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REPRESENTATION AND TRANSITIVITY

City University of New York

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REPRESENTATION AND TRANSITIVITY

by

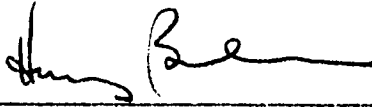
JOSEPH M. O'CONNOR

A dissertation submitted to the Graduate
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partial fulfillment of the requirements
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The City University of New York.

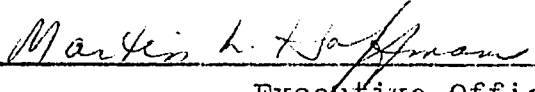
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Abstract

REPRESENTATION AND TRANSITIVITY

by

Joseph M. O'Connor

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Photographs share with other forms of pictorial representation the ability to depict physical objects and scenes. Photographs differ from other media in the impression given that they capture reality more truly than other pictorial forms. This study was concerned with the child's belief as to whether a series of color photographs depicting a transitivity task with illogical or logical outcomes represented reality with greater fidelity than the directly perceived logical and illogical referent events themselves.

240 children, 120 of whom were classified as concrete operational and another 120 classified as pre-operational were presented with a transitivity task using blocks of different height. Either before or after the task, each child viewed a series of color photographic slides depicting the same task. In one condition, the photographic slides were manipulated

causing the task to turn out illogically. In a contrast condition, the actual objects were manipulated in the same fashion. At the conclusion of both tasks, children were asked to make a judgment concerning the way the blocks "really" should have turned out. The results showed the compelling influence of the photographic depiction, which was influenced, however, by order of task presentation, correctness versus incorrectness of the photo, and the child's operational level. These results are contrasted with those of a study in which the task was conservation where the effects were similar in some respects and different in others.

Acknowledgments

I would like to express my sincere appreciation to Dr. Harry Beilin, not only for his intellectual guidance but for his encouragement and support throughout this project. I would also like to thank Dr. Joseph Glick for his illuminating insights and suggestions. Finally, a special note of thanks to my colleague Gary Kose, who helped in ways too numerous to mention.

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REPRESENTATION AND TRANSITIVITY

The purpose of this investigation was to examine the nature of the relationship between physical knowledge (specifically, knowledge of photographic representation) and logical knowledge. This was accomplished by presenting children at different cognitive levels (preoperational and concrete operational) with a color photographic slide presentation depicting a transitivity task (Piaget, 1970), and also having these same children perform this task using actual objects. The experiment was designed in such fashion that some of the children witnessed an incorrect ending to the slide presentation (and a correct ending with the actual objects), whereas for other children, the situation was reversed. There were two incorrect endings (termed "illogical" and "absurd") for both the slide presentation and the actual task. The difference between these endings concerned the magnitude with which each departed from the expected logical reality. There was, in addition, a base-line condition, in which children were administered two actual transitivity tasks (one turning out correctly and the other incorrectly).

Piaget specifies within his theory different forms of knowledge. These include: operative (which is divided into logico-mathematical and physical), and figurative knowledge (Piaget, 1971, 1977). These forms of knowledge are intimately related and do not as such constitute different kinds of knowledge but rather, are different

components within an overall knowing system. Within this system, each component serves a different function. In the present analysis of photographs, the role played by each knowledge component will be examined separately, although reference will be made to the interrelation Piaget proposes between them. Following this, there will be a discussion of various viewpoints on what is involved in photographic comprehension.

Operative knowledge

According to Piaget, operative knowledge is that portion of knowledge which is active, dynamic and transformational (Piaget, 1977). Its central feature is that it transforms reality rather than simply copying it. Piaget (1971), refers to operative knowledge as "knowledge as assimilation". By this, Piaget is referring to the idea that operative knowledge is attained as a result of the organism acting on the environment and transforming (i.e., modifying or changing) it and thereby discovering both the nature of reality and the results one's actions have upon that reality.

Operative knowledge is divided by Piaget into two categories: logico-mathematical knowledge and physical knowledge (Piaget, 1977). The difference between these forms of operative knowledge centers around how they are acquired and the kind of knowledge that is obtained. Logico-mathematical knowledge is knowledge of the organization of one's actions which is derived by what

Piaget refers to as reflexive abstraction (Piaget, 1969, 1971). When using reflexive abstraction, one derives information from the coordination of the physical or mental action that may be carried out on an object or set of objects. For example, the fact that counting a row of pennies from right to left eventuates in the same total as counting from left to right, would be logico-mathematical knowledge. The emphasis is almost totally on the activity of the organism and the object or objects play a rather secondary supportive role. The object in a sense is simply a vehicle which is utilized in the service of thought.

That form of operative knowledge which is referred to as physical knowledge is derived by what Piaget calls simple abstraction (Piaget, 1969, 1971). In this case, the person abstracts not knowledge of actions on objects, but rather, knowledge of the object itself. Knowing that a penny is a relatively hard object, or knowing that it functions as a form of money would be physical knowledge. According to Piaget, logico-mathematical knowledge is by far the more powerful form of knowledge and determines what physical knowledge is acquireable at any given moment. However, logico-mathematical knowledge (especially for young children) does not exist in a vacuum, but has its realization in specific content areas. The general concept of conservation, for example, is logico-mathematical in its purest form ("conservation is a

necessary condition for all rational activity", Piaget, 1965, p.3), however, it has its realization in a variety of contents, e.g., number, liquid, mass, etc. Piaget has, until quite recently, emphasized the nature and development of logico-mathematical knowledge and paid relatively little attention to physical knowledge. In an attempt to relate physical knowledge to logico-mathematical knowledge, Inhelder, Sinclair & Bovet (1974) have suggested that physical knowledge can have an effect upon logico-mathematical knowledge, but only if, a) the subject is already on the threshold of attaining the logico-mathematical knowledge (what Inhelder, 1977 p. 64 refers to as "zone of assimilation capacity"), and b) only if the physical knowledge causes friction or conflict between already acquired (but still incomplete) forms of logico-mathematical knowledge. A large number of training studies (see Beilin, 1976; 1978) have shown, however, that other sorts of experiences can also affect one's logico-mathematical knowledge.

Figurative knowledge

The third category of knowledge proposed by Piaget is figurative knowledge. The major difference between this form of knowledge and the two forms of operative knowledge is that figurative knowledge does not involve a transformation of reality (Piaget, 1977). Rather, figurative knowledge is an act of knowing that is geared toward the organization of sensory data. The focus here

is on the external aspects of an event, as in the fact that the wall I am looking at has a crack in it. Piaget (1969) proposes that in young children, figurative knowledge predominates over operative knowledge. Thus, a young child will assume that when water is poured from a wide glass to a narrow glass (and the water level rises), there is then more water in the narrow glass because it looks like more. Figurative knowledge, then, consists of the picking up of the specific configuration of an object (i.e., what an object looks like).

Piaget outlines three instruments of figurative knowledge or three ways in which figurative knowledge is acquired. These are, perception, imitation, and mental imagery. Perception is the most fundamental in that the very act of perceiving involves paying attention to the figural aspects of an object. Imitation is essentially the figurative counterpart of motor activity to an external event (which is gradually deferred), whereas the mental image is a kind of internalized imitation (Piaget, 1971). So called deferred imitation and mental imagery differ from perception and overt imitation in that they are symbolic. Piaget uses the term semiotic function to refer to those forms of activity or behavior wherein that which is not present is represented to the self in some fashion.

In addition to deferred imitation, Piaget includes within the semiotic function, symbolic play, drawing and

language. All semiotic activity is subordinate to operative knowledge (Piaget, 1969).

Recent consideration of semiotic activity has brought into question its subordinate relationship to operative knowledge (e.g., Ausubel, 1965; Beilin, 1976, 1980).

Beilin has argued for the semi-autonomous nature of language, and its ability to influence logico-mathematical knowledge. The important difference between Beilin's and Piaget's approach to language is that, for Piaget, language is a semiotic tool which simply serves thought, it does not and cannot alter logico-mathematical knowledge (except perhaps in the formal operational stage). For Beilin, language itself is an action (in Piaget's sense of the term) and therefore is capable of modifying logico-mathematical knowledge. Further Beilin proposes that language as a function of being a representational medium, has its own set of semi-autonomous rules, which are in a sense, the linguistic analog of Piaget's logico-mathematical principles (see Beilin, 1980, for a discussion of the problems concerning Piaget's notion of "action"). For Beilin then, language is not merely figurative knowledge, representing sensory data, but in addition, involves a domain of physical knowledge that defines this particular medium's functions and limitations.

Pictorial representation

Pictorial representation constitutes another form of semiotic activity. Following Beilin's thesis concerning

language, it is proposed that this form of representation involves not only the presentation of figurative information, but also involves a domain of physical knowledge which, similar to language, determines this medium's particular functions and limitations. The present investigation of picture perception is based on the premise that picture perception and comprehension are semiotic activities in which the pick-up of figurative (sensory) information, and the recognition of how sensory information (physical knowledge) in pictures should be used are critical. From this perspective, two important points of focus arise. The first involves the description of the characteristics of the physical knowledge of pictures, which will be of tangential concern in this study, while the second concerns the relationship between this domain of physical knowledge and logico-mathematical ways of knowing, which is the central focus of this study. An examination of the various approaches to picture perception and comprehension will suggest the kind of information that pictures involve, as well as imply the various relationships that may exist between specific physical knowledge and more formal logical knowledge.

Perhaps the most direct way to comprehend the nature of pictorial representation is by way of the perceptual mechanism. J.J. Gibson (1960, 1971, 1979) poses such an explanation of pictures. According to him, knowledge

of pictures is acquired by perceiving the equivalent light relations between the real world and information depicted in the picture. Consequently, picture perception is a by-product of learning how to perceive the real world. In line with this position, Hochberg & Brooks (1964) found that a 19-month-old child raised in a pictureless environment could recognize line drawings and black and white photographs of familiar objects. Dirks & Gibson (1977) similarly demonstrated that children as young as 22 months could recognize familiar faces depicted in color photographs. There is also cross-cultural evidence which shows that young children in pictureless cultures are capable of identifying objects in photographs (Jahoda, Deregowski, Ampene & Williams, 1977).

Hagen (1978), in reviewing Gibson's position suggests that the perception of the equivalent light depicted in pictures, corresponding to environmental light, may require a pictorial mode of perceiving to compensate for the distortions inherent in two-dimensional representation. Hagen proposes that in accurately perceiving the information contained in pictures, it is important to perceive the flatness of pictures as a cue to the perception of depth. Distortions of size must be compensated for by what is referred to as the "zoom" effect, i.e., seeing pictorial information at ten times the size of the item depicted. Thus, within the Gibsonian framework, pictures

are a presentation of equivalent sensory, or figurative information. The perception of this information seems to be a product of the perceptual mechanism, and for all intents and purposes, is distinct from logico-mathematical thought.

Sigel (1978) on the other hand, proposes a cognitive interpretation of pictorial comprehension in a Piagetian framework. Sigel argues that children have to learn to perceive pictures. He contends that identification or recognition of a picture does not necessarily imply understanding or comprehension of the picture. Here, comprehension refers to the ability to abstract meaning from the picture, i.e., to understand that it represents, and is therefore related to, some object. At the most basic level, picture comprehension is characterized as comparable to comprehension of written language. Although pictures and language may have different rule systems, both are reducible to a common cognitive core which deals with knowledge of representational forms. Sigel, in discussing comprehension of pictures, suggests that such comprehension is another instance of conservation (i.e., in this case conservation of meaning) and concludes that pictorial comprehension becomes possible only when the general principle of conservation begins to emerge. Consistent with Piaget's epistemological theory, pictures, as proposed by Sigel, are subordinate to logico-mathematical knowledge. The problem with Sigel's formulation

is that it does not take into account the unique properties of pictures. In other words, what it is that pictures do differently from or better than other forms of representation. This is not to say that logico-mathematical knowledge may not influence pictorial comprehension, as Sigel suggests, but rather, it is suggested further that physical knowledge (i.e., beliefs or rules) about pictures may reciprocally have an influence upon logico-mathematical knowledge. In a study by O'Connor, Beilin, & Kose (1979), preoperational and concrete operational children were shown either a series of color photographic slides or a series of line drawings that depicted a young child carrying out a standard conservation of liquid task. The last slide or drawing of each series depicted an illogical ending; the water levels in the standard and wide glasses came to the same height, instead of the level in the wide glass being lower as one would expect. Each child responded to the same conservation of liquid task using the actual glasses etc. Carrying out the task with real objects resulted, of course, in different water levels. (In another condition, the situation was reversed, i.e., the photo or drawing turned out correctly and the real objects incorrectly.) Half of the children in each cognitive level did the actual task first and the other half witnessed the photographs or drawings first. Upon completion, each child was asked the "really" question, i.e., "which is the way the

water really should look". The results of this study indicated that in general, actual objects were more believable than photos, and photos were more believable than drawings. Combining the photo-actual and the drawing-actual results revealed that the actual objects were selected as the true depiction 63% of the time and the representation (photo or drawing) 34% of the time. An examination of the photo-actual condition revealed that the actual objects were selected 56.3% of the time and the photo 39% of the time. In the drawing-actual condition these numbers were 70% and 30% for the actual objects and drawings, respectively. The results further indicated a strong primacy effect for photos and actual objects (when compared with photos or drawings), however, there was no such effect for drawings. This primacy effect was found to interact with illogicality, i.e., if the initial presentation turned out illogically, there was a strong tendency to select it as the true depiction. Concerning cognitive level, it was found that concrete operational children had less difficulty with the "really" question than preoperational children. Finally, in a base-line referent materials condition, subjects were presented with two actual conservation tasks, one of which turned out illogically. In this case, there were no primacy effects, suggesting that the above findings resulted from the fact that a pictorial representation

was involved in the comparison.

