AN ABSTRACT OF THE THESIS OF

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Title Surprised as a Reinforcing Element in Retention

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The purpose of this study was to test the hypothesis that four-year old children would better remember what happened in science experiments, and the basic concepts involved in them, when presentation of the experiments involved an element of surprise. Surprise for this study was considered as a situation in which there was a built in expectation that was dramatically and without warning contradicted.

To test this hypothesis, 37 four-year-olds observed four different science experiments that had a "high surprise" value. Half of the group received the experiments on a surprise basis and half on a non-surprise basis. The surprise or experimental group was given a preparatory statement to set the stage for the surprising reaction of the experiment. This was followed by a short statement of the rationale or basic concept involved. In the non-surprise or control group the children were told first what to expect and the basic concept involved, and then were given the experiment. After a period of 25 to 53 days,
the children were tested individually to determine their recall of the experiments and accompanying basic concept. Thirty-four children provided recall data; of these, 16 were in the experimental group and 18 in the control group. The recall data were analyzed statistically to determine between and within group differences. Two other kinds of information were obtained as part of the data for the study: (1) the child's report of whether he had seen the experiments before and (2) a record of the child's discussion about the experiments at home.

To determine the difference in recall between the surprise and non-surprise groups, a chi square analysis was computed. The analysis indicated there was no significant difference between the groups.

Since these results run counter to those expected on the basis of the literature, care was taken to analyze for possible sources of error in the data. Two such analyses were undertaken: the data were tested by regression analysis to determine whether time influenced the scores, and an analysis of variance was used to determine if there were any significant differences in recall amongst the four experiments. Neither analysis identified significant effects.

Three factors were reviewed which could have accounted for the lack of difference between groups in the present study: lack of background in experience and/or knowledge which would permit the
children in the experimental group to be surprised; the failure of the explanation before presentation of the experiments to reduce the surprise element of the experiments for the control group; and the surprising impact of the nursery school setting upon all of the children. The possibility that the initial hypothesis was incorrectly drawn was also discussed.

Several research directions seem justified on the basis of this study: (1) repetition of the study, but presentation of the experiments on an individual basis to eliminate peripheral events and allow the child to focus attention on the experiment; (2) the need for a study to determine if children who are sufficiently involved in an experiment to have established "expectations" as to appropriate stimuli are more surprised by the presentation of the unexpected stimuli than are children who are not so involved in the experiment; (3) the need for a study which determines the effect of introducing surprise stimuli in the daily nursery school setting where presentation of stimuli is based upon the child's interests and cues of readiness for learning.
SURPRISE AS A REINFORCING ELEMENT
IN RETENTION

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INTRODUCTION

Recent studies have indicated that there are certain internal responses which, if tapped properly, could lead to new methods of stimulating man's capacity to learn. One of the most exciting of these research directions involves the relationships between curiosity, motivation and surprise. A great deal of research (4, pp. 107-111), (9, pp. 444-448), (13, pp. 555-558) has demonstrated that curiosity is not only representative of a behavioral pattern in an organism, but it is self-sustaining and that it acts as a drive for further exploration.

While the role of curiosity in the behavior of animals is rather widely known, some recent research into the relationship between curiosity and "surprise" stimuli is not so well known, and it offers the possibility of a significant, new dimension within the learning process. Charlesworth (5, pp. 7-13) for example, has conducted a study on infants and pre-school children which indicates that surprising stimuli act as motivating forces for curiosity behavior. He suggested that there is a consistent internal response to surprising stimuli and that an organism will seek out those situations which are surprising to it. Research by Wilcocks (2, p. 75) who introduced new,
unexpected syllables into a series of nonsense syllables found that surprise was instrumental in increasing retention of the surprising stimuli. Maw and Maw (14, pp. 197-201) read stories to children of high and low curiosity levels of matched intelligence and found that children in the high curiosity group remembered more about the story when tested later than the children in the low curiosity group. They hypothesized that curiosity increases an individual's awareness of his informational field and proposed that the high curiosity group was actually more involved in or more aware of what was going on in the story at the time it was read and so could therefore be in a better position to recall what it was about.

Taken in combination the data on the relationship between curiosity behavior and surprise stimuli represent an inviting direction for exploration in the learning field. At the immediate practical level it suggests the possibility of developing techniques, situations, problems, etc. which would produce a surprise element in learning situations which should facilitate the intellectual growth and development of the individual. Since there are indications of neurophysiological readiness for complex learning around age three (11, pp. 62-70) thinking needs to be directed toward initiating learning patterns involving surprise at an early stage in life.

Certainly these implications are important in nursery school
education. Nursery school teachers are daily involved in situations with children in which they can hinder or help a child's learning. An observant teacher may pick up a child's cues for readiness to learn; but if the cues are ineptly handled the potential of the situation may not be realized. Suppose, however, the teacher is aware of the cues and responds in such a way that surprise is introduced at the peak of readiness. According to the studies reviewed above, surprise would serve as a stimulus to curiosity, and its use should increase the child's possibilities of gaining the maximum from a learning experience.

The present study was undertaken to investigate the effectiveness of surprise as an element in facilitating the learning of preschool children. The following hypothesis was tested: four-year old children would better remember what happened in science experiments, and the basic concepts involved in them, when the presentation of the experiments involved an element of build up and surprise.
REVIEW OF THE RELATED LITERATURE

While this study is concerned primarily with surprise and its effects upon learning, the review of literature will also cover the research on novelty, curiosity, and discovery -- topics which relate closely to the literature on surprise. Before moving to this research, however, some consideration needs to be given to the conditions of the learning field generally.

When Suchman was studying methods of developing skills for autonomous discovery in children, he found in his preliminary studies that there was a marked lack of autonomy and productivity in fifth-grade children, whose intelligence was considerably higher than average, when their props of dependence such as teachers, parents, and books were withdrawn.

When given new data, or a situation in which such data were available, the children rarely organized what they had, rarely gathered more data, rarely raised and tested hypotheses or drew inferences. Instead they blocked completely, began to offer unsupported conclusions, or produced a string of stereotyped probes that led nowhere. Accustomed to having concepts explained to them in discussions, pictures, films, and test books, the children were unwilling or unable to plan and initiate action with the purpose of discovering new concepts for themselves—even when all the data necessary for such discovery were available on demand (19, p. 155).

It has been suggested that this lack of independence and productivity when the children's props of dependence are removed may
be due in part to the influence of learning behaviorists in the field of education and their emphasis on external control and direction in teaching methods. For example, Hively (10, pp. 37-42) in his analysis of B. F. Skinner's behavior theory for classroom application, expresses the view that "The educator cannot make effective use of the knowledge supplied by such a science [psychology] unless he is willing to assume, as the scientist does, that behavior can be controlled and that is his job" (10, p. 38). Kenneth W. Spence is convinced that the knowledge gained from experimental psychology should be applied in the classroom situation. He places special emphasis upon reinforcement, building in goals, stimulus-response, and teaching machines. Teaching machines require the student to compose answers to questions with immediate reinforcement occurring if the correct answer is given. The programming of the material is so designed as to elicit a good percentage of appropriate answers, which keeps reinforcement frequency high. "The student is forced with such machines to make all of the desired responses at each stage of the training, thereby receiving immediate reinforcement" (18, p. 94). Emphasis is on external direction. Skinner even maintains that the behavioral elements of curiosity, exploration, and self-discovery (so essential to the learning process) are determined by the reinforcing and conditioning elements of the environment (16, pp. 5-14).
Allport has tabbed the theories of Skinner and his associates as "quasi-mechanical" methods of learning applicable to an individual's function on a non-cognitive basis (1, pp. 89-91). Pursuing an emphasis on the cognitive functions in learning Bruner proposes, in hypothesis form, that to the degree an individual can free himself from this external conditioning and "...approach learning as a task of discovering rather than 'learning about' it," can there be a "...tendency for the child to carry out his learning activities with the autonomy of self-reward..." (3, p. 26). He goes on to say that

...the degree to which competence or mastery motives come to control behavior, to that degree the role of reinforcement or 'extrinsic pleasure' wanes in shaping behavior. The child comes to manipulate his environment more actively and achieves his gratification from coping with problems (3, p. 29).

Bruner defines discovery as the expectancy of something new, something unknown; both of which are elements of curiosity. Reinforcement theory would consider this a conditioned response related to one of the primary drives.

