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The effect of stop-action video on children's understanding of the physical principles involved in balance.

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THE EFFECT OF STOP-ACTION VIDEO

ON CHILDREN'S UNDERSTANDING

OF THE PHYSICAL PRINCIPLES

INVOLVED IN BALANCE

A Dissertation Presented

by

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Dedicated to two very

wonderful children:

Damien and Joshua

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ABSTRACT

The Effect of Stop-Action Video
on Children's Understanding
of the Physical Principles
Involved in Balance

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This study investigated the effectiveness of stop-action video replay to improve young children's understanding of the physical laws of balancing blocks on a fulcrum. A total of 128 children from 4 to 8 years old were asked to balance 14 different wooden blocks (some symmetrical and evenly weighted; some asymmetrical with hidden weights embedded; some glued into configurations that required the use of counterweights).

Subjects were pretested to determine their approach to the task, classified as either egocentric or theory-oriented, then assigned to one of four treatment conditions. In Condition I, Predict Block, children viewed a video replay of their attempts. The action was stopped immediately after the block reached the fulcrum and

subjects were asked to predict whether the block would balance or fall. Condition II, Predict Placement was similar except that children were asked to predict the placement point of the block on the fulcrum. In Condition III, Summarize Replay, children watched a replay of their attempts without any stop-action and were asked to summarize that attempt. Condition IV, No Video, served as a control. Children were simply asked to summarize their recent attempts but received no video replay.

Planned comparisons showed Condition II to yield significantly greater improvement for children who began the task with a theory-testing orientation. No difference across conditions was found for egocentric subjects. A 2x4x2 ANOVA (covarying age) was performed to ascertain the effects of Pretest Ability, Treatment Condition, and Sex. No main effects were found for sex or condition. A main effect for Pretest Ability was significant at .03 and a two-way interaction between Pretest Ability and Condition was significant at .05. These findings were interpreted in terms of Piaget's theory of reflective abstraction, suggesting that feedback improves understanding only if the child assimilates the video replay to the confirmation or refutation of a "theory-in-action."

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

It cannot be disputed that scientific progress has brought about a technological society. Videotape recorders and monitors, cassette tape recorders, television, videodiscs, and computers are just a few of the technological advances readily available to the public at large.

Educators must make use of this technology. It not only serves as an important curricular content if learners are to be prepared for the future, but it can be a powerful instructional tool for the educator as well. The realization of this technological potential is, of course, attended by its own set of problems. In the words of Dustin Heuston:

> "But the most challenging task, as always with technology, will be to ensure that it is not misused. This may be a problem because the technology may be upon us before we are prepared... For this reason for the next ten to twenty years the general thrust of educational research and development should be focused on harnessing and learning how to handle this new additional source of work." (1977, p. 24-25)

A review of the literature on just one technological medium as an instructional tool, i.e., video, highlights the fact that technology's potential in education is tremendously underplayed. Most of the research on the educational use of video has been from one of three perspectives: 1) filmic presentation, 2) videotaped replay of self for feedback, and 3) supplantation of a mental process.

While each of these perspectives approaches the educational use of video differently, each is grounded on the theoretical premise that learning is a passive activity, i.e., a result of passive reflection or imitation of modeled behavior. Recent Genevan work on problem solving suggests that learning is a more active, self-regulated process. Learners attempt to understand and solve problems with current "assimilatory schemes." When these schemes are insufficient or contradictory, cognitive conflict results. Reflection then occurs on the contradiction causing the learner to construct new schemes in order to "accommodate."

From this framework, an important question for media researchers is whether video can be used as a "disturber of equilibrium"? To wit, can video be used as a device to create cognitive conflict and, if so, will such use of video affect the acquisition of problem solving strategies and theory construction? Secondly, if a developmental perspective is taken in an attempt to produce cognitive conflict, will the use of video be dependent on the initial cognitive level of the child?

Thus, with Heuston's challenge in mind, the intent of this study is to first review the literature on one technological medium as an educational tool, i.e. video and its use in affecting problem solving strategies and theory construction. Secondly, this study proposes and tests out empirically two assumptions: 1) video feedback can affect problem solving strategies if video is used in a stop action/predict consequence mode; 2) the manner in which video is used by the educator should be dependent on the entering developmental level of the learner.

The remainder of this chapter will examine the literature pertinent to these assumptions and will conclude with a rationale for use in choosing a task to study problem solving strategies and experimental uses of video.

Review of the Literature

Filmic Presentation

This perspective concerns the effectiveness of video in presenting new content to be learned. Research from this perspective has been based mainly on the theoretical premises of modeling theory (Bandura and Walters, 1963), the assumption being that the learner will model the observed behavior. Studies from this perspective have focused on whether video could effectively replace physically present teachers as the presenter of new content to be learned.

Thomas (1974) divided 69 first graders, chosen by their teachers as having attention behavior difficulties, into three groups. Group one served as an experimental group and was shown videotapes of model attention behavior with the accompanying direction, "We are going to see some scenes from other classrooms." Group two also was an experimental group and was shown the same videotapes, however the accompanying directions varied. This group was told, "This is the way your teachers like you to behave. You will see students having fun. They also do well in school." Group three was shown no videotapes and served as a control. Thomas' dependent measure was based on standardized observations and recording procedures of attention behavior. Using this measure, Thomas found a significantly greater pretest - post test change in attention behavior in the experimental group.

Other researchers from this perspective have focused on, not just behavioral change, but the possibility of teaching cognitive structures, such as conservation and seriation, via video. Henderson, Swanson, and Zimmerman (1975) attempted to train seriation by modeling operational behavior on video. Twenty subjects, ages 3-5 years, viewed videotapes depicting seriation concepts. The training, all given on a video monitor, consisted of a three stage progression of subskills, beginning with simple problems involving first the size discrimination of linear objects, and culminating in the complete and systematic ordering of a five object linear array. Intervening steps were gradually graded in terms of the complexity of the skill modeled as well as the complexity of the stimulus array employed. Tape segments were prepared to reflect, not only the specific skills presented in the hierarchy, but their sequencing as well. Each step was modeled on the tape two to three times contiguously, before modeling of a subsequent step was initiated, thus assuring linearity of programming. The verbal rule, "objects are in order when they go down like stairs," and the strategy, "imposing order by finding the longest object in the array," were given each time. A second group of twenty subjects served as a control. The authors concluded that carefully sequenced instruction in a rule-governed intellectual skill can be taught effectively by depicting the requisite skills and rule statement through the behavior of televised models.

Jovick (1976), on the other hand, attempted to teach multiple classification through video to second, seventh, and twelfth graders with not such clear success. One hundred and twenty subjects were assigned to one of four conditions: 1) Control, in which subjects performed the criterion task with no previous training; 2) Guided Practice, in which subjects performed a task, alike in structure but different in content from the criterion task, before performing the criterion task; 3) Concrete Modeling, in which subjects viewed a videotape of a male adult performing the practice task in a manner which concentrated on the attributes of the stimuli in making conjunctive sortings, before performing the criterion task; 4) Abstract Modeling, in which subjects viewed a videotape of a male adult performing the practice task in terms of the relevant dimensions, more abstractly considered than in the Concrete Modeling condition, before themselves performing the criterion task.

Significant main effects were found for age and condition. All three of the experimental groups did significantly better than the control. No difference was found among the experimental conditions. Seventh and twelfth graders however did significantly better across all conditions than second graders. Jovick interpreted the main effect of age to support Piaget's functional notion of modeling and active experimentation as ways of accommodating to the novel; but that neither is able to communicate the structure of a problem much in advance of the child's capacity to grasp it on his own.

In summary, while the filmic presentation research showed that children can learn from video, at best the results in regard to content and age have been contradictory. One is left with several questions unanswered. How is the content on the monitor assimilated by the child? Can tasks actually be taught that are developmentally beyond the present level of the child? While Henderson's (et al.) work suggests this possiblity, one is left wondering whether the logical structure of transitivity has actually been constructed by the child, or whether only an appropriate strategy to the task has been imitated.

Several learning theorists have criticized the assumptions inherent in approaches which characterize learning as a passive process resulting from observing a model. Current cybernetic models of learning suggest that reinforcement is an important factor in the learning process and must be meaningful to the child, while constructivists emphasize cognitive conflict and reflection on one's own actions. A second body of research on video began with these principles of feedback and self reflection in mind.

Video Replay of Self for Feedback

All instances of this type of research present the child with his/her own image on the video monitor with the assumption that self reflection will create behavioral change. Much of the work done from this perspective has dealt with interpersonal development and has shown the benefits of videotape replay as a counseling technique (Berger, 1978).

Goshko (1973) for example, attempted to determine if elementary school children could learn the skills of self-observation and then select and modify behavior of their own choice. The primary tool for change was the use of immediate video feedback. Sixteen subjects were used (male and female fifth and sixth graders). The design employed was a series of 16 single subject studies. Evaluation was conducted on the effect of media training in demonstrated behavior change between those who received media training and those who did not. Goshko concluded strong evidence exists that elementary school children are capable of learning the skill of identifying behaviors they wish to change in themselves, and then, through the use of such techniques as microcounseling and media therapy, modifying these self-selected behaviors. This study, however, did not differentiate between microcounseling and media effects as the variable causing change.

A study by Loss (1974) attempted to be more specific about the variables affecting change. Loss used a combination of cuing for positive self-reference statements, videotaping of the students emitting the comments, and the subsequent playing back of the videotape in an attempt to elevate self concepts of fourth graders. Subjects were randomly assigned to one of five groups: 1) control group receiving no treatment; 2) self discussion with no rules about limiting negative comments; 3) self discussion but positive self-reference statements only; 4) same instructions as group three except subjects were videotaped but shown only placebo tapes; 5) same as group four except subjects viewed the playback of themselves. A statistically significant positive change in the total gain score, assessed by the Coopersmith Self-Esteem Inventory, was found between the control group and the videotape playback group. All other treatments showed gains in the positive direction, in contrast to the control group, but were not significantly different among themselves.

In an attempt to change aggressive, maladaptive behavior through understanding, Astor (1977) gave one group of subjects the full technique of play and subsequent discussion of this play during vidoetaped replay. A second group of subjects played and watched their tapes but without discussion of behavior in terms of affect. Group three played and discussed their play in a format similar to traditional play therapy, but without viewing the videotapes. Behavior of the three groups was evaluated in terms of change during the play and taping sessions and in the classroom. An additional control group was evaluated for change in classroom behavior, but did not take part in treatment sessions. Aggression was significantly reduced in group one when compared to the other groups. Astor concluded that the combined play therapy-videotape feedback technique was effective in reducing aggressive behavior in a relatively short period of time. While Astor's study is interesting in that it shows the tremendous impact self reflection can have on subsequent behavior, her sample (N=16) was too small for results to be generalized.

A study by Garner (1973) is similar and compares a much larger sample size (N=325). Garner's subjects were randomly assigned to one of three groups: full treatment, partial treatment, or control. Full treatment consisted of eight twenty minute videotape recordings, and eighteen, weekly, forty minute classroom sessions devoted to self appraisal activities. During the self appraisal sessions the students in the full treatment group evaluated the behavior of other students and also evaluated their own behavior as recorded on videotape. Partial treatment differed from full treatment in one aspect: students in the partial treatment group were not videotaped; therefore, they never had the opportunity to evaluate themselves but did evaluate the behavior of others. Results showed that students who viewed themselves on videotape and who coded their own behavior did significantly change their positive nonverbal behavior. Students in the partial and full treatment groups made significant change in self concept in comparison to the control group; there was no difference between the experimental groups in changes of self concept. Garner concluded that intermediate grade children could accept responsibility for change in their own nonverbal classroom behavior, and that self appraisal activities could promote increased self concept.

The studies discussed thus far using video replay of the self were all attempts to study the effect of video on interpersonal development. A few exceptions to the interpersonal developmental research do exist.

Robinson (1974) assessed whether video self-appraisal activities would significantly change achievement as well as self-concept.

With an N of 380 from intermediate grades 4, 5 and 6, he used a pretest/posttest design with achievement scores as a dependent measure. Treatment consisted of videotaping students while their teacher taught a twenty minute lesson in Reading, Language Arts, or Arithmetic. This was followed on separate days by student verbal and nonverbal self-appraisal. A class discussion of the observations of the students was the final step in the procedure. The treatment was continued for a total of six video tapings for each class and took place during the time period of one semester. Students in grades 4 and 6, who participated in the self-appraisal activities, showed significant growth in the cognitive skills associated with reading when compared to the control group. Students in grade 6 also made significant gains in arithmetic applications.

Although this was the only study found assessing video replay's effect on achievement scores, two studies were found investigating the use of video on the organization of motor skills. Such a study by Wrenn (1969) used second, fourth, and sixth graders. Seventy-two subjects were randomly assigned to either a control or an experimental group. Each subject was given twelve trials to perform on a Motor Performance Multi-Recording Instrument (MPM-RI) on test day 1. Each subject returned for five additional trials on test day 2. Subjects in the experimental condition saw a videotape replay during the intertrial intervals on both days. A 2x3x2 factorial experiment, with repeated measures on the last factor, was used for analyzing the data. Factor one was the training condition; factor two was grade level; and factor three was the performance of each subject on both test days. The criterion measure for retention included the rate of change in performance scores between day 1 and 2. Performance scores included the mean of trials nine through twelve on day 1 and the mean of trials two through five on day 2. The analysis of data revealed a significant difference in performance for the two treatment groups, with the videotape feedback group being superior. No main effect for age was found.

Bunker, Shearer and Hall (1976) also assessed the effect of videotape feedback on the acquisition of motor skills, specifically flutter kicking while using a freestyle swimming stroke. This study used younger children (two groups of thirty-six subjects, ages 5.5 years and 7.5 years), and found a significant difference between the means of the videotaped group versus a control group which received no video. The results, however, were only significant for the older age group. The researchers concluded that older subjects were more able to analyze their own performance relative to the criterion movement and thus the video feedback was more meaningful to them.

In summary, while the research based on video replay certainly shows conclusively that the learner can and does benefit from a replay of his/her actions, the results as far as age effects are not as clear. One is still left wondering how the replay, or feedback, is assimilated. In other words, what is being abstracted by the learner during reflection on the replay? Certainly, given what is known about development, it seems erroneous to conclude that a young child abstracts and organizes the feedback in the same way as an older child. In fact, even within a group of older children is the same material being abstracted during the replay? To look at this question, a third group of researchers attempted to narrow the focus of the replay by using zooming-in or slow speeds. This body of research will be discussed next.

Supplantation of Mental Processes

This perspective highlights certain unique aspects of video such as zooming-in to focus on details or slowing down the action to emphasize transformations. Research in this area has attempted to answer questions such as the following: Could one learn new information processing techniques as a consequence of exposure to films in which the techniques are repeatedly used? For example, could one become a better cue-attender as a result of exposure to films which show intensively the operation of zooming-in on details?

Salomon (1979), in a large body of research, examined the issue of whether visual communication media, with their unique codes, could affect cognition, perception, and representational abilities. According to Salomon, slow motion, zooming-in, split screens, etc. are "grammatical forms" which are unique to film and TV. Each of these "grammatical forms" can also serve for a learner as mental operations or assimilatory schemes to process information. Salomon hypothesized that a learner who has already acquired the general assimilatory schemas, but has not yet mastered the one to which he/she is exposed, is most likely to imitate and internalize it. One who is highly skilled, hence can mentally perform on his/her own the action which is shown (such as "zooming-in" on details), will encounter interference. To test his hypothesis, Salomon selected the filmic procedure of zooming in and out as the code, or operation, to be learned and randomly assigned his subjects (eighty eighth graders) to one of four conditions, differing from each other in the amount of supplantation overtly provided. Maximum supplantation of an operation included three basic components: the initial state of the stimuli, the transformation applied to this state, and the resultant state. In the present case this meant showing a painting with a camera zooming in on randomly selected details. Subjects were asked to report in writing the details they observed as the picture was being shown. Once the criterion of 80 reported details was reached, the procedure was repeated with two other paintings. Minimum supplantation entailed showing the original display (initial state) only, leaving all the rest to the learner. The learner was then expected to activate on his/her own the necessary transformation (in the present case mentally zoom in and single out detail). A third condition, short circuiting, involved allowing the learner to observe the initial state and the singled out details, but not the transformation in between. Hence, this group viewed a series of 81 slides for each painting. The first depicted the whole painting while the rest showed singled out details. The control group received no treatment, but took part in pre and post testing only. Subjects were pretested on their ability to single out details from a complex visual display a week before the training. A second test of cue attendance based on a new complex visual array, plus a test of information seeking behavior, comprised the posttest.

