment) through auditory (including voice synthesis), physical movements, pictures or words.

Environmental Control . This category of environmental interaction includes the physical manipulation of the environment such as turning electrical toys and appliances on and off. Children with limited motor abilities miss out on these life experiences and must depend on others to perform the tasks for them. Again, the technology is available to return to them that lost independence. Home controllers are readily available for adult consumers and are very inexpensive. These devices can electrically control such things as the heat, burglar alarm, phone answering machine and house lighting either by remote control or program control. These same devices combined with thoughtful programming can allow the young handicapped child to be in control of such developmentally appropriate tasks as turning the TV, electrical and battery operated toys and other such things on and off.

Environmental Manipulation . Another category of devices or mechanisms that are available for environmental interaction is robotics. Robots can fulfill single or multiple functions, including communication and environmental control. However, manipulation of the environment in probably the most important aspect of the robot. A robot can become the extension of the individual by extending the child's accessible environmental space with a moblie, multi-directional arm which will allow the child to manipulate objects within his environment. As technolgy improves, the capabilities for providing meaningful, appropriate, and controlled experiences for young handicapped through robotics will increase too.

## DEVELOPING PARAMETERS FOR USING THE COMPUTER

Campbell, Bricker, and Esposito (1980, p.234-240) voice a number of areas of concern in using technology with severely handicapped individuals. First are the concerns of using technology as an end rather than a means to higher level development. The use of the computer to provide environmental control for the purpose of building a conceptual information base surely minimizes that concern as long as efforts to direct that learning are systematic and individually monitored. A second concern is the ability to find meaningful, motivating, and relevant consequences that will take control of the behavior. Many young and severely handicapped individuals have learned to be helpless and finding consequences strong enough to overcome that while still avoiding satiation and extinction are real challenges. This challenge is shared by all severely handicapped educators whether using microcomputers or not. The flexibility of the computer can help meet that challenge. A third problem area is in the generalization of these skills or uses when tey have been taught in fixed and contrived situations. Again a systematic plan for bringing the technology into the classroom and home is necessary. An additional concern in the area of generalization is cited by Campbell et. al. that children functioning in the primary circular reaction stage of cognitive development will be unable to generalize. They are under strict control of the consequences as they repeat new experiences for the sole purpose of reproducing the same experience. During this stage though, variations in schemas are developed to new stimuli, schemes become coordinated as functional relationships are realized, and perceptual recognition is achieved through the repetition of actions (Phililps, 1975, p.28). These stage characteristics do not rule out the use of computers but suggest a valid research area of looking at specific cognitive levels and their affect on computer interactions. Brinker & Lewis (1982) have used microcomputers to illustrate that handicapped infants (CA 3-5 mos and MA 2-5 mos) can learn cause/effect relationships using a switch. Beyond this, it would appear that minimum requisites in the areas of language and motor development need parameters established as well, for the successful use of this application of technology in the training of handicapped infants.

## PILOT RESEARCH

### Description of the Population

Two phases of a pilot research project have been conducted using students of a county health infant stimulation program as subjects. The program is governed by a non-exclusion policy thus these students range in abilities from 'at risk' or mildly handicapped to severely multiply handicapped. Their chronological ages range from birth through 30 months, at which time they enter the public school system. The initial research looked at 5 students, three of which were 11-14 months and non-handicapped and two older multi-handicapped children between 25 and 27 months (Behrmann & Lahm, 1982).

The second phase, which is currently in progess, looks at the older handicapped children attending the program. They were selected because they will soon move into the public schools and thus will not be candidates for further research. These second phase subjects can be divided into two groups, mildly and multiply handicapped.