William R. Charlesworth considers this point in the introductory part of his paper, "The Role of Surprise and Novelty in the Motivation of Curiosity Behavior." There he reviews the role of reinforcement in curiosity and states that studies have revealed that persistence of curiosity behavior in humans and other primates continues even when diverse consequences are the result of different
novel situations. He believes that evidence of this sort leaves reinforcement theory in a weak position to predict whether a response will occur again or extinguish. He further proposes that there are numerous instances where curiosity behavior precedes the novel stimuli, suggesting another limitation of the application of reinforcement theory to curiosity behavior (5, pp. 3-4).

Others support Charlesworth's position that curiosity does not appear to be linked with one of the primary drives. Studies by Harlow (9, pp. 444-448), Mason (13, pp. 555-558), and Carr (4, pp. 107-111), on rhesus monkeys have indicated that novel stimuli act as sources of curiosity drive even when there has been no previous reinforcement contact or need reduction associated with the stimuli.

Charlesworth suggests that since reinforcement theory is limited in its explanations of curiosity and its source, there is a need to hypothesize and test new sources. To this end he postulates that at the basis of curiosity a surprise mechanism is involved. The balance of this review will be directed to this mechanism, its characteristics, and related elements. Novelty will be the first point to be discussed. This will be followed by a discussion of surprise, curiosity, discovery, and the neurophysiological basis for the surprise mechanism.
Novelty

Berlyne indicates that there is a difference between absolute and relative novelty and operationally defines them as (a) an absolute novel stimulus being "...one with some quality that had never been perceived before," while (b) a relative novelty or stimulus pattern is one which "...would possess familiar elements or qualities in a combination or arrangement that had not been met with in the past (2, p. 19). He explains further that the

...nervous system relates any novel incoming stimulus to stimulus categories that it already recognizes; a new stimulus will evoke responses corresponding to familiar stimuli by generalization, and it will evoke them with strengths corresponding to its resemblance to the stimuli with which the responses are originally associated (2, p. 21).

To create a novel set of stimuli in order to gain the attention of the organism being tested a situation must be created contrary to the organism's expectations. Dember provides a good example of this in his experiments with rats.

Rats on Trial 1 were allowed to see into the two arms of a T maze but were prevented by means of glass partitions from entering either arm. During the 10-minute exposure period one arm was black, the other white. The animals were removed from the maze, the partitions removed, and one arm was changed so that both arms were either white or black. The rats on Trial 2 were reintroduced into the maze and, faced with a choice between the two arms equal in brightness, 17 out of 20 entered the arm whose brightness had been changed from Trial 1 to Trial 2. By the sign test, the above results are significant at the .001
level of confidence, one tailed. Undergraduate students have repeated this experiment several times since then with almost identical results (6, p. 92).

The rats preferred to select that maze which was novel to them rather than that which was familiar. A related type of study was one done by Smock and Holt in which they hypothesized that first grade children would maximize perceptual contact with novel objects. An accompanying hypothesis proposed that there would be an inverse relationship between rigidity and curiosity under the conditions of the study. The results generally supported both hypotheses and the authors suggested that it was the children's response to novel stimuli which led to the curiosity behavior (17, pp. 640-642).

A somewhat different use of novelty in an experimental study with animals is found in the study by Carr and Brown with rhesus monkeys. They found that when the monkeys were given a choice to manipulate metal, wire, wood, rubber, cork or plastic objects, the one most used was that which could be physically altered most in appearance. They suggested that the novelty resulting from the manipulation, and in turn the resulting change, was rewarding and self-sustaining (41, pp. 107-111).

In an instrumental learning study with kittens, Segall discovered during the course of the experiment that novel stimulation served as a control in reducing the anxiety-induced effect of the experiment. He
He concluded that his data suggest an anxiety-inducing effect of a meagre environment and a reinforcing effect of the reduction of that anxiety by the introduction of novel stimulation. This appears to be related closely to the characteristics of surprise, in that the surprise stimulus focuses the organism's attention on one particular item and tends to exclude peripheral events. Segall explains his hypothesis by suggesting that

...the apparatus of the study induced anxiety, but the display of the attractive objects (novel stimulus) to the experimental group served to reduce it. The reduction in anxiety may have served to reinforce the response which was instrumental in gaining exposure to those objects. Thus, the observations reported here suggest the hypothesis that a novel environment which provides a sensory deficit relative to the environment normally inhabited will evoke an emotional response. This drive state is such that the presentation of additional stimulation reduced drive strength. The resulting drive reduction serves to reinforce responses instrumental in obtaining the additional stimulation. In this fashion, then, drive reduction becomes the reinforcement mechanism involved in apparent curiosity-motivated learning situations (5, p. 204).

Novel stimuli as summarized from these studies could be considered to possess the following characteristics: they are not too remote from an individual's experience, nor too familiar; the novel stimuli are selected in preference to familiar stimuli; novelty occurring as the result of change from manipulation appears to be rewarding and self-sustaining; novelty can act as an anxiety reducing mechanism; novel stimuli may have a slight variation from a familiar
pattern thus producing novelty; novelty may result when an experience is compared with a particular set of previous experiences and there is sufficient discrepancy from expectation that an internal response occurs. How novel a particular stimulus may be is dependent upon the following: "how often patterns that are similar enough to be relevant have been experienced before, how recently they have been experienced, and how similar they have been (2, p. 22).

**Surprise**

There is a fine line between a situation which may be described as novel and one which may be described as surprise. For purposes of this study that line will be considered. Berlyne suggests that a novel stimulus is involved in surprise but that there is also something else present. He proposes:

A novel stimulus or a stimulus undergoing change may, in addition, be surprising. This implies more than that the stimulus was not expected or that it differs from what preceded it. It implies the existence of an expectation with which the stimulus disagrees (2, p. 23).

The difference, then, between a novel stimulus and a surprising stimulus is that the former is something new, not perceived before, or a new combination of events whereas the latter involves two stimuli, one introducing an expectation and one contradicting the expectation.
Charlesworth speaks of surprise in the following terms:

The surprise reaction has been examined at length in terms of overt behavior, subjective reports, and numerous neurophysiological changes...surprise is understood to consist of an identifiable class of involuntary or expressive behaviors which can be elicited under conditions where expectancies and outcomes are manipulated in such a way that they will be discrepant or incongruent with one another (5, p. 2).

He further states that those aspects of surprise which appear applicable to cognitive development are (a) "...the arresting of the individual's outgoing activities, and (b) the subsequent focusing of attention on the surprise-producing stimulus itself" (5, p. 2).

By securing a person's attention and directing it to a specific point, he is in a position to assimilate new information and thereby increase the probability that modifications in the existing schemata which influence behavior will occur. Surprise has the additional characteristic of acting as a general arousal mechanism, that is, of increasing the organism's awareness and interest toward novel stimuli in general. Although the stimuli may and will vary, the inward response to the novel or surprising stimuli will remain stable and recurrent (5, p. 2).

Charlesworth conducted a study on pre-school children and infants to determine the role of surprise and novelty in the motivation of curiosity behavior. The following are excerpts and summaries of his explorations with these two age groups.
The first hypothesis tested was whether pre-school children under surprise and novelty conditions would play the experimental game longer than children under non-surprise and non-novelty conditions. Surprise was produced by violating, by means of a trick, the law governing conservation of substances. The expectancy that physical substances—marbles in this case—were not changed in color and number by merely shaking them in the container was known to be present in pre-school children. Novelty was produced by using new sets of marbles on each successive trial of the game. The main dependent variable in these experiments was number of trials to response satiation, an index presumably of the response-instigation or reinforcement effects of the various experimental conditions. Other dependent variables were facial, vocal, and gross motor responses rated in terms of the degree to which they manifested surprise. Verbal responses, especially inquiries, were also recorded (5, p. 7).

The subjects consisted of 92 normal white and Negro pre-school children between the ages of 37 to 70 months. The tests conducted on the pre-school children consisted of four different groups: the surprise group, the non-surprise group, the weak expectancy group and the boredom group. The results indicated that "In all instances the surprise groups had a higher mean number of trials to satiation than any of the other groups" (5, p. 10). The children persisted longer in responding to situations that were surprising then those that were not.

The second part of the study conducted by Charlesworth was on infants. He hypothesized "...that infants who were peeked at from various loci in an unpredictable fashion would be surprised and hence tend to play the game longer than infants who were peeked at from one
locus in a predictable manner" (5, p. 11). Four-hundred twenty-eight experiments were handed in by beginning child psychology students who had been instructed in the mechanics of the test but were not aware of the hypothesis being tested. Of these 428, 128 were discarded with the remaining 300 being used for the final analysis. The data analyzed to date of the paper revealed that "...varying the loci in a peek-a-boo game was associated with a significantly greater number of trials to response satiation than not varying the loci..." (5, p. 12) which were in line with the hypothesis. Further analyses of the test results indicated that the 17 to 32 week period of age revealed the greatest infant persistence in playing the game longest (5, p. 13).