The present research was meant to serve as both a contrast and an extension of the O'Connor, Beilin, & Kose experiment. This was accomplished by presenting children with color photographic slides depicting a transitivity of size task. The logic behind using a transitivity task was that, as Miller & Lipps (1973) have suggested, transitivity bears a different relationship to physical reality from conservation. Conservation is tied to specific real world referents. Conservation of liquid for example, is associated with knowledge of liquids. In conservation, the child must deal with the effects of a variety of transformations in numerous content domains that have differing effects depending on the domain in question (e.g., a particular transformation may conserve weight but not length). In transitivity, on the other hand, there are no transformations, and the same rules are directly applicable whatever the properties of the objects. In line with this hypothesis, Miller and Lipps found that transitivity of weight was more difficult to extinguish than conservation of weight. They concluded that transitivity, more than conservation, may entail feelings of logical necessity. It is conceivable therefore, that this difference may have a direct bearing on how children react to and interpret departures from logical reality in photographs as opposed to actual objects.

In its traditional form (see Piaget, Inhelder, & Szeminska, 1960), the transitivity task involved either different sizes or different weights, and consisted of three separate stages. First, two quantities would be directly compared, A with B. Then, one of these quantities would be directly compared with a third, B with C. Finally, the child would be asked about the relations between the two quantities which had not been compared directly, A with C. The third stage, presumably involves an inference. That is, in order to answer the A-C question the child must combine the information from the separate direct comparisons between A and B and B and C.

The present study served as a contrast to the O'Connor et al., conservation study in that comparable experimental conditions were employed except for the concept in question, which was that of transitivity. The present study served as an extension of the previous work in two ways. First, instead of simply using one incorrect ending, in the transitivity task there were two degrees of "wrongness" as possible outcomes. These were labeled "Illogical" and "Absurd", respectively. In the "illogical" ending, the smallest block became the same height as the tallest block, i.e., $A < B$, $B < C$ and then $A = C$. In the "absurd" ending, the smallest block became even taller than the largest block, i.e., $A < B$, $B < C$, and then $A > C$. The reason for using these two conditions

was to see how the young child's notions regarding photographs and transitivity would fluctuate as a function of further departures from reality. Second, in an attempt to further probe the child's understanding, the child's rationale was required for judgments to the "really" question.

METHOD

Subjects

The subjects were 265 white, middle-class first grade children drawn from parochial schools in the New York metropolitan area. It was necessary to pretest this number of children to obtain 120 who were concrete operational and 120 who were preoperational, as defined below. The remaining 25 children were classified as transitional, or their assigned group was already filled and they were not used in the study. As shown in Tables 1 and 2, there were twenty-four treatment conditions, twelve for each cognitive level. Table 1 outlines the sixteen conditions which involved photographic/actual objects treatments, and Table 2 outlines the eight conditions (referred to as referent material treatments) which involved the comparison of two actual tasks. A four-way analysis of variance (Cognitive level by Treatment by Mode Correct by Degree of Wrongness) performed on the age data reported in Table 1 revealed significant age differences for Cognitive level, $F(1,143) = 4.223, p < .05$, and Treatment, $F(1,143) = 21.162, p < .001$. The average age of the preoperational children was 6:6 years and of the concrete children, 6:8 years. A three-way analysis of variance (Cognitive level by Treatment by Degree of Wrongness) performed on the age data reported in Table 2 revealed no significant effects for age. The average age of the preoperational children was 6:8 years and

Table 1
PHOTOGRAPHIC/ACTUAL OBJECTS TREATMENTS

<u>T^a</u>	<u>Number of Subjects</u>	<u>Mean Age</u>	<u>Age Range</u>	<u>Operational Level</u>	<u>Order</u>	<u>Mode Correct</u>	<u>Degree of Wrongness</u>
1	10	6:6	6:5-6:10	Concrete	picture 1st	actual	absurd
2	10	6:9	6:8-7:1	Concrete	picture 1st	actual	illogical
3	10	6:8	6:4-7:2	Concrete	actual 1st	actual	absurd
4	10	6:6	6:0-7:1	Concrete	actual 1st	actual	illogical
5	10	6:9	6:5-7:2	Concrete	picture 1st	picture	absurd
6	10	6:9	6:5-7:2	Concrete	picture 1st	picture	illogical
7	10	6:7	6:4-7:0	Concrete	actual 1st	picture	absurd
8	10	6:7	6:5-7:1	Concrete	actual 1st	picture	illogical
9	10	6:7	6:2-7:2	Preoperation	picture 1st	actual	absurd
10	10	6:7	6:3-7:2	Preoperation	picture 1st	actual	illogical
11	10	6:5	5:8-7:1	Preoperation	actual 1st	actual	absurd
12	10	6:4	5:8-6:9	Preoperation	actual 1st	actual	illogical
13	10	6:9	6:5-7:2	Preoperation	picture 1st	picture	absurd
14	10	6:9	6:4-7:2	Preoperation	picture 1st	picture	illogical
15	10	6:5	5:8-7:0	Preoperation	actual 1st	picture	absurd
16	10	6:3	5:9-7:2	Preoperation	actual 1st	picture	illogical

^aT = Treatment

Table 2

REFERENT MATERIALS TREATMENTS

<u>T^a</u>	<u>Number of Subjects</u>	<u>Mean Age</u>	<u>Age Range</u>	<u>Operational Level</u>	<u>Order</u>	<u>Degree of Wrongness</u>
1	10	6:9	6:4-7:3	Concrete	correct 1st	absurd
2	10	6:8	6:0-7:3	Concrete	correct 1st	illogical
3	10	6:10	6:5-7:4	Concrete	incorrect 1st	absurd
4	10	6:8	6:0-7:4	Concrete	incorrect 1st	illogical
5	10	6:7	6:4-7:2	Preoperation	correct 1st	absurd
6	10	7:0	6:8-7:5	Preoperation	correct 1st	illogical
7	10	6:7	6:3-7:3	Preoperation	incorrect 1st	absurd
8	10	6:7	6:3-7:2	Preoperation	incorrect 1st	illogical

^aT = Treatment

the concrete children, 6:9 years. Correlational analyses of age and performance on each of the dependent measures revealed that age was not significantly associated with performance.

Materials

Piagetian tests for operational level

A conservation of number task, using 14 pennies, and for a seriation task, eight wooden sticks ranging from 2 inches to 4 inches in length.

Transitivity test

In this task, eight wooden blocks of varying size and color were used. Four of the blocks were painted green. Two of these green blocks were $4\frac{1}{2}$ inches in height, another was $5\frac{1}{2}$ inches and the last 6 inches. Also, two white blocks, 5 inches in height, and two red blocks, $5\frac{1}{2}$ inches in height, were used.

Photographic color slides

A series of 15 2-inch by 2-inch color photographic slides were developed. The slides were presented on a Kodak carousel projector. The slide series depicted a young child going through a standard transitivity task. In the first slide, the child was shown sitting at a table. On the table were three blocks, i.e., the green block ($4\frac{1}{2}$ inches in height), the white block (5 inches) and the red block ($5\frac{1}{2}$ inches). The blocks were lying down on the table in such a pattern so as to make height comparisons very difficult. In the next slide

the child was shown putting the green block in an upright position. Following this, the child put the white block upright. Next, a close-up of the green and white blocks, etc. The last slide in the presentation showed the red block ($5\frac{1}{2}$ inches) with a green block. However, there were three different versions of this last slide. In the correct version, the green block turned out, as one would logically expect, smaller than the red block. In the "illogical" version, the green block was the same size as the red block (i.e., the $5\frac{1}{2}$ inch green block was substituted prior to taking the last slide). In the "absurd" version, the green block was larger than the red block (i.e., the 6 inch green block was substituted prior to taking the last slide).

Procedure

Both the conservation of number and the seriation task followed the procedures outlined by Inhelder, Sinclair & Bovet (1974).

Conservation of number

The experimenter laid out a row of seven pennies and asked the child to put the same number of pennies in another row. If the child did not put the pennies in one-to-one correspondence, the experimenter did so. The experimenter, by verbal interrogation, made certain that the child appreciated the numerical equivalence of the two rows. One of the rows was then modified by spreading it further apart (in front of the child), and

the child was then asked, "Are there as many pennies in this row (the extended row) as in this row (the standard), or are there more?" The experimenter then asked the child to explain how he arrived at his answer. The experimenter then put the pennies back into one-to-one correspondence and, after the child again asserted the numerical equivalence of the two rows, pushed the pennies of one of the rows together. The experimenter then asked, "Are there as many pennies in this row (the squashed row) as in this row (the standard), or are there less?"

Seriation

The child was presented with eight sticks in a pile. The experimenter asked the child to "make a staircase" by lining up all of the sticks, one beside the other. If the child failed to comprehend the instructions, the experimenter lined up a maximum of three sticks (i.e., the three smallest sticks) in the correct order and asked the child to complete the set.

If the child passed both the conservation of number and the seriation task he was judged concrete operational. If he failed both of these tasks, he was judged preoperational. The rationale for using these particular tasks was that conservation of number (i.e., discontinuous quantity) is a fairly early appearing concrete operational skill and therefore performance on this task can be considered a good estimate of whether a child has entered the concrete operational stage. Seriation on the other

hand, is a more advanced skill and, according to Piaget, "brings on the immediate understanding of transitivity", 1977, p.36). Thus a child who passes both conservation of number and seriation would not only be concrete operational but in addition, would be presumed to have knowledge of transitivity. (Youniss & Dennison, 1971, further corroborate Piaget's claim that transitivity is linked to seriation ability.) A child who fails both tasks, is not only preoperational, but also, according to this position, should have little or no understanding of transitivity.

Finally, if a child passed only one of these tasks, or if the child fluctuated in his answers, he was not used as a subject.

Experimental Task

Photographic/Actual objects conditions

In these sixteen different treatment conditions (outlined in Table 1), each child was individually given an actual transitivity task and was shown the photographic slide series of transitivity. In half of these conditions, the photographs were witnessed first and in the other half the actual task was given first.

In the photographic presentation, the child was told that he would be seeing some pictures of a child playing with some colored blocks. He was also informed that he would be asked some questions concerning the pictures. When the first slide was presented, the child

was asked to tell what he saw in the picture. After this, the next slide was shown, and again the child was asked what he saw. None of the children had any difficulty answering these questions. When the slide which depicted the close-up of the green block ($4\frac{1}{2}$ inches tall) and the white block (5 inches) standing next to one another was presented, the child was asked, "Which block is taller?" Later in the series, when the close-up of the white block (5 inches) and the red block ($5\frac{1}{2}$ inches) was presented, the child was asked, "Which block is smaller?" The next slide showed the child laying down the white and red blocks. At this point, the projector was turned off and the child was asked the same questions again, i.e., Which block was bigger, the white one or the green one; and "Which block was smaller, the red one or the white one". If the child did not remember both relationships, the slide presentation was re-run and the questions asked again. (The vast majority of children were successful on the first try, and no child needed more than one re-run.)