## Description of the Equipment

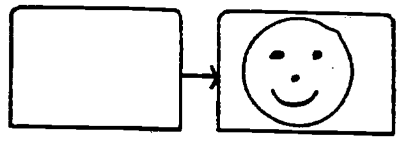
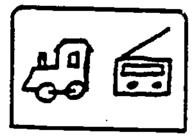
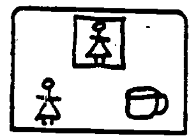
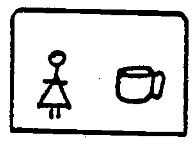
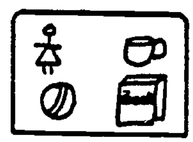
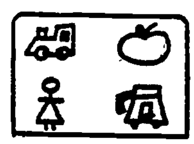
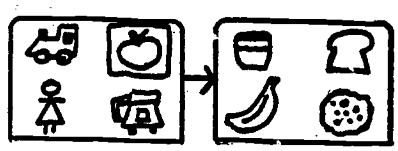
The project currently utilizes an Apple II+ microcomputer, Votrax Type 'N Talk voice synthesizer, a color TV monitor, and various custom made switches as input devices. Efforts are being made to use only readliy available commercial hardware to allow for replication of the program at other facilities in the future. The switches, though custom made, are inexpensive and easy to make or commercially available switches can be substituted.

## A Systematic Approach to Teaching Computerized Environmental Interactions

The second phase of the pilot research project is being undertaken to begin looking at the parameters (motor, language and cognitive developmental levels) for using the microcomputers with handicapped infants and toddlers to establish a cause/effect relationship (level 2). The entire project looks at eight levels of use ranging from establishing a cause/effect relationship to using a menu driven program for making choices to initiate an environmental interaction. The computer programs or software are developed to fit the needs of each individual. The objectives, response cues, screen diagram and measured variables for each level are shown in table 1.

The objectives in level 1 begin with assessing the needs of each individual through an information gathering process. Information related to the optimal working position of the child, the probable best switch and any unique program requirements such as those for visual or hearing impairments are obtained from the teachers, therapists and parents of the child. Using the initial information, objectives at level 2 attempt to establish the cause/effect relationship before requesting the child to learn the concept of decision making. The next levels (3 - 6) gradually increase the abstractness of the picture representation on the computer screen while teaching the child to make a selection. This is done to allow the child more flexibility and ability in his/her choice vocabulary. These levels also increase the number of pictures or options presented to the child at a given time. The end result will be a system of

TABLE 1

| LEVEL | OBJECTIVE | RESPONSE CUE | SCREEN DIAGRAM | VARIABLES |
|---|---|---|---|---|
| 1 | assess needs | N/A | N/A | position switch. program needs |
| 2 | establish cause/effect relationship | voice "press the switch" |  | response time average time |
| 3 | teach concept of making choices | teacher asks "which do you want to play with?" |  | monitor response times frequency of choices |
| 4 | select between 2 options of abstract pictures | voice/teacher "find <u>picture</u> " + visual cue |  | response time no. correct |
| 5 | select between 2 options of abstract pictures | voice/teacher "find <u>picture</u> " |  | response time no. correct |
| 6 | select between 4 options of abstract pictures | voice/teacher "find <u>picture</u> " |  | response time no. correct |
| 7 | select between 4 options of environmental controls | teacher asks "what do you want to do?" |  | response time frequency of responses |
| 8 | select between 4 main categories to find new "pages" of choices | teacher asks "what do you want to do?" |  | monitor response times frequency of responses |

categorizing choices that will facilitate finding a specific response or choice (levels 7 & 8). Table 1 relates the response cue or the command given to the child at each level. The format of the computer screen is also shown to give you an idea of the amount or information given to the child at a time. The column labeled variables simply lists the kind of information the program is collecting for further analysis.

Two kinds of feedback are given to the child when the switch is activated. Level 2 replies to the child's response by immediately displaying a fun, rewarding picture with an auditory response. Levels 4 - 6 use that same response reward when the child chooses the correct picture. These rewards are randomly generated to avoid satiation. In levels 3, 7, and 8, the computer rewards the child with a direct action, ie. it turns on or activates the object of the choice for a short period of time. These three levels utilize the concept of the child direct controlling their environment.

PRELIMINARY RESULTS

The first three levels of the project (assessment, cause/effect, and concept of choice) have been implemented to date with 10 infants and toddlers. The results of level two are shown in tables 2 and 3. The 10 subjects evaluated on this level can clearly be divided into two groups. Table 2 respresents a group of children whose Early Learning Accomplishment Profile (ELAP) scores indicated functioning levels from 55% to 77% of their chronological age. These children in general were more mildly handicapped and quite able of performing the level 2 task without assistance (ie. minimal positioning/adaptive equipment). Table 3 represents a lower functioning group. Their ELAP scores were significantly lower, showing functioning levels from 6% to 15% of their chronological age. In general, the children in table 3 were multihandicapped including severely motorically handicapped and sensory impaired. They required a great deal of teaching and assistance (positioning/adaptive equipment, prompting) to perform the task at this level.