It appears from these two studies that surprise does act as a motivating effect in curiosity behavior. A side result also indicated that there may be a critical period for the development of curiosity, as revealed by the greater persistence in the surprise game of the infants from 17 to 32 weeks of age.

Another characteristic of surprise is that of its role in retention. Berlyne points out that NOVEL stimuli have not had as long as other familiar stimuli to become involved in the learning processes. In his review of the related literature he found that familiar phrases and meaningful words or figures are easier to remember than others. He
proposes that past responses and experiences have become attached to these familiar areas and as a result become more distinctive and less susceptible to interference. He hypothesizes in addition that a generalization process may occur and so the familiar stimuli are well grounded in the memory system (2, p. 75).

SURPRISING items may also have an advantage in remembering, however. Berlyne reviewed a study by Wilcocks whose study would support this statement. He presented five times a series of eighteen nonsense syllables in different orders with the insertion during the fifth presentation of a new syllable. The subjects were then instructed to write down as many of the syllables as they could remember. Although the new syllable had only been presented once in contrast to five times for the others, the new one had more recall than the others (2, p. 75).

In other studies summarized by Berlyne, ones using numbers alone, numbers in combination with nonsense syllables, and ones using surprising statements, similar results were obtained. From these data it seems permissible to conclude that surprise plays a definite role in helping a person remember the surprising event.

In summary, surprise could be said to possess the following characteristics: it obtains the attention of the organism; it focusses that attention to one specific area; it keys the organism to greater
sensitivity toward future surprise stimuli; it stimulates covert or involuntary neurophysiological changes and overt or observable behavioral changes; it acts as a motivating stimulus for curiosity behavior; and it increases recall of the surprising stimuli better than non-surprising stimuli.

Curiosity

Research psychologists in the past have been so concerned with the primary drives of hunger, sex, thirst, etc., or with the learned drives, that they failed to consider the exploration drive in animals as anything but just exploration. Recent experimental work (4, pp. 107-111), (9, pp. 444-448), (13, pp. 555-558), however, has pointed to evidence that exploration-curiosity is not only a drive, with its satisfaction or permitance serving as a basis for additional learning (a reinforcer), but it is not satiated as are the tension-reduction drives.

The following are excerpts and summaries from primary sources that support the idea that manipulation and exploration are self-sustaining.

Harlow's test results on infant monkeys in relationship to manipulation tendencies indicated that the manipulatory behavior of six infant rhesus monkeys was

...found generally to increase in amount and efficiency with age and practice. The results suggest that manipulatory
behavior is self-sustaining and is not dependent upon, nor derived from internal drives such as hunger or thirst, or their incentive systems (9, p. 448).

In Mason's further studies on manipulation of rhesus monkeys the findings indicated that

...there was no relationship observed between these manipulatory activities and any events associated with feeding, such as transition from liquid to solid foods. The early appearance, persistence, and orderly growth of manipulatory responses suggest that these activities are innate and increase in frequency through maturation probably augmented by self-reinforcement. The data further indicated that the manipulatory responses were not dependent upon, nor derived from, association with satisfaction of hunger, thirst, or other biological drives (13, p. 558).

Carr studied 10 rhesus monkeys as they responded to a special manipulation box for 10 minutes each day for five days on each of six different stimulus objects (metal, wire, wood, rubber, cork, and plastic). The results indicated that manipulation occurred with those stimulus objects which the subject could physically alter most in appearance. It appeared that manipulatory behavior in Carr's experiment was self-sustaining and the novelty resulting from manipulation was rewarding (4, pp. 107-111).

While the bulk of the research supports this view some researchers have reported a reduction of the exploration drive with exposure. For example, Glanzer (8, p. 302) reports in his review of the literature pertaining to the exploratory drive that the exploratory tendency
appears to decrease in strength with continued exposure to the novel stimulus. Included in this review was a study by Montgomery. On the basis of his research with rats Montgomery proposed that

(a) animals will learn to choose the alternative that leads to exploratory opportunities, (b) the amount of exploratory behavior decreases regularly during one session in a maze, (c) decrement in exploratory behavior produced by one stimulus generalizes to other situations; the more similar the mazes, the less the amount of exploration on the succeeding maze and (d) exploratory behavior is dependent of opportunity for activity (8, pp. 303-304).

The studies supporting extinction of the exploratory drive after continued exposure to the novel stimuli and those advocating non-extinction do not appear to be in direct contradiction to each other when several factors are considered: (a) the extinction theororists' work has been mainly with rats and similar animals, whereas the non-extinctionists' work was with humans and other primates; (b) rats do not have the same intellectual nor physical capacities to evaluate and/or extend the exploratory drive as do the primates; (c) extinction therefore would be more likely to occur where the responses of the organism were limited and little or no extinction occur where the organism could draw upon a wide variety of responses.

For the purposes of the present study, however, the assumption will be made that curiosity, manipulatory, and exploratory behaviors are self-sustaining and that this self-sustaining quality acts as a drive for further exploration.
It was suggested earlier in the section on surprise that surprising stimuli were better remembered than non-surprising stimuli and that surprise acts as a stimulus for curiosity behavior. Related to this was a study conducted by Maw and Maw (14, pp. 197-201) on fifth-grade children with matched verbal intelligence and high and low curiosity levels. The curiosity levels of the children were determined by ratings given them by their teachers. Maw and Maw hypothesized that retention in children is determined, in part, by the level of their curiosity about their environments in general. To test their hypothesis, the Maws pursued the following program: In December of 1960, a story was read to 145 fifth-grade pupils in seven classrooms. In March, 1961, the same story was read to another 749 pupils in twenty-five classrooms. The children were given copies of the story, asked to follow it as it was read, and requested at the end of the story to state one thing they liked best about it. As far as the children were concerned, that was the end of the session. Seven days later a forty-item true-false test was administered to the pupils. The results of the test indicated that in each case the high-curiosity groups scored highest; the children who had been judged to be higher in curiosity remembered more of the material after one week than did children who were judged lower in curiosity. In conclusion, the Maws state, "It is reasonable to suppose that children with high curiosity, having a greater desire
to know, will keep examining the story, be thinking about it and will actually be closer to it at the time of the testing than will children of low curiosity" (14, p. 201).

Glanzer postulates a similar conclusion:

...the organism's information requirements are set by its past experience. An organism that has had a high flow of information directed at it in the past would have a high requirement or standard. An organism that has lived in an impoverished informational environment would have a low requirement or standard. The organism would respond in terms of the difference between its individual standard and the amount of information furnished by the situation (8, p. 312).

Glanzer, as well as the Maws suggest that children who are looking for more information in their environment will find more than those who are not. He also suggests that this is a pattern which is established early in life.

In his description of curiosity, Charlesworth follows a line of thinking which parallels the Maws and Glanzer:

...it appears that the connection between elaborate forms of curiosity behavior, such as those involving locomotion, manipulation, verbal inquiry, etc., and surprise stimuli must be learned in distinction to orienting responses where such a connection appears to be innate. The connection between curiosity behavior and surprise stimuli may be achieved through some form of response generalization which takes place in a classical conditioning setting where the unconditioned stimulus is the surprise stimulus and the unconditioned response the initial orienting responses...curiosity behavior may really be composed of classically conditioned, as well as instrumentally-conditioned responses...the initiation and persistence of curiosity behavior may actually be a function of prior
reinforcements, as well as a function of the instigating effects of surprise stimuli (5, p. 6).

Since curiosity behavior is so essential for survival, insofar as it provides the individual with new information that improves his potential to respond adaptively, it makes sense that it should be a dominant and stable behavior in the individual's behavior repertoire, especially during the early, formulative period of his life (5, p. 7). Thus, Charlesworth suggests that curiosity and surprise behavior, of a more intense and responsive nature, must be learned. He also proposes that surprise may act as a stimulus generalization for curiosity and that curiosity behavior serves to broaden the organism's information field.

In summary the following may be concluded about the area of curiosity: exploration acts as a stimulus rather than a response; animals will learn to choose those situations which lead to exploratory opportunities; exploration is independent from the basic drives of hunger, thirst, sex, etc. as well as opportunity for activity; manipulation and exploration are self-sustaining; the self-sustaining quality of exploration and curiosity acts as a stimulus for further exploration; a high curiosity level increases the organism's retention of the information coming from the environment; the connection between elaborate forms of curiosity, those involving locomotion, manipulation, verbal inquiry, etc. and surprise stimuli must be learned; surprise may be the motivating basis for curiosity; and curiosity tends to broaden the
organism's information field.

