AN INVESTIGATION OF MAGICAL CAUSALITY IN CHILDREN

THESIS FOR THE DEGREE OF M. A.

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LESLIE HASTINGS AULT

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AN INVESTIGATION OF MAGICAL CAUSALITY IN CHILDREN

By

Leslie Hastings Ault

AN ABSTRACT OF A THESIS

Submitted to

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in partial fulfillment of the requirements

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ABSTRACT

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Children's understanding of physical causality was investigated to test Piaget's theory that the development of causal thought passes through various stages (during which the child's thought is different in kind from adult thought) before a correct physical understanding of environmental phenomena is attained.

A review of the literature showed wide divergences in results based on the method of verbal questioning. Various differences in the conditions of investigation were suggested to account for these divergences. It was further suggested that the method itself does not get data which accurately represent the "real" causal beliefs of the child, and that for this reason a performance measure would be preferable.

There were four groups of 30 children each: Nursery, Kindergarten, First Grade, and Second Grade, all tested individually.

The test situation involved guessing which side of a small see-saw would fall. A red and a green block were placed at opposite ends of the see-saw, and a flashlight bulb was mounted on either side in front of the see-saw. The red block was actually but not apparently heavier than the green block, so whichever side the red one was on always fell. During training trials, the light in front of the red block was

lit, so that the light was a correct cue. On certain critical trials the light was lit in front of the green block. The hypothesis was that children with magical ideas of causality would respond to the red block. According to Piaget's theory, there should be an inverse relation between age and the number of "Light" choices on the critical trials.

In addition, the Kindergarten, First Grade, and Second Grade children were asked four questions about causality, and the Goodenough Draw-A-Man test was administered to each group.

The results showed little support for the prediction. There was no consistent decrease in the mean number of "Light" choices by age, either across or within the groups; furthermore, there was no decrease by age group in the number of Light choices on the first critical trial. At the same time, the Kindergarten group did significantly worse on the Questions than either the First or Second Grade. There was no consistent relation between the Questions and the Light scores within the groups.

The conclusion was that no real evidence was found to support the theory that the causal thought of the child undergoes progressive changes. Regarding answers to causal questions, it was proposed that the young child learns verbalizations, both correct and incorrect, which do not necessarily represent his "real" beliefs.

Approved: Charles Hanley

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Problem

If you ask a child to account for some natural or mechanical phenomenon, such as the movement of clouds, and he says "They follow me when I walk", what can be inferred about his understanding of physical causality? Perhaps he actually holds this view, and upon further questioning he might admit that the clouds do not stop when he does but follow other people as well. Now he has consistently explained the phenomenon, but the explanation is a "magical" one. On the other hand, suppose he answers "The wind, which is caused by changes in air pressure, pushes the clouds." This is an accepted explanation for our time. However, the ordinary person, and in particular the child, is unable to verify completely this explanation, but instead learns it. Thus it may well be that this "scientific" answer does not necessarily reveal a mind with correct ideas of physical causality, and conversely that a "magical" answer does not necessarily indicate a corresponding mental state. It is accepted practice to draw the child out by extended questioning on the subject of causation; the result is that the child may find it expedient to make some fanciful explanation. Further, the wording of the question, the personality of the child, and probably the personality of the interrogator and his association with the child also influence the results.

Historical background

To investigate the general development of ideas of physical causality, the traditional procedure is to get a number

of children at different age levels and question them. Piaget has done this with great perseverance. While he has used this method for various studies of the mental development of children (Piaget, 1926, 1929, 1932), what is pertinent here is his speculation on the development of causal thought in children (Piaget, 1930).

Piaget conducted his researches as the director of the Institute Rousseau in Geneva, Switzerland. Apparently adjunct to the Institute was a school, at which he, with various assistants, made observations and conducted studies. Unfortunately, Piaget has never been specific about his procedure, so that the number of children involved, their background, the conditions of observation, etc., are not mentioned. This does not lessen the profundity of his observations; these have made him one of the most important figures in the study of the child.

The child, Piaget (1926) had earlier observed, is egocentric. His language is mainly an accompaniment to his own play and not a means of communication, until the age of about eight. A related feature of the child's mind is his deficient understanding of physical causality. Piaget (1930) has identified 17 stages in the development of causal understanding. These stages are not meant to apply in strict order to every child, but represent a general progression. They are:

I. Psychological causality or motivational explanation - as a lake is there for people to swim in.

II. Pure finalism - much like above but less emphasis

on plan.

III. Phenomenistic causality - two facts contiguous in time and space are seen as causally related.

IV. Participation - (disappears at 5 or 6) two similar things are seen as connected.

V. Magical causality - personal actions seen as widely effective (this personal magic is related to autism and disappears at age four or five in favor of animistic notions).

VI. Moral causality - like clouds move because they must.

VII. Artificialist causality - complementary to above.

VIII. Animistic causality - attributation of life and will to objects.

IX. Dynamic causality - "forces" in objects.

(Stages VII-IX are related to egocentrism.)

X. Reaction of the surrounding medium - (beginning of a physical explanation).

XI. Mechanical causality - explanation by contact and transference of movement (appears at 7 or 8).

XII. Causality by generation - sun came out of a cloud.

XIII. Substantial identification - sun is now a collection of clouds in a ball.

XIV. Schemas of condensation and rarefaction - qualitative differences explained.

XV. Atomistic composition - extension of above.

XVI. Spatial explanation - utilization of spatial properties.

XVII. Explanation by logical deduction - the "correct" answer (increases in frequency after age 10 or 11).

(Note: this material adapted from pp. 258-67.)

"Having distinguished these seventeen types, we can now lay down three main periods in the development of child causality. During the first, all explanations given are psychological, phenomenistic, finalistic, and magical (types I-VI). During the second stage, the explanations

> are artificialist, animistic, and dynamic (types VII-IX), and the magical forms (III and IV /sic/) tend to diminish. Finally, during a third period, the preceding forms of explanation disappear progressively and give place to the more rational forms (X-XVII). Thus the first two periods are characterized by what we have called pre-causality (in the widest sense of the word), i.e. by the confusion of relations of a psychological or biological type in general with relations of a mechanical type, and true causality does not appear till about the age of 7-8 (third period)." (p.267)

Piaget concluded that the thought of the child during the first two periods (stages or types I-VI and VII-IX above) was not only of a different degree than adult thought but also of a different kind. This assertion raises a basic issue: whether the child has different thought processes (involving a tendency to give matter in the environment a form partly determined by the organism), or is just at a lower stage of development, his thought not different in kind.

