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The effects of incompatibility between perception and logic in Piaget's stage of concrete operations

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THE EFFECTS OF INCOMPATIBILITY BETWEEN PERCEPTION AND LOGIC IN PIAGET'S STAGE OF CONCRETE OPERATIONS

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by

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CHAPTER I

INTRODUCTION

This thesis examines the relationship between thinking dominated by perception and thinking guided by use of consistent logical structures, and the bearing this relationship has on two approaches to problem-solving: empirical and deductive. It was suggested by Piaget's theory of cognitive development, which is characterized by a genetic epistemological approach, that is, the investigation of the laws under which knowledge evolves. Piaget[1] defines consecutive modes of thinking in terms of logical forms as models of operation of the mind. Thus thinking unfolds in several stages, each characterized by a precursor of the ultimate abstract logic. In the intuitive stage, logic (operational thinking) is absent; thinking is prelogical and bound by perception. The succeeding stage of concrete operations refers to the onset of logical thinking, which is applied to discrete, concrete situations. The child demonstrates some characteristic of a

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[1] J. Piaget. Psychology of intelligence. London: Routledge and Kegan Paul, 1950.

given stage by solving problems typical of that developmental step. Intuitive thinking is reflected in an empirical approach, while operational thinking is reflected in a deductive approach.

These two successive modes of thinking have been investigated in studies on children lacking operational structures.[2,3,4,5] Attempts to teach the subjects to solve problems involving logical operations led, at best, to empirical learning. Although the newly acquired skill was correct for the particular situation, it lacked the underlying logical principles. This empirical approach to problem-solving was found to persist throughout the intuitive stage, being replaced by deductive problem-solving in the concrete operational stage. Piaget[6] points out that

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[2] P. Greco. L'apprentissage dans une situation à structure opératoire concrète. Etudes Ep. Gen., vol. VII, p. 68-182. Paris: Presses Universitaires de France, 1959.

[3] A. Morf. Apprentissage d'une structure logique concrète. Etudes Ep. Gen., vol. IX, p. 15-83. Paris: Presses Universitaires de France, 1959.

[4] J. Smedslund. Apprentissages des notions de la conservation et de la transitivité du poids. Etudes Ep. Gen., vol. IX, p. 85-124. Paris: Presses Universitaires de France, 1959.

[5] J. F. Wohlwill. Un essai d'apprentissage dans le domaine de la conservation du nombre. Etudes Ep. Gen., vol. IX, p. 125-135. Paris: Presses Universitaires de France, 1959.

[6] J. Piaget. Apprentissage et connaissance, II. Etudes Ep. Gen., vol. X, p. 159-188. Paris: Presses Universitaires de France, 1959.

such an outcome is to be expected, since logical structures cannot be merely taught, they are learned only when there is readiness for a reorganization into operational systems.

Most studies on the relationship between intuitive and operational thinking consider only one variable: the absence of operational thinking. The question then arises: is this the only variable in relation to which perceptually bound thinking should be considered? Could not such thinking with its empirical approach persist even after more advanced forms of thinking have emerged? Furthermore, in these studies the alternatives--to rely either on perceptually dominated or on logically guided thinking--were not present under controlled conditions. The question is thus extended: if given the opportunity, would perception predominate even in the presence of operational thinking?

The relationship between perceptually dominated and logically guided thinking was therefore examined in a situation where perceptual configurations and logic competed. The investigation was carried out during a period in the child's development which Piaget[7] has described as

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[7] J. Piaget. Apprentissage et connaissance, II. Etudes Ep. Gen., vol. X , p. 165. Paris: Presses Universitaires de France, 1959.

transitional between intuitive and operational thinking. The subjects, however, demonstrated having the rudiments of operational thinking but differed in their reliance on empirical laws in problem-solving. The inferences drawn from the results were intended to clarify further the nature of cognitive development, as viewed by a genetic epistemological approach.

CHAPTER II

THEORETICAL CONSIDERATIONS

In this chapter, the present study is related to certain aspects of Piaget's theory of cognitive development. The review of the literature is therefore limited to a brief exposition and discussion of this theoretical framework along the following lines: perception in the context of cognitive development; the concept of successive modes of thinking; pertinent earlier studies; and relevant experimental methodology.

Perception in the context of cognitive development

At all levels of cognitive functioning, Piaget[8] distinguishes between a logical, or "operational" aspect and a perceptual, or "figurative" aspect. Perception unfolds separately but not independently of logic.