**Discovery**

While curiosity and discovery are related, and may even overlap, discovery will be treated as a separate discussion for purposes of this study. Bruner defines discovery in the following terms:

Discovery, like surprise, favors the well prepared mind ... one must know to be surprised. I shall operate on the assumption that discovery... is in its essence a matter of rearranging or transforming evidence in such a way that one is enabled to go beyond the evidence so reassembled to additional insights. It may well be that an additional fact or shred of evidence makes this larger transformation of evidence possible. But it is often not even dependent on new information (3, p. 22).

Kersh has summarized Bruner's proposed advantages of discovery as (a) it increases the learner's ability to learn related material, (b) it fosters an interest in the activity itself rather than in the rewards which may follow from the learning, (c) it develops an ability to approach problems in a way that will more likely lead to a solution, and (d) it tends to make the material that is learned easier to retrieve or reconstruct (12, pp. 65-72).

Suchman reviewed White's, Dewey's and Bruner's theories in this field and concluded that discovery is intrinsically rewarding, build's self-confidence in the child which enables him to be intuitive and logical in his thinking, and have the ability to hypothesize about
and pursue the meaning of causal relationships even though the experience may be frustrating to him (19, pp. 148-149).

In an effort to empirically test the above assumption, theories, and hypotheses, Kersh and his associates designed a study to provide formal data about the motivating power of directed discovery. The following is a summary of the study and excerpts from the author's conclusions:

Ninety high school students participated in the experiment. They were selected on the basis of their ability to pass a pretest covering the arithmetical and geometrical concepts and procedures that were considered essential prerequisites to the tasks used in the experiment. The entire sample was taught two novel rules of addition by a programmed booklet procedure. Of these, one third of the 90 subjects were given individual guidance in discovering the explanation for the rules (guided discovery), one third were taught the explanation by a programmed booklet (directed learning), and the remaining one third were given no further instruction (rote learning). A questionnaire and a test of recall and transfer were given three days, two weeks, and six weeks later. The findings indicated that the rate of forgetting did not differ significantly across the teaching treatment groups and was constant for all groups. The rote learning group was found to be consistently superior in every respect to the other treatment groups.
The guided discovery group indicated superiority to the directed learning group three days after the learning period and since the rate of forgetting was constant for all of the test groups, this superiority was maintained (12, pp. 65-71).

The author concluded that:

Learning by self-discovery is superior to learning with external direction only insofar as it increases student motivation to pursue the learning task....the motivational power evidently does not appear in strength unless the student is required to learn almost completely without help....The student...may not benefit from knowing the explanations for rules and procedures he learns, i. e., the pattern of relationships involved. That which is meaningful (understood) may or may not be retained longer and transferred more effectively than that which had been learned by rote. Moreover, superficial efforts to gain understanding after a rule or principle has been memorized may have an inhibitory effect when the student attempts to recall and transfer the original learning. If it is important only that the task be understood...the essential relationships may be learned most economically when taught by another person or teaching program, not by the process of self-discovery (12, pp. 70-71).

Kersh's study only weakly supported Bruner's hypothesis about the gains or benefits in using the teaching method of self-discovery. However, in Kersh's study, subject bias could well have been introduced by the fact that self-discovery was unfamiliar as a learning technique and could have been threatening to the students. Bruner himself emphasizes that the act of discovery takes practice and repeated practice; and as brought out in the section on curiosity, the
more complex forms of curiosity behavior are learned patterns.

There are studies which suggest the validity of discovery as an important educational technique. For example, Suchman (19, pp. 148-149) in his review of the literature pertaining to discovery, cited Moore's study as an illustration. Pre-school children were allowed to play with an electric typewriter. Each letter that the child hit was clearly pronounced by the teacher. If children hit letters in sequence to form a word, the teacher pronounced the individual letters as well as the word. In this process the children discovered that letters in combinations made words. Through these discoveries, generalizations were induced and rules constructed to create a large range of new letter combinations. These children, Moore contended, learned to read at the age of four as the result of this process of discovery. Suchman listed other studies by Bruner, Beberman, Hendrix, Karplus, Wertheimer and Suchman which supported similar conclusions that discovery can be a valid educational technique (19, pp. 148-149). Although Suchman illustrated the above study by Moore as exemplary of discovery he could probably have used it as well to illustrate surprise, exploration, or curiosity.

From this review it is evident that novelty, surprise, curiosity, and discovery are closely related and that it is difficult to discuss one element in the group without referring to another element or
including the whole group. The relationship between these four elements can be best illustrated perhaps by an analogy to a ladder: novelty being the first rung, next surprise, next curiosity and at the top discovery. Each rung is important as it prepares and enables a person to take the next step, the ultimate rung reached being that of discovery. The reason for considering discovery as an end goal is best explained by Bruner, as he proposes a hypothesis about the value of discovery:

I would urge now in the spirit of an hypothesis that emphasis upon discovery in learning has precisely the effect upon the learner of leading him to be a constructionist, to organize what he is encountering in a manner not only designed to discover regularity and relatedness, but also avoid the kind of information drift that fails to keep account of the uses to which information might have to be put. It is, if you will, a necessary condition for learning the variety of techniques of problem solving, of transforming information for better use, indeed for learning how to go about the very task of learning. Practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving. So goes the hypothesis. It is still in need of testing. But it is an hypothesis of such important human implications that we cannot afford not to test it--and testing will have to be in the school (3, p. 26).

The Neurophysiological Basis of the Surprise Mechanism

Thus far in this review the discussion has been directed toward the psychological aspects of learning. Allusions, however, have been made as to the internal responses of the organism to various stimuli,
particularly in the section dealing with surprise. Since it is difficult to describe the psychological phenomenon of learning without including its neurophysiological base, the next few pages will be devoted to the latter subject.

Berlyne directs attention to what he calls the Reticular Arousal System or that part of the nervous system dealing with alertness or intensity of attention. It is this area of the nervous system which will be considered here as the locus of internal reaction to surprising stimuli. In technical language he describes this system as functioning in the following manner:

The RAS receives collateral fibers from the various sensory tracts as they rise toward the cortex, and it sends offshoots all over the cortex in its turn. It forms, therefore, one route by which excitation can reach the cortex from stimulated receptors. But its function as part of a diffuse projection system differs sharply from that of the more direct route constituted by the specific projection system. The latter preserves information about the exact location and quality of the stimulus all the way from receptor to cortical projection area. The diffuse projection system, in contrast, seems to take account mainly of the urgency of stimuli and to ignore their finely discriminable properties. Stimuli from all parts of the body's surface and all special sense organs seem to affect it in much the same way, and, when it is excited, it may send impulses to alert the whole cortex. Excitation of the reticular formation... gives rise to the activation pattern, also known as the arousal pattern or as desynchronization, in the EEG: alpha waves --the regular, high-amplitude, medium-frequency oscillations (8 to 13 cps in human adults and many other mammals) that tend to dominate the EEG in waking but relaxed subjects--give way to fast, irregular, low-amplitude fluctuations (2, pp. 46-47).
On the basis of this information it may be concluded that greater intensity of stimuli creates increased organism awareness of that stimuli at that given period of time, as well as engraining more completely, sharply, or clearly the stimuli into the memory system. This lends support to studies mentioned earlier in which results indicated that surprising stimuli were remembered better than non-surprising stimuli.

Studies by Gaito and Hyden (7, pp. 288-292), (11, pp. 62-70) have indicated that a biochemical process in the RNA and DNA molecules of the nerve cells occurs as stimuli traverse the nervous system. They hypothesize that these molecules may be the basis for learning and memory. The content of the RNA and DNA molecules begins to increase in its biochemical complexity from the third year of life to age 40, remains constant from 40 to 55 or 60 and then declines rapidly thereafter. However, if these molecules are not stimulated, they develop physiologically but biochemically they are "...deprived nerve cells..." which are "...more or less empty bags, impoverished both in RNA and proteins" (11, p. 66). Conversely, they have discovered "...that when a sensory or motor nerve center is stimulated within physiological limits, its individual nerve cells show an increased content of RNA, proteins and lipids. This increased production begins immediately when the level of stimulation is increased and reverses
within hours when it is decreased (11, p. 67).

These data would seem to suggest that there is a neurophysiological readiness for complex learning around age three. If so, this should certainly lead to a re-evaluation of thinking in the field of nursery school education.

With the mass of evidence which has been examined in this review of literature suggesting that surprise can be an influencing factor in the learning process, and with the data reviewed above suggesting a readiness for complex learning around age three in children, the present study was initiated to explore the relationship of surprise to learning in pre-school children.
METHOD AND PROCEDURES

The purpose of this study was to test the hypothesis that four-year old children would better remember what happened in science experiments, and the basic concepts involved in them, when the presentation of the experiments involved an element of surprise. Surprise for this study was considered as a situation in which there was a built in expectation that was dramatically and without warning contradicted (see Appendix A for examples).