Much of Piaget's writings consist of classification - with examples - of the material collected by him and his associates from conversations with, observations of, and simple experiments with children. This material is arranged into chapters according to the topic under consideration. The movement of clouds (which along with the movement of heavenly bodies consumes a chapter) has five stages of explanation:

1. magical - we make the clouds move by walking (age five).
2. artificialist and animistic - God or men cause (age six).
3. somehow move by themselves (age seven).

4. wind pushes clouds but wind comes from clouds - (age eight). (Piaget stated that by experience it was found that the answer "The wind blows the clouds" often concealed this circular logic, so that it was necessary to draw out the child's idea by further questioning.)
5. correct explanation - (see p. 1 above) (age nine).

A five year old gave the following testimony: /The clouds are smoke from the chimneys./ Q: "Why do they move along?" A: "It's the moon that makes them move." Q: "Do they know that they are moving?" A: "Yes." Q: "Do they know that the moon makes them move?" A: "Yes." Q: "And does the moon know it?" A: "Yes." (p. 65) What did the child really think? He did make several animistic replies, but they were suggested by the questions. This is a typical hazard of the interrogation method.

Allied to this concept of the precausal thought of the child are the theory of primitive man as being characterized by a mentality similar to the child (see the writings of Levy-Bruhl, 1926, 1928), the theory that every neurosis includes magical ideas of causality (Roheim, 1955), and Freud's (1919) perception of the similarity between practices of primitive men and European neurotics, e.g., taboo and obsession.

Before Piaget there had been many studies of children's ideas of physical causality. G. Stanley Hall (1883) collected extensive data on the knowledge of children, which served as a guide to elementary school teaching, to the effect that objects rather than names should be stressed. Later, Hall and Browne (1903) catalogued the misconceptions of children and

took the position that they are a qualitative feature of the mind of the child, equating the development of causal thought in children with the historical development of man's scientific ideas. Also, Carla Raspe (1924) noted the tendency of children, aged 6 to 14, to explain a size illusion by a conveniently provided metronome or light turned on as the illusion was presented. She interpreted these results as evidence of magical thought, but this is an inference which would be incorrect if the children were merely making an expedient answer.

This use of magical is broader than Piaget's usage, but is more common. Magical causality can be thought of as a readiness to believe in and/or to act in accord with relationships between persons (one's self included), objects, and events, identified or linked by the whim of the believer. In contrast, scientific causality is the acceptance of such relationships between things on the basis of sophisticated observation and principle (and as such is related to critical thinking).

After the translation and dissemination of Piaget's findings, follow-up investigations of causality in children were made in various parts of the world, and reports in the literature have continued to the present with less frequency but still with geographical dispersion.

In Germany, Herzfeld and Wolf (1930) asked children aged 6, 7, 8, and 9, for explanations for various demonstrations such as "magic" tricks and illusions. What they

classified as "mythical" and "magical" causal explanations decreased with advancing age while "realistic" explanations increased (see Table 1).

Table 1: Types of explanation from four age groups (from Herzfeld & Wolf, 1930)

Type	Chronological Age 6	7	8	9
Mythical	8.4%	3.4%	3.0%	...
Magical	42.6%	29.0%	16.5%	3.6%
Realistic	49.0%	67.6%	80.5%	96.4%

Johnson and Josey (1931) attempted to replicate Piaget's findings in Iowa, but reported that their subjects gave for the most part adequate explanations at an age when Piaget's subjects were giving various precausal explanations. They suggested by way of explanation that the English language is more conducive to logical thought than is French. In England, Hazlitt (1930) disagreed with the supposed different quality of thought in adults and children. She gave children practical test situations, in which they succeeded in making an exception, contrary to one of Piaget's hypotheses. Egocentrism in the child she attributed largely to simple lack of experience. As for the supposedly rational adults, she demonstrated that they also gave very naive answers when on unfamiliar ground. Accordingly, she criticized Piaget's conclusions as due to "over-evaluation of verbal expression as a measure of thinking, and as exaggeration of the logi-

cality of adult thought." The illogicality of adults was also demonstrated by Oakes (1945), who concluded "In general the adult has a more fully developed system of knowledge, but where a correct concept is lacking, the adult explains the event naively, just as does the child."

A further embarassment for Piaget's theoretical position was supplied by findings from a primitive culture, the Manus of the Admirality Islands. Manus adults accept and practice many magical and animistic concepts, so that it would seem that the children would also entertain such concepts. However, Margaret Mead (1932) reported the opposite. By means of free crayon drawings, the interpretation of ink blots, observations of everyday behavior, demonstrations of strange things (e.g., a typewriter), and test situations where she deliberately tried to shift blame to inanimate objects and attribute consciousness to them (e.g., evil intent on the part of a canoe drifting away), Mead found no spontaneous animistic or magical tendencies in the children. Her conclusion was "This type of thought was proved to be culturally determined, a potentiality of the human mentality under special, cultural, conditions, but not the inevitable concomitant of any stage of mental development." (Mead, 1933, p.915) As particular reasons in this case, she gave (1) the bare, simple language of the Manus, (2) Manus children are forced at an early age to make adjustments to the environment for themselves, and (3) Manus adults do not share their culture

with the children. All of these she considered opposite from Western culture, where the languages are rich in simile, where children are protected and do not have to fend for themselves, and are encouraged to believe in fairy tales. (Mead, 1932)

Dennis (1943), using his standardized procedure for investigating animistic beliefs in children (Dennis, 1939), found that Hopi children were more animistic, attributed consciousness to objects more, and had more "moral realism"[1] than American children. He criticized Mead's data as inadequate because proper conditions, such as his own standardized procedure, had not been given for the elicitation of animistic beliefs.