Once it was ascertained that the child remembered both relationships, the experimenter said, "If the child in the picture now stands up the red one with the green one, which block will be taller?" After the child answered, he was asked "How did you figure that out?" Both the judgment and the rationale were recorded. Following this, the slide projector was turned back

on, and a slide presented that showed the child putting upright a green block with the red block. The last slide showed a close-up of a green block and the red block, and depending on the condition (see Table 1), the green block either turned out correctly i.e., shorter than the red block, illogically, i.e., the same height as the red block, or as absurd, i.e., taller than the red block. No verbal feedback was given to the child at this point or at any point during this procedure. Either before or after witnessing this slide presentation, the child carried out an actual transitivity task, using the same blocks depicted in the slides. The experimenter would take the green block ($4\frac{1}{2}$ inches), and the white block (5 inches) out of a box (which was out of view of the child), and would place them upright next to each other. The child was asked, "Which block is taller?" The green block was then put away and the experimenter took out the red block ($5\frac{1}{2}$ inches) and stood it next to the white block and asked the child, "Which block is smaller?" Following this, the white and red block were returned to the box and the child was asked the same questions again, i.e., which block was bigger, the white one or the green one, and which block was smaller, the red one or the white one. If the child did not remember both relationships the task was re-run. Once it was ascertained that the child remembered both relationships, the experimenter asked,

"If we take out the red block and the green block and stand them next to each other, which one would be taller?" After the child answered, he was asked, "How did you figure that out?" Again, both judgment and rationale were recorded. Following this, the experimenter took out a green block and the red block. Depending on the condition, the experimenter either took out the original green block, which was smaller than the red block, or a green block which was the same height as the red block or the green block which was taller than the red block. As with the photographs, the child was given no feedback by the experimenter at any time.

Thus, each child either witnessed the actual objects turn out correctly and the photos incorrectly or vice versa. After completing both tasks, the experimenter asked the child to compare the appearance of the blocks in the last slide with the appearance of the actual blocks. All of the children confirmed that they saw a difference in appearance. The experimenter asked the child to explain what the difference was to make sure that the child was referring to the height discrepancy. The experimenter then asked the child the "really" question. Although the form of this question remained constant, the specifics changed as a function of which condition the child was in. For example, when the photographs turned out illogically, the question went as follows: "The child in the picture played exactly the same game

we did, didn't he?"(All children said yes). "He also used the same blocks that we used didn't he?"(again all said yes). "When he put the green block next to the red block, it was as tall as the red one, right?" (again all said yes). "When we put the green block next to the red block, it was smaller. Which is the way the blocks really should look, should the green one really be as tall as the red one as it is in the picture or should the green one really be shorter than the red one as it is here (actual objects)". After the child answered, the experimenter said, "How did you figure that out?" The experimenter recorded both the judgment and the rationale.

Referent Materials conditions

The procedure in these conditions (outlined in Table 2) was the same as in the photographic/actual object treatment conditions except that both transitivity presentations were given with actual objects, instead of one involving photographic slides. Again, children were asked for transitivity judgments and rationales, and, following both tasks, were asked the "really" question and rationale.

RESULTS

Photographs/Actual Objects

Following the presentation of both the actual blocks and the slide presentation, children were confronted with both the last slide and the final array of blocks, one of these (either the slide or the actual blocks) was either illogical or absurd, depending on the particular condition. Each child was then asked the "really" question (see method section). The children were scored either correct or incorrect. Children received a "correct" if they chose the array of blocks (either in the photographs or the actual) that were logically correct i.e., A<C. Following their choice, children were asked to provide a rationale. The rationales were classified into one of five possible categories (see below). A reliability analysis showed 92% agreement between two judges.

A four-way analysis of variance, Cognitive level by Treatment by Mode Correct by Degree of Wrongness was performed on children's responses to the "really" question. Also, five independent four-way analyses of variance were performed on the number of responses in each of the five rationale categories.

Really Question Response. The results of the analysis of variance revealed a significant main effect for Cognitive level, $F(1, 144) = 5.023, p < .05$, Treatment, $F(1, 144) = 6.837, p < .01$ and Degree of Wrongness, $F(1, 144) = 13.954, p < .001$. There was a

significant Treatment by Mode Correct interaction,
 $F(1, 144) = 16.884, p < .001$.

The effect of Cognitive level can be seen in Table 3. The concrete operational children gave significantly more correct responses to the "really" question than the pre-operational children (i.e., 71.2% as opposed to 56.3%). With regard to the Treatment effect, Table 3 reveals that the children in the photo first condition gave 55% correct responses, which was significantly less than the 72.5% in the actual first condition. The effect of Degree of Wrongness was due to the fact that children who witnessed the illogical outcome gave significantly fewer (i.e., 51.3%) correct responses than children who witnessed the absurd ending (i.e., 76.3%). It appears that Cognitive level, Treatment, and Degree of Wrongness independently influenced the childrens' responses to the "really" question. Interestingly, the Treatment by Mode Correct interaction (presented in Table 4) indicates that the photo first condition had a significant effect on whether the child chose correctly. Children who witnessed the slide presentation first, with either an illogical or absurd ending and then witnessed the actual presentation (ending in a logical fashion) gave significantly fewer correct responses to the "really" question than children in the other conditions ($p < .01$ in all cases); most notably, they gave significantly fewer correct responses than children in the actual first, photo-correct condition. In other words, witnessing the illogical

Table 3

Percentage of correct responses to the "really" question as a function
of Cognitive level, Treatment, and Degree of Wrongness
(Photographic/Actual Object Condition)

<u>Cognitive Level</u>	<u>Treatment</u>				<u>Mean %</u>
	<u>Photo first</u>		<u>Actual first</u>		
	<u>Illogical</u>	<u>Absurd</u>	<u>Illogical</u>	<u>Absurd</u>	
Preoperational	40.0	50.0	45.0	90.0	56.35
Concrete Operational	55.0	75.0	65.0	90.0	71.25
Mean %	47.5	62.5	55.0	90.0	

Table 4

Percentage of correct "really" responses as a
 function of Treatment and Mode Correct
 (Photographic/Actual Object Condition)

<u>Treatment</u>	<u>Mode Correct</u>		<u>Mean %</u>
	<u>Photo</u>	<u>Actual</u>	
Photo first	72.5	37.5	55.0
Actual first	62.5	82.5	72.5
Mean %	67.5	60.0	

or absurd photographs first significantly decreased correct responding to the "really" question, whereas witnessing the illogical or absurd ending first, with the actual objects, did not deflate performance in the same manner.

Rationales for the "Really" Question. To further analyze children's reasoning concerning the "really" question, each child was asked to give a rationale for his answer. The following categories were utilized:

- 1) "unintelligible", a rationale which makes no reference to any aspect of the problem and is essentially meaningless, e.g., "because" etc.
- 2) "photographic", rationale, a rationale which relies on the appearance of the photograph (regardless of whether it was wrong or right), e.g., the child might say "because I can see it in the photo".
- 3) "actual object" rationale, a rationale which relies on the appearance of the actual objects (regardless of whether they were wrong or right), e.g., a child might say "because I can see it here" (referring to the actual blocks).
- 4) "trick", a rationale which is based on the idea that somehow a "trick" has been carried out either in the photograph or with the actual objects, e.g., the child might say "because this is some kind of a trick".
- 5) "logical" rationale, a rationale based on the idea that regardless of how the blocks turn out (either in

the photo or actual), they must maintain their logical size relationships, e.g., the child might say "the red one was bigger than the green one and it has to stay that way all the time". A breakdown by cognitive level for each type of rationale is presented in Table 5 . Five independent four-way analyses of variance were performed on the frequencies of each type of rationale.

"Unintelligible". The analysis of variance performed on the number of "unintelligible" rationale's revealed a significant main effect of Treatment, $F(1, 144) = 3.927, p < .05$. A significant Cognitive level by Treatment interaction, $F(1, 144) = 10.909, p < .01$, and a significant Cognitive level by Treatment by Degree of Wrongness interaction, $F(1, 144) = 3.927, p < .05$.

The main effect of Treatment is illustrated in Table 6. The children in the photo first condition gave "unintelligible" rationales 33.7% of the time, which was significantly less than the 48.7% given by the children in the actual first condition.

Pairwise comparisons indicated that the Cognitive level by Treatment interaction was due to the preoperational children giving significantly fewer "unintelligible" rationales in the photo first condition than either the preoperational children in the actual first condition and also significantly fewer than the concrete operational

Table 5

Percentage of rationales given for "really" question response as a function of Cognitive level(Photographic/Actual Object Condition)

<u>Cognitive Level</u>	<u>Rationale</u>				
	<u>Unintelligible</u>	<u>Photo</u>	<u>Actual Object</u>	<u>Trick</u>	<u>Logical</u>
Preoperational	40.0	13.7	12.5	20.0	13.7
Concrete Operational	42.5	13.7	10.0	23.7	10.0

Table 6

Percentage of "unintelligible" rationales given for
 "really" question response as a function of Cognitive
 Level and Treatment(Photographic/Actual Object Condition)

<u>Cognitive Level</u>	<u>Treatment</u>		<u>Mean %</u>
	<u>Photo first</u>	<u>Actual first</u>	
Preoperational	20.0	60.0	40.0
Concrete Operational	47.5	37.5	42.5
Mean %	33.7	48.7	

children in the photo first condition ($p < .01$). In the actual first condition, the inverse occurred. The preoperational children gave significantly more "unintelligible" rationales than the concrete operational children in the same condition ($p < .01$). Thus, witnessing the photo first tends to increase the probability that a preoperational child will give something other than a "unintelligible" rationale, on the other hand, witnessing the actual first condition tends to serve the same function for the concrete operational children.

"Photographic" rationale. The analysis of variance performed on the number of "photo" rationales revealed a significant effect of Treatment, $F(1, 144) = 12.60$, $p < .001$, and Mode Correct, $F(1, 144) = 9.257$, $p < .01$. There were also significant two-way interactions between Cognitive level and Treatment, $F(1, 144) = 4.114$, $p < .05$, Treatment by Mode Correct, $F(1, 144) = 4.114$, $p < .05$, and Cognitive level by Degree of Wrongness, $F(1, 144) = 4.114$, $p < .05$. Finally, there were two significant three-way interactions Cognitive level by Treatment by Mode Correct, $F(1, 144) = 6.429$, $p < .05$, and Cognitive level by Treatment by Degree of Wrongness, $F(1, 144) = 4.114$, $p < .05$.

The main effect of Treatment is illustrated in Table 7. The children in the photo first condition gave significantly more "photo" rationales (22%) than the children in the actual first condition (5%). Thus

Table 7

Percentage of "photo" rationales given for "really" question response as a function of Cognitive level, Treatment, and Mode Correct(Photographic/Actual Object Condition)

<u>Treatment</u>	<u>Cognitive Level</u>				<u>mean %</u>
	<u>Preoperational</u>		<u>Concrete</u>		
	<u>Photo correct</u>	<u>Actual correct</u>	<u>Photo correct</u>	<u>Actual correct</u>	
Photo first	5.0	50.0	15.0	20.0	22.0
Actual first	0	0	5.0	15.0	5.0
Mean %	2.5	25.0	10.0	17.5	

if the photographs were witnessed first, it increased the probability of their being cited as evidence for the child's "really" judgment. The effect of Mode Correct is also apparent upon examination of Table 7. Children who saw the actual objects turn out logically gave significantly more "photo" rationales than children who saw the photographs turn out logically. The two-way interaction of Cognitive level and Treatment resulted from the pre-operational children giving significantly more "photo" rationales in the photo first condition. This effect of Mode Correct and the two-way interaction of Cognitive level by Treatment crystallizes in the three-way interaction of Cognitive level by Treatment by Mode Correct. Specifically, this interaction was the result of the preoperational children using a "photo" rationale significantly more often when the photographic slides were viewed first, but turned out incorrectly (i.e., the photo first, actual correct condition). The Cognitive level by Degree of Wrongness interaction can be seen in Table 8. The pre-operational children utilized a "photo" rationale more often when the incorrect version of the transitive inference task (either photographic or actual) turned out illogical. On the other hand, the concrete operational children utilized a "photographic" rationale when the incorrect version of the task turned out absurd. Finally, the Cognitive level by Treatment by Degree of Wrongness interaction (which can be seen in Tables 7 & 8) illum-

Table 8

Percentage of "photo" rationales given for "really" question response
as a function of Cognitive level, Treatment and Degree of Wrongness
(Photographic/Actual Object Condition)

<u>Cognitive Level</u>	<u>Treatment</u>				<u>Mean %</u>
	<u>Photo first</u>		<u>Actual first</u>		
	<u>Illogical</u>	<u>Absurd</u>	<u>Illogical</u>	<u>Absurd</u>	
Preoperational	40.0	15.0	0	0	13.75
Concrete Operational	10.0	25.0	10.0	10.0	13.75
Mean %	25.0	20.0	5.0	5.0	

inates the above findings by indicating that preoperational children utilized a "photographic" rationale most if, the photos were witnessed first, were incorrect and were illogical in terms of degree of wrongness. Concrete operational children, on the other hand, were more evenly distributed, however, in the photo first, photo absurd condition, the number of "photographic" rationale's did increase (but not to a significant extent).