Of the 5 mildly handicapped children represented in table 2, two of them met a criterion of responding in 5 seconds or less 80% of the time over 3 of 4 sessions. Two other children are very close to that criterion but are showing a deterioration of response time. The fifth child, although never close to criterion, shows this same deterioration of response. In all cases, the researchers immediately noted that the 5 children in Table 2 apparently understood the task but with the last three children, interest was lost and other aspects of the testing environment became more attractive (ex. knobs on the TV, other people present). It was concluded that if the program was more highly motivating, they too would reach criterion rapidly.

The 5 multihandicapped children represented on table 3 depict clearly different results. The two that reached criterion were the first two subjects and took part in the initial pilot work. Their scores are comparable to the others because the computer program and testing situations were essentially the same. However, no ELAP scores were collected for them. Their level 2 results are similar to those of the more mildly handicapped children on table 2. However, each of these two subjects were severely limited due to their multiple handicaps unlike those in table 2. The other three children have not come close to criterion yet. Subjectively, the researchers have noted that on most trials they appear to make the effort and show an understanding for the task but are unable to perform to criterion. This raises questions about expected levels of performance and what response time might be considered a functional for the severely multihandicapped child, as well as the ability of the level 1 assessment to address optimal positioning and switch.

Table 4 compares the ELAP scores of the two subjects that have met criterion and the two that have come the closest from Table 2. This comparison is the first attempt to look at the motor, language and cognitve levels of successful children to identify parameters for success. Four subjects is clearly not enough to make statements about predictors of success but this is a beginning. The next stage of the research project will evaluate approximately 80 subjects at this level.

Only one subject to be tested on level 2 has advanced to level 3 of the program (teaching the concept of making a choice). Table 5 shows results on level 2 and table 6 his progress on level 3. A clear trend toward responding with faster more consistent responses in making a choice between two toys is seen. Anecdotal observations of the researcher note a coinciding understanding of the concept of the scanning indicator and making the choice via the switch. Since it is not possible to measure the correctness of choices when given a free choice, the child's accuracy of choosing is not be reported. It is interesting to note that, even though the child reached a more stringent criterion for response time in level 2, the response time in level 3 is slower. No criterion was set at this level even though it was monitored. Free choice decisions also did not have a time restraint attached and therefore were not be measured. The increased response time is attributed to the mental process of decision-making and the amount of time involved for the indicator to scan the two choices. The objective at level 3 then is not the response time, but rather the trend to improve it, showing the child's better understanding of the concept and functional use of making choices.

## DISCUSSION

The research conducted thus far has begun to answer some basic questions about the ability of infants and toddlers to interact with microcomputers. It appears that they understand the cause/effect relationship between the computer screen and their switch. It also appears that their response time can become adequate and consistant within a very short period of time.

The question of what is an appropriate response time needs re-evaluation after looking at the two distinct groups of handicapped children used in this study. Subjectively it has been noted that the lower functioning group appear to understand the cause/effect relationship which is the prerequisite for using a computer system to functionally control the environment. However the data also indicates that these children may never reach preset criterion of five second resonse times. The appropriateness of the criterion must be evaluated before deciding whether the lower functioning group can benefit from the computer system.

The major continuing question of level 2 is the identification of success indicators or parameters using developmental levels or scores from the ELAP. This question will be analyzed more completely when more subject data is available. Once identified, the parameters will be used to help select individuals to continue through level 8 of the program.

IMPLICATIONS FOR FURTHER RESEARCH

The research design and results discussed in the previous sections of this paper represent only the beginning stages of the technology applications research planned. Level 1 and 2 data, when evaluated for approximately 80 children, should provide indicators as to which multi-handicapped children will benefit most from this type of training.