Analysis of the data revealed two important points. First, it was found that subjects in both the maximum and minimum supplantation groups outperformed significantly those of the short-circuiting group; the latter did significantly better than the control group. Secondly, while initially high scorers profited most from minimum supplantation, their performance appeared to be depressed when exposed to maximum supplantation. For the low scorers the results were reversed: they learned very little under minimal supplantation conditions, but gained quite a lot when exposed to maximal supplantation. With the other two groups the better initial cue attenders performed the best. Thus, Salomon concluded that filmic supplantation of the process led all subjects to imitate it and was particularly beneficial to those who did not have the process initially. Those subjects who could cue in to detail initially, on their own, experienced interference between the already represented operation and the observed.

A similar study using the operating characteristics of media was done by Rovet (1976). Rovet's study examined whether a mental skill, such as the ability to mentally transform mental images by rotating them about fixed axes, could be improved by viewing a filmed representation of that skill. She initially tested 128 third graders on a series of spatial tasks and verbal tasks and then assigned them randomly to one of five groups. Three groups viewed films of objects being rotated: one group viewed the complete rotation, one viewed a partial rotation, and one group viewed only the initial and final state of the objects with the rotations edited out. A fourth group received individualized training in rotating blocks to determine congruence, and a fifth, which served as the control group, received no training. Following training, the five groups were given two batteries of posttests, one immediately following the final training session and one two weeks later.

The results indicated that both the complete rotation group and the manipulation group did significantly better than the control group, particularly with the larger-sized mental rotations of 90 degrees. No significant difference was found between the film groups although both the partial and full rotation groups did show slightly better performance. Interestingly however, on a transfer task the greatest facilitation resulted from the partial rotation film in which the subject had to imagine the final appearance of the object prior to determining congruence, although transfer was also signficant for the full rotation and manipulation groups in contrast to the control.

In a similar fashion to Salomon, Rovet performed a post hoc analysis to look at individual differences. Regression information of pretest scores plotted on post test scores for the five different conditions showed that not only did the treatments differ in effectiveness as a function of ability level, but the more a treatment provided information about rotations, the greater its benefit for less competent children.

In sum, both Salomon's and Rovet's work show that audio-visual media can indeed facilitate the development of cognitive skills in children. Although the studies cited do not use age as an independent variable, the post hoc regression analyses in both studies highlight the fact that prior knowledge affects the resulting assimilation of the processes demonstrated by media. The next section will expand on this point and also provide several other general comments on the cited research in all three perspectives.

Discussion of the Literature and Rationale for This Study

The first, most obvious point which needs to be made is the existing lack of developmental research on video as an educational tool with very young children, i.e., preschoolers. Even though it has been well documented that children recognize themselves on simultaneous video by 20 months of age, evidenced by self conscious behavior (Asterdam and Greenberg, 1977), and in a replay situation by 26 months (Bigelow, 1977), almost no research using video as an instructional medium with preschoolers could be found. Although Jovick (1977) found second graders to be resistant to the training of classification by video and Bunker, Shearer, and Hall (1976) found five year olds to learn little from a replay of themselves as they learned to flutter kick, other researchers such as Wrenn (1969) and Henderson, Swanson, and Zimmerman (1975) had contradictory results with young elementary children. While it is possible that young children do benefit little from media, it seems more likely, with the contradictory results, that the content of the task or the mode in which the video was used may simply have been inappropriate.

The fact that Salomon (1979) and Rovet (1976) found the medium's "code" (process exemplified) to be more frequently adopted by the learners most in need of it, suggests that a developmental approach in relation to the mode in which video is used is necessary. Piaget and Inhelder (1971), in a discussion of the child's mental imagery, report that the preschooler does not use transformational imagery but understands change only as a series of discrete states. It follows that video used to slow transformations may be of great benefit to the young child. As far as the processing of information the major difference between children and adults is that, rather than simply possessing "smaller" or "slower" short term memories, children appear to be deficient in prior knowledge of facts, procedures, and strategies; in control of attention; and in utilization of memory processes. Evidence for this viewpoint can be found in several studies, including Chi (1976, 1977) and Huttonlocher and Burke (1976). If this is the case, zooming in or replay may help children notice details or remember episodes otherwise forgotten.

A second point in need of discussion is the distinction between success and understanding. Most of the studies attempting to look at video's effect on cognition have used quantitative measures such as success and failure, e.g. do learner's remember more details (Salomon, 1979); can they perform mental rotations of objects successfully (Rovet, 1976); do they score higher on achievement tests

(Robinson, 1974)? Piaget has pointed out that understanding is not analogous to success. For example a child might be successful at hitting a target with a rock in a sling, but be confused about where in its spin the rock is released; or, in the case of a younger child, he/she may know how to make a seesaw balance without having an understanding of a moment theory.

Karmiloff-Smith and Inhelder (1974) investigated the development of these two orientations, success and understanding, in a balance task. They asked 67 subjects, aged 4:6 to 9:5 to "balance so that they do not fall" a variety of blocks across a narrow bar. Some of the blocks were symmetrically balanced; others asymmetrically balanced. Some had conspicuously added weights; others hidden weights.

The authors interpreted children's actions on the blocks in two very different ways, either in terms of success or failure, or in terms of refuting or supporting a "theory-in-action," an implicit or explicit idea concerning the phenomenon involved. For example, a block falling off was construed by one child as a failure, but as support of a theory by another ("it ought to fall...it's not in the middle"). Developmentally, the progression that occurred was one of "decentration" from a reliance on one's own actions for success to a theoretical understanding of the principles involved in balancing.

More specifically, the following levels were observed. Youngest children relied on their own actions to balance the blocks or used their fingers as "nails," holding the block in a stationary, horizontal position. Their main objective was to make the block stay up. When their attempts failed, they frequently shifted to an exploration of other dimensions of the block, thus oscillating between seeking the goal of balancing and seeking to "question" the block. Around the ages of 5 or 6 years children developed a simplified theory of visual symmetry which they generalized for all blocks. Thus, each block, regardless of shape, was tried at its visual center even though failure occurred with all weighted blocks. In fact, these children met with less success in terms of balancing than younger children who had no generalized theory. Once children constructed a theory however, even if erroneous, failures were construed as contradictions to their theories. Thus, they went on to develop new theories, eventually considering weight as a factor.

The authors, as suggested by the title of their article, "If you want to get ahead, get a theory," place heavy emphasis on theorizing. They purport that success apart from understanding has limited power. While a child who experiences success without an understanding of why he/she has been successful may be able to repeat the specific action or actions that led to achievement, experience of success within a success-failure orientation tells him/her no more.

Piaget (1978) and his collaborators studied the relationship between success and understanding within the broader context of the evolving relationship between overt actions and conceptualization and described three developmental levels. On the first level the subjects pursue some "more or less conscious aim" and this aim remains the focus of their actions. There is a clear primacy of overt actions over conceptualization. In fact, conceptualization entails only an analysis of the results of the actions. In the case of balancing, the child focuses only on whether the block stays up or falls.

Gradually the focus of conceptualization shifts from the results of the actions to the <u>means</u> by which various results are achieved and the reasons for these results. Actions can no longer be considered as primary as there is a constant exchange between trials and conceptual inferences. Conceptualization becomes the source of limited plans that the subject is able to modify and improve by virtue of his/her actions. In terms of an understanding of balancing, the subject focuses on the means that caused the block to balance, i.e. lateral shifts and direction of the corrections.

The third and final stage is marked by a lesser importance on overt actions. At this level, by means of conceptualization, the thinker develops a comprehensive theory and a comprehensive and systematic program for experimentation. Regarding balancing, the subject constructs a theory about why blocks balance and systematically tests out the hypothesis. In other words, the emphasis is no longer on the blocks, but on abstract relations.

To summarize, since a developmental progression was found to exist from an early emphasis on the actions of the objects, to a focus on the means which produced success, to the eventual relating of the two into a system of abstract relations, the work of Piaget and his collaborators suggests that a distinction between success and understanding must be made. As educators our concern should be primarily the development of thought, the construction of theories and principles. If we assume learning is sufficient at the level of success then we have missed one of the primary objectives of education. Thus, in relation to educational uses of video, an important question remaining is: How can video be used to aid children in developing new theories or problem solving strategies?

The first step in addressing this question is to consider what constitutes feedback. Past research on the educational uses of video was grounded on the theoretical premise that learning results from passive reflection or imitation. For example, assumptions were made that children would learn from training which modeled certain behaviors, strategies, or processes, or that reflection during a replay of the self's behavior would necessarily be constructive. The question arises as to whether the learner actually reflects on new information or more relevant detail during the replay. Certainly video replay presents the student with richer content with which to work than does raw memory, but one wonders how much more potent training might be if the replay is in relation to the learner's own question.

The realization that meaningful learning occurs best when the child is testing a hunch or prediction caused Inhelder, Sinclair, and Bovet (1974) to teach without telling. They simply confronted the student with his/her own contradictory guesses regarding quantitative changes in sets of objects that were changed only in position. For example, in the well-known conservation of length task, children were asked to predict which path would take the longest time to walk. Preoperational children of course predicted the straight line which extended the farthest. These children were then asked to count the match sticks which made up the paths. After they discovered that the zigzag length was made up of 8 sticks while the straight path was made up of only seven, they vacillated between opposite conclusions regarding essentially the same event. Eventually they constructed a new theory that synthesized the contradictions--a clear example of what Piaget (1977) means by "equilibration through compensation". At first the contradictions were denied, later they became troublesome exceptions, and still later they became mere instances of the new theory.

This training paradigm, called the Predict-Observe paradigm, was also used in the Karmiloff-Smith and Inhelder (1974) study with younger children. Children from 4 to 6 years old tried to balance symmetrically and asymmetrically weighted blocks on a fulcrum. The experimenters allowed the children to choose at will from an assortment of blocks and occasionally asked the children to think outloud as they worked. It became obvious to the observers that after a period of time these children developed definite expectations about what determines balance. Usually these expectations were seen more in a series of actions, such as trying all blocks at their geometric center, rather than in an explicitly stated unifying rule. Kariloff-Smith and Inhelder (1974) termed these action schemes "theories in action."

The question can be raised, how can modern techology be used to help these "theories in action" to emerge, or better yet, to become more explicit for the child? What would happen if children, given the Karmiloff-Smith and Inhelder task, had the benefits of video replay? Video provides the ability to stop the action during the replay and thus provide the learner the opportunity to predict the ensuing action. Use of this strategy makes the remaining replay meaningful to the learner's prediction and promotes involvement with the feedback. In this paradigm, the power of the replay comes in the fact that the action can be stopped at critical points, the focus of the reflection thus narrowed and made relevant to the learner's predictions -- variables that the teacher has no control over as the child works in real time.

A predict consequence/observe feedback paradigm also heightens the possibility for the occurrence of cognitive conflict. The beneficial aspects of conflict inducement have been well documented by many theorists such as Hunt (1968), Piaget (1978) and McCall and Kagan (1967). As previously discussed, Inhelder, Sinclair, and Bovet (1974) found conflict inducement to be a powerful instructional technique. Winn (1974), in an award winning article on learning, called for research into media's use as "disturbers of equilibrium" (p. 26). If the action during the replay is stopped and the learner is asked to predict what will happen, for example whether a block will balance or fall or an object float or sink, the remainder of the replay then affirms or negates the prediction. When the learner's prediction is erroneous, the remainder of the replay may serve as a conflict situation and thus the reflection may be more constructive.

Stop-action video replay may not only affect learning through conflict inducement and focused reflection. It also makes use of hypothesis testing. A strategy widely found in the behavior of successful problem solvers is the setting up of an hypothesis and the subsequent testing of it. In fact, experimental designs are based on the use of predictions and observations. Use of stop-action/predict/observe with video replay may facilitate such problem solving behavior if the learner imitates the process.

Both Rovet (1976) and Salomon (1979) assert that the medium's "code" will be adopted by the learner if it matches his/her mental codes. While their research provides much insight into the effect of media on cognition, it is limited in its scope in that only two processes, zooming-in and rotation, have been studied. If media's full potential as an educational tool is to be understood, many studies using the unique "codes" of video still remain to be done, such as: stop action for predict/observe approaches; fast forward and reverse to survey rapidly and concentrate on those areas of most interest; deletion of certain frames to playback contradictory actions or to highlight competing schemes.

To summarize, it has been pointed out that the processes of reflection, conflict resolution, and hypothesis testing are all important factors in learning. Past uses of video technology have not activated these processes to their full extent. Video used in a stop action/predict/observe paradigm during the replay may make the remainder of the replay more meaningful to the child and activate these processes.

A second point made was that developmental factors need to be considered. Recall that Karmiloff-Smith and Inhelder (1974) found children to progress from an egocentric orientation to a success/failure approach, to a eventual theoretical understanding (which was first overgeneralized and only later understood as mere instances of a more global, stable principle). Also recall that Piaget found children's intentions to change from a focus on the results of their actions, to the means by which various results were achieved, to an understanding of abstract principles involved. In essence, a developmental shift occurred from a focus on "what" would happen to a focus on "why" it happened.

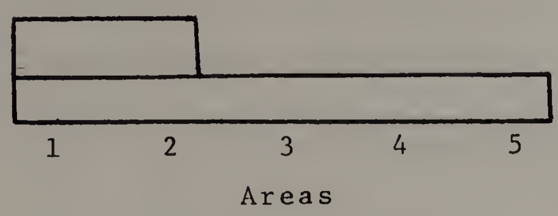
Although children in general may be aided in developing new strategies and theories by reflecting on their actions, the developmental studies of Karmiloff-Smith and Inhelder (1974) and Piaget (1978) indicate that children at different phases might need to reflect on different aspects of action. In relation to Karmiloff-Smith's and Inhelder's block balancing task, egocentric children who rely on their own action might profit more from video replay focused on the consequences of the blocks. Focusing on the action of the block may help children decenter from their own egocentric actions, to the action of the block. According to Piaget

(1977) it is the reflection and coordination on the action of the object and the self that brings about this decentering and the later development of a theory. On the other hand, children who begin with a theory about balance but who overgeneralize a partially correct strategy might profit more from video-assisted reflection on the exact nature of how they place the blocks.

More specifically in terms of the benefits of conflict inducement, young children first asked to predict whether the block will balance or fall and then secondly shown the remainder of the replay, may meet with cognitive conflict if the replay contradicts their prediction. Since young children have not yet developed theories about why blocks balance in general, their expectations are action oriented and block specific. Thus, when asked to predict where they will place the block, they should receive no benefits. In fact the question should have no meaning to them since they have no theory about a "correct" placement. It follows then that no contradiction will occur. Although their predictions may be disconfirmed, the disconfirmations are not in relation to a theory, and thus are not conflict producing.

Older children who begin the task with a theory about balance have specific expectations about "correct" placements (even if their theory is overgeneralized). If they are asked to predict the placement of the block on the fulcrum and then shown a replay of the action, not only is their prediction confirmed or disconfirmed, but their theory about placement is also affected. For example if a child assumes that blocks need to be placed at their geometric midpoint, area 3 (see Figure 1.1), and then during a replay he/she sees that it was actually a shift towards area 2 that caused the block to balance, his/her theory-in-action is contradicted. In contrast, older children who are asked to predict the action of the block should not benefit as much as from prediction of placement since the former does not necessarily entail the invoking of a theory.

Figure 1.1
Drawing of Block with Added Weight



A distinction made between surprise and paradox by Forman and Fosnot (1982) may shed some light on this issue. Surprise is defined as an unexpected event that does not challenge a general principle. For example, a balloon that bursts on the third or fourth blow may surprise us, but it does not challenge our view of balloons in general. This particular balloon may just have had a weak spot. However, a balloon that never gets larger than six inches in diameter, in spite of our continued huffing and puffing additional air into it, would indeed challenge our understanding of a leakless balloon. Additional air needs more space, yet no new space is taken by this expansion. The second case is paradoxical because it violates a deductive system of relations.

An older child who predicts that a block will balance and then sees it fall may show surprise, but probably will not feel paradox. He/she may just think that the block needed to be shifted a tiny bit until the balance point was achieved. In contrast, a child who thinks the block will balance at area 3, but then sees that it actually balanced at area 2, might experience paradox and resolve this contradiction to his/her theory.

The research conducted herein empirically tests the effect of such stop-action video replay techniques on the construction of physical knowledge regarding balance. Using the predict/observe paradigm, a video tape replay was stopped at critical points to have the child predict the remainder of the replay in terms of 1) what the block will do (balance or fall), or 2) what placement the child will make just after he/she grasps the block. After the child made a prediction, the tape was advanced for the child to observe and confirm or disconfirm his/her prediction. Two control groups were added; one group received a video replay in its entirety and was asked to relate what happened, while the other received no video but was asked to relate what happened. Two age groups were used with the hypothesis that the younger children would profit more from a reflection on the block's action, given their tendency to egocentrically form assumptions about the role of their own action (pushing hard will help). Older children were expected to profit more from reflection on the placements that are either consistent or inconsistent with their dominant theory. The following chapter describes in detail the methods, null hypotheses tested, materials, and dependent measures used.