"Actual Object" rationale. As was noted in Table 5, 12.5% of the preoperational children and 10% of the concrete operational children gave an actual object rationale. The four-way analysis of variance performed on the number of "actual object" rationale's revealed no significant main effects and no significant interactions. Thus, none of the variables measured had a significant impact on whether a child would use this type of rationale. This is in sharp contrast to the data on the "photographic" rationale, where all of the measured variables had some form of effect. Particularly noteworthy was the fact that there was no Treatment effect for this type of rationale, as there was for the "photographic" rationale. For example, preoperational children who witnessed an incorrect version (either illogical or absurd) of the actual task did not feel compelled to rationalize their "really" response by an appeal to the illogical or absurd blocks which they

viewed first. In other words, a number of these children seemed to go by the assumption that a photograph, if viewed first constituted proof of something; an actual presentation viewed first however, did not imply the same.

"Trick" rationale. As noted in Table 5, 20% of the preoperational and 23.7% of the concrete operational children offered a trick rationale. The four-way analysis of variance performed on this type of rationale revealed no significant main effects and no significant interactions. Thus, as with the actual object rationales, this type of rationale was not sensitive to any of the effects measured, despite the fact that approximately a fifth of all subjects utilized it. It should be pointed out that this type of rationale is, in a sense, different in quality from the others in that it focuses upon the experimental manipulation itself, rather than on its outcome.

"Logical" rationale. As noted in Table 5, 13.7% of the preoperational children and 10% of the concrete operational children gave "logical" rationales. The four-way analysis of variance performed on the number of "logical" rationales revealed no significant main effects and a single three-way interaction, Cognitive level by Treatment by Mode Correct, $F(1, 144) = 13.966, p < .001$ (see Table 9). This interaction was the result of the preoperational children in the photo first, photo correct condition

Table 9

Percentage of "logical" rationales given for the "really" question response as a function of Cognitive level, Treatment and Mode Correct(Photographic/Actual Object Condition)

<u>Treatment</u>	<u>Cognitive Level</u>				<u>Mean%</u>
	<u>Preoperational</u>		<u>Concrete</u>		
	<u>Photo correct</u>	<u>Actual correct</u>	<u>Photo correct</u>	<u>Actual correct</u>	
Photo first	35.0	0	5.0	15.0	13.75
Actual first	5.0	15.0	20.0	0	10.0
Mean%	20.0	7.5	12.5	7.5	

offering a "logical" rationale significantly more than either the preoperational children in the actual first, photo correct condition, or the concrete operational children in the photo first, photo correct condition.

Table 10 presents the distribution of frequencies of rationales for correct and incorrect judgments to the "really" question. A correlation analysis performed between transitive inference judgments and rationales revealed a non-significant negative correlation ($r = -.025$) for "unintelligible" rationale's, a significant negative correlation ($r = -.34$, $p < .001$) for "photo" rationale's, a significant negative correlation ($r = -.161$, $p < .05$) for "actual object" rationale's, a significant positive correlation ($r = .213$, $p < .01$) for "trick" rationale's and a significant positive correlation ($r = .279$, $p < .001$) for "logical" rationale's. Thus, an incorrect judgment of the "really" question was often justified with either a "photo" or "actual object" rationale, whereas a correct judgment of the "really" question was most often justified by either a "trick" or "logical" rationale.

In summary, the data revealed that Cognitive level, Treatment, and Degree of Wrongness each had an effect on the child's "really" response. Specifically, the results indicated that the concrete operational children responded correctly significantly more often than the preoperational children, that children in the photo

Table 10

Frequencies of rationales for correct and incorrect responses to the "really" question(Photographic/Actual Object Condition)

Cognitive Level	Response to "really" question	Rationale				
		Unintelligible	Photo	Actual Object	Trick	Logical
Pre-operational	correct	19	1	3	11	11
	incorrect	13	10	7	5	0
Concrete Operational	correct	22	4	4	18	8
	incorrect	12	7	3	1	0

first condition gave significantly fewer correct responses than children in the actual first condition and that children who witnessed the illogical outcome gave significantly fewer correct responses than children who witnessed the absurd outcome. The significant Treatment by Mode Correct interaction was the result of children in the photo first, actual correct conditions (in which the photo turned out either illogical or absurd) giving significantly fewer correct "really" question responses than children in any of the other conditions. Thus, witnessing the illogical or absurd photographs first had a significantly greater impact on performance than initially witnessing the actual objects turn out either illogical or absurd.

With regard to the rationales, the data indicated that there were no main effects for Cognitive level for any of the types of rationales. There was a main effect for Treatment for "unintelligible" rationales and "photo" rationales. For "unintelligible" rationales, this effect was due to the children in the photo first condition giving significantly fewer "unintelligible" responses than children in the actual first condition. For "photo" rationales this effect was the result of children in the photo first condition giving significantly more "photo" rationales than children in the actual first condition. There was a main effect for Mode Correct for the "photo" rationales which resulted from the fact

that children who witnessed the actual objects turn out logically gave significantly more "photo" rationales than children who saw the photographs turn out logically. In other words, "photo" rationales were utilized significantly more often when the photos turned out either illogical or absurd. For these children then, it would appear that when the photograph departs from what one would logically expect, it takes on a special significance which it does not apparently have when it is in line with logical reality. The data also revealed that preoperational children were most likely to utilize a "photo" rationale if a) the photographs were witnessed first, b) they were incorrect, and c) they were illogical in terms of degree of wrongness. Although the use of this rationale among the concrete operational children was more evenly distributed among the various conditions, nevertheless, the number of such rationales did increase when a) the photographs were witnessed first, b) they were incorrect, and c) they were absurd in terms of degree of wrongness. Overall, the utilization of a "unintelligible" rationale and most especially a "photo" rationale was very much influenced by the experimental variables. For example, for the "photo" rationale, there were two main effects, three two-way interactions and two three-way interactions. In sharp contrast was the finding that there were no main effects and no interaction effects for either the

"actual object" or "trick" rationales, and for the "logical" rationale, only a single three-way interaction.

Finally, a correlational analysis which examined the relationship between performance on the "really" question and type of rationale revealed significant negative correlations for both "photo" and "actual object" rationales, and significant positive correlations for the "trick" and "logical" rationales.

Referent Materials Condition

Following the presentation of both the correct and incorrect versions of the task, children were asked the "really" question. The children were again scored either correct or incorrect. They were correct if they chose the array of blocks that were logically correct, i.e., A<C. Following their choice, the children were asked to provide a rationale. The rationales were again categorized into one of the five types previously outlined (in fact, all children in this referent materials condition gave either "unintelligible" or "logical" rationales). These rationales were scored with 92% agreement between judges.

A three-way analysis of variance, Cognitive level, Treatment, and Degree of Wrongness was performed on the children's responses to the "really" question. Also two independent three-way analyses of variance were performed on the number of responses in each of the two

rationale categories which children here utilized.

Really Question Response. The results of the analysis of variance revealed no significant main effects and no significant interactions. Thus, in contrast to what was found for the "really" question analysis in the photographic/actual object condition (where Cognitive level, Treatment and Degree of Wrongness all were significant), here, none of these variables had a significant effect on performance.

Rationales for the Really Question. As noted above, children only utilized two types of rationales, i.e., "unintelligible" and "logical". A breakdown by Cognitive level for the two types of rationale is presented in Table 11.

"Unintelligible". The analysis of variance performed on the number of "unintelligible" rationales revealed no significant main effects and no significant interactions.

"Logical" rationale. The analysis of variance performed on the number of "logical" rationales revealed no significant main effects and no significant interactions.

In this condition then, children in both cognitive levels essentially divided, with half of the children in each cognitive level giving an "unintelligible" rationale

Table 11

Percentage of rationales given for "really" question response as a function of Cognitive level (Referent Materials Condition)

<u>Cognitive Level</u>	<u>Rationale</u>	
	<u>Unintelligible</u>	<u>Logical</u>
Preoperational	47.5	52.5
Concrete Operational	55.0	45.0

and the other half giving a "logical" rationale.

Table 12 presents the distribution of rationales for correct and incorrect judgments to the "really" question. Correlations between rationales and performance on the "really" question response revealed a significant negative correlation ($r = -.39, p < .001$) for "unintelligible" rationales, and a significant positive correlation ($r = .39, p < .001$) for "logical" rationales. (The results obtained for transitive inference performance are presented in the appendix.)

Table 12

Frequencies of rationales for correct and incorrect responses to the "really" question(Referent Materials Condition)

<u>Cognitive Level</u>	<u>Response to "really" question</u>	<u>Rationale</u>	
		<u>Unintelligible</u>	<u>Logical</u>
Pre-operational	correct	17	4
	incorrect	18	1
Concrete Operational	correct	8	10
	incorrect	21	1

DISCUSSION

The purpose of the "really" question was to ascertain how children would react to the same event resulting in two different endings. In the photographic/actual object conditions, the child witnessed the event turn out incorrectly in a photographic slide and correctly using a set of actual objects, or vice versa. In the referent materials conditions, the child witnessed the same event twice, with actual objects being used in both cases. Again, one of the endings turned out correctly and the other incorrectly.

An interesting finding which emerges from an examination of these data is the fact that in the photographic/actual objects conditions, every variable (i.e., Cognitive level, Treatment, Degree of Wrongness, and Mode Correct) had an effect on performance whereas in the referent materials conditions (where no photos were used) none of the variables had an effect. In the referent materials conditions, performance was essentially at a chance level for each of the measured variables. Thus, it would appear that both preoperational and concrete operational children are not treating the photographic/actual object condition and referent materials condition as equivalent circumstances.

In the photographic/actual object condition, concrete operational children successfully judged the "really"

question significantly more often than preoperational children (i.e., 71.2% correct, as opposed to 56.2%). On the other hand, in the referent materials conditions, these figures were 45% and 52.5% for the concrete and preoperational children respectively. Thus, the concrete operational children had a much easier time dealing with the photographic/actual object comparison, whereas for the preoperational children there was essentially no difference. These results are similar to those obtained in the O'Connor et al. conservation study which also showed that concrete operational subjects more readily resist the effects of witnessing an incorrect version of the task (in that case, conservation) and also that for both preoperational and concrete children performance is at chance level when two actual tasks are under comparison. Across the two studies then, the data indicate that concrete operational children find the resolving of two discrepant endings to the same task less troublesome when one of the endings appears in photographic form, as opposed to both endings involving actual objects (i.e., the referent materials condition). On the other hand, in both studies both concrete and preoperational children were influenced by Treatment. In the conservation study, whatever was viewed first (either photographs or actual objects) was most likely to be chosen as "the way the water really should look". In

the present study, on the other hand, the Treatment effect was the result of children being more likely to select the photo as correct when it was witnessed first. Additionally, the Treatment by Mode Correct interaction showed that the effect of Treatment was primarily the result of both preoperational and concrete operational children selecting the photo as correct when it was viewed first and was either illogical or absurd (i.e., incorrect). Interestingly, the actual objects did not have the same effect when incorrect and witnessed first. The question arises as to why this primacy effect should work for both photos and actual objects in the conservation task and only for photos (when they turn out incorrectly) in the transitivity task. One possibility might be that, as suggested by Miller & Lipps (1973), on a point made by Piaget, conservation bears a different type of relationship to reality from transitivity. They suggest that conservation is more closely tied to knowledge of specific real world referents, e.g., liquids, etc., whereas transitivity which is logico-mathematical does not. This difference in relationship, Miller proposes, may result in children, and perhaps adults, having less of a sense of logical necessity concerning conservation as opposed to transitivity. He cites as evidence the finding that conservation is more readily extinguishable than transitivity. The present data and the conservation study

support this assumption in that, for conservation, the primacy effect holds regardless of whether one is using photos or actual objects. With transitivity, on the other hand, children do not readily believe counterfactual evidence presented with real objects, simply because it is presented first. They do succumb to such evidence when, in addition to being witnessed first, it is also presented in photographic form, thus indicating that the photograph may be the critical difference as to whether or not the counterfactual evidence is accepted as true. These differing effects for conservation and transitivity disappear when children are presented with two actual tasks (i.e., the referent material conditions). There is no primacy effect for either task and responding is essentially random. The rationales concerning the really question judgments shed some light on the above findings.