Levels 3-8 of the project will provide a systematic training approach to teach developmentally young children to effectively utilize microcomputer technology to interact with their environment. The technology involved includes use of an Apple II+ computer, voice synthesizer, environmental control mechanism (BSR X-10 Controller) and robotics (Heath Hero-1). These combined technologies will be programmed so that the child will be able to select options from a "menu". The selection of an option will then be translated into an interaction with the child's environment in a preprogrammed format using one or more of these technologies.

When a child reaches level 8, s/he will be able to select from a variety of categories - robot, communications, environmental control. From these categories additional choices will be available (ie. robot to get X toy or robot get teacher).

The general purpose of the project is to apply commercially available technology that is relatively inexpensive to the learning needs of developmentally young handicapped children. Technology is growing at an almost uncomprehensible pace, but the technology and need are both present now and the wait for "something better" may never end. The robot which is being utilized inthe project was not available 6 months ago. It may well make some of the hardware obsolete almost before the project starts. This robot can "see", "hear", move about, manipulate objects and turn off and on switches. Thus, it may have already removed the necessity of an environmental controller and voice synthesis communication. What has NOT changed though, is the need to systematically train handicapped individuals to utilize technology that can benefit them.

Systematic training can be done in such a manner that the technology and/or application can change while the "format and interaction mechanism" between the handicapped individual and the technology remains the same. If one thinks of one of the major problems for training severely and profoundly handicapped - training the handicapped person to generalize from one situation to another - the potential is there for developing a constant format for enabling an individual to make choices while others "programming" the technology to generalize or adapt to different environments.

It is hoped that the capabilities of microcomputer systems to extend environmental interactions to infants of limited motor abilities will provide them with the consistent control of their environment necessary for normal concept development. This in turn should affect the language development, self-concept development, ability to communicate and their social interactions. By developing these skills at normal developmental ages it is hoped that secondary handicaps will be prevented. As their skills advance, the technology can advance with them, always giving them appropriate opportunities for interaction and communication. Ultimately, they will have the ablity to reach outside their immediate environment by using telecommunication networks. This will enable then to transmit information or communicate with others through telephone and television lines.

The findings of this research should impact other populations of handicapped individuals in addtition to physically handicapped. It can have direct application to all individuals who have a mental age in the range of 0 through 30 months, as studied in this project. Mentally handicapped individuals who have additional physical handicaps should also be able to utilize a similar approach REGARDLESS OF THEIR AGE.