CHAPTER II

METHODS AND MATERIALS

Subjects

A total of 128 children were recruited from the following schools: Worthington Preschool, Northampton Headstart, Skinner Laboratory School at the University of Massachusetts, Marks Meadow Elementary in Amherst, Massachusetts, and the Russell H. Conwell Elementary in Worthington, Massachusetts. Children were randomly assigned to one of four treatment conditions, equally balanced by sex and age (see Table 2.1). Thus, there were eight boys and eight girls in each cell. The age groups ranged from 48 months to 66 months (mean = 57 months) and 78 months to 96 months (mean = 87 months).

Materials

Training Task

Materials consisted of a 1/4 inch fulcrum raised along the length of a platform 6" x 10" and a series of blocks to be balanced, modified from the Karmiloff-Smith and Inhelder task. For purposes of scoring placement, the bottom plane of each block was differentiated into five areas. These areas were not marked on the blocks themselves but existed only psychologically for the benefit of the coders. The blocks were further classified by clusters which were felt to invoke the same theoretical principle of balance (see Figure 2.1).

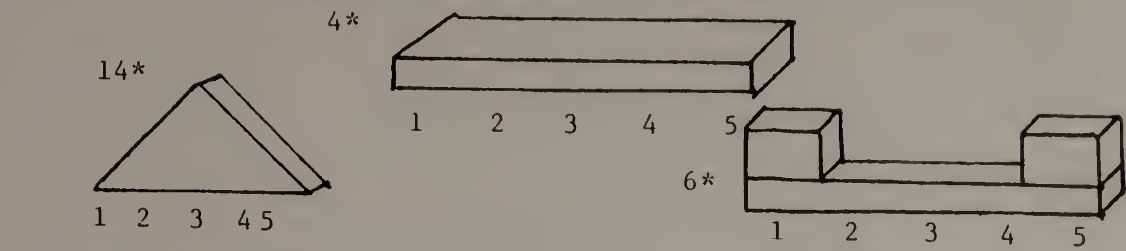
TABLE 2.1

BREAKDOWN OF AGE (IN MONTHS)
BY SEX AND CONDITION

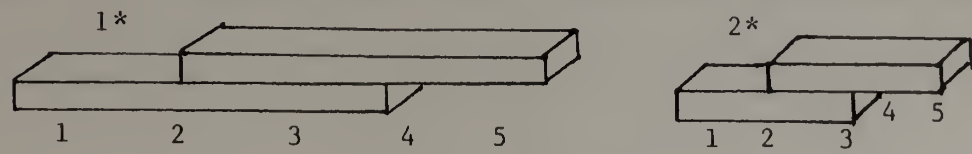
Age/Sex	Treatment Condition			
	Block I	Placement II	Replay III	No Video IV
Young Boys	$\bar{x}$=59 SD=6.0 R=48-66	$\bar{x}$=57 SD=6.5 R=48-66	$\bar{x}$=57 SD=5.0 R=49-62	$\bar{x}$=58 SD=5.0 R=49-65
Young Girls	$\bar{x}$=57 SD=6.0 R=48-66	$\bar{x}$=57 SD=6.2 R=50-66	$\bar{x}$=58 SD=6.1 R=48-66	$\bar{x}$=56 SD=6.5 R=49-66
Old Boys	$\bar{x}$=85 SD=5.6 R=78-91	$\bar{x}$=86 SD=4.1 R=81-94	$\bar{x}$=87 SD=6.0 R=79-95	$\bar{x}$=86 SD=6.6 R=78-94
Old Girls	$\bar{x}$=88 SD=5.6 R=79-95	$\bar{x}$=88 SD=3.7 R=83-93	$\bar{x}$=88 SD=6.4 R=78-96	$\bar{x}$=88 SD=5.7 R=78-94

Figure 2.1 Training Task Blocks
(Drawn to a 1:6 scale)

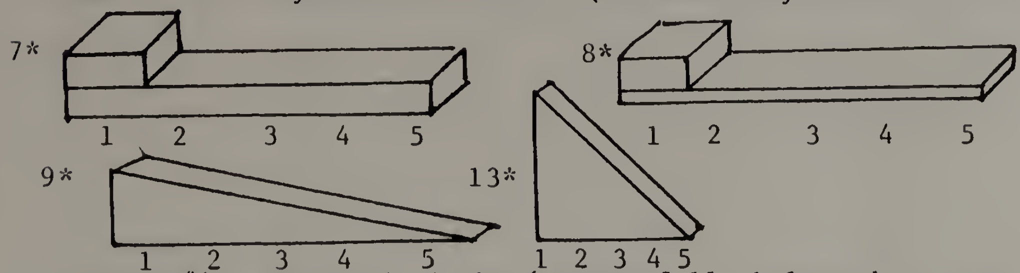
Cluster #1: Length Blocks (successfully balanced at area 3)



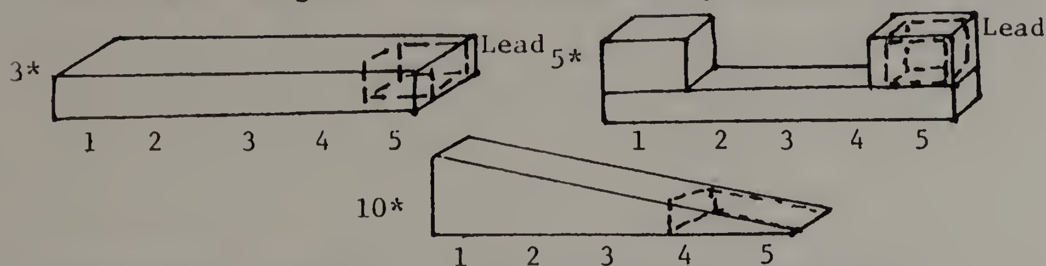
Cluster #2: Displaced Base Blocks (successfully balanced at area 3)



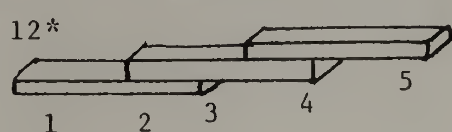
Cluster #3: Asymmetrical Blocks (successfully balanced at area 2)

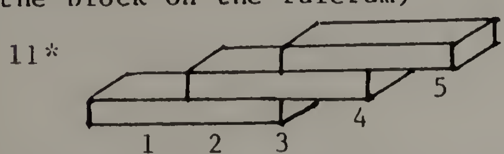


Cluster #4: Weighted Blocks (successfully balanced at area 4)



Cluster #5: Impossible Blocks (successfully balanced by counter-weighting with "helper blocks" at area 1 and shifting bottom plane of the block on the fulcrum)





* Designates presentation order

Blocks #9, 19, 13, 14, and 12 were not used by Karmiloff-Smith and Inhelder but were added to the task for the following reasons: #13 and #14 actually are the same block. On one plane (#14), the block can be balanced at the visual center (area 3), however when the block is turned on its side (#13) it must be placed at area 2 in order to successfully balance it. Thus the child must take into account the fact that the weight distribution has changed and make adjustments. In other words the child must shift his/her placements away from the center for some edges but not others within the same block. This need to use two different strategies for the same block was assumed to heighten the child's awareness of weight distribution. Blocks #9 and #10, because they look identical, were added to contradict the child's area theory (the greater the visual area, the heavier the weight). Because the tip of block #10 was weighted, the narrow half of the block was heavier than the wide half. Thus the child had to place the block away from the wide half in order to successfully balance the block.

A group of "helper blocks" was also provided each subject to use as he/she wished. All helper blocks were painted blue, to contrast with the blocks for balancing which were painted green. There were six blocks in all: two 2-3/4 x 2-3/4 x 1-7/8 inches, one 1-3/8 x 1-3/8 x 1-7/8 inches, and two 5-1/2 x 2-3/4 x 1-7/8 inches.

Transfer Task

A transfer task was also given. The materials used consisted of two blocks 2-3/4 x 2-3/4 x 1-7/8 inches glued together, attached to a plywood base and spaced 8" from another identical stack also attached to the same base. A small doll was placed between the stacks and two (5-1/2 x 2-3/4 x 1-7/8 inches) and four (2-3/4 x 2-3/4 x 1-7/8 inches) unpainted blocks were provided. Subjects were asked to build a roof for the doll. Success at this task requires counter-weighting (see Figure 2.2).

Video Equipment

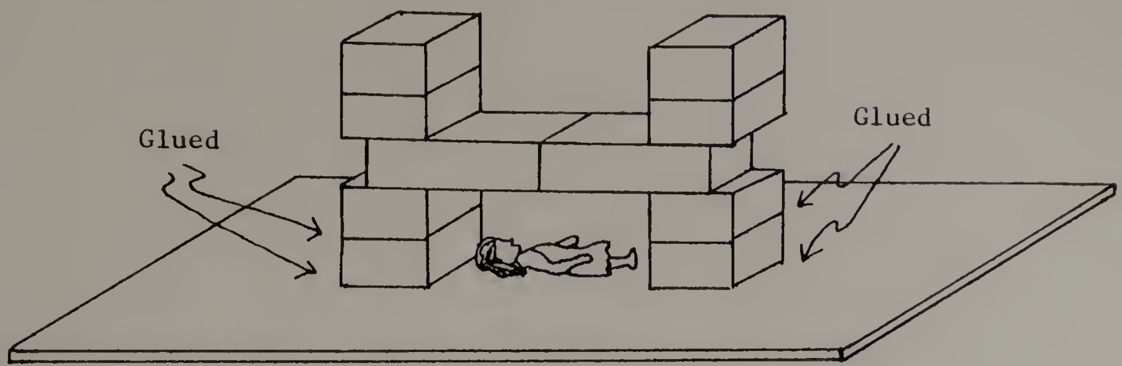
Video equipment consisted of a Sony 365vt recorder and a CVM-112 video monitor. Children's responses were recorded with a Sony 3200 camera and a Sony microphone on a stand.

Research Design

A basic factorial design of two age groups, sex, and four training conditions was used. Children were pretested on the transfer and training tasks in session one, later given four training sessions, followed by a post test session on the training and transfer tasks. Briefly, in Treatment Condition I, called the Predict Block condition, the child was asked to predict what the block on the fulcrum, stopped in action on the video replay, would do when the tape was reactivated. In Treatment Condition II, the Predict Placement condition, the child was asked to predict the placement from looking at the replay of the block stopped in mid-air just before placement on the fulcrum. In Treatment Condition III, called the Summarize Replay

Figure 2.2

Transfer Task. Cantilever Roof Showing the Only Possible Solution. (Drawn to a 1:6 Scale.)



condition, the child saw the entire footage from the first grasp of the block to the end of the first clear release of the block and its subsequent balance or fall. The child in this condition was then asked to summarize what he/she had just seen in the tape segment. In Treatment Condition IV, called the Summarize No Video condition, the child was simply asked to summarize his/her most recent attempt to balance a block.

The design tested the null hypotheses that the means of the pre to post test difference within each condition would be the same for the younger group and that the means within each condition for the older group would be the same. No main effect for sex or condition was expected. A main effect for age was expected given the effects found in past studies. A significant interaction effect between age and condition was also expected with the youngest group performing the best in the Predict Block condition and the oldest group performing the best in the Predict Placement condition.

Task Presentation

All subjects met with the experimenter for four sessions. The time between session one and four ranged from 5 to 28 days with a mean of 13.5 days, SD of 4.6. The extreme time ranges were due to school vacations. This was not seen as a problem since the frequency of extreme scores was very low. The 95% interval was 12.7 to 14.4. See Table 2.2 for the breakdown within each cell.

Session one consisted of a pretest on the training task blocks

TABLE 2.2

BREAKDOWN OF TIME (IN DAYS) BETWEEN SESSIONS 1 AND 4 BY AGE, SEX, AND CONDITION

Age/Sex	Treatment Condition			
	Block I	Placement II	Replay III	No Video IV
Young Male	$\bar{x}$=15 SD=6.9 R=8-28	$\bar{x}$=15 SD=6.7 R=7-26	$\bar{x}$=15 SD=4.7 R=10-21	$\bar{x}$=16 SD=3.4 R=7-20
Young Female	$\bar{x}$=14 SD=5.4 R=7-21	$\bar{x}$=14 SD=6.9 R=5-28	$\bar{x}$=13 SD=5.0 R=7-23	$\bar{x}$=14 SD=4.5 R=7-23
Old Male	$\bar{x}$=11 SD=3.7 R=7-16	$\bar{x}$=13 SD=3.4 R=9-19	$\bar{x}$=11 SD=5.2 R=7-21	$\bar{x}$=13 SD=3.3 R=7-19
Old Female	$\bar{x}$=12 SD=2.5 R=7-15	$\bar{x}$=12 SD=2.2 R=8-14	$\bar{x}$=13 SD=1.8 R=12-16	$\bar{x}$=13 SD=4.3 R=10-20

with no video and the transfer task. Immediately thereafter the first of four training sessions began on the training task blocks. Sessions two and three consisted only of training; session four was training, then post test on the training and transfer tasks.

Pretest training task. The pretest was a free play period in which the child was given the opportunity to try each block in whatever order she/he chose. Blocks to be balanced (green) were placed to the right of the child in the following spatial array:

#1	#3	#2
#4	#8	#9
#5	#7	#6
#13	#12	#10
X(child)	#11	

"Helper blocks" (blue) were placed to the left of the child. Video recorder and monitor were also placed to the child's right. The camera was placed 180 degrees from the child at the level of the fulcrum. The scope of the recording showed the child's face, hands, the fulcrum, and the action of the blocks. The monitor was covered during the pretest and post tests, as well as during all sessions in treatment condition IV. The experimenter said, "I would like you to try to balance these blocks (points to green blocks) one at a time, on here (points to the fulcrum). These are helper blocks (points to the blue blocks). You may use these to help if you like. You can begin with any of these that you wish (points again to green blocks)."

After each block was tried the experimenter removed it and put it aside so that the child only tried each block once.

Transfer task pretest. After the child tried each of the blocks in the training task pretest the experimenter placed the plywood base with the two glued stacks in front of the child with the other unpainted blocks randomly spread out behind the stacks. The experimenter said, "These are two walls (points to the stacks) and this woman (points to the doll) lives in here. But, one day it starts to rain. We don't want her to get all wet so I brought in these blocks (points to other unpainted blocks) so that you could build a roof for her." If the child built a roof by adding more walls for support the experimenter asked, "Is there any way you can build a roof using only my walls?" When the child was satisfied with his/her attempts or said, "There is no way to do it," the experimenter removed the transfer task and began the first of four training sessions.

Training session general directions. The experimenter designated the green blocks and said, "I would like you to balance these blocks one at a time on here (points to the fulcrum). These are helper blocks which you may use to help you if you wish." Blocks were then presented to the child one at a time by the experimenter. In sessions one and three the blocks were presented in numerical order as indicated in Figure 2.1. In sessions two and four the order was reversed. The remainder of the directions differed depending on the treatment condition and will therefore be discussed separately.

Predict block condition. The experimenter presented each block, one at a time, with hands on each side of the block so that the bottom length of the block was clear. She said, "Try this one." At the presentation of blocks, #2, 4, 5, 6, 10, 11, and 14 the experimenter pressed the counter on the video recorder to zero. After the completion of the episode (child attempted to balance the block and it balanced or fell) with each of the aforementioned blocks, the experimenter rewound the tape to zero and said, "Let's look at you trying that block on television." The tape was then replayed until the point where the child placed the block on the fulcrum. The experimenter stopped the action by pushing the recorder switch to pause and asked, "What is the block going to do?" If the child did not respond, the experimenter probed with, "Will it balance or fall?" With a response of fall, the child was asked to show on the T.V. which direction. The experimeter recorded each prediction on data sheets, then said to the child, "Let's see." The switch was then pushed to play and the remainder of the episode was replayed for the child to observe the correctness of the prediction. Blocks #1, 3, 6, 7, 9, 12, and 13 were presented to the child for balancing but no video replay was given.

Predict placement condition. The same beginning directions were given as above, however, during the replay, stop action occurred just before the child placed the block on the fulcrum. The child was then asked to predict the placement of the block. The experimenter said, "Show me where on the block you are going to place it." If the child did not understand the question, the experimenter said, "Here, or here, or here?" while moving her finger across the bottom of the block from area one to five. Predictions were again recorded. The experimenter said, "Let's see." The remainder of the episode was then replayed.

Summarize replay condition. Directions were the same as in conditions I and II except that the tape was rewound to zero in the designated episodes and replayed for the child without stop-action. The experimenter then said, "Tell me what happened." Responses were recorded.