As for the development of causal understanding as measured by answers to questions, all later experiments have also shown that causal understanding increases with age, but there were differences in the exact ages for various types of explanations. This is not surprising, for there were different investigators in different cultures using different languages, different criteria, and different procedures. In Japan, Seki (1957, 1959) reported the establishment of sensory understanding at age five to seven, concrete understanding at eight or nine, and sudden increases in logical explanations at ten to

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[1] "Moral Realism" was identified and investigated by Piaget (1932). An example is: some boys steal some apples, but while they are walking away across a bridge, it collapses. Why did the bridge collapse? If because the boys were bad, this is moral realism.

twelve. From Russia, Venger (1958) reported that pre-school children can recognize and discuss logically the simplest causal relations between objects. This ability increased with age, depended on what was being asked, and was explained as largely due to learning. Danziger and Sharp (1958) in Australia questioned children aged five to eight on various natural and mechanical movements. They consider the large number of stages listed by Piaget as due to "failure to discover common stages of development", and themselves differentiated only four (see Table 2).

Table 2: Number at levels of explanation at four ages (from Danziger & Sharp, 1958)

Level	Chronological Age 5	6	7	8
I. (lowest)	45	27	20	13
II.	15	13	15	16
III.	4	23	23	26
IV. (best, correct)	3	7	10	17

Note: There were 12 children at each age, each asked 6 questions. The total would thus be 288, except that a few "don't know's" are omitted.

Beginning with Hall (1883), much of the considerable amount of research concerning the causal development of the child done in the United States has been concerned with the pragmatic problem of how to educate children, which is outside the scope of this paper (Oakes, 1947, presents a summary

and an extensive bibliography). However, several studies have been psychologically oriented and are more pertinent here. A good summary of earlier studies from all countries may be found in Huang (1943).

Deutsche (1937) used written answers to questions and explanations of simple experiments, obtaining much larger samples than could be had by individual, verbal questioning. Altogether she obtained answers from 732 school children from 3rd to 8th grade; also there were data from 13 Kindergarten children gathered verbally. Huang (1943) gave the following data taken from Deutsche but rearranged by him for the sake of brevity (see Table 3):

Table 3: Type of explanation by age (from Huang, 1943, after Deutsche, 1937)

Type	Kindergarten (questioned) (N=13)	8 year olds (written) (N=52)	15-16 year olds (written) (N=28)
Naturalistic	29.5%	44.1%	74.8%
Precausal	16.0%	12.0%	7.5%
Phenomenistic	36.5%	37.3%	10.3%
Unclassifiable	18.0%	6.6%	7.4%
(Same data regrouped:)			
Materialistic	61.9%	81.3%	85.2%
Non-materialistic	19.2%	12.1%	7.5%
Unclassifiable	18.9%	6.6%	7.3%

While there is the trend toward "better"[2] answers with age, there is considerable overlap between categories, and the types of explanation varied more from question to question than from age to age. Further, even at the Kindergarten level over 60% of the explanations were materialistic. Deutsche therefore rejected Piaget's notion of stages.[3] While the efficacy of gathering written material was shown, her study is the only one in the literature using the written method; probably this is because of the general agreement that the "real" beliefs of the child must be drawn out, a process which requires follow-up questioning.

An examination of Oakes' (1947) data likewise shows a general improvement of answers with age but a wide range of variation depending on the question. Oakes questioned individually a total of 163 children (Kind., 2nd, 4th, 6th grades) and 35 adults (the adult data were reported elsewhere: Oakes, 1945). In addition, he reported that the wording of the question made a difference ("What made Lake Erie?" vs. "How did the Lake begin?" The latter yielded more "physical" answers - no statistical data given); and that high IQ children in each of the four grades gave better answers than low IQ children.

Granich (1940) compared normal boys of 7-8, normal boys

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[2]The usage of "better" applying to causal explanations, etc., is herein intended to mean more realistic, naturalistic, physical, etc.

[3]This is a judgment of interpretation. Surely Piaget was aware that there was some overlap; he might not have seen Deutsche's data as contradictory to his own theory.

of 13-14, and feeble-minded boys of 13-14 with M.A.'s of 7-8. He found that the answers varied considerably by the problem, but in general the younger normal and the older feeble minded boys were most alike, although there were certain characteristic differences. For one thing, the feeble-minded boys had a better idea of some environmental features such as breathing and radiator heat.

The wording of the question, along with two other variables, was investigated in more detail by Nass (1958), who found a greater number (statistically significant) of "non-naturalistic" answers (1) from "withdrawn" children as opposed to "normal" children, (2) on his questions about less (vs. more) familiar things, and (3) when "Why?" was used in wording the question as opposed to "How?". The withdrawn and normal groups were matched for IQ, and from his findings Nass unjustifiably concluded that withdrawn children have an inferior understanding of physical causality, neglecting the possibility that withdrawn children, construing the interview as more threatening, would be more reluctant to give their best answers.

Ausubel and Schiff (1954) used a device similar to the one employed in the present study. They used a small see-saw with three balance positions (left of center, center, right of center) and asked Kindergarten, 3rd, and 6th grade children to predict which side would fall. Then they covered the fulcrum and placed a red block on one end and a green block

on the other end and again asked which side would fall. The former arrangement they called a "relevant" situation, the latter an "irrelevant". They also gave the two tasks in reverse order for three other groups from the same grades. The children for each order were matched on the basis of scores on a pretest consisting of four demonstrations with predictions (scored 0, 1, or 2); these results, incidentally, showed the usual increase of better answers with age (see Table 4). The results on the see-saw test can be seen in Table 5. This study demonstrates that older children learn better than young-

Table 4: Predictions and Explanations score by age group (from Ausubel & Schiff, 1954)

		Predictions		Explanations	
Group	N	Mean	S.D.	Mean	S.D.
Kind.	46	2.74	.84	1.22	.95
3rd	54	3.11	.83	2.67	.98
6th	48	3.33	.75	4.33	1.62

Note: All differences for means are significant at.01.

Table 5: Results on see-saw task (from Ausubel & Schiff, 1954)

	Group I (Rel. first)				Group II (Irrel. First)			
Grade	Relevant		Irrelevant		Irrelevant		Relevant	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Kind.	3.70	2.74	3.61	2.43	3.48	2.25	3.61	2.84
3rd	2.56	2.53	3.67	2.67	3.07*	2.05	1.41*	2.08
6th	.83*	1.74	4.70*	2.25	3.04*	2.47	.83*	1.74

(* significant at .01)

er children on a "relevant" causal task, but it does not shed much light upon the question of qualitative differences in thought.