To test this hypothesis, 50 four-year olds were selected to observe four different science experiments. Half of the group received the experiments on a surprise basis and half on a non-surprise basis. The surprise or experimental group was given a preparatory statement to set the stage for the surprising reaction of the experiment. This was followed by a short statement of the rationale or basic concept involved. In the non-surprise or control group the children were told first what to expect and the basic concept involved, and then were given the experiment. After a period of several weeks, the children were tested individually to determine their recall of the experiments and the accompanying basic concept. The recall data were analyzed statistically to determine between and within group differences.
Subjects

Fifty four-year-old children were selected from five junior 
sunday schools of local churches. Selection was based upon the 
willingness of parent and child to participate and their availability 
for followup one month after the presentation of the experiments. The 
sunday schools of the Methodist, Episcopal, Church of Jesus Christ 
of Latter-day Saints, Congregational and First Christian churches 
were used. Only 37 of the 50 subjects observed the experiments; 
34 provided recall data. Of these, 16 were in the experimental group 
and 18 in the control group. Thirteen of the 50 subjects either did not 
show up or were dropped from the study because of their age. All of 
the subjects were experimentally naive'.

Procedure

Contact of Subjects. The subjects were contacted in the follow-
ing manner: a letter (see Appendix B) was sent to the five directors of 
the sunday schools explaining the general purpose of the study and 
requesting permission to obtain the names of the four-year-old chil-
dren in their schools and their parents. After permission was obtained 
and the names received, the parents of the children in the study were 
contacted by letter (see Appendix B) explaining the research project
and asking them to consider the possibility of their child becoming a subject for the study. The letter was followed by a telephone call. At that time any questions which the parents had were answered and a decision reached as to whether they would cooperate in the study. If the parents did agree to participate the mother was told the date and time which she and her child were to be at the nursery school. Each mother was asked to accompany her child and stay in the nursery school observation booths during the test session. This was done in order to give the child the security of his mother's presence in an unfamiliar nursery school setting.

**Nursery School Setting.** The study was conducted at the Orchard Street Nursery School on the Oregon State University Campus. Four science experiments were located in four different areas of the school, each at such a distance and arrangement from the other that the children could neither hear nor see the other experiments, and yet the children could still see their mothers who were in the observation booths. There was a teacher for each experiment and two college girls who assisted the children as they moved in small groups from one experiment to another.

**Design.** All of the subjects observed all of the science experiments (four) in a single day. The children were randomly assigned within each church group to a control and experimental group. The
children were kept in groups of five or less to allow them a close view of the experiments, to reduce the distraction of large groups of children, and to permit the teacher to establish some degree of rapport with the children. The children were kept within their own church groups so that they would be with children who were familiar to them.

Diagramatically, the placement of children into the experimental and control grouping was as follows:

\[
\begin{align*}
I & \quad II & \quad III & \quad IV & \quad V \\
\begin{array}{cc}
e_1 & c_1 \\
e_2 & c_2 \\
end{array} & \begin{array}{cc}
e_3 & c_3 \\
e_4 & c_4 \\
\end{array} & \begin{array}{c}
e_5 & c_5 \\
\end{array}
\end{align*}
\]

Figure I. Division of Church Groups into Experimental and Control Groups

The administration of the experiments were as follows:

<table>
<thead>
<tr>
<th>Time</th>
<th>Group</th>
<th>Group</th>
<th>Group</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 a.m.</td>
<td>16 children</td>
<td>2 G. E.*</td>
<td>2 G. C.**</td>
<td></td>
</tr>
<tr>
<td>10:45 a.m.</td>
<td>17 children</td>
<td>2 G. E.</td>
<td>2 G. C.</td>
<td></td>
</tr>
<tr>
<td>11:30 a.m.</td>
<td>4 children</td>
<td>1 G. E.</td>
<td>1 G. C.</td>
<td></td>
</tr>
</tbody>
</table>

*Groups Experimental **Groups Control

Figure 2. Schedule of Administration of Experiments

The parents were requested to stay in the observation booths
during the experimental session. They were instructed when they entered the booths as to the purpose of the study and the procedures involved. They were able to observe the entire presentation and they were where the children could see them. There was no discussion between parent and child during the presentation of the experiments.

Experiments. Four science experiments (see Appendix A) were presented to the experimental and control groups. The science experiments used were the following: a color wheel spun very fast until a yellow-white color appeared, a napkin in a glass tipped upside down into a bowl of water, pepper floating on top of water which was then touched by a bar of soap, and a glass of water with a piece of cardboard placed over the top tipped upside down.

In order to determine which science experiments would produce the optimum of surprise with four-year olds, the writer selected 15 experiments from pre-school and elementary school science books. These experiments were then reviewed and screened by a staff member in the Department of Family Life and a graduate student in Health Education. The selection of experiments was narrowed to six and these were presented to four four-year olds to observe their surprise reaction. The determination of this reaction was based upon Charlesworth's criteria of surprise: facial, vocal, and gross motor responses as well as verbal responses, especially inquiries (5, p.7)
The four experiments which elicited the greatest surprise quality on the basis of these trials were selected for the study.

The method of presentation of the experiments varied for the control and experimental groups. The experimental or surprise groups were given a simple preparatory statement to set the stage for surprise, for example, "We usually think that if we put a piece of cardboard over a glass of water and tipped it over, the cardboard will fall off and the water will pour out." The experiment was then presented. After the children had an opportunity to observe the outcome a short explanation of the basic concept or rationale involved in the experiment was given. The presentation of the explanation after the experiment was based upon the assumption that the surprise element in the experiment would draw the child's attention to the experiment, arouse his curiosity, and set him in a mood of receptivity for the explanation of what had happened. An example of the experimental presentation is as follows:

PREPARATORY STATEMENT: "We usually think that if we put a napkin in some water it will get wet. Watch what happens when we put this napkin in the water."

PERFORM EXPERIMENT: Put a napkin in a glass and tip the glass upside down into a bowl of water. The napkin stays well up inside the glass and thus remains dry.

RATIONALE: "The napkin is still dry because the water couldn't get into the glass; the glass was full of air."

In contrast to the experimental method, the control or
**non-surprise groups** were given the explanation of what was going to happen and the basic concept or rationale involved before the experiment was presented. No explanations followed the experiment. There were two reasons for this procedure: (1) the surprise element was not to be a part of the experiments presented to the control groups and by presenting the rational before seeing the experiment it was assumed that the element of surprise would be sharply reduced; (2) if the rationale were repeated after the experiment it would provide a greater degree of exposure to the basic concept involved in the experiment than that provided the experimental groups, thus loading the experiment in favor of the control group and thereby masking the effects of the experimental variable.

An example of the control group presentation follows:

**PREPARATORY STATEMENT AND RATIONALE:** "We usually think that if we put a napkin in some water it will get wet. I'm going to put the napkin in this glass and put the glass in the water upside down. The napkin won't get wet. The napkin will still be dry because the water won't be able to get into the glass; the glass is full of air."

**PERFORM EXPERIMENT:** Put a napkin in a glass and tip the glass upside down into a bowl of water.

**Adminstration of Experiment.** Each science experiment was presented by one leader. This person was responsible for memorizing the dialogue and presenting the accompanying experiment to the surprise and non-surprise groups. This procedure was followed in
order to eliminate differences in the administration of any one experiment for the experimental and control groups. A different leader was used for each experiment in order that the constant error introduced by any one individual be controlled.

**Collection of Data.** In order to test the effect of surprise as an element in learning the children who had observed the experiment were tested for their recall of what had happened and the basic concepts or rationale involved in the experiments observed 28 to 30 days after their observation. This time period was arbitrarily established and was intended to serve only as an assurance that the recall of the experiments and their rationale would involve more than a memory of the immediate impressions of the day. However, due to unexpected conflicts with this schedule on the part of parents, the period of follow-up varied from 25 to 53 days.

The data gathered were the children's verbal recall of what had happened in the experiments and why. These were recorded and judged by an interviewer as "correct", "incorrect", or "partially correct". The interviewer's reliability in judging the data was determined by comparing judgments with another person. There was 100 percent agreement.

The children and their mothers were requested to return individually for the follow-up study. All subjects were tested for recall by
the same person. The pattern followed in each test session was as follows: The materials for each experiment were placed before the child on a small table. He was then asked, "can you tell me what happened in the experiment you saw with these things?" If the child was able to describe what happened in the experiment he was then asked, "Can you tell me why it happened?" The question for the basic concept to the color wheel experiment was different from the others because it involved relating what had happened in the experiment to another phenomenon, the white or yellow color of the sun. That question was, "What else is white and has the colors all mixed up?"