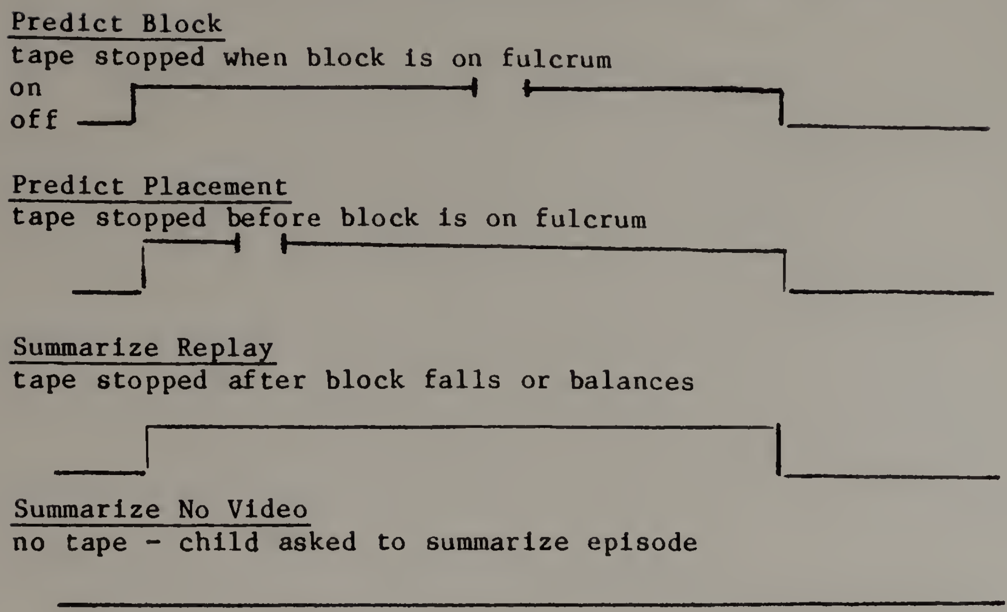
No video Condition. The child was presented each block to balance as in the other conditions. After the designated episodes, the child was simply asked, "Tell me what happened." Responses were written down by the experimenter.

Thus in all conditions subjects were questioned on seven episodes during a session. The length of each episode was the same across conditions since the replay began with the presentation of the block and ended when the child finished with the block (see Figure 2.3).

Presentation order of the blocks was determined by first pairing the blocks according to visual similarities. Through piloting, blocks were then assigned a difficulty level and order was purposely varied so that the easiest or hardest block was not always presented first. The seven blocks used for questioning were chosen randomly although difficulty level was mixed. Thus three easy blocks were chosen and four difficult ones, #2, 4, 5, 8, 10, 11, 14. The

Figure 2.3

Representation of the Length of the Episode and the Point of Stop-Action Across Conditions



presentation order in sessions 1 and 3 was reversed in sessions 2 and 4 to control for children learning a sequence of correct placements rather than a general understanding of balance (see Figure 2.4).

Post test directions. The directions for the post tests were the same as for the pretests on both the training task and the transfer task. The post test transfer task was the exit task for all children.

Dependent Variables

In order to look closely at the distinction (discussed in chapter one) between success and understanding, three different dependent measures were used. The first was a simple assessment of the number of blocks the subject successfully balanced, called the Success Score. The second assessed the strategies or procedures used by the subject as he/she attempted to balance the blocks. This measure was called the Strategy Scale. The third dependent variable measured understanding and was called the Cluster Score. Each of these dependent measures is further defined and elaborated in the next section.

Success Score

Each subject was given a score determined by the number of blocks he/she successfully balanced. Since there were 14 blocks, each subject received a score from 0 to 14 on the pretest and post test. The number of times the block fell was considered irrelevant as long

Figure 2.4

Presentation Order and Difficulty Level of Blocks
Used for Training (Determined Through Piloting)

#1 more difficult
#2 less difficult . . . . training

#3 more difficult
#4 less difficult . . . . training

#5 more difficult . . . . training
#6 less difficult

#7 less difficult
#8 more difficult . . . . training

#9 less difficult
#10 more difficult . . . . training

#11 more difficult . . . . training
#12 less difficult

#13 more difficult
#14 less difficult . . . . training

as the child continued to move the block laterally in a search for the balance point and eventually met with success. The dependent variable used in the analysis of the training effects was the pre to post difference.

Strategy Scale

This scale was derived from an analysis of the Karmiloff-Smith and Inhelder (1974) study and assessed the degree to which the child's performance indicated a theory testing orientation to the task. The use of the helper blocks, direction of lateral corrections, anticipation of the effect of such factors as area or weight, and the degree to which the child tested out his/her theories about balance were all factors taken into account in constructing this scale. The scale was further detailed and expanded from the Karmiloff-Smith and Inhelder study through piloting to include 13 levels. These levels are described as follows.

Level 1. This level is characterized by an ego orientation to all the blocks. In other words the child believes that his/her actions should balance the block; blocks are placed at any point erratically on the fulcrum and let go, or pushed hard above the point of contact, or held horizontally in place. No lateral shifts across the fulcrum to find the center of gravity occur. In fact the child at this level frequently describes the block in terms of a seesaw, having an "up" and a "down" side. He/she pushes down on one side or holds the other side up but only one side at a time is the focus.

Level 2. This level is still characterized by an egocentric orientation although it represents a beginning decentration off a reliance on the self to a focus on the block and its properties. Different dimensions of the block are tried as well as different points of contact with the fulcrum. In place of a hand, helper blocks are used under the block to be balanced in order to "push the down side up." Even though the properties of the block are beginning to be questioned, no lateral movements, no experimentation as to the relationship of the sides of the block to the fulcrum and each other, occur.

Level 3. Although a child on this level originally places the block on the fulcrum in an egocentric fashion, lateral shifts occur towards the midpoint of the bottom plane of the block. The child appears to be beginning to form a theory (general principle) about balance, e.g. all blocks will balance if you shift to the middle of the bottom plane of the blocks. The child does not yet have a stable "theory-in-action" but is beginning to test out variables that might produce success. As the child experiments with lateral movements, he/she discovers that the sides of the block are related. A shift to the right can make the "up" side go down and the "down" side go up.

Level 4. Level four is demonstrative of the first real theory. The child at this level believes the midpoint of the bottom plane of the block to be the exact point of balance. He/she in fact struggles through measurement or lateral corrections to find this point. The original placement is a VCB (visual center of the bottom plane) placement, with the expectation that this is the correct placement, rather than an ego oriented, random placement.

Level 5. Although the child at this level still believes the VCB to be the correct placement, since this strategy does not work for many of the blocks, the child begins to test out whether the visual center (midpoint) of the whole block (rather than the bottom plane) is a better theory. For example, blocks #1 and #2 have a VCB at area 2. This placement will not successfully balance the blocks. The child shifts the block towards area 3. These actions and a subsequent reflection on them bring about the next level.

Level 6. The distinction between level five and six is that, whereas the original placement in level five was a VCB placement, the original placement at this level is a bisection of the whole block in order to find the midpoint. Specifically, at level five, blocks in clusters two and five would be placed originally at area 2 and then shifted to area 3. By level six, the child is certain that the whole block must be bisected and thus places these specified blocks at area 3 originally.

Level 7. At this level, the child is still sure that the visual center (VC) is the balance point, but since this point obviously does not work for all the blocks, he/she again makes use of the helper blocks. However, this time they are placed on top of the block, rather than underneath for support. Importantly, they are placed on top of the "up" side to make the "down" side come up. This fact suggests that the child is testing whether adding a block to the main block will affect balance. This testing of the effect of adding blocks serves as a transition to the next level.

Level 8. The child at this level reasons that if the addition of helper blocks affects balance, then the glued-on blocks on #7, and #8 must be a factor. Thus the child at this level originally places the blocks at the VC but corrects towards the side with the greater area. This behavior is obvious with blocks #7, 8, 9, 13, and 10. Interestingly, this action occurs even in block #10, even though these corrections are away from the obviously more heavily weighted side.

Level 9. Level nine suggests that the child has given up the insufficient theory about the visual center and now assumes weight to be a factor. However, weight is determined by visual cues; bigger space is assumed to weigh more. Original placements are by the side with the greater area (e.g., area 2 of blocks #7, 8, 9, 13, 10). Since the child seems sure of this placement as the only "correct" one, all corrections consist of a struggle to find the balance point within area 2.

Level 10. The child at this level is beginning to question whether greater space is really analogous to greater weight. In the face of conflict, he/she reverts back to an earlier theory and uses the visual center as an anchor point. Corrections are made both towards the weighted side and the side with greater space, depending on the block. For example, cluster three blocks are originally placed at area 3 and corrected towards area 2; cluster four blocks, in contrast, are originally placed at area 3 and then corrected towards area 4.

Level 11. This level is characterized by a reaffirmation about the need to bisect the area of the block. Thus original placements are again at this bisection (area 2 for cluster three). Corrections are made, in contrast to level nine, towards the more heavily weighted side.

Level 12. At this level the child has finally constructed a theory about weight and understands that it is the weight that must be bisected. Thus, the original placement is an estimate of this bisection, area 4 on the weighted blocks. Corrections consist only of a struggle to find this midpoint.

Level 13. This last level requires production. Because the child has a stable understanding of weight, he/she knows that helper blocks must be added to the impossible blocks (cluster five). He/she adds helper blocks and then makes the appropriate lateral shifts to find the balance point, evidence that the reciprocal nature of distance and weight is understood.

This ordinal scale was further operationalized in terms of expected behavior for each of the blocks thus defining an idealized profile for each level (see Appendix A). For example, a child at level 4 should place the length blocks at area 3 originally and struggle with this area searching for the midpoint. The displaced base blocks, in contrast, would be placed originally and corrected around the visual center of the bottom plane, area 2. The same placement would occur with the impossible blocks. With the asymmetrical and weighted blocks, area 3 again becomes the focus even though these attempts at balancing are unsuccessful. The child just deems these blocks impossible.

Two raters, blind to the age of the child, viewed the video tapes of the pre and post test on the training task and assigned each child to one of the 13 levels based on the rule of best fit. Since there were cases where children did not exhibit a perfect fit to any one of the 13 idealized profiles, the raters double coded 20% of all video tapes. The interrater reliability score was 86% based on the number of perfect matches divided by the number of subjects double coded. The particular subjects used for double coding were randomly chosen from both age groups, all four conditions, and both sexes.

Cluster Score

Since Karmiloff-Smith and Inhelder (1974) found that younger children frequently were more successful than older children in terms of the number of blocks balanced, this measure was designed to assess children's understanding of the principles involved. The blocks were categorized (see Figure 2.1) into clusters which ostensibly tapped the same level of understanding. For instance, the length blocks were hypothesized to be the easiest blocks to balance since they could be successfully balanced with a theory about bisecting the bottom plane. Cluster two, composed of the displaced base blocks, was assumed to be the next level of difficulty since subjects holding a theory about bisecting the whole block, rather than just the base, should pass it.

Cluster three, the assymmetrical blocks, should be passed by subjects holding a theory about area as analogous to weight. The weighted blocks, cluster four, should only be passed by subjects having an understanding about weight. Cluster five, the impossible blocks, was hypothesized to be the most difficult cluster since it required an understanding of the physical necessity of, not only the need to add weight, but the reciprocal nature of also needing to move the block on the fulcrum to equally balance that weight.

In order to alleviate the possibility that success could occur by luck, this measure was made very stringent. Every block in the cluster had to be balanced successfully before the subject was coded as passing that respective cluster. It was assumed that for subjects to pass a cluster they had to make an inference about how the blocks in that cluster were alike and then struggle with them to find the exact balance point. Since there were five clusters, subjects were given a score on the pre and post tests from 0 to 5.

Transfer Task

In order to assess transfer or generalization of learning, an ordinal scale for a separate transfer task was also used as a dependent measure. This scale was determined through piloting and was comprised of four levels (see Appendix B).

Level 1 children would try to build supports from underneath the roof pieces, such as building a pretend wall. These children were also fond of filling in the space between the two pedestals with an assortment of blocks as if the task was to make the blocks rise to the common level of the pedestals without concern for a vacant space beneath. Level one children would also simply hold a long block in between the two pedestals, over the sleeping doll, in an apparent need to see the final configuration even though they had not the slightest idea how to make the roof self-supporting without support from underneath. Thus this level closely parallels levels one and two of the training task in that no lateral shifts for weight distribution occur. The child simply relies on his/her placement of the block or props it up from underneath.

Level 2 children begin to show some awareness of the conflict between pushing the overhang block so far inward that it falls, versus opening a rain gap when it is pushed back to render support. Thus, these children were at least experimenting with the limits of providing support via lateral shifts outwards and closing the rain gap via lateral shifts inward. What these children did not do was to invent some sort of lintel structure that spanned both overhang blocks or even several layers of overhang blocks that were staircased inward toward each other. Nor did they invent counterweights. Level two parallels level three of the training task in that the child is experimenting with weight shifts via lateral movements.

Level 3 is characterized by a beginning understanding that the alternation between pushing the overhang block back for support and forward to close the gap is necessarily insufficient. These children use additional blocks above the overhang blocks rather than under the overhang blocks. They would do such things as place a lintel between the two ends of the facing overhang blocks or place an additional layer of overhang blocks pushed inward slightly more than the first layer of overhang blocks. What distinguishes these children from the next and final level is that their attention was always drawn to filling the gap with the second layer of blocks rather than using this second layer as counterweights. Analogously in the training task, subjects at level seven place helper blocks on top of the block to be balanced.

Level 4 children discovered the creative use of the second layer of blocks, not as filling the rain gap, but as providing support to a block as weight. By placing the small block on the outside ends of the two overhang blocks the overhang blocks gain enough cantilevered support to be pushed together without collapsing in on the doll. Level 13 of the training task requires a similar knowledge of the result of placing blocks on top as weight and shifting the block until the weight is distributed appropriately.

The videotapes from the pre and post tests for the cantilever roof task were extensively notated and coded for each move, realignment of blocks, use and position of counterweights, use and position of lintels, and use of supports from underneath. Subjects were assigned to one of the four levels by two raters, blind to the age of the child and experimental group. A total of 20% of all subjects, equally distributed across age, sex, and treatment condition, were double coded. Interrater reliability was 83% on the final assignment level. This reliability subsequently came to a prior establishment of intercoder reliability of 87% on translating the videotapes into action schemes using a special shorthand system to notate each block choice, displacement, and block configuration.

Since the dependent measures described in this chapter were constructed solely from pilot data, validity and reliability tests were needed. The next chapter discusses the statistical validation of these measures and the relationships between them.

CHAPTER III

VALIDATION OF DEPENDENT MEASURES

Because the ordinality of the dependent measures had not been established in other studies, the first purpose of this dissertation was to provide empirical validation of the levels as psychologically discrete behaviors and as hierarchical steps in terms of a scale. The pretest scores were used for this purpose and several statistics were performed. Thus there were 128 subjects whose ages ranged from 48 months to 96 months, with a gap between 66 and 78 months. The mean age of the population was 72.1 months with a standard deviation of 15.96. Appendix C provides the frequency data on the ages of the population studied.

Training Task Measures

Strategy Scale

In order to establish ordinality of the thirteen point scale, the correlation between age and level was ascertained using the Pearson. The correlation coefficient was .65 with a P = .001. Because the Pearson Product Moment Correlation assumes the variables to be continuous and parametric, the Spearman Correlation Coefficient appropriate for non-parametric measures, was also derived. This test yielded a correlation coefficient of .63 with a P = .001. Table 3.1

TABLE 3.1

13 POINT STRATEGY SCALE SHOWING AGE (IN MONTHS) BY LEVEL

Levels	Freq.	Mean	SD	Range	95 PCT Conf. Int. for Mean
1	25	55.4	7.5	48 - 79	52.2 to 58.5
2	1	66.0	0	66 - 66	66 to 66
3	3	54.3	2.3	53 - 57	48.6 to 60
4	0				
5	19	68	15.6	51 - 96	60.4 to 75.4
6	26	73.5	16	51 - 95	67 to 79
7	8	80.5	8.5	62 - 90	73.4 to 87.6
8	17	78.2	13.3	58 - 95	71.4 to 85
9	4	67.0	16	49 - 88	41.5 to 92.5
10	15	85.6	7.6	66 - 94	81.4 to 89.9
11	9	88.5	4.2	82 - 94	85.2 to 91.7
12	0				
13	1	90.0	0	90 - 90	90.0 to 90.0

shows the breakdown by level. As can be seen from the table, only one case existed of levels 2 and 14, and no cases were found of levels 4 and 12. These levels, however, were observed in the post test and thus were left in the scale and coded when observed.

Level 4 probably occurs infrequently because this level requires the child to struggle with the visual center of the bottom plane of the displaced base blocks. The proprioceptive cues are probably much too strong a pull for the child to struggle with this obviously unsuccessful strategy for long. Thus although many cases were observed of an original VCB placement, children quickly corrected towards the VC and were coded as level 5. It is assumed that level 4 exists but that children move very quickly from level 3 to 5. Because of the stringency of the coding (best behavioral fit across all blocks) the behavior was frequently observed but rarely prevalent enough across all blocks for the child to receive a final score of level 4.