Purpose of the present investigation

In an attempt to deal with the question of the mentality of the child regarding physical causality without relying exclusively on the method of verbal questioning, the investigator devised a learning problem using a modification of Ausubel and Schiff's see-saw. A red and a green block (both decorated with decals) were used, with the fulcrum visible. During guessing trials, a light was manipulated in such a way as to entice guessing on the basis of the light position rather than of the side with the red block, which was actually but not apparently heavier. The assumption was made that guessing on the basis of the light, determined by certain critical trials, involves the perception and acceptance of a magical relationship; in contrast, while there is nothing about the red block to make subjects think it will fall on the first trial, guessing by using the red block as a cue involves an appreciation of a simple physical phenomenon. The Ausubel and Schiff experiment indicates that there will not be a great difference in the speed with which children will learn to pick the red block, and presumably this would hold true for the level of learning over a series of trials. In other words, all groups will learn about equally well, but the question is what will they learn? On the basis of Piaget's theory, it was predict-

ed that younger children (with less fully developed causal understanding) would be led astray by the light cue more often than would older children, as measured by the number of light choices on the critical trials.

Method

Subjects

There were four groups of subjects: Nursery, Kindergarten, First Grade, and Second Grade, described in Table 6.

The Nursery children were tested first - during March, 1963 - for pilot purposes. These data have been preserved for presentation here with one change: one of the original subjects was in Kindergarten and was replaced. The first few subjects were tested in the entrance room at the Nursery, but most were tested in a workshop where greater privacy was assured. Many of the children were reluctant to enter a room alone and had to be enticed ("This is a fun game--I think you'll like it"). Several times the investigator lured a reluctant child as far as the door and then explained the game which was now in sight, thereby evoking interest and confidence. Sometimes another person (the mother, a teacher, a friend who had taken the test already) was allowed in the room during testing under directions to stay in the rear and remain silent. Two children became too upset during testing to continue (one was completed later), while one testing was terminated by the experimenter because of the non-cooperation of the subject. The subjects were selected on the basis of availability (being in the right place at the right time and not immersed in some activity) and willingness. There were three groups or shifts represented, each divided into a younger and an older section; the total N of 30 represents a

Table 6: Composition of Groups

	Nursery	Kinderg'n	1st Grade	2nd Grade
School	Spartan Nursery*	Neff Elementary School, Grand Ledge		
N	30	30	30	30
Age Range (months)	38-62	63-81	77-91	90-116
Mean Age	50.5	69.2	85.2	96.8
Male	17	13	13	12
Female	13	17	17	18
Method of Sampling	Opportunity	Random from 2 classes (total= 67)	All members of one class with one older problem child and absentees omitted in each case.	

* with two exceptions, tested in their homes.

Note: All 120 children were White. The Spartan Nursery is provided for employees of Michigan State University; thus the children come from intellectually if not financially superior home backgrounds. The Neff Elementary school serves Grand Ledge, Michigan (a small city about 10 miles west of Lansing), and some surrounding farms. There were two classes at both the First and Second Grade level, not composed so as to differ in ability.

handful from each of six sub-groups.

The other three groups from the Neff School were tested in a large room near their classrooms. All of these children accepted the testing situation and accompanied the investigator to the test room without any visible reluctance, and in most cases with eager anticipation. The Kindergarten group was tested during two days in early April, 1963. Fifteen children were selected from each the morning and afternoon classes by a random number table; this was done in front of the class and those selected were considered quite lucky by the remainder. The First Grade was tested during two days of the following week, and the Second Grade was tested a week later, also during two days.

Due to the exploratory nature of this investigation it was not known in advance just what groups would be tested: hence the serial testing by groups. This procedure has the obvious disadvantage that each group is tested at a different time by a slightly changed tester, but there are advantages in completing the testing in one class as rapidly as possible.

Apparatus

The appartus was a screen, a red and a green block (about 2" x 2" x 4"), a heavy cardboard flap for a stop, a fiberboard shield, and the mounting board, on which was a small see-saw (20" long), 2 mounted flashlight bulbs (set just in front of the ends of the see-saw), and a perpendicular piece of wood to screen the battery and light switch from

the subject. See Figure 1. The green block was hollowed out slightly (not visible to the subject) to make it lighter. Since there is some evidence that young children have difficulty responding to color as a cue (e.g., Miller, 1934), animal decals were added to the blocks to make them more noticeable. A small duck and a squirrel were put on the green block, and a small (slightly different) duck and a cat on the red block. Pyles (1939) showed that familiar animals as cues substantially facilitate recognition in children. Also, the decals probably make the procedure more attractive to the child.

Procedure

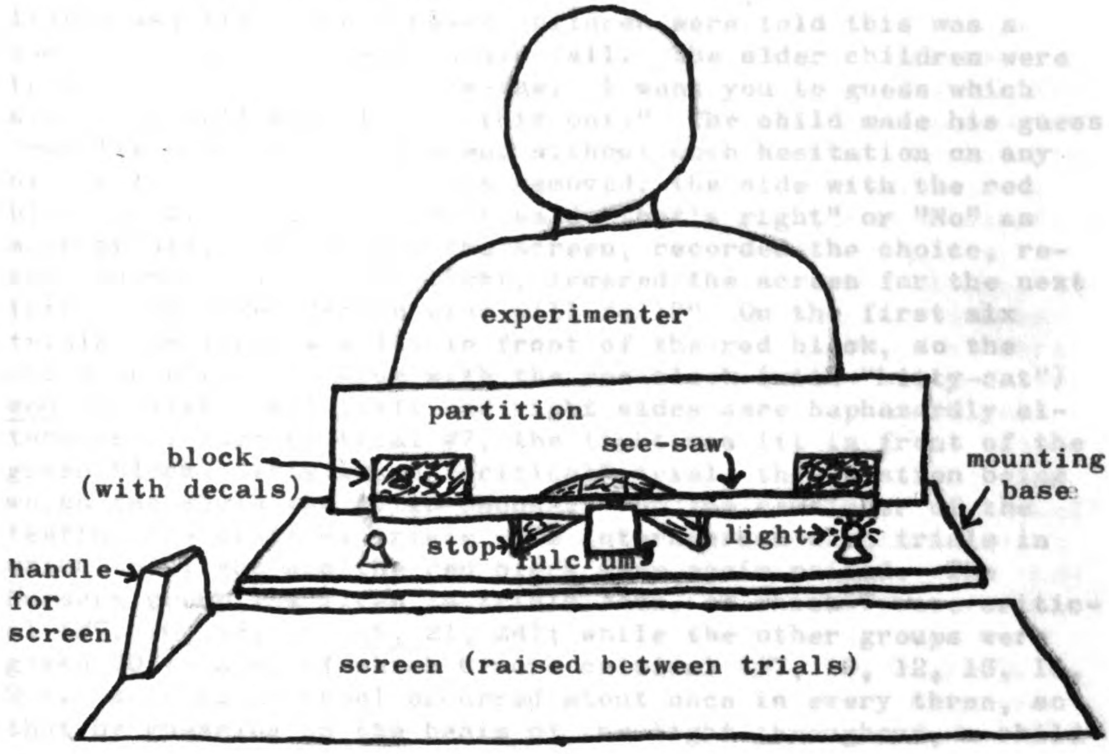
For the Nursery group, the child was in most cases escorted to the testing room by the investigator "to play a fun game", and was made to feel at ease in the testing room. The see-saw test[4] was given and the subject dismissed.