The pattern for collecting recall was chosen for the following reasons: (1) the materials for each experiment were placed on the table to help the child visually differentiate between the experiments about which he was being questioned because three of the four experiments involved water and two of the four involved a glass with something in it; (2) a verbal description of the materials in the experiments may have been more clearly understood by some children than others; thus, by all the children seeing the materials of the experiments, recall based upon the child understanding the word picture of the interviewer would be reduced or eliminated; and (3) the two sets of questions provided a media to test recall by soliciting a verbal
response from the child of what had transpired during the experiment and the basic concept involved.

The answers of the child were recorded by the interviewer as "correct" if he remembered correctly what had happened during the experiment and why it had happened or "incorrect" if he did not respond, or if the response was wrong. If the answer contained a mixture of correct and incorrect phrases, the answer was judged "partially correct" and recorded verbatim.

Two other kinds of information were obtained as part of the data for the study: (1) the child's report of whether he had seen the experiments before and (2) a record of the child's discussion about the experiments at home. In order to obtain some indication as to whether the children had seen the experiments before they were asked by the teacher at the end of each experiment: "Has anyone seen this experiment before?" The teacher then recorded the number who said "yes" and any other comments the children may have added. In collecting this data it was recognized that many times children respond to what they think is teacher expectation and answer accordingly.

In order to obtain a record of the child's discussion about the experiments at home, the parents were requested to give a verbal report, including examples, in the follow-up study of the extent and nature of these discussions. The interviewer recorded the information
given by the parents, and placed it into one of the following categories:

(1) the child talked about the experiments for a week or more

(2) the child discussed the experiments in some length but the discussion did not continue over an entire week

(3) the child made only passing reference to the experiments

(4) the child made no reference to the experiments.

Several problems were recognized in relation to these data:

(1) the parents were not trained as reliable observers, and (2) they could not be aware of all conversations the child had with his siblings or friends about the experiments. These factors must be considered in assessing the worth of these data.
RESULTS

The purpose of this study was to compare two methods of presenting science experiments (surprise or non-surprise) to young children to determine if one or the other of these methods related significantly to the recall of the experiments and the basic concepts involved. Thirty-seven four-year old children observed four different science experiments. Half of the group received the experiments on a surprise basis and half on a non-surprise basis. After a period of several weeks, the children were tested individually to determine their recall of the experiments and accompanying basic concept.

Statistical Treatment of the Data

In the follow-up study the raw data were recorded as "correct", "incorrect" or "partially correct". Only 10 out of the entire group of 135 answers were judged to be "partially correct". For purposes of statistical analysis these were later changed to "incorrect" answers; they were not totally correct as opposed to those answers which were. Since the rest of the data was binomial and the statistical method for analyzing such data does not include partial degrees, it was concluded that strict adherence to the "correct" or "incorrect" policy would be followed.
In order to determine the significance of the difference observed between the surprise presentation group and the non-surprise presentation group in recall of the four experiments, a chi square analysis was computed. Since the data was of the binomial nature the variance was known, and therefore the chi square test became the most appropriate analysis tool. A within group analysis of variance with significance level at 2.5 percent (one-tailed test) was run in order to determine the significance of differences observed in the recall of the four experiments within the experimental and control groups.

In order to determine whether variation in length of time between experiment and recall affected recall, a regression analysis was run on all the data using time as the independent variable and recall scores as the dependent variable. An F-test was used to determine if time had a significant effect on the scores.

Results of the Analysis

The data which were collected from the follow-up study appear in Table I. The first analysis to be made of the data was the regression analysis to determine the effect of the variation in lapse of time between observation of the experiment and recall. Since the period of follow-up ranged 25 to 53 days following presentation of the experiments, the hypothesis was tested that time had an influence on the scores. The data going into the analysis appear in Table I.
### TABLE I.
A SUMMARY OF RECALL DATA BY SUBJECT, EXPERIMENT AND EXPERIMENTAL GROUP

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject of recall</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>of recall</td>
</tr>
<tr>
<td></td>
<td>Aug.**</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
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<tr>
<td>8</td>
<td>16</td>
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<tr>
<td>9</td>
<td>16</td>
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<td>10</td>
<td>17</td>
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<td>11</td>
<td>17</td>
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<tr>
<td>12</td>
<td>19</td>
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<tr>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Totals</td>
<td>13</td>
</tr>
</tbody>
</table>

*Experiment Recall  **Concept Recall
Upon analysis it was found that time was not related significantly to recall scores. The data from this analysis appear in Table II.

**TABLE II.**
**ESTIMATED EFFECT OF TIME UPON SCORES**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Regression* Coefficient</th>
<th>Calculated F-Value</th>
<th>F-Valued needed for significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>(x)</td>
<td>(b)</td>
<td>(F)</td>
<td>(F)</td>
</tr>
<tr>
<td>Scores for</td>
<td>Time measured</td>
<td>-.227</td>
<td>4.8797</td>
<td>6.2979</td>
</tr>
<tr>
<td>experimental group</td>
<td>in days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scores for</td>
<td>Time measured</td>
<td>-.034</td>
<td>.7915</td>
<td>6.1151</td>
</tr>
<tr>
<td>control group</td>
<td>in days</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*b-values were not significant at the 2.5 percent significance level using an F-test with 1 and 14 d.f. and 1 and 16 d.f. respectively.

The basic analysis in the study centered on the difference in recall between the surprise presentation group and the non-surprise presentation group for the four experiments. Since the data were of a binomial nature, a chi square analysis was used to test this difference. The data coming from the chi square analysis appear in Table III.
TABLE III.
RECALL OF WHAT HAPPENED IN THE EXPERIMENTS AND THE BASIC CONCEPT INVOLVED IN THE SURPRISE AND NON-SURPRISE GROUPS

<table>
<thead>
<tr>
<th>Surprise vs. Non-surprise</th>
<th>$X^2$-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>What happened</td>
<td>.0897 with 1 d.f.</td>
</tr>
<tr>
<td>Basic concept</td>
<td>.0489 with 1 d.f.</td>
</tr>
</tbody>
</table>

*A chi-square value of 5.02 is required for significance at the 2.5 percent level and 3.84 at the 5 percent level of confidence.

It will be seen from these data that there was no significant difference between the surprise group and the non-surprise group in relationship to recall of the experiment and the basic concept involved.

In order to see if there were differences in recall by experiments the hypothesis of no significant differences amongst the four experiments, within both the surprise and non-surprise groups, was tested. Analysis of variance was the statistic used in making this test. The data coming from this analysis appear in Tables IV through VII.\(^1\)

\(^1\) In the analysis of the data that is reported in the following pages, variance due to church groups and child to child variability was pooled with the error term. Subsequent analyses identifying the variance due to these factors were computed and it was found that they did not contribute significantly to the total variance within the data. On the basis of these analyses it appeared reasonable to permit the original pooling to stand.
### TABLE IV.
ANALYSIS OF VARIANCE FOR RECALL OF WHAT HAPPENED IN
THE FOUR EXPERIMENTS IN THE SURPRISE GROUP

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares SS</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among-sample</td>
<td>0.5469</td>
<td>3</td>
<td>0.1823</td>
<td>0.8597</td>
</tr>
<tr>
<td>Within-sample</td>
<td>12.8125</td>
<td>60</td>
<td>0.2135</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>13.3594</td>
<td>63</td>
<td>0.2121</td>
<td>---</td>
</tr>
</tbody>
</table>

*An F-value of 3.3425 is required for significance at the 2.5 percent level of confidence.

### TABLE V.
ANALYSIS OF VARIANCE FOR RECALL OF THE BASIC CONCEPT INVOLVED IN THE FOUR EXPERIMENTS IN THE SURPRISE GROUP

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares SS</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among-sample</td>
<td>0.8750</td>
<td>3</td>
<td>0.2917</td>
<td>2.8572</td>
</tr>
<tr>
<td>Within-sample</td>
<td>6.1250</td>
<td>60</td>
<td>0.1021</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>7.0000</td>
<td>63</td>
<td>0.1111</td>
<td>---</td>
</tr>
</tbody>
</table>

*An F-value of 3.3425 is required for significance at the 2.5 percent level and 2.7581 at the 5 percent level of confidence.
### TABLE VI.
ANALYSIS OF VARIANCE FOR RECALL OF WHAT HAPPENED IN THE FOUR EXPERIMENTS IN THE NON-SURPRISE GROUP

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares (SS)</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among-sample</td>
<td>.5349</td>
<td>3</td>
<td>.1783</td>
<td>1.0075</td>
</tr>
<tr>
<td>Within-sample</td>
<td>11.8595</td>
<td>67</td>
<td>.1770</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>12.3944</td>
<td>70</td>
<td>.1771</td>
<td>---</td>
</tr>
</tbody>
</table>

*An F-value of 3.3291 is required for significance at the 2.5 percent level of confidence.