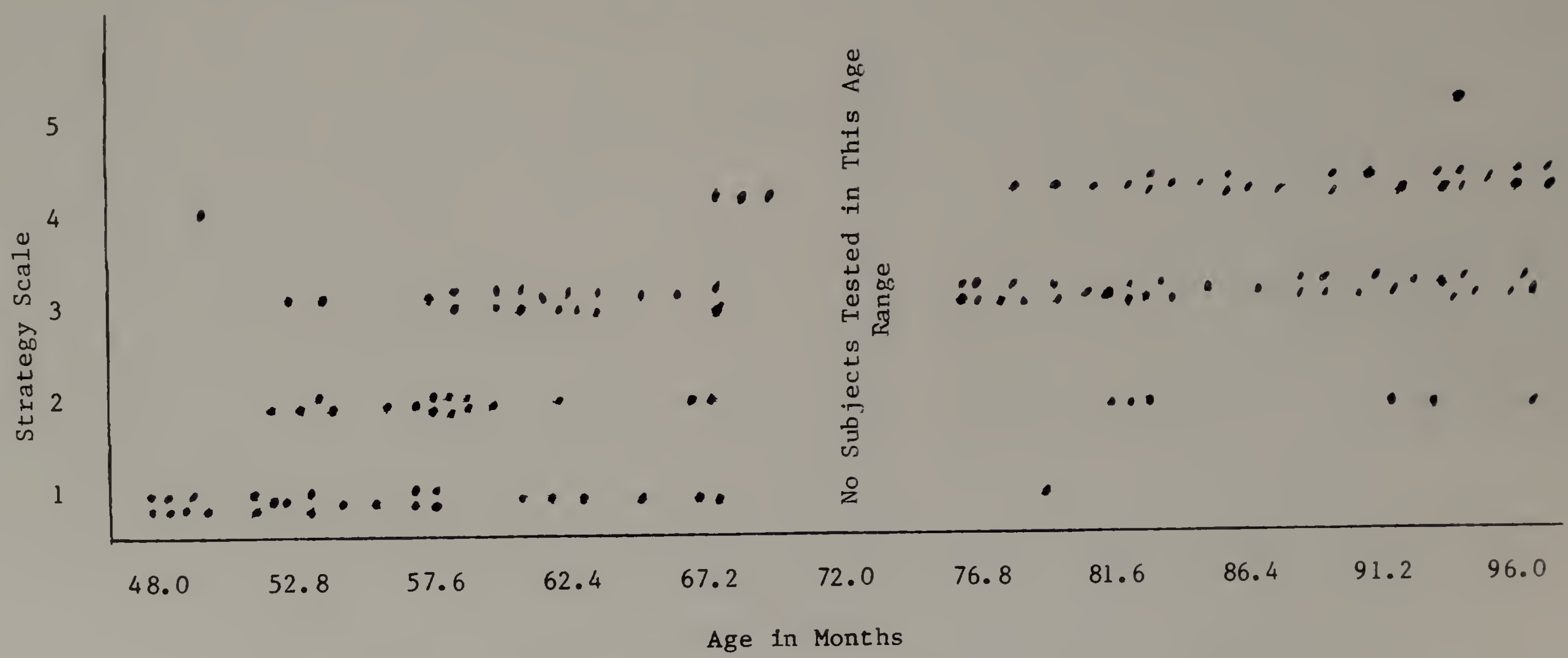
Level 12 and 13 were simply not frequently found in the pretest because of the age of the children. These levels were hypothesized to be the most difficult and the children were probably not old enough to exhibit the behavior. These levels were found with high frequency however in the post test situation, across conditions, even in the control group. Thus it was assumed that they existed and were not produced by training.

A one-way analysis of variance (age by level) yielded an F Ratio of 10.28 with a probability of .0001. This result is due to the fact that at least one level is significantly different from another. However, a look at Table 3.1 shows that further T tests to establish discreteness of each of the levels would be an erroneous step. Several levels have too few subjects for any discreteness test to be valid. Also the wide range of ages within each level, and the fact that 13 levels were coded for such a small age range (with, in fact, a gap of 12 months) make it very difficult to get significance between levels. The scale, therefore, was collapsed into a five point scale on theoretical justifications. Levels were collapsed only within the category of the theory they tapped. For instance, levels 1 and 2 are both representative of an ego orientation. Levels 3, 4, and 5 all require a theory based on the Visual Center of the Bottom Plane (VCB). Levels 6,7, and 8 are manifested by a Visual Center (VC) theory. Levels 9, 10, and 11 suggest an Area Center (AC) theory; whereas a Weight (WT) theory is mandatory in levels 12 and 13. Collapsing the scale in this manner maintained the theoretical constructs of the scale, yet allowed the frequencies of each of the levels to be larger and more evenly distributed.

A Pearson Correlation Coefficient and a Spearman Correlation Coefficient were derived for this collapsed scale in relation to age yielding an R of .62, significant at .00001 and an R of .60, significant at .001, respectively. Figure 3.1 shows a scattergram of the relationship between age and the five point scale. As can be readily observed, the correlation is still affected by the age gap. Because of this gap, but also because establishment of discreteness of the

Figure 3.1

Scattergram of Relationship of Age to Strategy Scale



Correlation (R)	.624	R Squared	.389	Significance of R	.00001
STD Err	.827	Intercept (A)	-.325	STD Err of A	.33953
Significance of A	.170	Slope (B)	.041	STD Err of B	.00460
Significance of B	.00001				

levels makes the scale a far more powerful tool to measure learning, a oneway analysis of variance and Bonferroni t tests were run. Table 3.2 shows the mean ages of the levels and the 95% confidence intervals to be discrete and hierarchical in nature. The Bonferroni t tests held to a .05 significance between levels 1 and 2, 2 and 3, and 3 and 4. The difference between levels 4 and 5 was not possible to compute given that only one child scored at level 5 on the pretest. However, the age of this subject was 90 months, an age that does not fall into the 95% interval of level 4. Also, as discussed earlier, the frequency of this level on the post test was high and found only in the oldest children. Thus it was assumed that had older children been tested, level 5 would have been more prevalent and probably discrete from level 4. These data led to the conclusion that the 5 point scale was ordinally arranged and that each level designated psychologically distinct stages of development.

Success Score

The mean number of blocks successfully balanced was 5 with a standard deviation of 3.6. A Pearson Correlation Coefficient (with age) was ascertained to be .63 with a P = .001, showing that as children got older they were more successful with the task. The Spearman was similar with a coefficient of .64, P = .001.

Cluster Score

This score was also correlated to age but not as highly as the previous measures (Pearson r = .57, P = .001; Spearman r = .59, P =

TABLE 3.2

5 POINT STRATEGY SCALE SHOWING AGE (IN MONTHS) BY LEVEL

Levels	Freq.	Mean Age	SD	Range	95% Conf. Int. for Mean
1	26	55.8	7.7	48-79	52.7 to 58.9
2	22	66.0	15.2	51-96	59.3 to 72.8
3	52	76.3	14.1	51-95	72.4 to 80.3
4	27	83.9	10.9	49-94	79.6 to 88.2
5	1	90.0	0	90-90	90.0 to 90.0

ANALYSIS OF VARIANCE*

Source	df	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	4	12706.1762	3176.5441	19.892	.0000
Within Groups	123	19642.2925	159.6934		
Total	127	32348.4688			

*Bonferroni *t* test ($p < .05$) held between levels 1 and 2, 2 and 3, 3 and 4.

.001). Since it was hypothesized that passing the clusters would be highly related to the theories children held about balancing, and that a hierarchical difficulty order would exist, several statistics were performed on the pretest data for this measure. Table 3.3 shows a breakdown of each cluster, giving the frequency and mean age of the subjects passing each. As can be seen from this table the mean age of the subjects increases with the order of the clusters, 0 to 5.

A Guttman scalogram analysis was performed to test the hypothesis that a difficulty order existed from 1 to 5 and that subjects passing cluster 2 had also passed cluster 1, subjects passing cluster 3 had also passed clusters 1 and 2, etc. Table 3.4 provides the results of the analysis. The coefficient of reproducibility was .95 with a coefficient of scalability at .80.

The weakest point of the Guttman analysis was between clusters 1 and 2 with 11 errors out of 53 (passing cluster 2 when they had not passed cluster 1). These errors are probably due to three causes. First, the proprioceptive cues of the blocks in cluster 2, the displaced area blocks, are very strong. Very few children struggled with a VCB placement with the blocks in cluster 2 since the block so obviously toppled over at this placement. Passing a cluster required successfully balancing <u>all</u> the blocks in that cluster. Thus even though children may have had a strong VCB theory (level 2 of the 5 point Strategy Scale), they rapidly shifted these blocks from an original VCB placement to a VC placement. These shifts sometimes brought about success even though the child may not have had a strong enough

TABLE 3.3

AGE OF SUBJECTS PASSING OR FAILING EACH CLUSTER

CLUSTER	PASS/FAIL	MEAN	SD	N
1	+	80.2	13.7	62
	-	64.5	14.1	66
2	+	81.9	12.9	53
	-	65.2	14.3	75
3	+	87.9	6.6	18
	-	69.5	15.5	110
4	+	88.4	4.3	14
	-	70.1	15.7	114
5	+	78.0	16.6	3
	-	71.9	15.9	125

TABLE 3.4

GUTTMAN SCALOGRAM SHOWING NUMBER OF SUBJECTS PASSING EACH CLUSTER AT EACH LEVEL

CLUSTERS	I	II	III	IV	V	VI
5	0	0	0	1	0	2
4	0	0	0	3	9	2
3	0	0	0	7	9	2
2	0	11	20	11	9	2
1	0	20	20	11	9	2

GUTTMAN LEVELS

theory to successfully balance (requiring a struggle to find the exact balance point) cluster 1.

Secondly, cluster 2 consisted of only two blocks, whereas cluster 1 was comprised of three blocks. Obviously some error will occur simply from the fact that success is more probable when a lower number is needed to pass. This same rationale may explain the error (1 out of 3) in cluster 5. Again only 2 blocks needed to be balanced to pass cluster 5, whereas cluster 4 contained 3 blocks.

Thirdly, the blocks within clusters 2 and 5 were perceptually similar. A child having success with one of the blocks in the cluster may have simply generalized the successful strategy to the other block in the cluster. This was not the case within the other clusters. The blocks within the other clusters were perceptually very different and demanded inferences in relation to a theory about balance before a strategy would be generalized from a block within the cluster to the others. In other words the child had to understand how the blocks were similar. This relationship could be made perceptually in clusters 2 and 5, but not as readily in the other clusters.

To summarize, the Strategy Scale was found to be ordinal and composed of five discrete levels of difficulty. As far as understanding, the Guttman analysis demonstrated that children must pass cluster 1 before 2, and 2 before 3, etc. The Cluster Score, being the stiffest, seemed to assess well children's true understanding of the task.

Since it was hypothesized that these measures might not be analogous, several statistics were derived to ascertain the relationship between the measures. The next section discusses this issue.

Relationship Between the Dependent Measures

The Pearson (see Table 3.5) and the Spearman (see Table 3.6) Correlation Coefficients were highly significant. As can be seen from the tables, these measures were also highly correlated to age. Therefore a first order partial correlation coefficient was determined, parcelling out age as a factor (see Table 3.7). These coefficients were still fairly high in terms of the Success Score with the Cluster Score (.87, P = .001) and the Success Score with the Strategy Scale (.60, P = .001).

Surprisingly, the correlation between the Cluster Score and the Strategy Scale was only .47, P = .001. Figure 3.2 represents this relationship as a scattergram in order to look more closely at this issue. There is a group of subjects evidencing rather advanced strategies, but not having the expected success with the clusters. Since it is realistically impossible for a subject to successfully balance all the blocks in, say, cluster 3 (asymmetrical blocks) without at least the willingness to move the block laterally towards the greater area, the absence of scores in the upper left of the scattergram is not surprising. Apparently, though, while related strategies are necessary for success, they are not sufficient. In other words, many subjects were willing to test out the effect of other variables by moving the block laterally, thus scoring high on the Strategy Scale.

TABLE 3.5

PEARSON CORRELATIONS SHOWING RELATIONSHIP BETWEEN THE DEPENDENT MEASURES

	MONTHS	STRATEGY SCALE	CLUSTER SCORE	SUCCESS SCORE
MONTHS	1.0	r=.6227 P=.001	r=.5714 P=.001	r=.6273 P=.001
STRATEGY SCALE	r=.6227 P=.001	1.0	r=.6604 P=.001	r=.7585 P=.001
CLUSTER SCORE	r=.5714 P=.001	r=.6604 P=.001	1.0	r=.9170 P=.001
SUCCESS SCORE	r=.6273 P=.001	r=.7585 P=.001	r=.9170 P=.001	1.0

TABLE 3.6

SPEARMAN CORRELATIONS SHOWING RELATIONSHIP BETWEEN DEPENDENT MEASURES

	MONTHS	STRATEGY SCALE	CLUSTER SCORE	SUCCESS SCORE
MONTHS	1.0	r=.6030 P=.001	r=.5895 P=.001	r=.6425 P=.001
STRATEGY SCALE	r=.6030 P=.001	1.0	r=.6506 P=.001	r=.7745 P=.001
CLUSTER SCORE	r=.5895 P=.001	r=.6506 P=.001	1.0	r=.8659 P=.001
SUCCESS SCORE	r=.6425 P=.001	r=.6425 P=.001	r=.8659 P=.001	1.0

Figure 3.2

Scattergram Showing Relationship Between Strategies and Passing Clusters

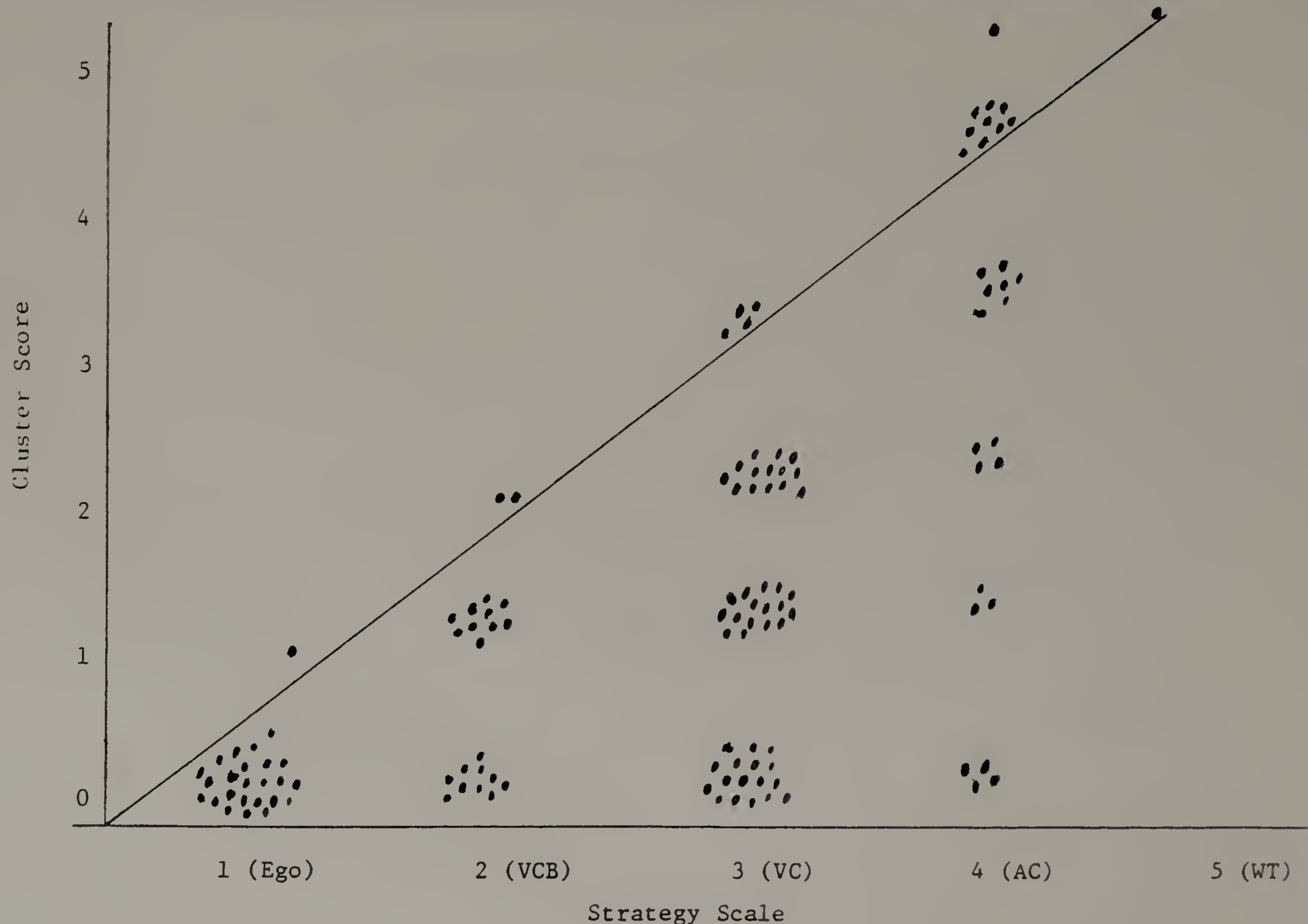


TABLE 3.7

FIRST ORDER PARTIAL CORRELATION (CONTROLLING FOR AGE) SHOWING RELATIONSHIP BETWEEN DEPENDENT MEASURES

SUCCESS SCORE WITH CLUSTER SCORE	r=.8739 P=.001	 df=125
SUCCESS SCORE WITH STRATEGY SCALE	r=.6038 P=.001	 df=125
CLUSTER SCORE WITH STRATEGY SCALE	r=.4743 P=.001	 df=125

But, until they reflected on these actions and they understood, with necessity, the possibility of balance for each block, they did not struggle to find the exact balance point.