The procedure was more complicated for the Kindergarten, First, and Second Grades. Each child was escorted by the investigator from his class to the testing room. Half in each group were given the see-saw test and then were asked four questions[4] about causality. For the other half this order was reversed. In both groups, after the see-saw test the child was asked to explain what made a particular side fall. At the beginning of the second day of testing for the Kindergartners and prior to it for the First and Second Graders, The Goodenough Draw-A-Man Test (Goodenough, 1925) was admin-

[4]A detailed description of the see-saw test and the questions is given below.

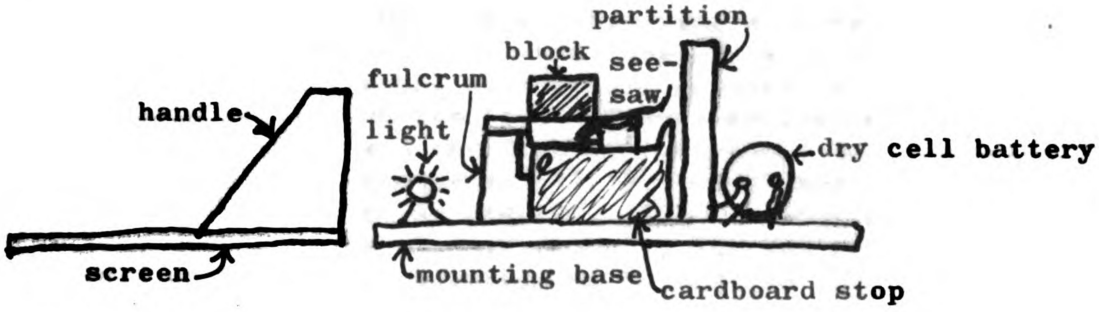
Figure 1: The apparatus

A. Front view as seen by the subject



(subject sits here on opposite side of the table)

B. side view



istered to each class as a whole in the classroom.

The see-saw test The child sat at a table about a foot and a half in front of the see-saw, which was revealed by lowering the screen. The see-saw was held up by stops, the red and the green block were at opposite sides, and one of the lights was lit. The Nursery children were told this was a game to guess which side would fall. The older children were told: "This is a little see-saw. I want you to guess which side will fall when I pull this out." The child made his guess (usually done by pointing and without much hesitation on any of the trials), the stop was removed, the side with the red block fell, the investigator said "That's right" or "No" as appropriate, then raised the screen, recorded the choice, reset the see-saw and the light, lowered the screen for the next trial, and asked "Which side will fall?" On the first six trials the light was lit in front of the red block, so the child observed the side with the red block (with "kitty-cat") and the light fall (left and right sides were haphazardly alternated). But on trial #7, the light was lit in front of the green block. This was a "critical" trial, the question being which cue would the child choose. For the remainder of the testing the critical trials were interspersed with trials in which the light and the red block were again paired. The Nursery group was given 24 trials each, of which 7 were critical (#7, 10, 12, 16, 18, 21, 24); while the other groups were given 20 trials, of which 6 were critical (#7, 10, 12, 15, 18, 20). A critical trial occurred about once in every three, so that by guessing on the basis of the light throughout, a child could still be right much of the time.

Two measures were derived from the see-saw test: (1) Light score: number of light choices on the 6 (or 7 for the Nursery children), and (2) Consistency score: number of correct choices on the 11 (or 14) non-critical trials (light and red block paired) after the first three (by which point other possible cues - position, alternation - can be ruled out). The Consistency score measures how well the child learned the problem when both the red block and the light were on the same side.

The Questions Four questions were formulated by the investigator for the purpose of obtaining a score for verbal answers to causal questions to be compared with the light score. To the degree that verbal answers and guesses on the critical trials both reflect on the "real" causal beliefs of the child, the Questions score and the Light score should be inversely related. The questions were: (1) "How do clouds move?"; (2) "Where does the sun go at night?"; (3) "How does a car move?"; (4) "Why does a piece of wood float on the water?". Each was followed up by further questioning to draw the child out, unless the first answer was considered correct. The answers were scored on a three point scale as follows:

0 points: failure to explain (all "I don't know" answers or silences were followed up by restatements of the problem); any totally irrelevant answer; and religious, magical, or animistic answers (these were rather rare and were given almost exclusively to question 1; examples: "God makes them move." "They follow the cars." "They crawl on their hands and feet.").
1 point: given where an attempted or partial explanation was given in physical terms, as long as it was even slightly relevant. For #1, "The air" without elaboration when queried, or that the clouds move when it rains. For #2, if the child said it goes away and comes back, not necessarily in a different place. For #3, any answers involving parts of the car or actions to start it: the wheels, gas, turn the key, etc. For #4, the follow up to an "I don't know" or a no response was to point out that the chair the child was sitting on would sink if it were thrown into the river, while a piece of wood would float. At this point the answer "the wood is lighter" was pursued by "What about a big log?" If the answer was that it would sink, 1 point was allowed.
2 points: for the correct explanation. For #1, "The wind" or "The air pushes 'em." The investigator decided to accept this and not pursue by asking about the wind, essentially another question. For #2, the idea that the sun goes away at night, comes back in the morning, and in a different place. For #3, "The motor" or the "engine". A 1 point answer was always followed by the question of how that particular part made the car go, which sometimes elicited the correct reply. For #4, "It's light" was accepted if given immediately. If, however, it was necessary to explain about the chair, the requirement was stiffened to also stating that a big log would float, which not many passed.