### TABLE VII.
ANALYSIS OF VARIANCE FOR RECALL OF THE BASIC CONCEPT INVOLVED IN THE FOUR EXPERIMENTS IN THE NON-SURPRISE GROUP

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares (SS)</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among-sample</td>
<td>.1018</td>
<td>3</td>
<td>.0339</td>
<td>3.247</td>
</tr>
<tr>
<td>Within-sample</td>
<td>6.9968</td>
<td>67</td>
<td>.1044</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>7.0986</td>
<td>70</td>
<td>.1014</td>
<td>---</td>
</tr>
</tbody>
</table>

*An F-value of 3.3291 is required for significance at the 2.5 percent level of confidence.
It will be seen from these data that there were no significant differences amongst the experiments within the control or experimental groups, either as to recall of what happened or recall of the basic concept underlying what happened. One of the four analyses, that involving the experimental (surprise) group's test of recall of the basic concept, was significant at the five percent level of significance but not at the established level of 2.5. The magnitude of this variance was due to the recall of the color wheel experiment. It is difficult to know how to interpret these results. On the one hand the greater recall of the concept involved in the color wheel experiment by the surprise group may be a function of sampling or random error. On the other hand, it may be a reflection of the greater initial familiarity of the subjects with the color wheel experiment (see Table VIII). The difficulty in this interpretation is that the report of familiarity with experiments was not kept separately for the surprise and non-surprise groups. Whatever its source, the difference does not seem to appreciably alter the general results of the study, for the other three F-values did not approach significance, and the hypothesis was accepted that there was no significant differences in recall amongst the experiments. There appeared to be an equality in the environment of each experiment and the construction of the experiments themselves.
Non-Statistically Treated Data

In addition to the recall data two other sets of data were collected: the children's report of whether they had seen the experiments before and a record of the children's discussions about the experiments at home. These are treated separately below.

In Table VIII it may be observed that there were 19 reports that one of the experiments had been seen before; this was out of a total of 148 possible opportunities (37 children observing four different experiments). From these data it may be concluded that the experiments were new to most of the children and that the recall data were probably not appreciably influenced by the factor of familiarity.

**TABLE VIII.**
CHILDREN'S REPORT OF FAMILIARITY WITH THE EXPERIMENTS

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Pepper</th>
<th>Color Wheel</th>
<th>Napkin in Glass</th>
<th>Cardboard over glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number seen before</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total reported seen</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total possible</td>
<td>148</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A child's discussion at home about the experiments was reported by his mother at the time of testing. Her report was categorized into
one of four possible categories: the child talked about the experiments for a week or more; the child discussed the experiments in some length but the discussion did not continue over an entire week; the child made only passing reference to the experiments; and the child made no reference to the experiments. As seen in Table IX the majority of the children's responses fell into the two middle categories. Only six responses were placed in either of the two extreme categories.

**TABLE IX.**
RECORD OF CHILDREN'S DISCUSSION ABOUT THE EXPERIMENTS AT HOME

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number of Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) The child talked about the experiments for a week or more.</td>
<td>1</td>
</tr>
<tr>
<td>(B) The child discussed the experiments in some length but the discussion did not continue over an entire week.</td>
<td>14</td>
</tr>
<tr>
<td>(C) The child made only passing reference to the experiments.</td>
<td>11</td>
</tr>
<tr>
<td>(D) The child made no reference to the experiments.</td>
<td>5</td>
</tr>
</tbody>
</table>

* 3 parents made no report
To see if the amount of discussion at home was related to recall, each child's total recall score was compared with his categorized discussion response at home. These data appear in Table X. Upon inspection there appears to be a tendency for the children who discussed the experiments at home to score higher than those who did not discuss them, but the difference appears to be small.

**TABLE X.**
CHILDREN'S DISCUSSION AT HOME AND SCORES IN THE RECALL TESTS

<table>
<thead>
<tr>
<th>Discussion at Home (Categories A-B in Table IX)</th>
<th>Little or No Discussion at Home (Categories C-D in Table IX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children Attaining the Score Attained*</td>
<td>Number of Children Attaining the Score Attained*</td>
</tr>
<tr>
<td>Score</td>
<td>8 Points Possible, Four for Recall of the Experiments and Four for the Recall of the Basic Concept Involved.</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

The meaning of these data are not clear in view of the lack of a systematic record on the part of parents of the amount of discussion.
that actually took place and the relationship between interest and/or intelligence and discussion. While suggestive of differences these data must be viewed in light of these limitations.
DISCUSSION

Discussion of the Findings

The purpose of this study was to compare the relative contribution of two methods of presenting science experiments (surprise or non-surprise) to four-year old children. The major hypothesis of the study was that four-year old children would better remember what happened in science experiments and the basic concepts involved in them when the presentation of the experiments involved an element of surprise. Two groups were studied (surprise and non-surprise) to determine which of these two methods related most significantly to the recall of the experiments and the basic concepts involved. Of the two groups studied, no significant difference appeared. The results were consistent for test of recall of what happened and the accompanying basic concept. From these results it seems that there would be no advantage of using one method over the other.

Since these results run counter to those expected on the basis of the literature, care was taken to analyze for possible sources of error in the data. Two such analyses were undertaken. Since the period of follow-up for collecting the data ranged from 25 to 53 days after the presentation of the experiments, the data were tested to determine whether time influenced the scores. The results indicated
that it did not. This eliminated one of the more obvious variables that could have affected the other analyses of the data.

The data were also tested to determine if there were any significant differences amongst the four experiments, or the teacher presentation of them. The results showed that no significant differences appeared here either.

As indicated above, the data obtained in the study are contradictory to that expected on the basis of the literature. The question is why? Some of the possible reasons are outlined below.

It may be noted that a number of the studies in the review of literature using children and adults placed them in situations where they could observe for a given period of time a certain aspect of the experiment or actually participate in it. When the surprising stimuli were introduced, the situation in which the subjects were involved was markedly changed. The children in this study, however, were observers only while the experiments were presented, and this may have been a factor in minimizing their expectations as to the outcome of the experiments. Related to this could be the children's lack of sophistication or experience in science experiments, or the basic concepts involved, which would give little or no back-log of knowledge to prepare the child to be significantly surprised. As Bruner pointed out earlier, "...one must know to be surprised." Thus,
following Bruner’s line of thinking, one explanation for the difference between the hypothesized and observed outcome of this study may be the lack of background of the children to know that they should be surprised.

Another line of reasoning rests upon the fact that pre-school children are daily involved with the task of learning more about the world in which they live, and to them life may be a continuum of surprises. All new experiences may well be accompanied with a quantity of surprise, and if this is so an explanation before the experience would make little or no difference in reducing the surprise element. From this point of view, the explanations given to the control group before the science experiments were presented could well have been ineffective in reducing the surprise element of the experiments. If this were the case, one would expect a similarity of results from the two groups.

Charlesworth has suggested that surprise focuses the individual's attention on the surprise producing stimulus. It may well have been the case in this design that there was another surprise situation which was holding the child's attention. This focal point could have been the nursery school setting itself for it was a new and interesting building full of new and interesting toys, and it was full of new faces. Young or old, children or teachers--all could cause the child to be
excited or afraid to the point that he would neither see nor hear much about the experiments. Interpreted in this way one might consider that the surprising stimuli in the study were represented by the environment in which the child was temporarily placed, and since this was roughly equivalent for all children one would expect little difference between groups.

In summary, three factors have been reviewed which could account for the lack of difference observed between groups in the present study: a lack of background in experience and/or knowledge which would permit the children in the experimental group to be surprised; the failure of the explanation before the presentation of the experiments to reduce the surprise element of the experiments for the control group; and the novel if not surprising impact of the nursery school setting itself upon all of the children.

While these factors may have accounted for the lack of difference between groups, it is also possible that the initial hypothesis was incorrectly drawn or that the relationships between surprise and learning reported thus far in the literature is an artifact of a particular research design or a second order variable that has not yet been identified. The meaning of the results of the present study in relation to the bulk of the literature in the field awaits further research.
Research Implications

Several research directions seem justified on the basis of this study.