TABLE 2

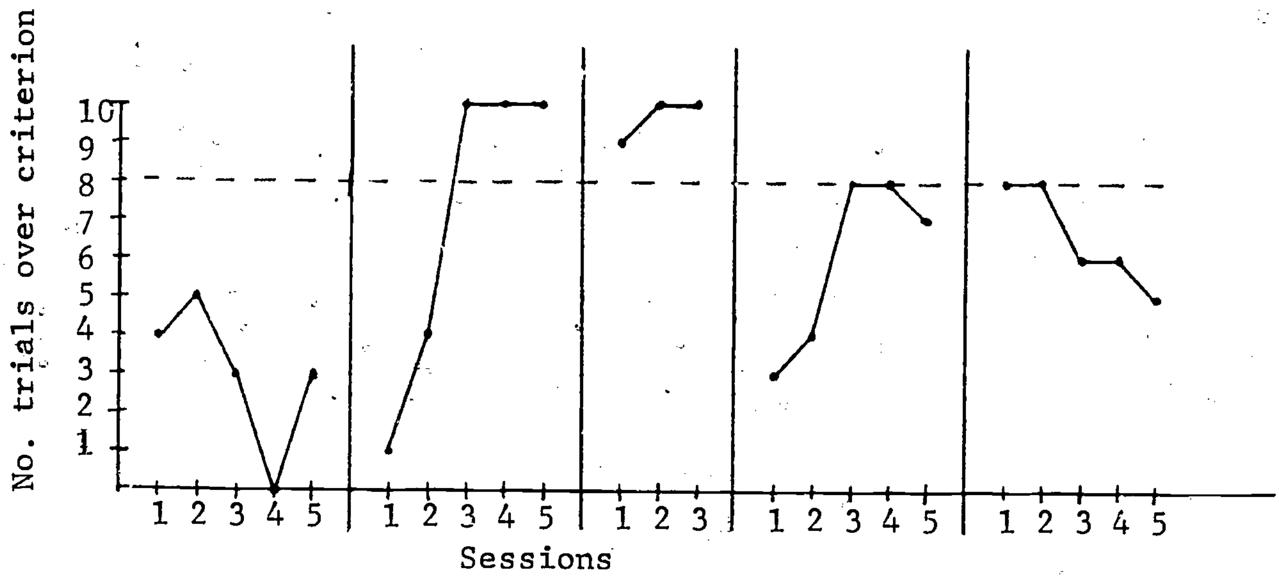



TABLE 3

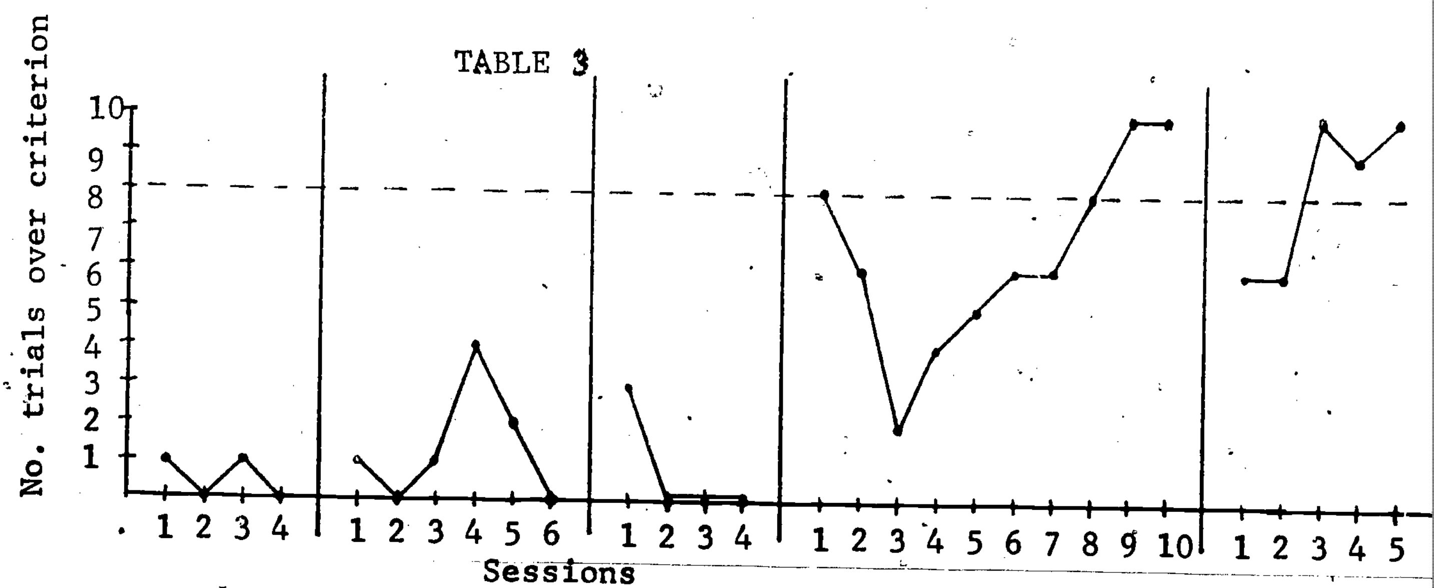


TABLE 4

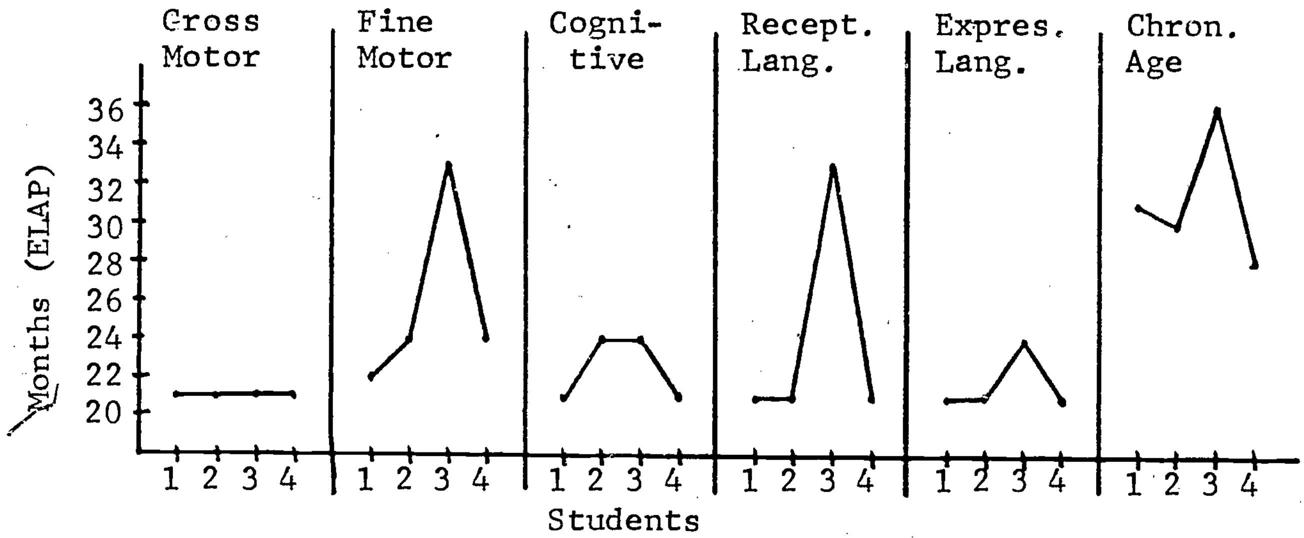