The scoring was done by the investigator as follows: the answer to each question was written on a piece of paper; the 90 answers to each question were then shuffled and scored. The answers were then shuffled again and rescored to check accuracy and consistency; there was one inconsistency out of 360 answers. As a further check of the objectivity of the scoring, the scoring directions and two sets of answers were each given to two other people. Rater M scored question 1, agreeing with the investigator on 87 out of 90 answers, and question 3, agreeing on 89 out of 90; rater P scored question 2, agreeing on 88 out of 90, and question 4, agreeing on 84 out of 90 (with two disagreements being by two points). For all four questions combined, there was 97% agreement with the investigator.

Results

The means on the Light score, the Consistency score, and the Questions score for each group are given in Table 7. The major hypothesis that the Light score would decrease with age is not clearly confirmed. While the Nursery group had the highest mean and the Second Grade group the lowest, the First Grade had a higher mean than the Kindergarteners. These scores were analyzed by the non-parametric Kolmogorov-Smirnov Test[5] (see Table 8); the only significant differences are between the Second Grade and Nursery (.01) and the Second Grade and the Kindergarten (.05). The Median Test[5] for heterogeneity of means was significant at the .02 level.

The Consistency scores show a uniform increase from the Nursery through the Second Grade, although the means for the Kindergarten and the First Grade are virtually the same. Only the difference between the Nursery and the Second Grade was significant (.05) by the Kolmogorov-Smirnov Test. The Median Test failed to invalidate the null hypothesis of no difference between the means, but the regular order of the means is worthy of note.

The Questions score improves from Kindergarten to First Grade as would be expected, but the Second Grade mean is very slightly below that of the First Grade.

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[5] A description of both the Kolmogorov-Smirnov Test and the Median Test can be found in Walker & Lev, 1953, ch. 18.

Table 7: Mean Light, Consistency, Questions scores by groups

Group	Light	Consistency	Questions
Nursery	2.8	8.0	...
Kindergarten			
TQ	1.9	7.9	4.3
QT	1.1	9.3	2.5
Total	1.5	8.6	3.4
First Grade			
TQ	2.2	8.0	5.9
QT	2.0	9.4	5.5
Total	2.1	8.7	5.7
Second Grade			
TQ	1.0	9.5	5.6
QT	1.2	9.9	5.6
Total	1.1	9.7	5.6

Note: TQ=15 children tested first; QT=15 children questioned first. The extra four trials for the Nursery group have been omitted, so that data for all four groups are based on 20 trials.

Table 8: Cumulative frequency data for Light and Consistency by groups

A. Light: cumulative frequency by score

	0	1	2	3	4	5	6
Nursery	6	10	13	19	22	26	30
Kindergarten	13	14	23	27	28	30	30
First Grade	9	16	18	20	24	29	30
Second Grade	14	23	25	27	28	30	30

B. Consistency: cumulative frequency by score

	0	1	2	3	4	5	6	7	8	9	10	11
Nursery	0	0	0	2	2	5	11	14	14	18	23	30
Kindergarten	0	0	0	0	2	4	7	13	14	15	17	30
First Grade	0	0	0	1	1	4	7	10	11	15	20	30
Second Grade	0	0	0	0	0	1	3	5	9	9	12	30

Note:: The extra four trials for the Nursery group have been omitted, so that the data for all groups are based on 20 trials.

The Questions scores also were treated by an analysis of variance, shown in Table 9. The only two significant sources of variation are Grade Level and Questions (variation from question to question), but the latter is inflated by whatever order effects there are in the four questions. The order of testing and the Grades x Questions interaction are close to significance.

Table 9: Analysis of variance for Questions scores

Source	SS	df	MS	F	P
Grade Level	25.350	2	12.675	15.78	.005
Tested 1st or 2nd	3.025	1	3.025	3.77	.05-.10
G x T	3.717	2	1.859	2.32	NS
Error (a)	67.433	84	.803		
Questions	4.697	3	1.566	2.97	.05
G x Q	6.728	6	1.121	2.12	.05-.10
T x Q	.475	2	.238	.45	NS
G x T x Q	3.184	6	.531	1.01	NS
Error (b)	134.166	254	.528		
Total	248.775	359			

The Draw-A-Man test was scored by the investigator following the scoring directions given in the Manual (Goodenough, 1925). For the purpose of correlating the scores with other measures, the raw score was used. Ratio I.Q.'s were computed and show a mean about 30 points above the average with a fairly normal distribution for all groups (see Table 10).

In the early days of its use this test was found to correlate well (Goodenough gives .714) with the Stanford-Binet, and to have a comparable standard deviation. What then do these unusually high scores mean? That this was a very bright group of youngsters is doubtful for the following reasons: (1) the norms are forty years old, and the test has been shown to be widely influenced by cultural factors; and (2) the investigator later had the opportunity to test individually three children from the Kindergarten class, with the following results: a girl, IQ=192 on the Draw-A-Man, IQ=128 on the Stanford-Binet; a boy, 116 on the Draw-A-Man, 89 on the Stanford-Binet; a boy, 89 on the Draw-A-Man, 64 on the W.I.S.C. Thus it seems likely that the norms for the Draw-A-Man have changed; however, as far as the subject population is concerned, a wide range of abilities is represented. What is not clear is whether the test retains any validity, although in favor of a positive answer is the fact that the scoring scale with norms somewhat lowered has been applied successfully in other cultures (e.g., Greece and India).