The rationales to the "really" question were classified in five categories: "unintelligible", "photographic", "actual object", "trick", and "logical". Again as with the really judgments, the data showed marked differences between the photographic/actual objects conditions and the referent materials conditions. Most notably, the data revealed that in the photographic/actual object conditions, there was (aside from "unintelligible rationales), an even distribution across all of the types of

rationales. In the referent materials condition, on the other hand, only "unintelligible" and "logical" rationales were given. The "photographic" rationale is not, of course, an issue in the referent materials conditions, however, the fact that not one child used an "actual object" rationale or "trick" rationale in these circumstances, again indicates that children were not treating the "really" question and rationale in the same way when it involved a photo/actual object comparison, as opposed to comparing two sets of actual objects. Thus, pointing to an actual object and saying "I can see it there" (i.e., the "actual object" rationale) was, apparently, only appropriate when a photo/actual object comparison was being made, but not when two sets of actual objects were being compared. Similarly, over one-fifth of the children in the photographic/actual object conditions deemed it appropriate to announce as their rationale the idea that somehow, a "trick" had been carried out. This same idea either did not occur or was felt to be inappropriate as a rationale when the two sets of actual blocks were under scrutiny.

A parallel finding was that, as occurred with the "really" judgments, none of the variables had an effect on the type of rationale that was used in the referent materials condition, whereas in the photographic/actual objects conditions, two of the rationales (i.e., "unintelligible" and especially "photographic" rationales) showed

several significant measures. This so-called "photographic" rationale is of course, of special interest. As noted in Table 5, it was employed by exactly the same number (13.7%) of preoperational and concrete operational children. This is, perhaps, the most clear instance in the present study of children's belief in the fidelity of photographs. The children who gave this rationale apparently believed that the photograph constituted indisputable proof concerning the correct outcome to the transitivity task. Interestingly, this "photographic" rationale was given significantly more often when the photos were incorrect and witnessed first, which is further evidence that a photo takes on special significance when it shows the child something he or she did not expect. On the other hand, an examination of the "actual object" rationales revealed that when the actual objects were incorrect and witnessed first, they did not carry the same weight. Thus the "photographic" rationale was used almost exclusively to explain incorrect "really" question judgments (i.e., the child would select the incorrect photo as the way the blocks "really" should look" and then would justify this answer by saying he could see it in the picture). In contrast with these data, was the finding that children who gave "trick" rationales also correctly responded to the judgment question most of the time. In those cases where the

child announced that some kind of "trick" was occurring with the photos (sometimes of course it was with the actual objects) it implies that the child has gone beyond the more primitive "photographic" rationale with its naive belief in the truthfulness of photographs, to a more sophisticated understanding of how photos can be manipulated to distort reality.

The present study, as noted, was an attempt to examine the relationship between particular forms of logico-mathematical knowledge and physical knowledge. The specific physical knowledge domain of choice was photographs, and the specific logico-mathematical domain was the concept of transitivity. As Feldman (1980) points out, Piaget has devoted himself primarily to the study of so-called cognitive universals, where given a "normal" environment, "normal" children will eventually attain an understanding of the concept in question. Although a particular culture might speed up or slow down the acquiring of such universal concepts as object permanence, conservation, transitivity, etc., it seems reasonable that at least a basic understanding of such ideas is a part of the cognitive repertoire of most normal adults, regardless of where they are brought up. These cognitive universals are, in a sense, both a part and a product of logico-mathematical thought. That is, they represent a conceptual understanding of how reality is organized and functions, which is a

product of the person's having reflected upon the results of their interactions with that reality. For example, Piaget (1977) notes that an understanding of transitivity is a product of one's assimilating and reflecting upon the consequences of ordering objects, i.e., seriating by various dimensions. This logico-mathematical knowledge of transitivity, once achieved, takes on what Piaget refers to as a "logical necessity", i.e., the child understands that transitivity is an unavoidable, logical, and intrinsically necessary state of affairs. Feldman, in agreement with Piaget, suggests that these universal forms of knowledge are not simply copies of "what is really out there", but rather reflect the level of cognitive evolution which man has achieved thus far. In other words, an understanding of transitivity has become a universally shared actuality only because it has proven to be an adaptive way of conceptualizing reality (e.g., see Piaget, 1978).

On the other hand, an understanding of photography and photographs has been a rather recent development in terms of man's history, and is not, at this point, a universally shared domain of knowledge, and perhaps never will be. At this time then, there is nothing inevitable about a child developing an understanding of photographs, e.g., where they come from, what they are used for, etc. This knowledge, within Piaget's system

would represent physical knowledge since it is knowledge of some-thing as opposed to some action. This bit of physical knowledge will only be acquired by children who grow-up in cultures, or have had contact with cultures, which have adopted this medium (i.e., photography) as a "cultural amplifier", i.e., a tool for sharing and preserving the culture (Bruner, 1971). Thus, whereas an understanding of transitivity seems for normal human beings to be an inevitable achievement, an understanding of photographs is not so inevitable and does not occur independent of specific environmental conditions.

As several authors have noted (McLuhan, 1964; Olson, 1974; Salomon, 1979) different media (e.g., language, photographs, etc) have structures which are at least partially independent of the information they carry. Part of the structure of photographs appears to be the impression they give that they are not interpretations of reality, but rather are pieces of reality, frozen in time, usually minaturized and sometimes divested of color. As Sontag (1977) puts it, "Photographed images do not seem to be statements about the world so much as pieces of it, miniatures of reality that anyone can make or acquire (p.4)." "A photograph passes for incontrovertible proof that a given event happened. The picture may distort, but there is always a presumption that something exists, or did exist, which is like what is in the pic-

ture (p.5)." Although the recognition of the images contained in photographs appears not to require any specific experiences with photos (e.g., Hochberg & Brooks, 1964; Dirks & Gibson, 1977; Jahoda, Deregowski, Ampene & Williams, 1977), the sort of understanding reflected in the present study would certainly appear to necessitate an environment where photographs are a part of one's everyday experience. The problem posed in this study was what would occur if this culturally based physical knowledge concerning the fidelity of photographs came into conflict with the logical necessity of transitivity. The data indicate that in certain circumstances the logico-mathematical concept of transitivity takes precedence and that in other circumstances photographic fidelity takes precedence. The fact that concrete operational children passed the really judgment question significantly more often than the preoperational children would suggest that these children were not particularly dislocated by the incongruity. On the other hand, both concrete operational and preoperational children chose in favor of photographic fidelity when the photographs were incorrect and were witnessed first. Since the same effect was not found with actual objects, it would seem that the order effect has its impact primarily because the information is being carried in a photograph. Thus, the medium in this instance appears

to be more important than the information which it is conveying. As noted earlier, in the O'Connor et al. study, this primacy effect held regardless of whether a photo or actual object was presented first, so the particular type of concept which is being portrayed in the photos appears to interact with the belief in photographic fidelity.

APPENDIX

Performance data - Transitive Inference (photographs/
actual objects condition)

Children in each condition were scored as either correct or incorrect for their transitive inference judgments to the actual blocks and in the slide presentation. Also, children were asked to provide a rationale for each of their judgments. Rationale was classified in three categories (see below). A reliability study of classification based on judgments indicated 88% agreement between two judges.

Two independent four-way analyses of variance, Cognitive level (preoperational, concrete operational) by Treatment (photographs first, actual first) by Mode Correct (photograph correct, actual correct) by Degree of Wrongness (illogical, absurd) were performed on the number of correct transitive inference judgments for both the photographic slides and the actual presentations. Also, three independent four-way analyses of variance were performed on the frequencies of the types of rationales given for the transitive inference judgments.

Transitive Inference Judgments/Rationales-Actual Objects

The analysis performed on transitive inference judgments using the actual objects revealed significant main effects for Cognitive level, $F(1, 144) = 11.919, p < .001$, Treatment, $F(1, 144) = 8.757, p < .01$, and Mode Correct,

$F(1, 144) = 6.081, p < .05$. There was a significant two-way interaction for Treatment by Mode Correct, $F(1, 144) = 29.432, p < .001$, and a three-way interaction for Treatment by Mode Correct by Degree of Wrongness, $F(1, 144) = 6.081, p < .05$.

As can be seen in Table 13, the main effect of Cognitive level was the result of the concrete operational children giving significantly more correct transitive inference judgments than the preoperational children ($p < .01$). Overall, 73.7% of the preoperational children successfully answered the transitive inference question, whereas 91.2% of the concrete operational children did so. Thus, the concrete operational children performed better than the preoperational children, although performance was high for both groups. The main effect of Treatment, indicated that children in the actual first condition, i.e., seeing the actual presentation first and making a transitive inference judgment prior to witnessing the photographic presentation, gave significantly more correct responses, i.e., 90%, than the children in the photograph first condition, i.e., 75%, ($p < .01$). Furthermore, the main effect of Mode Correct indicated that 88.7% of all children in the picture correct condition answered the judgment question correctly, whereas 76.2% of the children in the actual correct condition did so. The main effect of Mode Correct becomes interpretable upon

Table 13
 Percentage of correct transitive inference judgments
 as a function of Cognitive Level and Treatment
 (Actual Objects Condition)

<u>Treatment</u>	<u>Cognitive Level</u>		<u>Mean %</u>
	<u>Preoperational</u>	<u>Concrete</u>	
Photograph first	62.5	87.5	75.0
Actual object first	85.0	95.0	90.0
Mean %	73.7	91.2	

examination of the two-way interaction with Treatment (see Table 14). The children in the actual first condition were not affected by either the photograph correct or the actual correct condition. In this condition, the children made their transitive inference judgments prior to seeing either the photograph correct or actual correct outcomes. However, in the photograph first, actual correct condition (where subjects saw the entire slide presentation with either an illogical or absurd ending) only 55% gave correct responses, which was significantly lower than the 95% correct responses given by the children in the photograph first, photograph correct condition ($p < .01$). With regard to the main effect of Degree of Wrongness, 87.5% of all children who witnessed an illogical ending (i.e., $A = C$), to either the pictures or actual objects, correctly judged the transitive inference question, whereas 77.5% of all children who witnessed the absurd ending judged the transitive inference problem correctly. Finally, the Treatment by Mode Correct by Degree of Wrongness interaction (see Table 14) suggests that in the photograph first, actual correct condition, the children gave significantly less correct responses when they saw an absurd outcome in the slide presentation prior to making their transitive inference judgments than when they witnessed an illogical outcome in the slide presentation ($p < .05$).

Table 14

Percentage of correct transitive inference judgments as a function of Treatment, Mode Correct, and Degree of Wrongness (Actual Objects Condition)

<u>Mode Correct</u>	<u>Treatment</u>				<u>Mean%</u>
	<u>Photo first</u>		<u>Actual first</u>		
	<u>Illogical</u>	<u>Absurd</u>	<u>Illogical</u>	<u>Absurd</u>	
Photo correct	95.0	95.0	95.0	70.0	88.8
Actual correct	65.0	45.0	95.0	100.0	76.3
Mean%	80.0	70.0	95.0	85.0	

In order to further analyze transitive inference reasoning, each child was asked to give a rationale for his answer. The following categories were utilized:

1. "Unintelligible" i.e., rationale's which make no reference to the logical premises that were presented to the child, e.g., "because they are", etc.
2. "Exclusion" i.e., rationale's which reflect the use of only one of the two relational premises provided, i.e., in reasoning about the A-C relationship, the child mentions either the A, B or the B, C relationship.
3. "Juxtaposition" i.e., rationale's which use both of the presented relationships, but do so in a non-integrative fashion, i.e., the child mentions both the A,B and B,C relationships, but does not explicitly integrate them in his rationale. In the present study, none of the children utilized a fully integrated rationale i.e., explicitly integrating the A,B premise and the B,C premise in an "if, then" formulation, therefore the category is not dealt with in the analysis.

Among the preoperational children, 76.3% of their rationales were unintelligible, 17.5% exclusions, and 6.3% juxtapositions. Corresponding values for the concrete operational children were 54.4% (unintelligible), 8.9% (exclusions), and 36.7% (juxtapositions). A test of independence revealed this difference to be significant at the .001 level.