Karmiloff-Smith and Inhelder discuss the fact that the younger children in their study sometimes had more success at balancing the blocks because they were willing to move the block laterally. As they put it, "Younger children frequently made use of the proprioceptive cues, whereas the older children were constrained by their erroneous theories and unwilling to give them up." While the data in this study do not point to age as a factor (age was correlated highly to the Success Score), they do show that much lateral exploration and a willingness to give up old theories occur before new theories are stable enough to mandate the struggle required to balance each of the blocks in the cluster.

In summary, the Cluster Score appears to be the stiffest measure. Although highly correlated, the Success Score is not analogous to the Cluster Score. It is possible for subjects to have erratic success with the blocks, but not stable enough theories to make inferences about the blocks in the cluster and thus understand the necessary possibility of a balance point. It is not surprising that the Success Score and Strategy Scale are also related in that as the child moves the block laterally, giving up old theories and testing new variables, he/she is bound to have more success at balancing. However as pointed out, while these strategies are necessary to pass the clusters, they are not always sufficient. While the correlation between the measures is high, the data show that the measures are not analogous. Thus, in testing the effect of video (results discussed in chapter four) all three measures are used separately in order to assess the effect of the training on success, strategies, and understanding.

Transfer Task

Ordinal Scale

An analysis of variance showed there to be no significant sex differences (see Table 3.8). Thus the remainder of the analysis to assess ordinality was done with sex combined. Table 3.8 also represents the frequencies, mean age, and standard deviations of each of the four proposed levels. Figure 3.3 shows a scattergram of the relationship between age and level. A Pearson Product Moment Correlation Test was done yielding a coefficient of .35, P = .001. Since the transfer task comprised only four levels, many ties existed when the scores were rank ordered. Hence, the Kendall Correlation Coefficient was also derived, .25, P = .001. As can readily be observed, the relationship between age and level was very weak, casting much doubt as to whether the proposed ordinal scale was in fact ordinal. Further analysis by *t* tests to determine discreteness of the levels was deemed fruitless since the levels so obviously overlapped.

Since the scale was originally theoretically conceived as being related to the Strategy Scale, a first order partial correlation (controlling for age) was run on the relationship between the scales.

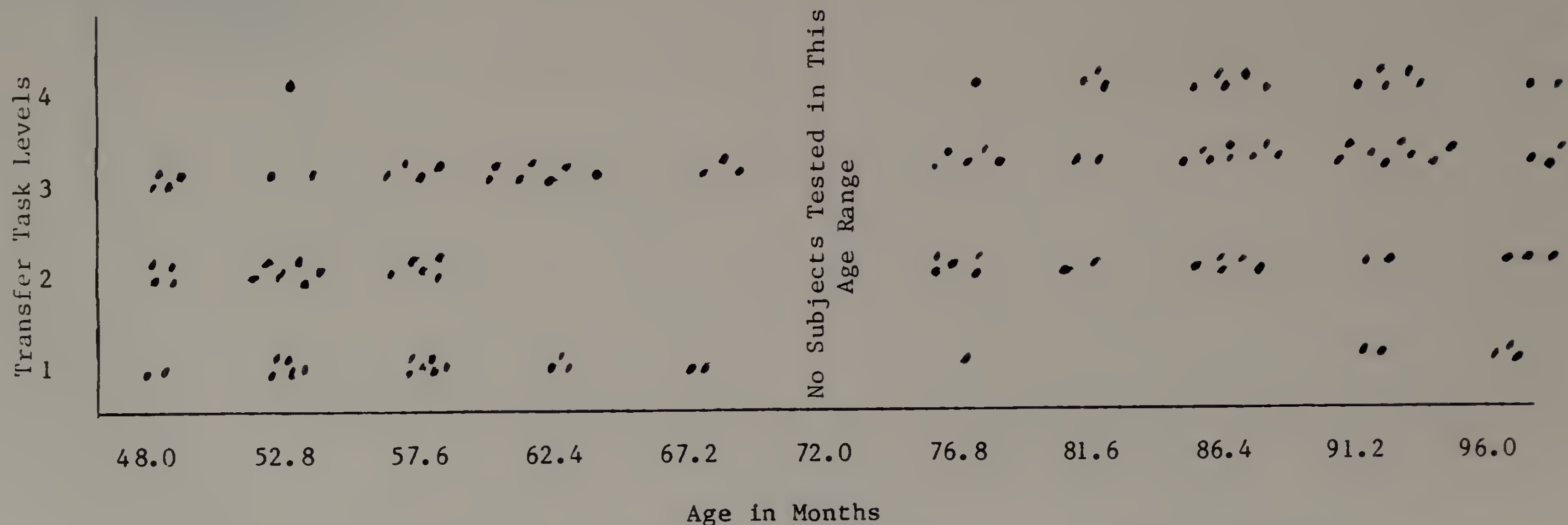
TABLE 3.8

BREAKDOWN BY LEVEL, MONTHS, AND SEX ON THE TRANSFER TASK

	MEAN MONTHS	STANDARD DEVIATION	FREQUENCIES
LEVEL 1	65	15.7	24
FEMALE	64	15.7	12
MALE	66	16.3	12
LEVEL II	68.8	15.3	41
FEMALE	68.3	16.4	19
MALE	69.2	14.7	22
LEVEL III	73.8	15.7	46
FEMALE	74.7	16.2	23
MALE	72.8	15.6	23
LEVEL IV	85.0	10.1	17
FEMALE	85.4	12.7	10
MALE	84.6	5.3	7

Figure 3.3

Scattergram of Relationship of Age with Levels on the Transfer Task



Correlation (R)	.353	R Squared	.125	Significance of R	.00002
STD Err of est	14.98	Intercept (A)	57.55	STD Err of A	3.675
Significance of A	.00001	Slope (B)	5.97	STD Err of B	1.40
Significance of B	.00002				

It was felt that although the transfer task levels might not be ordinal, a significant correlation between the two scales would make the transfer task a viable assessment of generalization of learning. This however was not the case. The partial correlation coefficient, controlling for age, was -.03, P = .39, df = 125.

Perhaps one of the problems in constructing an ordinal scale for this task was in the manner in which the behavior was coded. Because children frequently tried several solutions to the task which spanned across the levels, a decision was made to credit the child with the highest level behavior observed. This decision may have credited many children with a higher level than was valid, thus granting many young children a high score and making the range of scores and standard deviations of each level wide.

In summary, the transfer task scale did not have the construct validity of being related to age; nor was the test significantly correlated with performance on the strategy scale of the training task. Further analyses using the transfer task as an assesent of generalization of learning seemed unjustifiable.

Since extensive notations of behavior were made on this task, further analysis in the future is certainly warranted. However, an attempt should be made at coding the most prevalent strategies, rather than the highest, for each subject, in order to construct a more psychologically valid ordinal scale. Also, because the data on this task is so rich and detailed, what might be of more interest than a structural analysis is several in depth case studies of all the strategies employed by each subject, what causes these adjustments, what children do in the face of conflict, what causes the conflict, etc. An analysis such as this would bring us much closer to looking at the mechanisms of cognitive development, rather than static stage descriptions.

To conclude this chapter, the three dependent measures were found to be valid and reliable assessments of success, strategies, and understanding. While they were found to be correlated, they were not found to be identical. Theoretically the strategies were necessarily related to the successful balancing of the clusters, and yet the data showed that willingness to test out variables such as area or weight was not sufficient to produce success with the clusters. Children had to know with certainty that the blocks within a cluster could balance. This certainty probably was what enabled them to persevere in finding the balance point. Chapter 4 provides the results of the video training.

CHAPTER IV

EFFECTS OF VIDEO TRAINING
RESULTS AND DISCUSSION

Age by Treatment Condition

To test the effect of video, an analysis of variance was computed using the variables of age, sex, and treatment condition in a 2 x 2 x 4 design. The dependent variables were the pretest and post test difference on each of three scores: the Strategy Scale, the Success Score, and the Cluster Score. For all three dependent variables there was a significant main effect for age, no main effects for sex or treatment condition, and no significant two-way interaction effects. Appendices D, E, and F provide the details of these results.

The significant main effect for age was not surprising in that the literature review clearly pointed out that older children benefit more from video replay than younger children. What was surprising was that the hypothesized two-way interaction between age and condition was not signficant. The reader will recall that since young children focus on a success/failure approach and rely on egocentric assumptions about the role of their own action, it was hypothesized that they would do best in the Predict Block condition. Older children who are theory oriented, but over generalize a partially correct theory were hypothesized to do best in the Predict Placement condition. Since these behaviors were found to be highly correlated with age ($r = .63$, $p = .001$), the fact that video did not have a significant effect was unexpected. Although the results were in the expected direction, the difference was not significant.

Since only 37% of the variance on the ordinal scale could be explained or predicted from age, it was determined that the pretest scores themselves could establish the ability level of the subjects. All children who passed at least one cluster of blocks were assigned to the Theory Category, called theory because these children at least had a rule that worked for a subset of all blocks. All children who did not reach criterion on at least one cluster of blocks were assigned to the Ego Category, called ego because these children attended more to their desire to have each block balance rather than to general principles about balance. Even though this sorting occurred after the study had been completed, it seemed preferable to using the more indirect index of age. This new independent variable was called the Pretest Ability Score. Furthermore, since no main effect for sex was found, males and females were combined. The remainder of the data analysis, thus, deals with pretest ability by treatment condition.

Pretest Ability by Treatment Condition

For the total sample of 128 children the division was fairly even between those passing one or more clusters on the pretest and those who passed none. Mean ages across conditions, however, varied.

Since age was determined to have a main effect, 16 subjects were deleted from the analysis, chosen only by their age with no awareness of their scores on the dependent measures. This elimination equalized the mean age for each of the four treatment conditions. Table 4.1 presents the resulting mean ages and frequencies for each Pretest Ability Group and Treatment Condition. Table 4.2 shows the mean time span from session one to four and the standard deviations for each of the cells.

Planned Comparisons

The mean difference scores between pre and post tests on the three dependent measures for each of the cells were calculated and planned comparison two-tailed Dunnett *d* tests were done to compare the performance of the experimental groups with the control groups. No significant difference was found between conditions for children who began with an ego orientation. This was true on all dependent measures. For children who began with a theory strong enough to pass at least one cluster, this was not the case. Since the results were different depending on the dependent measure used, the analysis will be reported for each measure separately.

Success score. As hypothesized, a significant difference ($p = .05$) was found for the experimental video group asked to predict the placement of the blocks in comparison to the control group receiving no video feedback. As can be seen from Table 4.3, showing the means of the groups, theory children did best in general in con-

TABLE 4.1

MEAN AGE IN MONTHS BY PRETEST ABILITY AND TREATMENT CONDITION

	Treatment Condition			
Pretest Ability	Block I	Placement II	Replay III	No Video IV
Ego	$\bar{x}$=60.5 SD=9.3 n=10	$\bar{x}$=57.6 SD=5.1 n=10	$\bar{x}$=59.4 SD=10.7 n=11	$\bar{x}$=57.3 SD=8.9 n=12
Theory	$\bar{x}$=78.5 SD=14.9 n=18	$\bar{x}$=82.6 SD=10.5 n=17	$\bar{x}$=78.6 SD=14.6 n=17	$\bar{x}$=81.3 SD=13.1 n=17

TABLE 4.2

MEAN TIME SPAN (IN DAYS) FROM SESSION 1 AND 4
(PRE TO POST) BY TREATMENT CONDITION
AND PRETEST ABILITY

	Treatment Condition			
Pretest Ability	Block I	Placement II	Replay III	No Video IV
Ego	$\bar{x}$=12.9 SD=5.4 n=10	$\bar{x}$=13.8 SD=7.2 n=10	$\bar{x}$=14.5 SD=5.7 n=11	$\bar{x}$=14.4 SD=4.5 n=12
Theory	$\bar{x}$=12.7 SD=5.7 n=18	$\bar{x}$=12.5 SD=2.6 n=17	$\bar{x}$=13.1 SD=3.1 n=17	$\bar{x}$=14.1 SD=4.1 n=17

TABLE 4.3

CHANGE IN NUMBER OF BLOCKS SUCCESSFULLY BALANCED
BY TREATMENT CONDITION AND PRETEST ABILITY

	Treatment Condition			
Pretest Ability	Block I	Placement II	Replay III	No Video IV
Ego:				
pre test	1.8(1.5)*	2.5(2.1)	2.1(1.4)	2.2(1.3)
post test	3.3(2.4)	2.6(3.1)	2.9(3.1)	3.3(1.3)
mean change	1.5	.1	.82	1.17
Theory:				
pre test	6.7(3.4)	7.1(2.9)	6.4(2.7)	7.8(3.7)
post test	8.7(4.0)	10.8(3.3)	8.1(4.2)	8.5(4.6)
mean change	1.94	3.76	1.71	.71

*standard deviations are in parentheses.

dition II, although the difference was not statistically significant with groups other than the control.

Cluster score. (Pre to Post Difference) With this measure the predict placement condition produced more learning than any of the other conditions ($p = .05$). Thus if a child began with a theory orientation, he/she learned more when asked to predict the placement of the block on the fulcrum and then reflect on the related ensuing action shown on video. This condition was significantly better than video replay, no video, and even stop action video with prediction of the action of the block. Table 4.4 summarizes these results.

Strategy score ordinal scale. (Pre to Post Difference) No significant difference (tested at the .05 level) was found between experimental conditions and controls (see Table 4.5).

Discussion. The results of the planned comparisons highlight the fact that stop-action video with a reflection on developmentally appropriate action can and does increase understanding about balance. Specifically, children who begin with a theoretical orientation to the training task and are asked to predict the placement of the block and then view the remainder of the video replay to confirm or disconfirm their prediction are aided by this intervention. While it is interesting to note that these differences did not exist across dependent measures, it is of particular importance that they did with the Cluster Score. As was discussed earlier, this measure was felt to have the greater construct validity in assessing true understanding of balance. The difference between groups was not significant when

TABLE 4.4

CHANGE IN NUMBER OF CLUSTERS SUCCESSFULLY PASSED BY TREATMENT CONDITION AND PRETEST ABILITY

	Treatment Condition			
Pretest Ability	Block I	Placement II	Replay III	No Video IV
Ego:				
pre test	0(0)*	0(0)	0(0)	0(0)
post test	.6(.8)	.4(1)	.5(1)	.5(.9)
mean change	.6	.4	.5	.5
Theory:				
pre test	2.0(1.1)	1.9(1)	1.7(1)	2.3(1.2)
post test	2.6(1.7)	3.5(1.3)	2.2(1.6)	2.7(1.8)
mean change	.6	1.6	.5	.4

*standard deviations are in parentheses.

TABLE 4.5

CHANGE ON 5 POINT STRATEGY SCALE BY TREATMENT CONDITION AND PRETEST ABILITY

Pretest Ability	Treatment Condition Block I	 Placement II	 Replay III	 No Video IV
Ego:				
pre test	1.7(1.2)*	2.4(.8)	1.9(.9)	1.8(1.1)
post test	2.3(1.1)	1.9(1.2)	2.4(1.1)	2.3(1.1)
mean change	.6	-.5	.45	.42
Theory:				
pre test	3.0(.9)	3.2(.7)	3.1(.7)	3.4(.6)
post test	3.7(1.2)	4.1(.7)	3.8(1.1)	3.6(1.3)
mean change	.67	.88	.76	.24

*standard deviations are in parentheses.

assessed by number of blocks successfully balanced or change in strategies (the exception being the contrast between Conditions II and IV for Theory children measured by number of blocks successfully balanced). These data suggest that children across conditions were learning "what works". They learned to balance more blocks and changed their strategies appropriately. Video did not have enough of a measurable effect as to make the discrepancy significant. However, in terms of affecting children's understanding of balance, video did bave a significant effect, at least for children who began with some theoretical orientation to the task.

In order to better understand the differential effects of training, an analysis of the errors of children's predictions was done. Children who began the task with a theory and received training asking for a prediction of the action of the block had a mean number of errors of 9 out of 28 predictions (SD = 2.6). Similarly, theory children receiving placement training had a mean of 8 errors out of 28 (SD = 3.1). Since the other two conditions heightened reflection but did not make use of a predict consequence (hence conflict) paradigm, there were no errors.