1. Repetition of the study, but presentation of the experiments on an individual basis to eliminate peripheral events and allow the children to focus attention on the experiment.

2. The need for a study to determine if children who are sufficiently involved in an experiment to have established "expectations" as to appropriate stimuli are more surprised by the presentation of the unexpected stimuli than are children who are not so involved in the experiment.

3. The need for a study which determines the effect on learning of introducing surprise stimuli in the daily nursery school setting where presentation of the stimuli is based upon the child's interests and cues of readiness for learning.
Summary

The purpose of this study was to test the hypothesis that four-year-old children would better remember what happened in science experiments, and the basic concepts involved in them, when presentation of the experiments involved an element of surprise. Surprise for this study was considered as a situation in which there was a built-in expectation that was dramatically and without warning contradicted.

To test this hypothesis, 37 four-year-olds observed four different science experiments that had a "high surprise" value. Half of the group received the experiments on a surprise basis and half on a non-surprise basis. The surprise or experimental group was given a preparatory statement to set the stage for the surprising reaction of the experiment. This was followed by a short statement of the rationale or basic concept involved. In the non-surprise or control group the children were told first what to expect and the basic concept involved, and then were given the experiment. After a period of 25 to 53 days, the children were tested individually to determine their recall of the experiments and accompanying basic concept. Thirty-four children provided recall data; of these,
16 were in the experimental group and 18 in the control group. The recall data were analyzed statistically to determine between and within group differences. Two other kinds of information were obtained as part of the data for the study: (1) the child's report of whether he had seen the experiments before and (2) a record of the child's discussion about the experiments at home.

To determine the difference in recall between the surprise and non-surprise groups, a chi square analysis was computed. The analysis indicated there was no significant difference between the groups.

Since these results run counter to those expected on the basis of the literature, care was taken to analyze for possible sources of error in the data. Two such analyses were undertaken: the data were tested by regression analysis to determine whether time influenced the scores, and an analysis of variance was used to determine if there were any significant differences in recall amongst the four experiments. Neither analysis identified significant effects.

Three factors were reviewed which could have accounted for the lack of difference between groups in the present study: lack of background in experience and/or knowledge which would permit the children in the experimental group to be surprised; the failure of the explanation before presentation of the experiments to reduce the surprise element of
the experiments for the control group; and the surprising impact of
the nursery school setting upon all of the children. The possibility
that the initial hypothesis was incorrectly drawn was also discussed.

Several research directions seem justified on the basis of this
study: (1) repetition of the study, but presentation of the experiments
on an individual basis to eliminate peripheral events and allow the child
to focus attention on the experiment; (2) the need for a study to
determine if children who are sufficiently involved in an experiment to
have established "expectations" as to appropriate stimuli are more
surprised by the presentation of the unexpected stimuli than are chil-
dren who are not so involved in the experiment; (3) the need for a study
which determines the effect of introducing surprise stimuli in the daily
nursery school setting where presentation of stimuli is based upon the
child's interests and cues of readiness for learning.
BIBLIOGRAPHY


APPENDICES
APPENDIX A

EXPERIMENTS

I. NAPKIN IN A GLASS TIPPED UPSIDE DOWN INTO WATER

A. Experimental Presentation

PREPARATORY STATEMENT: "We usually think that if we put a napkin in some water it will get wet. Watch what happens when we put this napkin in the water."

PERFORM EXPERIMENT: Put a napkin in a glass and tip the glass upside down into a bowl of water. The napkin stays well up inside the glass and thus remains dry.

RATIONALE: "The napkin is still dry because the water could not get into the glass; the glass was full of air."

B. Control Presentation

PREPARATORY STATEMENT AND RATIONALE: "We usually think that if we put a napkin in some water it will get wet. I am going to put the napkin in this glass and put the glass in the water upside down. The napkin will not get wet. The napkin will still be dry because the water will not be able to get into the glass; the glass is full of air."

PERFORM EXPERIMENT: Put a napkin in a glass and tip the glass upside down into a bowl of water.

II. CARDBOARD OVER A GLASS OF WATER TIPPED UPSIDE DOWN

A. Experimental Presentation

PREPARATORY STATEMENT: "We usually think that if we put a piece of cardboard over a glass of water and tipped it over, the cardboard will fall off and the water will pour out. Now watch while I put this cardboard over the glass of water and tip it upside down."
PERFORM EXPERIMENT: Place the cardboard over the glass of water and hold securely while tipping the glass upside down. Remove hand from supporting the cardboard; the cardboard will stay on the inverted glass of water.

RATIONALE: "The cardboard did not fall off because the air is pushing on it."

B. Control Presentation

PREPARATORY STATEMENT AND RATIONALE: "We usually think that if we put a piece of cardboard over a glass of water and tip it over, the cardboard will fall off and the water will pour out. Watch when I put this cardboard over the glass of water and tip it over. The cardboard will not fall off because the air is pushing against it."

PERFORM EXPERIMENT: Place the cardboard over the glass of water and hold securely while tipping the glass upside down. Remove hand from supporting the cardboard; the cardboard will stay on the inverted glass of water.

III. PEPPER FLOATING ON WATER

A. Experimental Presentation

PREPARATORY STATEMENT: "If we put pepper on this water it floats in the middle. It stays there. Now watch when I touch a piece of soap in the water."

PERFORM EXPERIMENT: Sprinkle pepper into bowl of water. Touch a bar of soap to the surface of the water. The surface tension of the water will be broken and the pepper will quickly move to the sides of the bowl.

RATIONALE: "The droplets of water on top are stuck together like they are holding hands. When the soap touches the water they let go of hands and move away from each other, moving the pepper with them."

B. Control Presentation

PREPARATORY STATEMENT AND RATIONALE: "If we put pepper on this water it floats in the middle. It stays there."
Now I am going to touch a piece of soap to the water. The droplets of water on top stick together like they are holding hands. When the soap touches the water they will let go of hands and move away from each other, moving the pepper with them."

PERFORM EXPERIMENT. Sprinkle pepper into bowl of water. Touch a bar of soap to the surface of the water. The surface tension of the water will be broken and the pepper will quickly move to the sides of the bowl.

IV. COLOR WHEEL SPUN VERY FAST TO YELLOW OR WHITE COLOR

A. Experimental Presentation

PREPARATORY STATEMENT: "We think of sunlight as being just yellow or white light. Now watch the color that comes when I mix up all of these colors by making them go very fast."

PERFORM EXPERIMENT: Spin color wheel very fast until a yellow or white color appears.

RATIONALE: "All the colors mixed up together make yellow or white light. Sunlight is all the colors mixed up."

B. PREPARATORY STATEMENT AND RATIONALE: "We think of sunlight as being just yellow or white light. Now I am going to mix up all the colors by making them go very fast. All mixed up, they will become like yellow or white light."

PERFORM EXPERIMENT: Spin color wheel very fast until a yellow or white color appears.
(Letter sent to supervisors of Junior Sunday Schools)

We are planning an investigation of learning patterns shown by preschool children in a series of planned science experiments, and we hope to begin by testing a selected number of four-year olds in this community.

We plan to have 50 children in our study. The child and his mother will be asked to come to the Orchard Street nursery school for approximately 45 minutes and then return 28 to 30 days later for a 15 minute period.

We are writing to the five directors of Junior Sunday Schools in the Episcopal, Methodist, Church of Jesus Christ of Latter-day Saints, Christian, and Congregational churches in order to obtain the names of parents who have children registered in the four-year old groups so that we may write them about participating in this study. We hope that it will be possible for you to provide us with the necessary information.

Mrs. Kathy Fagg Gee, who has been one of our graduate students and is now a member of the staff, is working on this study. She will telephone you in the next few days and will be ready to answer questions which you may have.

Sincerely,

H. D. Schalock, Acting Chairman
Department of Family Life

HDS:kg
We are planning an investigation of learning patterns shown by pre-school children in a series of planned science experiments, and we hope to begin by testing a selected number of four-year olds in this community.

We plan to have 50 children in our study. The child and his mother will be asked to come to the Orchard Street nursery school for approximately 45 minutes and then return 28 to 30 days later for a 15 minute period.

We are writing to parents who have children registered in the Junior Sunday Schools of the following churches: Episcopal, Methodist, Church of Jesus Christ of Latter-day Saints, Christian and Congregational. We would like to invite you to participate with us in this study and hope that you may find it possible.

Mrs. Kathy Fagg Gee, who has been one of our graduate students and is now a member of the staff, is working on this study. She will telephone you in the next few days and will be ready to answer questions which you may have.

If you are interested, we hope you and your child may be able to participate in this learning program.

Sincerely,

H. D. Schalock, Acting Head
Department of Family Life

HDS:kg