A four-way analysis of variance, Cognitive level

by Treatment by Mode Correct by Degree of Wrongness performed on the number of "unintelligible" rationales revealed a significant difference due to Cognitive level, $F(1, 144) = 8.836, p < .01$. A similar four-way analysis of variance performed on the number of "exclusion" rationales showed no significant differences for any factor and no significant interactions. Finally, a four-way analysis of variance performed on the number of "juxtapositions" showed a significant difference due to Cognitive level $F(1, 144) = 25.922, p < .001$. None of the other factors was significant and there were no significant interactions.

Table 15 presents the distribution of frequencies of rationales for correct and incorrect judgments to the transitivity question for each cognitive level. As Table 15 indicates, a large proportion of both preoperational and concrete operational children who passed the transitivity question also gave an "unintelligible" rationale (i.e., among the preoperational children 41 of 59 or 69.4% and among the concrete operational children, 37 of 72 or 51.4%). This may indicate that these children either do not have the linguistic sophistication to explain their answers, or as suggested by Trabasso (1975), they may be solving the transitivity problem in other than logical ways. If one examines the "exclusion" and "juxtaposition" rationales, a much clearer picture emerges. Of the remaining preoperational

Table 15

Frequencies of rationales for correct and incorrect transitive inference judgments (Actual Objects Condition)

<u>Cognitive Level</u>	<u>Judgment</u>	<u>Rationale</u>		
		<u>Unintelligible</u>	<u>Exclusion</u>	<u>Juxtaposition</u>
Preoperational	correct	41	13	5
	incorrect	20	1	0
Concrete Operational	correct	37	6	29
	incorrect	6	1	0

children who made correct transitive inference judgments, 13 (22%) gave "exclusion" rationales and 5 (8.5%) gave a "juxtaposition" rationale. On the other hand, among those preoperational children who failed the transitivity question, all but one (who gave an "exclusion" rationale) gave "unintelligible" rationales. Similarly, among the concrete operational children, of the remaining children who passed the transitivity question 6 (8.3%) gave "exclusion" rationales and 29 (40.3%) gave "juxtaposition" rationales. On the other hand, among those concrete operational children who failed the transitivity question (7 in all) all but one gave "unintelligible" rationales. A correlation analysis performed on the rationales and performance on the transitivity question revealed a significant negative correlation ($r = -.267$, $p < .001$) for "unintelligible" rationales, and a significant positive correlation ($r = .241$, $p < .01$) for "juxtapositions". The "exclusion" category was in the positive direction but no significant. These data indicate then, that giving an "unintelligible" rationale was significantly associated with having failed the transitivity question, whereas giving a "juxtaposition" rationale was significantly associated with having passed the transitivity question.

To summarize, concerning transitive inference judgments

to actual objects, the data revealed that concrete operational children performed significantly better than preoperational children, although both groups responded correctly a large proportion of the time. The data also indicate that these judgments were significantly effected by treatment, mode correct and degree of wrongness. The effect of treatment resulted from children in the actual first condition successfully answering the transitivity question significantly more often than children in the photograph first condition. The effect of mode correct relates to the treatment effect in that when children witnessed either an illogical or absurd ending to the photos prior to taking the actual task (i.e., the photo first, actual correct condition) performance on the actual task decreased significantly. With regard to degree of wrongness, the data revealed that the absurd ending had a more powerful negative impact on later transitivity judgments than did the illogical ending. Concerning rationales, the data indicated that only Cognitive level was significantly related to the type of rationale used by the child. Thus, it appears that such variables as Treatment, Mode Correct and Degree of wrongness may have an impact on a child's performance (i.e., judgment) but not on the child's understanding (i.e., rationale). The rationale data revealed that the preoperational children gave significantly more "unintelligible" rationales than the con-

crete operational children, a small percentage of both groups gave "exclusion" rationales and concrete operational children gave significantly more "juxtaposition" rationales than preoperational children. Finally, the data revealed a significant negative correlation between performance on the judgment question and the likelihood of giving an "unintelligible" rationale and a significant positive correlation between performance on the judgment question and the likelihood of giving a "juxtaposition" rationale.

Transitive Inference Judgments/Rationales-Photographs

The four-way analysis of variance performed on transitive inference judgments using the photographic slides revealed a significant effect for Treatment, $F(1, 144) = 8.416, p < .01$ and Mode Correct, $F(1, 144) = 28.286, p < .001$. There were significant interactions for Treatment by Mode Correct, $F(1, 144) = 23.377, p < .001$, and Cognitive level by Degree of Wrongness, $F(1, 144) = 5.844, p < .05$.

Overall, 78.8% of the preoperational children successfully answered the transitivity question, on the other hand 83.7% of the concrete operational children did so. Thus, as with the actual objects, both groups answered this question correctly the majority of the time. However, in contrast to the actual objects conditions, there was no significant difference

between the groups.

As shown in Table 16 the main effect of Treatment was due to the fact that children in the photograph first condition gave significantly more correct judgments (i.e., 88.7%) than the children in the actual first condition (73.7%), $p < .01$. A further examination of Table also reveals that the effect of Mode Correct was due to the fact that children made significantly more correct judgments in the actual correct condition (i.e., 95% as compared to 67.5% in the photograph correct condition). The significant Treatment by Mode Correct interaction explains more fully the pattern of performance in the photograph slide presentation. In the photograph first condition, children have not witnessed any outcome (either photographic or actual) to the transitivity problem and performance was uniformly high. Similarly, in the actual first, actual correct condition, the actual blocks depicted the logical outcome and again, children had no problem in correctly providing a transitive inference judgment when they switched to the photographs. However, in the actual first, photograph correct condition, the children witnessed either an illogical or absurd ending with the actual blocks and then proceeded to make judgments about the photographs, which resulted in a significant decrease in correct transitive inference judgments to the photographs. Thus, the children in general appeared able to solve the transitive inference

Table 16

Percentage of correct transitive inference judgments as a function of Treatment and Mode Correct(Photographs Condition)

	<u>Treatment</u>		
<u>Mode Correct</u>	<u>Photo first</u>	<u>Actual first</u>	<u>Mean %</u>
Photo correct	87.5	47.5	67.5
Actual correct	90.0	100.0	
Mean %	88.7	73.7	

judgment problem when presented in a slide presentation, however, when the slides were preceded by an actual presentation of the problem which demonstrates an incorrect (illogical or absurd) outcome, the children's performance, regardless of cognitive level, decreases. In other words, they were influenced by what they witnessed first.

Although both the concrete operational and preoperational children were influenced by the prior presentation of the actual problem with an incorrect outcome, the Cognitive level by Degree of Wrongness interaction, ($p < .05$), suggests that the preoperational children and concrete operational children were affected differently. As can be seen in Table 17 the preoperational children in the actual first condition were influenced by both illogical and absurd endings witnessed prior to responding to the slides. The concrete operational children, on the other hand, only showed a significant decrease in performance when they saw the presentation of the actual problem with an illogical outcome first ($p < .01$), but were not influenced by the absurd ending.

An examination of rationales revealed that among the preoperational children, 82.5% of their rationales were "unintelligible", 11.2% were "exclusions" and 6.2% were "juxtapositions". Corresponding values for the concrete operational children were 55% (unintelligible), 11.2% (exclusions) and 33.7% (juxtapositions) respectively. A test of independence revealed this difference to be

Table 17

Percentage of correct transitive inference judgments as a function of
Cognitive Level, Degree of Wrongness and Treatment(Photographs Condition)

<u>Cognitive Level</u>	<u>Degree of Wrongness</u>				<u>Mean%</u>
	<u>Illogical</u>		<u>Absurd</u>		
	<u>Photo first</u>	<u>Actual first</u>	<u>Photo first</u>	<u>Actual first</u>	
Preoperational	90.0	50.0	90.0	40.0	67.5
Concrete Operational	80.0	20.0	90.0	80.0	67.5
Mean %	85.0	35.0	90.0	60.0	

significant at the .001 level. Again, three independent four-way analyses of variance (Cognitive level, Treatment, Mode Correct and Degree of Wrongness) were performed on the frequencies of each type of rationale. The analysis for the "unintelligible" rationales revealed a significant main effect of Cognitive level, $F(1, 144) = 15.125$, $p < .001$, and a main effect of Treatment, $F(1, 144) = 6.125$, $p < .05$. These data are presented in Table 18.

Scheffe post-hoc comparisons indicated that the main effect of Cognitive level was due to the preoperational children giving significantly more "unintelligible" rationales than the concrete children ($p < .01$). The main effect of Treatment was due to children in the photo first condition giving significantly fewer "unintelligible" rationales than in the actual first condition. Thus seeing the actual presentation prior to responding to the photographs tends to increase the probability of giving an "unintelligible" rationale. The analysis of "exclusion" rationales again (as occurred with the actual presentation) revealed no significant differences for any factor and no significant interactions. Finally, the analysis performed on the number of "juxtaposition" rationales revealed a significant main effect for Cognitive level, $F(1, 144) = 22.926$, $p < .001$, and a significant main effect for Treatment, $F(1, 144) = 6.821$, $p < .01$, and a significant Cognitive level by Treatment interaction. These data are presented in Table 19.

Table 18

Percentage of "unintelligible" rationales given for transitive inference judgments as a function of Cognitive level and Treatment(Photographs Condition)

<u>Cognitive Level</u>	<u>Treatment</u>		<u>Mean%</u>
	<u>Photo first</u>	<u>Actual first</u>	
Preoperational	77.5	87.5	82.5
Concrete Operational	42.5	67.5	55.0
Mean %	60.0	77.5	

As shown in Table 19 the Cognitive level effect was due to the concrete operational children giving significantly more "juxtaposition" rationales than the preoperational children. The effect of Treatment resulted from the children in the photograph first condition giving more "juxtaposition" rationales than the children in the actual first condition. The Cognitive level by Treatment interaction revealed that the preoperational children gave significantly fewer "juxtaposition" rationales, but were not affected by Treatment, while the concrete operational children gave significantly less "juxtaposition" rationales in the actual first condition than in the photograph first condition ($p < .01$). Thus, for concrete operational children, seeing a real presentation first tends to inhibit their ability to provide "juxtaposition" rationales in the photographic presentation.

Table 20 presents the distribution of frequencies of justifications for correct and incorrect judgments to the transitivity question for each cognitive level. As can be seen in Table 20 a large proportion of both preoperational and concrete operational children who passed the transitivity question also gave an "unintelligible rationale (i.e., among the preoperational children 51 of 63 or 81% and among the concrete children, 31 of 66 or 47%). This result is similar to that obtained with the actual objects. Another similarity emerges regarding the ex-

Table 19

Percentage of "juxtaposition" rationales given for transitive inference judgments as a function of Cognitive Level and Treatment(Photographs' Condition)

<u>Cognitive Level</u>	<u>Treatment</u>		<u>Mean%</u>
	<u>Photo first</u>	<u>Actual first</u>	
Preoperational	7.5	5.0	6.2
Concrete Operational	47.5	20.0	33.7
Mean %	27.5	12.5	

Table 20

Frequencies of rationales for correct and incorrect judgments to the transitivity question(Photographs Condition)

<u>Cognitive Level</u>	<u>Judgment</u>	<u>Unintelligible</u>	<u>Exclusion</u>	<u>Juxtaposition</u>
Preoperational	correct	51	8	4
	incorrect	15	1	1
Concrete Operational	correct	31	8	27
	incorrect	12	1	0

clusion" and "juxtaposition" rationales. Of the remaining preoperational children who passed the transitive inference judgment question, 12.7% gave exclusion rationales and 6.3% gave "juxtaposition" rationales. On the other hand, among those preoperational children who failed the transitivity question, all but two gave "unintelligible" rationales. Among the concrete operational children who passed the transitive inference judgment question, 12.1% gave "exclusion" rationales and 41% gave "juxtaposition" rationales. Among the concrete operational children who failed the judgment question, (13 children in all), all but two gave "unintelligible" rationales. A correlation analysis performed on rationales and performance on the transitivity question revealed a significant negative correlation ($r = -.223$, $p < .01$) for "unintelligible" rationales, and a significant positive correlation ($r = .202$, $p < .05$) for "juxtapositions". The "exclusion" category was in the positive direction but was not significant.