The Draw-A-Man test correlations in Table 11 show some discrepancies for the First Graders as compared to the other groups for the Light and Consistency measures - this discrepancy for the First Graders can also be seen in the Light-Consistency correlation - but these could well be due to chance. As a matter of fact, there is not a single correlation involving the Draw-A-Man test that is significantly different from zero. While all groups did show positive correlations be-

Table 10: Draw-A-Man IQ distribution for samples

	Kinder-garten I	Kinder-garten II	First Grade	Second Grade
N	31	36	31	30
Mean IQ	137.4	131.1	131.0	129.8
S.D.	21.5	19.4	19.2	11.6
Lowest IQ	84	83	92	98
Quartile 1	128	120.5	119	124
Median	138	127.5	132	128
Quartile 3	148	137.5	143	137.5
Highest IQ	192	180	170	157

Note: Kindergarten data are divided into groups I and II, based on whether the children were called to participate in the see-saw test (I) or not (II). The former group included 31 children because one extra name was called by mistake. The selections were known to the children before they took the Draw-A-Man. A t-test between the means for I and II showed no significant difference.
The first grade included one child who was absent during part of the see-saw testing and was therefore not given that part.

tween the Draw-A-Man and the Questions, these were quite low. While a relationship between answering questions and intelligence has been reported (Oakes, 1947), the degree of correlation has not been.

Correlation coefficients were computed for each pair of measures (Light, Consistency, Age, Draw-A-Man, and Questions) within each group and are shown in Table 11. Scattergrams were made for each correlation and checked for curvilinearity and for glaring differences within groups for sex and those tested or questioned first. One sex difference was obvious: at the Nursery level girls had a much lower Light score than boys (significant at.01 by the Kolmogorov-Smirnov Test); what this is due to is an open question. There was one obvious curvilinear relationship, the r_{LC} for the Nursery group - a high C score was associated with either a low or a high L score - but overall there was still a mild negative correlation (there were only 3 L scores of 7).

The Light-Age correlations were essentially zero with the exception of the Nursery group, within which there was a significant relationship in the predicted direction. The fact that only one of the four groups showed this relation also speaks against the major hypothesis that the Light score would decrease with age.

Table 11: Intercorrelations among all measures, by groups

	Cons.	Age	DAP	Questions
Light	N=-.323	N=-.374	...	...
	K=-.795	K=+.101	K=-.208	K=+.222
	F=-.491	F=+.153	F=-.088	F=-.008
	S=-.773	S=-.142	S=-.196	S=-.397
Consistency		N=+.254	...	...
		K=-.260	K=+.243	K=-.217
		F=+.246	F=-.078	F=+.073
		S=+.448	S=+.353	S=+.373
Age			...	...
			K=-.239	K=-.104
			F=-.225	F=-.021
			S=+.013	S=+.058
Draw-A-Man (raw score)				...
				K=+.122
				F=+.267
				S=+.053

Note: The Nursery correlations are based on the full 24 trials.
N=Nursery; K=Kindergarten; F=First Grade; S=Second Grade.
The one-sided P values for correlations with N=30 are:
P=.05, r=.306
P=.01, r=.423

The Kindergarten and Second Grade groups have very high negative correlations between Light and Consistency, with the Nursery and First Grade somewhat less so, meaning that those who learned the problem tended to learn it by the red block rather than the light. The other sets of correlations show no consistent relationships. Noteworthy among them is the set for Questions - Light; only the Second Graders showed the expected relationship of high Questions score and low Light score.

The number guessing correctly at each trial is shown in Table 12. As can be seen, by the fourth trial a high proportion of children in each group are guessing correctly, and this proportion does not improve (e.g., compare the number correct on #4, 5, and 6 with the number correct for the last three non-critical trials). Only the Second Graders show an improvement in guessing correctly on the critical trials.

Of particular interest is the number picking the red block on the first trial (Nursery = 16, Kindergarten = 24, First Grade = 17, Second Grade = 20); again there is no clear advance with age (or decrease in Light score), contrary to a prediction implicit in the major hypothesis. Furthermore, when those not guessing correctly on trials #5 and 6 were eliminated, the relationship was even less clear (see Table 13); only the total qualifying by this criterion showed a steady increase by age.

The explanation of the see-saw falling was considered

Table 12: Choices at each trial, totals by groups

Trial	Nursery		Kinderg'n		1st Grade		2nd Grade	
	RL	GL	RL	GL	RL	GL	RL	GL
1.	20*		19*		15*		23*	
2.	17		16		26		24	
3.	14		14		16		19	
4.	21*		26*		27*		29*	
5.	21		25		26		30	
6.	22*		26*		27*		28*	
7.		14*		6*		13*		10*
8.	22		17		13		21	
9.	22		19*		23*		26*	
10.		15		9		14		7
11.	24*		27		24		24	
12.		15		11*		11*		3*
13.	23		23*		25*		28*	
14.	20*		23		21		26	
15.	20*			5		7		5
16.		16*	21*		24*		24*	
17.	23		23		25		28	
18.		12		9*		8*		3*
19.	22		28*		26*		27*	
20.	24*			5		11		5
21.		12						
22.	21							
23.	23*							
24.		8*						

Note: RL column is the number of correct choices on non-critical trials; GL is the number of "light" choices on critical trials. An asterisk* denotes that the choice was made on the subject's right (there was a very slight right hand preference for each group).

Table 13: Choice on Trial #7 counting only those correct on #5 and #6

	Chose Light	Chose Red Block	Total
Nursery	5	13	18
Kindergarten	5	17	22
First Grade	11	14	25
Second Grade	10	18	28

correct if the child mentioned that the red side fell because it was heavier. The results showed an increase by groups with age (correct: Kindergarten =8; First Grade =11; Second Grade =22) and a correct explanation was associated with a low Light score, as was to be expected. Only at the Second Grade level did it matter if the children were first tested or questioned: the former had 8 out of 15 correct, the latter group had 14 out of 15 correct--perhaps because they picked up the verbalization of the idea from question 4 (involving a weight concept), although this did not help them any during the test, where they had a Light score of 18, as compared with 15 for the group tested first (see Table 2).

Discussion

While the method of guessing on see-saw trials was proposed to avoid the entanglements of verbal questions, there is srill no basis for the assumption that when a child says that a particular side will fall he really thinks it will, or that he is really trying to answer correctly and objectively. While most of the children tested operated efficiently in the test situation, many did not for various reasons. Some possible reasons include not caring to do well or not cooperating, making guesses to see what would happen, guessing wrong intentionally, being satisfied to pick the light and be right most of the time rather than find another cue, and being thrown off by a wrong guess. Such a dilemma for the experimenter can be solved by discarding unsatisfactory subjects or by ignoring them and leaving their answers in the data; both of these merhods assume that these effects are not present differentially in any of the groups to be compared. This assumption is sometimes reasonable, but here it is not. One differential factor which stood out was that several of the Nursery children did not seem to take the problem seriously, asking when the "game" would be over, while the Second Graders particularly seemed challenged by the test ("Only two wrong! How many did so-and-so have?").