Although quantitatively the errors in conditions I and II are similar, a more qualitative discussion on the distinction between these conditions may help explain the training effects. As previously discussed in Chapter One, a difference exists between surprise and paradox. Children who see a block placed at area 3 and predict that it will balance and then see it fall, may not actually feel paradox, only surprise. They may rationalize that the block just wasn't exactly on the balance point, or that a slight wind knocked it off balance, etc. To the point, they may have their prediction disconfirmed, but not necessarily their theory about balance. In contrast, children who believe area 3 to be the correct placement, predict it, and then see on the monitor that they placed it at area 3 and then laterally shifted it to area 2 at which point it balanced, have a theory disconfirmed. There is no way to explain the result as a variation; it is a paradox. A new theory must be constructed in order to explain this apparent contradiction. In essence, the data suggest that reflection alone is insufficient to affect understanding. Reflection on apparent contradictions is far more powerful.

This analysis also fits well in explaining why the expected results with the ego children did not occur. It was hypothesized that Condition I, predict the action of the block, would be an effective training paradigm for children who need to decenter off their own actions. Although this was perhaps a developmentally appropriate focus for reflection, it probably did not result in a contradiction of a theory. Ego children as a whole made no relations between the blocks. They focused on each block as a separate identity and were simply success oriented. Thus, while a prediction about whether the block would balance or fall may have resulted in surprise or the disconfirmation of a prediction, it did not contradict a "theory-in-action". A look at the main effects found when an analysis of variance was performed lends even further credence to this explanation.

Analysis of Variance

An analysis of variance with the regression approach for unequal N's was performed with each of the three dependent variables. Age was covaried since the previous analysis of variance had demonstrated it to have a main effect. Table 4.6 summarizes these results.

Main effects. A main effect ($F = 4.9$, $P = .03$) was found for the variable Pretest Ability in relation to the Cluster Score. Interestingly a main effect for the Pretest Ability was not found with the other two dependent measures. These data show that if a child has a strong enough theory about balancing to pass at least one cluster, he/she is apt to progress more rapidly in relation to passing the other clusters than a child who originally has no theory, but is success oriented. A look at the mean scores (see Table 4.4) shows that the primary reason for this main effect is due to the significant gain in the Placement Group, Condition II. An original theory orientation does not have the same effect on a change of strategies and number of blocks successfully balanced. It appears that children with an ego oriented strategy are not significantly different in their use of feedback (across conditions) than children who begin with a theory about what makes blocks balance, at least in terms of learning a change of strategy or balancing more blocks.

Earlier, in chapter three, the point was made that success was not analogous to understanding and that the truer measure of understanding was the Cluster Score. The fact that a main effect for

TABLE 4.6

ANOVA SHOWING DEPENDENT VARIABLES BY CONDITION AND PRETEST ABILITY (COVARYING AGE)

PRE TO POST DIFFERENCE IN NUMBER OF BLOCKS SUCCESSFULLY BALANCED

SOURCE OF VARIATION	SUM OF SQUARES	df	MEAN SQ.	F	SIG. OF F
COVARIATES					
months	128.197	1	128.197	18.2	.001
MAIN EFFECTS	34.464	4	8.616	1.2	.305
pretest ability	6.27	1	6.273	.89	.35
condition	28.32	3	9.44	1.34	.27
2-WAY INTERACTIONS					
ability/cond.	55.57	3	18.5	2.6	.05
RESIDUAL	724.687	103	7.03		

PRE TO POST DIFFERENCE IN NUMBER OF CLUSTERS PASSED

SOURCE OF VARIATION	SUM OF SQUARES	df	MEAN SQ.	F	SIG. OF F
COVARIATES					
months	21.5	1	21.5	18.4	.001
MAIN EFFECTS	12.8	4	3.2	2.7	.03
pretest ability	5.7	1	5.7	4.9	.03
condition	6.9	3	2.3	1.97	.123
2-WAY INTERACTION					
ability/cond.	5.78	3	1.9	1.6	.183
RESIDUAL	120.63	103	1.17		

PRE TO POST DIFFERENCE ON 5 POINT STRATEGY SCALE

SOURCE OF VARIATION	SUM OF SQUARES	df	MEAN SQ.	F	SIG. OF F
COVARIATES					
months	14.29	1	14.29	16.76	.001
MAIN EFFECTS	3.63	4	.908	1.07	.377
pretest ability	.735	1	.735	.862	.36
condition	3.03	3	1.01	1.18	.319
2-WAY INTERACTION					
ability/cond.	8.265	3	2.75	3.23	.025
RESIDUAL	87.801	103	.852		

Pretest Ability on the Cluster Score was found adds further credence to that point. Just as Karmiloff-Smith and Inhelder suggested, once a child has a theory about balancing, he/she is able to make more use of the feedback and develop better, more inclusive, theories. Children without theories originally may learn to balance more blocks and in fact may even change their strategies, but may not necessarily be constructing newer and stabler understandings.

The reader will also recall that a main effect for age was found on all dependent measures in the original analysis of variance with age as an independent variable. Since the Pretest Ability score was not determined to have a main effect on the Success Score or the Strategy Scale, but age did, it appears that age, rather than a theory about balancing, is a more powerful determiner of whether a child will be more successful or change strategies. To wit, as a child gets older, he/she is more apt to succeed in balancing more blocks and in developing more useful strategies, regardless of whether he/she begins with some theory about balance. In contrast, children that begin with a theory, regardless of their age, are more apt to develop more stable and higher level theories allowing them to balance more clusters than children who are ego or success oriented at the start.

Interaction effects. As can be seen from Table 4.6 a significant two-way interaction between Pretest Ability and Treatment Condition was also found. This statistic was significant for both the Strategy Scale and the Success Score, but not for the Cluster Score.

These first two ANOVAS were submitted to post hoc Bonfonerri t tests to discover which cells were significantly different from each other at the .05 level or better. In both cases a significant difference was found between ego and theory children in Condition II. Specifically, asking children to predict where they would place the block, and then showing the remainder of the video replay, was most beneficial for children who began the task with a theory. However this condition seemed to diminish performance for children who began the task with an ego orientation. An inspection of the means in Table 4.5 shows that ego children in Condition II actually did worse on the post test than they did on the pre test.

The reasons for the diminished performance of ego children were obvious during the data collection. First, because they had no theory about a necessary placement, the question ascertaining placement made no sense to them and thus probably served as a distractor. Many ego children during training were observed (in response to the question) drawing a line on the monitor from the fulcrum to the point on the block directly above the fulcrum. In other words their responses were based on proximal causes rather than any theory about a "correct" placement. Other ego children were just simply confused by the question and appeared to be guessing randomly.

Secondly, this condition for ego children was a negative reinforcer. For ego children, the question, "Show me the spot on the block where you are going to put it" was interpreted with an emphasis on the "you." Thus the ensuing action of the block falling became a negative reinforcer, a criticism of their placement. In contrast, theory children emphasized the placement question in relation to a theory about balance, rather than themselves, and the ensuing action of the block became feedback to confirm or disconfirm that theory. While this condition did not produce a significant difference in learning for ego children, their regressed performance coupled with a facilitated performance for theory children brought about a significant difference between the two means. Chapter V provides a more detailed discussion of the results.

CHAPTER V

SUMMARY AND CONCLUSIONS

The central purpose of this study was to explore the effect of video-assisted reflection on children's understanding of balance. It was predicted that training with stop-action video, in a predict consequence/observe paradigm, would heighten children's understanding of the principles involved in balancing blocks on a fulcrum. Furthermore, it was predicted that different aspects of the action during a learning episode needed to be reflected on, depending on the entering level of the learner. Specifically, ego oriented children would benefit from reflection on the action of the block since this reflection might aid them in decentering from their own actions to the action of the blocks. In contrast, children who entered the task with a theory about why blocks balance (even if it was a wrong or over-generalized theory) would benefit from reflection on the placement of the block. To wit, reflection alone is insufficient; reflection must be <u>in relation to</u> the learner's assimilatory schemes, in other words, developmentally appropriate.

A secondary purpose of this study was to examine the relationship between success and understanding and to empirically validate a developmental ordinal sequence of strategies and theories constructed while solving balance tasks. It was hypothesized that children would progress from an original ego orientation to a belief that bisection of the bottom plane of the blocks was necessary. This bisection assumption would eventually be translated to the whole block, then area, and finally weight. It was further assumed that before a child would give up an erroneous or insufficient theory, he/she would: 1) move the block in the direction of a new variable (for example an original area center placement with corrections towards the side with the greater weight); 2) reflect on these actions; and then, 3) construct a new theory based on the new information. In essence, a change in strategies would be necessary but not sufficient for the construction of new theories. While success and understanding might be related they were not expected to be the same index of learning.

The data substantiated the predicted ordinal scale of strategies. The youngest children attempted to balance the blocks by egocentrically placing them at random points on the fulcrum. If the block fell, which happened frequently, they declared the block impossible to balance. The first corrections observed were towards the middle of the bottom plane of the blocks, even when these corrections were obviously in the wrong direction. This VCB theory was eventually transcended to include the whole block. Visual center theories, while successful for some of the blocks, when generalized to all the blocks became insufficient. Thus children eventually determined that area and weight were factors, made corrections towards these factors, and finally understood that weight must be equal on both sides of the balance point. The Guttman analysis demonstrated that the lower level theories were necessary to the construction of the higher levels. The scattergram representing the relationship between the strategies and success on the clusters, however, showed that these strategies were in no way sufficient to produce success on the clusters. In other words, children, in attempting to balance the blocks, frequently were willing to test out other variables than the one they believed to have an effect. For example, children with a VC theory were willing to move the block towards the greater area or weight. But until they developed "physical necessity" (the understanding that each block was indeed possible), they did not struggle with the midpoint enough to be successful with the cluster. Reflection on these strategies appeared to be the key in causing children to construct higher level theories.

Yet even this reflection must be viewed developmentally for the data confirmed the hypothesis that video feedback works in different ways for chidren at different levels of development. For children who had already begun to think about a general means to balance, rather than what they themselves do in a specific instance (theory vs ego children), reflection in general facilitated understanding. All the conditions trained for reflection. Condition I required the child to reflect on the action of the block; condition II the placement. Conditions III and IV, while different in terms of the use of video, both required verbal summarizing of the event. A main effect for Pretest Ability was found, demonstrating that across conditions, children who entered the task with a general theory about balance made better use of the reflection training. This main effect was not significant when measured by number of blocks balanced or strategies employed, but only in terms of the number of clusters passed. A more qualitative description of the two groups of children (ego and theory) may help explain these results.

Ego children, while being younger than the theory group, were also characteristically different in their approach to the training task. Response protocols indicated that these children were more often the children who made only brief adjustments with a block if it did not balance. They were more likely to attribute a failure to a "bad block" than to their own placement strategy. They were frequently children who explored the physical attributes of each block independent of how those attributes related to the balancing task. Children in the theory group understood, at least in part, that there was some rule that could be applied to several blocks, if not all blocks, that could be discovered if one thought clearly about several blocks at a time. These children would make spontaneous comments such as, "Hey, this one is not like the other one." This was most prevalent when two blocks looked alike but were weighted differently. Thus it is reasonable to conclude that children in the theory group during training reflected more on the means to establish balance. The rules they constructed were the results of reflecting on means-ends relations.

The study by Karmiloff-Smith and Inhelder, _If You Want to Get Ahead, Get a Theory_, provides further justification for the main effect. These authors suggest that once a child has a theory, feedback is used as a confirmation or disconfirmation of that theory. In other words ego children see each block as a completely different object and each trial as a separate event. Theory children, in contrast, are guided by general rules, hence expectations for each of the blocks. Thus the results of each trial are related and provide conflict or reinforcement in terms of those rules.

Not only was entering ability (ego versus theory orientation) found to be important in making use of the feedback, but the content of the reflection was also effective. The data showed conclusively that for children who have already begun to think about a general means of balance, rather than what they themselves do in a specific instance, stop-action video improves performance if the stop-action orients the child to where he/she is about to place the block. This was seen in the Theory category of children in the Predict Placement condition. In terms of the Cluster Score, this group did significantly better than the same category in all other conditions. With this type of video feedback the children had to reflect on their placement strategies. Having to predict the placement strategy just prior to the continuation of the feedback tape, combined with the feedback of the consequent success or failure, helped to bring the whole episode into an integrated system of means-ends relations. Straight replay was not as potent a training condition, nor was reflection on the action of the block, suggesting that assumptions cannot be made about the content of the child's reflection. Repeated exposure is not necessarily constructive.

Piaget's notion of reflexive abstraction may be helpful in understanding these results. He defines this abstraction as including two inseparable aspects: "a reflecting in the sense of projecting on an upper level what is happening on a lower level, and a reflection in the sense of a cognitive reconstruction or reorganization of what has thus been transferred" (1977, p. 35). His proposed process of equilibration as the mechanism to explain cognitive restructuring is also inherent in this definition of reflexive abstraction. The child attempts to assimilate new data which contradicts his/her current theory. The contradiction makes the assimilatory schemes insufficient and reflection occurs, abstracting principles from the new data to form a higher level theory, an accommodation.

Specifically in terms of the balance task, a theory oriented child begins the task with an anticipation of a correct placement. The stop-action video/predict placement condition highlights the action of the block trial in terms of the child's assimilatory schemes. During the remainder of the video replay, after the child's prediction of placement, the information abstracted either confirms or contradicts the placement theory. If the child's working theory is contradicted (such as visual center placement should make the block balance but it took corrections towards the area center to make the block balance), a new theory must be constructed to explain the contradiction in order to accommodate. Thus the reflection in this condition is more potent because it narrows the focus of the replay to the child's assimilatory schemes and facilitates reflexive abstraction.

The reflection facilitated by Condition I, Predict Block, is not as appropriate a match to the theory-oriented child's assimilatory schemes. The focus of this reflection is not means or theory oriented, but simply object/action oriented. The theory child is not thinking about "what" happens, but "why" it happens. Evidently reflection on the success and failure of the block, without relating the means by which that success/failure occurred, has no positive effects for problem solving in these situations.

Although the hypothesis about the advantage of the Predict Block condition for the ego oriented children was not supported, there was a trend for this group to do better on all dependent measures in condition I than in the other conditions. It is possible that had training been longer than four sessions, a significant difference may have been found between conditions for the ego children. Perhaps Condition I facilitated decentering from one's own actions to the action of the block more than the other conditions, but the step from an ego orientation to the first theory is a big one, requiring more time than going from a VC theory to an AC theory.

Significance of the Study

This study shed light on 3 important points, the first of which is the nature and process of reflection. While it has been an accepted principle for years that reflection is facilitative to learning, little research had been done to illuminate the content of that reflection. This study is evidence that, while reflection in general can be conducive to the development of higher understanding, when reflection is in relation to the learner's own question and focuses on contradictions it is more powerful. Such a conceptual understanding of reflection is in concert with the notions of learning as a constructed, self-regulated process. In the process of problem solving, the learner has expectations and hypotheses which he/she is testing. Reflection on the result of actions related to these hypotheses is more conducive to learning than simply reflecting on the whole episode. Assumptions cannot be made that because replay is provided the learner is necessarily focusing on the relevant aspects of the episode.

The second point relates to the obvious developmental progression in the construction of physical principles of balance. This study replicates and adds statistical validation to the study of balance by Inhelder and Karmiloff-Smith (1974). As discussed by those authors, children progress from an egocentric orientation to a theory testing orientation. This theory-testing orientation also has a developmental sequence, moving from theories based on visual symmetry, to area center, to the eventual understanding of weight.

These progressions are exemplary of the process of decentering. The learner first focuses on his/her own actions and assumes that balance is a direct result of placing the block on the fulcrum. The child believes that his/her initial placement should be sufficient to balance the block; if the block falls it must be a block that "can't be balanced." In order to progress to the next stage, the child must negate a sole reliance on his/her own actions and begin to think about the properties of the block. At first these observables are specific to each block separately; later relationships between blocks are constructed and rules about balance are applied across blocks. The first rules, or theories, are based on the observable properties of the blocks. Originally the child focuses only on the bottom plane of the blocks. This specific theory then becomes negated and applied to encompass the whole block, including asymmetrical area. Finally the child negates the observable properties of the blocks and makes an inference about a property not directly observable, that of weight.

In summary, the child's theories progress from an initial reliance on self, to theories about specific blocks and specific properties, to general rules based on inferences across all blocks. Although this decentering from the self, to the objects, to general principles cannot be applied as a normative process of cognitive development inherent in all problem solving activities, this progression was statistically validated in at least the development of an understanding of balance. Since much of the Genevan work is pure case study with little statistical analysis, validating at least one study is an important step in illuminating the relationship between the "knower" and his/her understanding of the world.