To summarize this section, concerning transitive inference judgments to the photographs, the data indicate that both preoperational and concrete operational children responded correctly in the majority of instances. Although the concrete operational children performed better on this task, the difference in this case was not significant (as it had been with the actual objects).

The data again indicate that judgments were significantly affected by treatment, mode correct and degree of wrongness. The effect of treatment resulted from children in the photograph first condition giving significantly more correct judgments than children in the actual first condition. The effect of mode correct relates to the treatment effect in that when children witnessed either an illogical or absurd ending to the actual objects presentation prior to witnessing the photographs (i.e., the actual first, photo correct condition), performance on the photographic task decreased significantly. The above findings are in line with what was found for the actual objects. On the other hand, these data (for the photographs) revealed a significant cognitive level by degree of wrongness interaction, which was not found with actual objects. Specifically, the data showed that witnessing either the illogical or absurd ending to the actual task decreased correct responding on the photographic task among the preoperational children. On the other hand, among the concrete operational children performance declined significantly only if the children witnessed the illogical ending. Thus in contrast to the previous data on the actual objects, which showed that regardless of cognitive level performance decreased after the children witnessed an absurd ending to the photo presentation, these data (for the photo judgments) showed that for the preoperational child both the illogical

and the absurd ending effectively reduced successful photo judgments, and for the concrete operational child witnessing the illogical ending now significantly reduced correct judgments.

Concerning rationales, the data again indicate that cognitive level is significantly related to the type of rationale the child uses. Preoperational children gave significantly more "unintelligible" rationales than the concrete operational children, an equally small percentage of both groups gave "exclusion" rationales, and the concrete operational children gave significantly more "juxtaposition" rationales. Contrary to what was found with the actual objects, treatment appeared as a significant variable for both the "unintelligible" and "juxtaposition" rationales. Witnessing the actual presentation prior to responding to the photographs tended to increase the probability of giving an "unintelligible" rationale, whereas witnessing the photograph first tended to increase the number of "juxtaposition" rationales. Finally, as was the case with the actual objects, the data revealed a significant negative correlation between performance on the judgment question and the likelihood of giving an "unintelligible" rationale and a significant positive correlation between performance on the judgment question and the likelihood of giving a "juxtaposition" rationale.

Performance data - Transitive Inference (referent materials)

This section presents data from the referent materials conditions, where two actual transitive inference tasks (one logical and the other illogical or absurd) were administered. Again, children in each condition were scored either correct or incorrect for their transitive inference judgments to the two actual conditions. Also children were asked to provide a rationale for each of their judgments. The rationales were classified into three categories (the same as used with the photographic/actual objects conditions). A reliability analysis showed 91% agreement between two judges.

Two independent three-way analyses of variance, Cognitive level by Treatment by Degree of Wrongness were performed on the number of correct transitive inference judgments for both the correct and incorrect versions of the task. Three independent three-way analyses of variance were performed on the frequencies of the types of rationales given for the transitive inference judgments.

Transitive Inference Judgments/Rationales-Correct Version

The analysis performed on transitive inference judgments when the task turned out in a logically correct fashion revealed a significant effect for Treatment, $F(1, 72) = 13.444, p < .001$. No other main effects were

significant and there were no significant interactions.

As can be seen in Table 21 both the preoperational and concrete operational children answered the transitivity question correctly much of the time (i.e., 77.5% for the preoperational and 90% correct for the concrete operational). The main effect of Treatment was the result of children in the correct first condition giving significantly more (i.e., 97.5% as opposed to 70%) correct transitive inference judgments. Thus, as was the case with the transitive inference judgments in the photographic/actual object conditions, children, regardless of cognitive level were influenced in their transitive inference judgments by witnessing an incorrect version of the task.

Among the preoperational children, 60% of their rationales were categorized as "unintelligible", 32.5% as "exclusions", and 7.5% as "juxtapositions". Corresponding values for the concrete operational children were 32.5% ("unintelligible"), 30% ("exclusions"), and 37.5% ("juxtapositions"). A test of independence revealed this to be significant at the .01 level.

A three-way analysis of variance performed on the number of "unintelligible" rationales revealed a significant difference due to Cognitive level, $F(1, 72) = 6.936$, $p < .05$ and Treatment, $F(1, 72) = 9.688$, $p < .01$. There were no significant interactions.

The main effect of Cognitive level was due to the

Table 21

Percentage of correct transitive inference judgments
 as a function of Cognitive Level and Treatment
 (Correct version, Referent Materials Condition)

<u>Treatment</u>	<u>Cognitive Level</u>		<u>Mean %</u>
	<u>Preoperational</u>	<u>Concrete</u>	
Correct first	95.0	100.0	97.5
Incorrect first	60.0	80.0	70.0
Mean %	77.5	90.0	

preoperational children giving significantly more "unintelligible" rationales than the concrete operational children. The main effect of Treatment was due to the children in the incorrect first condition giving significantly more "unintelligible" rationales than the children in the correct first condition (see Table 22).

The analysis of "exclusion" rationales revealed a significant main effect for Degree of Wrongness, $F(1, 71) = 4.24$, $p < .05$. There were no significant interactions.

The three-way analysis of variance performed on the number of "juxtapositions" showed a significant main effect for Cognitive level, $F(1, 72) = 13.787$, $p < .001$, and Treatment, $F(1, 72) = 9.574$, $p < .01$. There were no significant interactions. The main effect of Treatment was due to the children in the incorrect first condition giving significantly fewer "juxtaposition" rationales (i.e., 10%) as compared to the children in the correct first condition (i.e., 35%).

Table 23 presents the distribution of justifications for correct and incorrect judgments to the transitive inference question for each cognitive level. In a manner similar to what was obtained in the photographic/actual objects conditions, a large number of both preoperational and concrete operational children who passed the transitive inference judgment question also gave "unintelligible" rationales. Also similar was the fact

Table 22

Percentage of "unintelligible" rationales given for transitive inference judgments as a function of Cognitive Level and Treatment(Correct version, Referent Materials Condition)

<u>Cognitive Level</u>	<u>Treatment</u>		<u>Mean%</u>
	<u>Correct first</u>	<u>Incorrect first</u>	
Preoperational	40.0	80.0	60.0
Concrete Operational	20.0	45.0	32.5
Mean %	30.0	62.5	

Table 23

Frequencies of rationales for correct and incorrect judgments to the transitivity question (Correct version, Referent Materials Condition)

<u>Cognitive Level</u>	<u>Judgment</u>	<u>Rationale</u>		
		<u>Unintelligible</u>	<u>Exclusion</u>	<u>Juxtaposition</u>
Preoperational	correct	15	13	3
	incorrect	9	0	0
Concrete Operational	correct	10	11	15
	incorrect	3	1	0

that among those children (both preoperational and concrete operational) who gave either "exclusion" or "juxtaposition" rationales (43 children in all) all but one passed the transitive inference judgment question. A correlational analysis of rationales and performance on the transitive inference question revealed a significant negative correlation ($r = -.407$, $p < .001$) for "unintelligible" rationales, a significant positive correlation ($r = .224$, $p < .05$) for "exclusions", and a significant positive correlation ($r = .237$, $p < .05$) for "juxtapositions".

Transitive Inference Judgments/Rationales-Incorrect Version

The analysis performed on transitive inference judgments when the task turned out incorrectly revealed a significant main effect for Treatment, $F(1, 72) = 6.4$, $p < .05$. There were no other main effects and there were no significant interactions.

As can be seen in Table 24, the main effect of Treatment was the result of children in the correct first condition giving significantly more correct transitive inference judgments. As Table 24 indicates, both the preoperational and concrete operational childrens' performance was uniformly high in both the correct first and incorrect first conditions, however, both groups of children were aided in their judgments by witnessing the correct outcome (i.e., in the correct first version) prior to making a judgment in the incorrect version.

Table 24

Percentage of correct transitive inference judgments
as a function of Cognitive Level and Treatment(Incorrect
version, Referent Materials Condition)

<u>Treatment</u>	<u>Cognitive Level</u>		<u>Mean %</u>
	<u>Preoperational</u>	<u>Concrete</u>	
Correct first	90.0	100.0	95.0
Incorrect first	75.0	75.0	75.0
Mean %	82.5	87.5	

Among the preoperational children, 57.5% of their rationales were categorized as "unintelligible", 35% as "exclusions" and 7.5% as "juxtapositions". Corresponding values for the concrete operational children were 35% ("unintelligible"), 35% ("exclusions"), and 30% ("juxtapositions"). A test of independence revealed this difference to be significant at less than the .05 level.

A three-way analysis of variance performed on the number of "unintelligible" rationales revealed a significant main effect for Cognitive level, $F(1, 72) = 4.472$, $p < .05$, and Treatment, $F(1, 72) = 9.331$, $p < .01$. There were no significant interactions. The main effect of Cognitive level was due to the preoperational children giving significantly more "unintelligible" rationales than the concrete operational children. The main effect of Treatment was due to the children in the incorrect first condition giving significantly more "unintelligible" rationales than the children in the correct first condition.

The analysis of "exclusion" rationales revealed no significant main effects and no significant interactions. Finally, the analysis performed on the number of "juxtapositions" showed significant main effects for Cognitive level, $F(1, 72) = 7.839$, $p < .01$, and Treatment, $F(1, 72) = 11.710$, $p < .01$. There were no significant interactions. The main effect of Cognitive level was due to the con-

crete operational children giving significantly more "juxtaposition" rationales than the preoperational children, and the main effect of Treatment was due to children in the correct first condition giving significantly more "juxtaposition" rationales than children in the incorrect first condition.

Table 25 presents the distribution of frequencies of rationales for correct and incorrect judgments to the transitive inference question for each cognitive level. These data essentially replicate the findings in the other conditions, i.e., a large number of both preoperational and concrete operational children who passed the transitive inference judgment question gave "unintelligible" rationales, and among those children (both preoperational and concrete operational) who gave either "exclusion" or "juxtaposition" rationales (43 in all) all but 4 passed the transitivity question. A correlational analysis between rationales and performance on the transitive inference question revealed the same pattern found previously, i.e., a negative correlation ($r = -.172$) for "unintelligible" rationales, and positive correlations for both the "exclusion" ($r = .015$) and "juxtaposition" ($r = .202$) rationales, however, in this case none of the three reached significance.

In summary, both the correct and incorrect versions

Table 25

Frequencies of rationales for correct and incorrect judgments to the transitive inference question (Incorrect version, Referent Materials condition)

<u>Cognitive Level</u>	<u>Judgment</u>	<u>Rationale</u>		
		<u>Unintelligible</u>	<u>Exclusion</u>	<u>Juxtaposition</u>
Pre-operational	correct	18	12	3
	incorrect	5	2	0
Concrete Operational	correct	11	12	12
	incorrect	3	2	0

revealed a significant main effect for Treatment. In the correct version this resulted from children in the correct first condition giving significantly more correct transitive inference judgments. In other words, performance decreased when children witnessed an incorrect outcome first. In the incorrect version, the treatment effect resulted from children in the correct first condition giving significantly more correct transitive inference judgments, i.e., performance increased when children witnessed a correct outcome to the task prior to making their judgment. In line with the previous findings (i.e., in the photographic/actual objects conditions) the majority of both preoperational and concrete operational children successfully answered the judgment question. There were no significant differences due to either cognitive level or degree of wrongness and there were no significant interactions.

Concerning the rationales given for the transitive inference judgments, the data showed that in both the correct version and incorrect version, preoperational children gave significantly more "unintelligible" rationales than concrete operational children and concrete operational children gave significantly more "juxtaposition" rationales. Similar to what was found in the photographic/actual objects conditions, there was a negative correlation between performance on the judgment question and offering an "unintelligible" rationale,

and a positive correlation between performance on the judgment question and giving either an "exclusion" or "juxtaposition" rationale.

DISCUSSION

In respect to transitive inference, an examination of performance revealed that across all conditions, (photographic/actual and referent materials), concrete operational children performed better than preoperational children. Averaging across all conditions, the data revealed that 88.1% of the concrete children successfully answered the transitivity question, whereas 78.1% of the preoperational children did so. The only condition in which the difference between preoperational and concrete operational children reached significance was in the actual object condition where 91.2% of the concrete children and 73.7% of the preoperational children were correct. This high level of performance for both the preoperational and concrete operational children was essentially the same whether actual objects were used or photographs.