However, these limitations are present in the verbal questioning method to an even greater degree, because not only is there the stimulus situation of the testing or inter-

view which must be coped with by the child, but his response requires him to deal with words, an ability that improves with age. In the see-saw test, the response required is of a very elementary nature.

The data for the see-saw test showed no clear confirmation of the main hypothesis that the Light score would decrease with age; according to Piaget's theory there should have been a decrease. There was no consistent decrease over the age groups: while the Nursery had the highest average Light score and the Second Grade the lowest, the First Grade had a higher average than the Kindergarten. Regarding the difference between the Nursery and the Second Grade, there are alternative explanations unrelated to the main hypothesis, such as the fact that the former group seemed the least motivated to do "well" in the test situation while the latter group seemed the most motivated. Another explanation is that the Second Graders, being oldest, learned best. The data in Table 11 and 12 support this explanation; there is no clear distinction between the groups in the response to the first critical trial (both for all 30 in each group and for only those who had guessed correctly on #5 and 6), but thereafter the Second Grade children improved on the critical trials and achieved a lower average Light score.

Other ways of examining the data regarding the main hypothesis also do not clearly confirm it. Within the groups only one Light-Age correlation was significant (Nursery), while

the others were essentially zero. The very high correlations between Light and Consistency for the Kindergarten and the First Grade indicate that those who learned a cue well learned the red block cue, and that conversely, those who had high Light scores were haphazardly or inefficiently guessing. This correlation is lower (though not significantly so) for the First Graders. The Nursery correlation was not significant, because three boys consistenly chose the light throughout. This may have been because they had strong magical beliefs, but more likely was because they happened to fix on the light as a cue during early learning and were satisfied to continue using it.

While the Light score does not decrease steadily over the groups, the Questions score does. The questioning was not intended to be a deep or complete examination, but it is an approximation of the child's expression of ideas of physical causality. It is unusual that the First Grade should score higher on the Questions than the Second Graders; what this result is due to is not known-----the answers were scored blindly. At any rate, one of the most obvious conclusions from the Questions data is that the average First Grader has a better understanding of physical causality than the average Kindergartner, but the Light score data show the opposite. Furthermore, even after the First Graders had averaged a higher Light score than the Kindergartners, more First Graders were able to verbally explain why the see-saw fell on a par-

ticular side. This discrepancy between the test and verbal method indicates that verbal answers do not adequately represent the "real" causal beliefs of the child. This being true, what happens is that the child simply must learn to verbalize correct explanations, and gives incorrect answers before this learning has taken place. Just what kind of answers depends upon the cultural context. In our case we live in a culture which considers magical and animistic expressions in children cute, which encourages their formation by fairy tales, animated cartoons (where all sorts of animals act like humans, occasionally trees and cars talk, and any desired object not at hand materializes at a literal snap of the fingers), and by institutions such as Santa Claus and the Easter Bunny. Neither is our adult society free from concepts such as lucky religious statues, rabbits' feet, unlucky days, lucky and unlucky numbers, horoscopes. This interpretation with regard to children's verbal answers is in agreement with Mead's; the difference between the Manus society and ours in this respect is that Western adults actively instill magical and animistic beliefs in their children.

There were other features in the data that deserve mention. For the Kindergarten group it made a difference (just short of statistical significance) on several measures if the children were tested or questioned first. Those tested first had higher Questions scores but also higher Light scores and lower Consistency scores. While this might have been a trans-

fer effect, more likely it was the effect of getting used to being alone in a room with a strange adult. It may be that the Kindergartners performance is sensitive to emotional feelings such as anxiety. At the higher grade levels the order of testing did not make much difference (see Table 7).

Among the predominantly zero correlations in Table 10 there is an interesting feature in the progression of the correlations of the two test measures, Light and Consistency, with the Questions scores. For r_{LQ}, Kindergarten = +.222, First Grade = -.008, Second Grade = +.397; for r_{CQ}, Kindergarten = -.217, First Grade = +.073, Second Grade = +.373. Neither set of correlations is significantly heterogeneous (for both P = .05 - .10), but together they suggest that there may be a progressive ordering toward a relationship between verbalization and performance regarding physical causality. There are, however, other explanations for this trend, such as older children are more at ease in a strange situation and so give a more "typical" performance.

Summary

Children's understanding of physical causality was investigated to test Piaget's theory that the development of causal thought passes through various stages (during which the child's thought is different in kind from adult thought) before a correct physical understanding of environmental phenomena is attained.

A review of the literature showed wide divergences in results based on a method of verbal questioning. Various differences in the conditions of investigation were suggested to account for these divergences. It was further suggested that the method itself does not get data which accurately represent the "real" causal beliefs of the child, and that for this reason a performance measure would be preferable.

There were four groups of 30 children each: Nursery, Kindergarten, First Grade, and Second Grade, all tested individually.

The test situation involved guessing which side of a small see-saw would fall. A red and a green block were placed at opposite ends of the see-saw, and a flashlight bulb was mounted on either side in front of the see-saw. The red block was actually but not apparently heavier than the green block, so whichever side the red one was on always fell. During training trials, the light in front of the red block was lit, so that the light was a correct cue. On certain critical trials the light was lit in front of the green block. The hypothesis

was that children with magical ideas of causality would respond to the red block. According to Piaget's theory, there should be an inverse relation between age and the number of "light" choices on the critical trials.

In addition, the Kindergarten, First Grade, and Second Grade children were asked four questions about causality, and the Goodenough Draw-A-Man test was administered to each group.

The results showed little support for the prediction. There was no consistent decrease in the average number of "light" choices by age, either across or within the groups; furthermore, there was no decrease by age group in the number of Light choices on the first critical trial. At the same time, the Kindergarten group did significantly worse on the Questions than either the First or Second Grade. There was no consistent relation between the Questions and the Light scores within the groups.

The conclusion was that no real evidence was found to support the theory that the causal thought of the child undergoes progressive changes. Regarding answers to causal questions, it was proposed that the young child learns verbalizations, both correct and incorrect, which do not necessarily represent his "real" beliefs.

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