TABLE 5

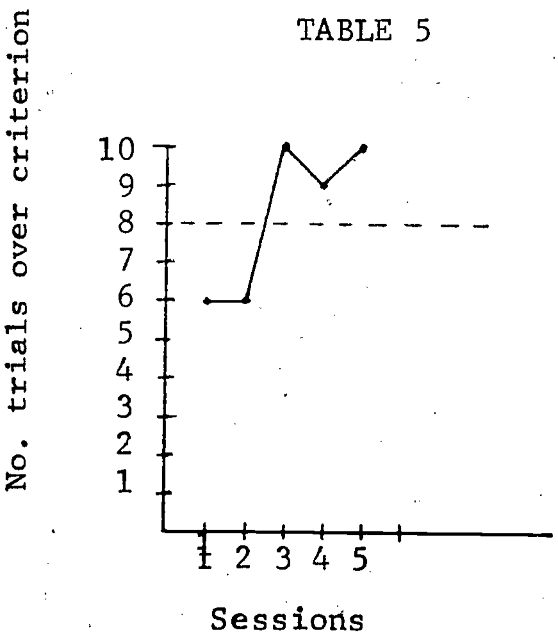
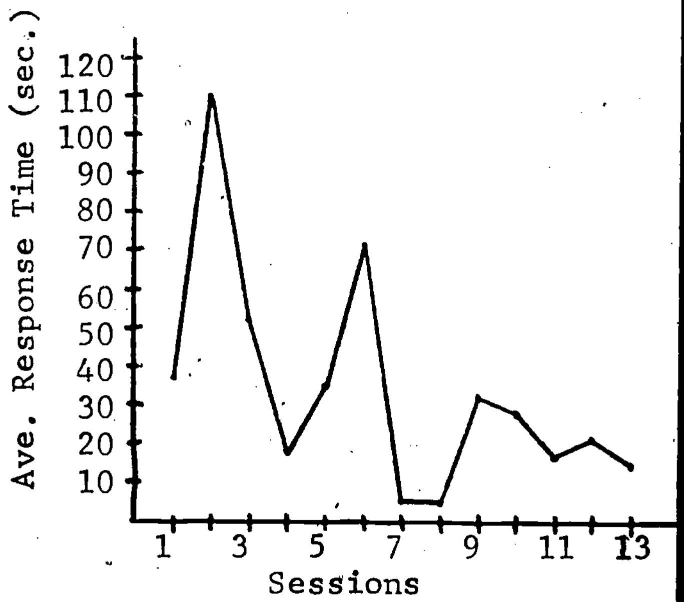



TABLE 6



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