In order to interpret the above findings, it is necessary to briefly examine the literature concerning transitivity. The chief proponent of the structural interpretation of transitivity is Piaget, (e.g., Piaget, 1970) whereas a functional interpretation is given by Trabasso (e.g., Trabasso, 1975). Underlying their

different views on transitivity is a more general difference concerning the nature of cognitive development. Briefly, Piaget's position is that cognitive development is a stage-like progression wherein qualitatively different thought structures emerge during development. The ability to successfully deal with a transitivity problem reflects for Piaget, the use of the underlying cognitive structures. The structures necessary for a true understanding of transitivity do not emerge until the child is in the concrete operational stage, i.e., around seven or eight years of age. A number of studies (Smedslund, 1960, 1963; Murray & Youniss, 1968; McManis, 1969; Youniss & Murray, 1970; Youniss & Furth, 1973) confirm Piaget's claim concerning the age of attainment of transitivity understanding.

Trabasso approaches cognitive development from an information processing standpoint. He proposes that cognitive development is a quantitative increase in stored information and the development of more efficient and adaptive methods of processing information. According to Trabasso, children and adults deal with the transitivity problem in the same way, what is different, is the efficiency with which they function and the amount of information they have stored concerning problems of this variety.

Trabasso, as well as a number of other researchers (Braine, 1959; Roodin & Gruen, 1970; Brainerd, 1973b;

Bryant, 1973, 1974; Bryant & Kopytynska, 1976; Bryant & Trabasso, 1971; Deboysson-Bardies & O'Regan, 1973; Trabasso, 1975; Trabasso, Riley, & Wilson, 1975) have shown that, contrary to Piaget's assertions, transitivity problems are solvable by children as young as four and five years of age. The obvious question of course, is why this difference in findings. The answer, to a large extent, appears to lie in methodology. That is, these different schools of thought have generated studies which vary in response requirements, type of task and training. For example, Trabasso(1975) has argued that children do not, as suggested by Piaget, solve transitivity problems via logical inference, but rather, solve such problems via the scanning of a linear spatial array which the child represents in memory, if given appropriate training. Huttenlocher(1968) suggests that adults also use spatial arrays in solving this type of problem. Trabasso emphasizes the role of memory in cognitive performance and has found that extensive training results in successful transitivity among four and five-year-olds. The Piagetian view (e.g., Flavell & Wohlwill, 1969) of course, would be that this is only "pseudo-transitivity" and does not reflect true understanding. Given the above, it is important when considering the present results(particularly concerning preoperational performance) to examine how the current method-

ology may have influenced responding on the transitivity task.

It will be remembered(see method section) that in this study, a three term series problem was employed using blocks which varied in height by one-half inch. Just prior to making the transitivity judgment, children were questioned concerning the initial two premises and if they did not remember both, the experimenter started from the beginning and went through the enter procedure again. In an attempt to avoid simple labeling of the blocks i.e., the green one is small and the red one is big etc., the experimenter asked the memory questions in such a fashion so that only the intermediate size block was labeled, and in both directions, so that it was "larger" than one block and "smaller" than the other. This is not to imply that subjects could not or did not spontaneously label the smallest and largest blocks, but rather, that the experimenter did not supply such labels. Although the memory training was not so extensive as Trabasso (Bryant & Trabasso, 1971) suggests as necessary, the fact that only a three term series problem was employed seemed to minimize the need for extensive training. In general then, this experiment established a context which appeared to offer the subject a reasonably large amount of aid in solving the problem, which may account for the high level of performance among preoperational children.

As noted earlier, the majority of both preoperational and concrete operational children (who were all first graders and approximately the same age) successfully answered the transitivity question. In every condition, however, the concrete operational children had a higher percentage correct. With age and school grade held constant, along with training and task, these data indicate that concrete operational children, when confronted with a task context as outlined above, have a small but consistent advantage over preoperational children. Regarding task context, it may be, as Flavell(1971, 1977) notes, that certain situations make evoking and utilizing an ability more or less difficult. In the present circumstance, the problem was biased in the direction of simplifying the evocation and utilization of whatever skills the child might have available. With only judgments to go on however, it would be difficult to decide which set of abilities (e.g., Trabasso's linear array technique, Piaget's logical inferencing or simple perceptual discrimination) children were using. Several of Trabasso's studies,(see Trabasso, 1975), which required only judgments, were designed in such fashion, i.e., using five and six series problems, to test for the child's utilization of a linear spatial array. It may be however, that altering the task in this fashion, also alters which abilities the child evokes and utilizes.

One possible way of examining this issue, is to ask the child for a rationale. However, before discussing the matter of rationales, several further comments are necessary concerning how other variables beside cognitive level had an effect on transitivity performance.

Unlike cognitive level, treatment was a significant variable in all of the conditions tested. This effect clearly indicates that children, regardless of cognitive level were influenced in their judgments as a result of first witnessing an incorrect ending to a problem. In all conditions, correct performance was reduced significantly when a child first witnessed an incorrect ending to the transitivity problem. As this result also occurred in the referent materials condition (where no photographs were used), it appears that this effect is not dependent upon the use of photographs.

Degree of wrongness was only significant in the photographic/actual object condition. Specifically, the data revealed that with the actual objects, performance for both cognitive levels declined as a result of witnessing the absurd ending (especially among the preoperational children). On the other hand, in the photographic condition, preoperational performance declined as a function of witnessing either the absurd or illogical ending, and concrete operational performance declined after witnessing the illogical but not the absurd ending.

These data appear to indicate that a photograph, in respect to its fidelity to reality, is more closely heeded when it departs significantly from reality (as was the case in the absurd ending). A similar finding in the O'Connor et al. conservation study, indicated that when children viewed the photographs before doing the actual conservation task, they were more likely to select the photo as "the way the water really should look" when it turned out incorrectly. On the other hand, the present data indicate that with actual objects, especially for the concrete operational children, a less dramatic departure from reality (i.e., the illogical ending) is more readily believed and paid attention to. Thus, it would appear that although both groups of children successfully answered the judgment question the majority of the time, their ability to withstand counterfactual evidence varied as a function of how the material was presented (photographic or actual object) and the extent to which it departed from what would logically be expected.

The next issue to be discussed is the rationales given for transitivity judgments. As outlined in the results section, these rationales were classified as "unintelligible", "exclusions", and "juxtapositions". Averaging across all conditions, the data revealed that preoperational children gave "unintelligible" rationales 69.1% of the time whereas concrete operational children

did so 44.2% of the time. In every condition, the preoperational children gave significantly more "unintelligible" rationales than the concrete operational children. Concerning "exclusion" rationales, preoperational children gave on average 37.5%, whereas concrete children gave 21.3%. However, there was no significant cognitive level difference for this type of rationale in any of the conditions. Finally, an examination of "juxtaposition" rationales revealed that on average preoperational children gave such a rationale 6.9% of the time, and concrete children did so 34.5% of the time. In every condition, the concrete children gave significantly more "juxtaposition" rationales than the preoperational children. Contrasting the photographic/actual object condition with the referent materials condition revealed that the number of "unintelligible" rationales decreased in the referent materials condition for both the preoperational and concrete operational children, whereas the number of "exclusion" rationales increased for both groups. Specifically, in the photographic/actual object condition, preoperational children gave on average 79.4% "unintelligible" rationales and 14.4% "exclusions", whereas in the referent materials condition, these percentages were 58.8% and 33.8%, respectively. Similarly, for the concrete children, in the photographic/actual object condition they gave 54.7%

"unintelligible" rationales, and 10.5% "exclusion", whereas in the referent materials condition these figures were 33.8% and 32.5%, respectively.

These categories were adopted from Glick and Wapner(1968)¹, who report a transitivity study which examined cross sectionally (i.e., 8 to 13-year-olds) the judgment versus judgment/rationale issue as a function of age, mode of presentation(actual object versus verbal presentation), and form of presentation (isotropic e.g., A<B<C versus heterotropic, e.g., B>A; B<C). The results of that study revealed an ontogenetic trend of more successful judgment and more logical type rationale use with age. In the present study, age was held constant (i.e., 6-year-olds) and cognitive level varied, and the same type of trend emerged, i.e., more "unintelligible" rationales were given by preoperational children and more "juxtaposition" rationales were given by concrete operational children.

It is necessary at this point to consider exactly what these rationales imply. The so-called "unintelligible" rationale, e.g., "because", or "I just know", etc., may imply several things. For example, it could conceivably mean that a) the child has no understanding and is simply guessing, b) the child has solved the problem

¹In the present study the term "unintelligible" was used in preference to "tautology"(employed by Glick & Wapner). The former term more accurately reflects the nature of the category in question.

by some method other than logical inferencing (e.g., direct perceptual discrimination, scanning of a linear spatial array) and does not have the ability to verbalize this process, c) the child has solved the problem by a logical inference and cannot verbalize this logic d) some combination of b and c. The "exclusion" rationale, wherein the child announces one but not both of the premises, e.g., that $A \setminus B$ or $B \setminus C$, could conceivably imply one of the meanings previously outlined for "unintelligible" rationales, except that the child is demonstrating an ability to verbalize what is, from a logical standpoint, a more adequate explanation. Finally, the "juxtaposition" rationale, i.e., where the child announces both premises, appears to reflect an understanding or belief on the child's part that an adequate explanation in this circumstance requires the stating of both the relational premises which the child has witnessed. One further meaning, which entails all three rationales, is that the rationale which the child gives may not reflect so much the way the child has solved the problem, but the social understanding which the child has concerning what types of rationales are appropriate in these circumstances. In other words, the child may, for example, have actually solved the problem using a linear spatial array, but when called upon to justify his answer may either not be aware of how he solved the problem

or if aware, may be unable or unwilling to verbally express it. Interestingly, Huttenlocher(1968) notes that adults tested on this type of problem reported feeling embarrassed over solving the problem by the use of an internally represented spatial array.

As noted by several authors (Braine, 1959; Bryant, 1973; Bryant & Trabasso, 1971; Brainerd, 1973a) the requirement of a rationale as part of the criteria for passing a transitivity problem may result in type II errors, i.e., false negatives wherein the child really understands the problem but does not have the ability to verbalize his answer. The more demanding type of Piagetian response to this assertion would be that if the child really has the logic then he will be able to verbally express it. However in more recent works (Piaget, 1974) Piaget has acknowledged that there is a developmental gap between understanding something and being able to verbally express it. In the present study, a rationale was not treated as evidence of the understanding of transitivity, but was used to see if children at different cognitive levels would use different types of rationales and how photographs might affect those rationales, and not to define one rationale as better than another. On the other hand, it could be argued(e.g., see Glick & Wapner, 1968), that the more logical type rationale, such as juxtaposition(or integration, which

Glick & Wapner obtained from older subjects) is a more "adequate" type of justification than "unintelligible" and "exclusion" rationales. However, "adequate" in this case might mean "giving the experimenter what he is looking for". Going back to the point made about what rationales might mean, if they simply reflect social understanding of what the situation calls for rather than reflecting how the problem was really solved, then it would be conceivable that passing and failing of the judgment question would not necessarily have a great deal to do with the type of rationale which followed such judgment. In line with this assumption is Glick and Wapner's finding that logical rationales (i.e., integration type rationales) were given by their oldest subjects (18-year-olds) regardless of whether they answered the judgment question correctly. This might indicate that these older subjects know, in a social sense, what kind of answer is appropriate, but among those who failed the judgment question either the logic was misused or perhaps actually not used at all in solving the problem. In this regard then, the present data are illuminating.

The most clear cut finding was that, except in a very few instances, children who gave either an "exclusion" or "juxtaposition" rationale were also correct in the transitivity question. On the other hand, among those children, both preoperational and concrete op-

erational, who gave "unintelligible" rationales 25.4% . . . failed the transitivity question. In other words, the vast majority of children who failed the transitivity question also gave an "unintelligible" rationale. Glick and Wapner suggest (consistent with Werner, 1937) that the same judgment may reflect different sets of underlying processes. The present data, taken together with the Glick and Wapner findings reflect the possibility that the same rationale may mean different things as one develops. For example, the six-year-old data seem to support the idea that there is a direct link between their logical rationale and their understanding of the problem. In other words, for these children, it may be that the logical rationale reflects the attainment of transitivity understanding, which they are now able to articulate, and also an understanding that this task context is a socially appropriate moment for such a response. For the older subjects in the Glick and Wapner study who failed the transitivity question but still used a logical type rationale, it may be more out of social habit, i.e., thru schooling etc., that they are able to realize that this situation calls for something like a logical type statement of premises, so they simply figure out the right type of statement to make and fill in the blanks with the wrong answers.

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