A third point in need of discussion is the distinction between success and understanding. This study lends strong support to the premise that the two are not analogous. As previously discussed in chapter three, several younger children were frequently successful in balancing the blocks because they were willing to move the block all around until the block balanced. Children a little older who began with a theory were frequently constrained by that theory in that they believed their placement to be correct and were unwilling to move away from it. Whereas success could occur by making use of proprioceptive clues or luck, understanding as measured by the Cluster Score required the knowledge of "physical necessity," knowing that balancing the block was indeed a possibility and hence struggling with it. Thus success is seen as a necessary but not sufficient condition for understanding.

The fact that reflection training produced different results in terms of success and understanding adds further support for this distinction. Children in all conditions learned more successful strategies and were more successful as far as balancing more blocks from pre to post test, regardless of training. This was not the case when measured with the Cluster Score. Reflection in terms of the learner's developmental level, coupled with conflict, produced a measureable effect on understanding. Thus although children across conditions learned more successful behaviors, a true understanding of the principles involved was affected only when reflection in relation to their theory occurred.

The distinction between success and understanding is an important one. As discussed earlier in chapter one, much of the research on video technology dealt only with technology's effect on behaviors, e.g., can video affect the learner's ability to discriminate more details (Salomon, 1979), or to successfully perform mental rotations of objects (Rovet, 1976). To truly understand the thinking processes involved in theory construction and problem solving, more than just success with the task needs to be studied. Researchers need to look closely at how children's understanding of the task changes, and in relation to technology, how its use affects understanding.

Educational Implications

The distinction between success and understanding, the validated ordinal progression towards an understanding of balance, and the use of reflection via video with a developmental perspective, all have important implications for educators. Too frequently educators use success as a measure of understanding in school related tasks. This study establishes the fact that we need to go further. Assumptions can not be made that as long as a child completes a task correctly, he/she understands the principles involved.

The significance of the scalogram analysis is that it shows that a definite difficulty scale exists as children attempt to understand balance, depending on the type of block. The Bonferroni t tests between ordinal levels and the Guttman analysis on the clusters prove that children progress from an Ego orientation, to VCB, to VC, to AC, to WT, and that they will be more successful with objects that tap these theories. Since the main objective of educators is to help children develop qualitatively better theories and strategies for problem solving, knowledge of the developmental progression of these theories is necessary. The Guttman not only highlights this developmental progression, but also demonstrates that each level is necessary to the construction of the next. In essence, children will not develop a theory about say, weight, until they have developed a theory about area and then negated it. Thus, educators need to present children with materials that will enable them to construct theories in that order.

The fact that a main effect was found with the Cluster Score as a dependent measure, while an interaction effect was found with the Success Score and the Strategies Score, suggests that the mode of instruction must fit the developmental needs of the child. In other words, there is no predetermined best way to use video. Teachers must assess the child's level and approach to problem solving tasks. If technology is used in relation to these factors then it can facilitate the learning process. This study emphasizes the need for child centered education, rather than a set of predetermined curricular objectives and instructional principles.

Limitations of the Study and Implications for Future Research

The fact that no ordinal scale could be validated from the coded behaviors on the transfer tasks was disappointing. Since the transfer task was impossible to use to assess generalization of learning, one cannot conclude that the principles of balance learned in relation to the blocks were understood as general principles in any balance task. However, given the fact that three dependent measures were used in order to discriminate success, behavioral strategies, and understanding, some light may be shed on this question.

The cluster score required success on each of the blocks within the cluster. In order for children to struggle with each of the blocks within the clusters, it is highly probably that inferences were made as to how the blocks were similar. The reader should recall that the blocks were not presented in order of cluster but were mixed in difficulty order and also counterbalanced by presentation order. Thus, for a child to pass for instance cluster three, he/she had to have some notion as to how the blocks were similar in relation to a theory about balance, i.e. greater area or space makes a difference. The reader should also recall that the Guttman analysis revealed that no child passed cluster 4 before passing cluster 3. This validated scalogram adds further credence to the hypothesis that children had theories about balance and understood the similarities in the blocks in relation to those theories. Since this dependent measure seems to validly assess children's understanding of balance and assumes that they have made relationships (classifications) among the blocks, it seems plausible to conclude that these principles are understood as general theories and would have transferred to other balance tasks.

Such an assumption can not be made about the Success Scale or the Strategy Scale. It is very possible that these behaviors were learned specifically in relation to the training blocks, thereby being a product of training and possibly not generalizable. Further research should address the effect of video assisted reflection in regards to whether learning transfers to similar tasks. Perhaps a more appropriate transfer task would be to use materials very similar to the training task materials, but different in shape, color, and size. These materials would provide a direct correlation with the training task, yet be different enough to eliminate memory factors or strategies learned specifically in relation to the training task.

A second point in need of consideration is the effect of the mirror image/real image representations that the child had to deal with in viewing the videotapes. It can be argued that because young children have difficulty with perspective taking (Piaget, 1969), when asked to predict which side of the block would fall they may have had difficulty making the transference from the real image to the representation. On the other hand it can be also argued that if perspective taking is not yet operative in the young child, understanding the representation may be easier for that child than for a child with perspective taking ability. The older child may attempt to translate the real image in memory to a mirror image on the monitor, whereas the younger child may respond to the monitor as if it were real time.

This issue of perspective taking was considered in the design of the study but the decision was made to place the camera 180 degrees from the child for the following reasons. Placing the camera directly in back of the child so that the monitor would show the same scene the child saw in real time was difficult because children frequently moved and obliterated the view of the block on the fulcrum with their bodies. To angle the camera, alleviating the possibility of blocked views, resulted in a bird's eye view. This placement presented a host of other problems, the most obvious being an obscured view of the fulcrum and the placement position of the block. Although hardware was available to have the camera situated 180 degrees from the child and then reverse the image 180 degrees, it was believed that then the older child with perspective taking ability would be confused and expect a mirror image due to his/her past experience with cameras and television.

During piloting the experimenter frequently asked children to find key points in the representation in order to assess whether the children, particularly the younger ones, would have trouble with the real versus mirror translation. Children did not appear to be having difficulty and therefore the decision was made to place the camera 180 degrees from the child. Admittedly however, the question of the effect of perspective taking ability is a debatable one and future research might deal with this issue in more detail.

A third consideration is the fact that both control groups (video replay and no video) made use of verbal summarizing, thus limiting this study in its ability to conclude anything about replay versus no replay and the role of language. The addition of a control group using replay only with no verbal summarization might result in some interesting data on the effects of verbalization per se and the role of observational learning. The decision to eliminate this obvious control was based solely on the feasibility of actually collecting all the data in a limited period of time, given the duration of the grant funds. Further research is warranted to discriminate these interesting variables.

Perhaps the most interesting point to be made, in regards to the implications of this study, relates to the way in which media select, highlight, structure, and affect information processing and theory construction. Salomon (1979) has demonstrated that learners will model the process of discriminating details when trained using the zooming capacities of film. Rovet (1976) presents similar evidence that films depicting rotations can affect the learner's ability to rotate objects in space. This study makes use of two unique aspects of video: its ability to provide repeated exposure for reflection and its ability to stop the action of real time and allow for predictions.

If technology can indeed affect learning and cognition, researchers need to continue to study how the unique aspects of technology can be used in relation to these processes. Studying media only as convenient delivery systems misses perhaps their greatest potential.

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APPENDIX A

SPECIFIC OPERATIONAL DEFINITIONS OF EACH ORDINAL LEVEL BY CLUSTER*

Ordinal Levels	CLUSTERS: Cluster 1 Symmetrical Length Blocks (Expected behavior occurred in at least 2 out of 3 blocks.)	Cluster 2 Displaced Base Blocks (Expected behavior occurred in at least 1 out 2 blocks.)	Cluster 3 Asymmetrical Blocks (Expected behavior occurred in at least 3 out of 4 blocks.)	Cluster 4 Inconspicuously Weighted Blocks (Expected behavior occurred in at least 2 out of 3 blocks.)	Cluster 5 Impossible Blocks (Expected behavior occurred in at least 1 out of 2 blocks.)
1.	Blocks are placed at any point on the fulcrum. No lateral shifts. Ego orientation (e).	(e)	(e)	(e)	(e)
2.	Blocks are placed randomly. No lateral shifts. Helpers placed under the block (u).	(u)	(u)	(u)	(u)
3.	Original (e) but lateral shifts towards area 3.	Original (e) but lateral shifts towards area 2.	Original (e) but lateral shifts towards area 3.	Original (e) but lateral shifts towards area 3.	Original (e) but lateral shifts towards area 2.
4.	Original area 3 placement and struggle to find midpoint.(VC)	Original area 2 placement and struggle at 2 (VCB).	Original area 3 placement and struggle (VC).	(VC)	(VCB)
5.	(VC)	Original area 2 placement but corrects towards area 3 (VCB_2).	(VC)	(VC)	(VCB_2)
6.	(VC)	(VC)	(VC)	(VC)	(VC)

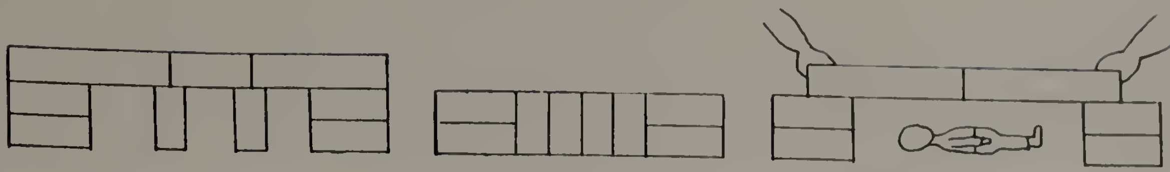
APPENDIX A (continued)

Ordinal Levels	Clusters				
	Cluster 1 Symmetrical Length Blocks (Expected behavior occurred in at least 2 out of 3 blocks.)	Cluster 2 Displaced Base Blocks (Expected behavior occurred in at least 1 out 2 blocks.)	Cluster 3 Asymmetrical Blocks (Expected behavior occurred in at least 3 out of 4 blocks.)	Cluster 4 Inconspicuously Weighted Blocks (Expected behavior occurred in at least 2 out of 3 blocks.)	Cluster 5 Impossible Blocks (Expected behavior occurred in at least 1 out of 2 blocks.)
7.	(VC)	(VC)	(VC) placement and helpers on (0)	(VC)	(VC) may add helpers on but no shifts occur.
8.	(VC)	(VC)	Original VC placement, shifts to area 2 (VCT_2).	(VC)	(VC)
9.	(VC)	(VC)	Original placement at area 2 and struggles to find midpoint (AC).	(VC) (0)	(VC) (0)
10.	(VC)	(VC)	(VCT_2)	Original (VC) Shifts to area 4 (VCT_3).	(VC)
11.	(VC)	(VC)	(AC)	(VCT_3)	(VC)
12.	(VC)	(VC)	(AC)	Original placement at area 4 (WT).	(VC)
13.	(VC)	(VC)	(AC)	(WT)	Adds weight and shifts block to balance.

* Success at balancing was not a criteria for this scale. Only strategies were viewed.

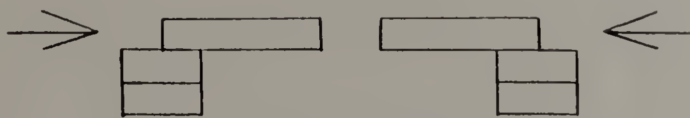
APPENDIX B

LEVELS OF TRANSFER TASK SCALE



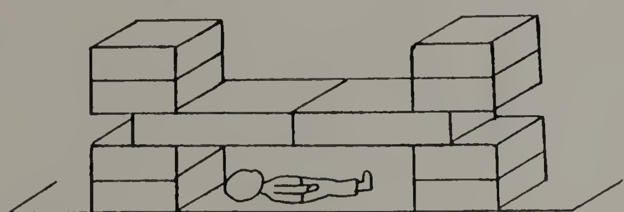
building a wall   filling space   holding in place

Level 1/ Reliance on self or support from underneath



Level 2/ Lateral displacements

Level 3/ Adding blocks on top to fill gap



Level 4/ Cantilevered support

Note; As in the training task, success was not necessary. Only the strategies were viewed.

APPENDIX C

FREQUENCY CHART ON POPULATION BY AGE

MONTHS	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT)	ADJUSTED FREQ. (PCT)	CUM. FREQ. (PCT)
48	4	3.1	3.1	3.1
49	4	3.1	3.1	6.3
50	2	1.6	1.6	7.8
51	3	2.3	2.3	10.2
52	2	1.6	1.6	11.7
53	5	3.9	3.9	15.6
54	2	1.6	1.6	17.2
55	2	1.6	1.6	18.8
56	1	.8	.8	19.5
57	6	4.7	4.7	24.2
58	11	8.6	8.6	32.8
59	3	2.3	2.3	35.2
60	1	.8	.8	35.9
61	1	.8	.8	36.7
62	3	2.3	2.3	39.1
63	2	1.6	1.6	40.6
64	1	.8	.8	41.4
65	3	2.3	2.3	43.8
66	8	6.3	6.3	50.0
78	4	3.1	3.1	53.1
79	5	3.9	3.9	57.0
80	3	2.3	2.3	59.4
81	1	.8	.8	60.2
82	2	1.6	1.6	61.7
83	3	2.3	2.3	64.1
84	3	2.3	2.3	66.4
85	6	4.7	4.7	71.1
86	4	3.1	3.1	74.2
87	2	1.6	1.6	75.8
88	3	2.3	2.3	78.1
89	2	1.6	1.6	79.7
90	6	4.7	4.7	84.4
91	4	3.1	3.1	87.5
92	2	1.6	1.6	89.1
93	3	2.3	2.3	91.4
94	7	5.5	5.5	96.9
95	3	2.3	2.3	99.2
96	1	.8	.8	100.0
total	128	100.0	100.0	

APPENDIX D

CHANGE ON STRATEGY SCORE BY TREATMENT CONDITIONS AND AGE

Age	Treatment Condition: Block I	Placement II	Replay III	No Video IV
Youngs	pre x = 1.875 s = 1.025	pre x = 2.125 s = .885	pre x = 2.125 s = .957	pre x = 2.063 s = 1.063
	post x = 2.438 s = 1.094	post x = 2.125 s = 1.204	post x = 2.313 s = 1.078	post x = 2.188 s = 1.047
Olds	pre x = 3.188 s = .834	pre x = 3.5 s = .7	pre x = 3.062 s = .574	pre x = 3.313 s = .704
	post x = 3.813 s = .981	post x = 4.3 s = .7	post x = 4.0 s = .816	post x = 4.0 s = .816

ANOVA

Main Effects	F	Sign of F
Cond.	.353	.787
Age	10.547	.002
Sex	.009	.926
2-Way Interactions		
Cond./Age	1.019	.387
Cond./Sex	1.868	.139
Age/Sex	.009	.926
3-Way Interactions		
Cond./Age/Sex	1.455	.231

APPENDIX E

CHANGE IN NUMBER OF BLOCKS SUCCESSFULLY BALANCED BY TREATMENT CONDITION AND AGE

	Treatment Condition			
Age	Block I	Placement II	Replay III	No Video IV
Youngs	pre x = 2.688 s = 1.852	pre x = 2.875 s = 2.217	pre x = 3.250 s = 2.295	pre x = 3.06 s = 2.14
	post x = 4.250 s = 3.0	post x = 3.688 s = 3.754	post x = 2.938 s = 2.792	post x = 3.50 s = 2.75
Olds	pre x = 6.687 s = 3.825	pre x = 8.062 s = 3.549	pre x = 5.780 s = 3.088	pre x = 7.625 s = 3.948
	post x = 8.438 s = 4.320	post x = 11.625 s = 3.096	post x = 9.063 s = 3.820	post x = 49.938 s = 4.106

ANOVA

Main Effects	F	Sign of F
Cond.	.473	.688
Age	17.173	.001
Sex	1.02	.31
2-Way Interactions		
Cond./Age	2.076	.107
Cond./Sex	1.514	.215
Age/Sex	.416	.520
3-Way Interactions		
Cond./Age/Sex	.697	.556

APPENDIX F

CHANGE IN CLUSTER SCORE BY TREATMENT CONDITION AND AGE

Age	Treatment Condition: Block I	Placement II	Replay III	No Video IV
Youngs	pre x = .563 s = .727	pre x = .187 s = .403	pre x = .625 s = .885	pre x = .563 s = .964
	post x = .812 s = 1.102	post x = .750 s = 1.291	post x = .625 s = .957	post x = .688 s = 1.078
Olds	pre x = 1.750 s = 1.528	pre x = 2.438 s = 1.315	pre x = 1.313 s = 1.250	pre x = 1.937 s = 1.526
	post x = 2.625 s = 1.708	post x = 3.875 s = 1.310	post x = 2.563 s = 1.548	post x = 3.188 s = 1.682

<u>ANOVA</u>

Main Effects	F	Sign of F
Cond.	.821	.485
Age	20.416	.001
Sex	1.041	.310
2-Way Interactions		
Cond./Age	.418	.741
Cond./Sex	1.494	.220
Age/Sex	.765	.384
3-Way Interactions		
Cond./Age/Sex	.538	.657