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[8] J. Piaget. Les mécanismes perceptifs. Paris: Presses Universitaires de France, 1961.

Piaget assumes an interaction between the two aspects and considers that the successive forms of perception are therefore not a direct outcome of the previous ones. At each step, new forms are determined by the interaction with contemporaneous logical functions. This interaction eventually results in perceptual activity and enriches perception while decreasing its deceiving effects.

Piaget qualifies his stand further by contrasting it with the unitary theory of cognitive functioning as expounded by Koehler and Wertheimer, where there is the implication of a linear relation between the perceptual and the higher intellectual structures to which it directly gives rise.[9] More recently Michotte[10] most clearly exemplifies the unitary point of view. He holds that certain meanings are intrinsic, present on the perceptual plane before they are actually acquired through experiences. While acknowledging the learned meanings of much that is perceived, in his phenomenological approach Michotte can also see intrinsic meanings in sensory structures. As

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9 J. Piaget. Les mécanismes perceptifs. Paris: Presses Universitaires de France, 1961, p. 353-440.

10 A. Michotte. Rapport de A. Michotte. La perception. Symposium de l'association de psychologie scientifique de la langue française, Louvain, 1953, p. 31-45. Paris: Presses Universitaires de France, 1955.

opposed to this approach, Piaget points out that perception is deceiving and that its misleading qualities wane only through interaction with logical thinking.

In the absence of the unifying stability of logical structures, perception, as an intrinsic aspect of the child's relation to the world, contaminates the first attempts at thinking. The unreliability of early perception stems from its "centering" effects. On the one hand, centering refers to the tendency of sense organs to move in one direction at once. On the other hand, centering is seen when prominent portions of the figure (e.g., large areas in the visual field) capture the attention with consequent distortions.[11] Hence thinking is at the mercy of changes resulting from successive centerings.[12] The child is egocentric, and everything becomes relative to his perception of things.[13]

Piaget's position on perception contrasts with other current theorists primarily in his view that percep-

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[11] D. E. Berlyne. Recent developments in Piaget's work. Br. J. Ed. Psychol., 1957, 27.

[12] B. Inhelder. Some aspects of Piaget's genetic approach to cognition. Paper read at the Conference of Intellective Processes Research, Dedham, Massachusetts, April, 1960.

[13] J. Piaget. Les mécanismes perceptifs. Paris: Presses Universitaires de France, 1961, p. 356.

tion, with its centering effects and consequent distortions, can hinder thinking until there is some reliance on stored information through the development of logic.

Successive modes of thinking

The constant interaction between the logical and perceptual aspects of cognition can be best understood in the context of successive modes of thinking. Piaget's perspective in tracing stage after stage of thinking is known as "genetic epistemology". Whereas the philosophical epistemologist's query is, "What is knowledge?", Piaget, the genetic epistemologist, asks, "Under what laws does knowledge develop and change?" He defines cognitive growth in terms of logical forms, as models of operation of the mind. The ultimate form of thinking, reached only during and after adolescence, is characterized by an equilibrium, stable, mobile, and encompassing a wide field in an individual's experience.[14] It is never quite perfectly attained, but may be regarded as a sort of mathematical limit. In problem-solving it is reflected by a deductive approach.

Piaget searches for the roots of logical think-

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[14] J. Piaget. Logique et équilibre dans les comportements du sujet. Etudes Ep. Gen., vol. 11, p. 25-117. Paris: Presses Universitaire de France, 1957.

ing in biological principles, as organism and environment reach their first forms of equilibrium through assimilation and accomodation. He follows logic throughout the child's cognitive development, and sees the various incomplete equilibria as temporary overall halts where cognitive changes are integrated. These periods of integration of each successive mode of thinking are the stages of development.

The notion of stages is essential to Piaget's understanding of the development of cognition.[15] They define the successive boundaries of intelligence, describing the child's behaviour system and reflecting the rules by which the child operates at any particular phase.

During the pre-verbal period of life the child develops the blueprints of logic in action at a sensory-motor level. During the next period, the preconceptual and intuitive stage, he relearns at a symbolic level what he knew in a world of concrete objects and actions. This new reorganization also incorporates an intuitive logic that later leads to operational thinking:

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[15] Murchison. A history of psychology in autobiography. Vol. IV. An autobiography by Jean Piaget. Clark University Press, 1952.

> . . . there is new structuring . . . we see gradual coordination of representative relations and thus growing conceptualization, which leads the child from the symbolic or preconceptual phase to the beginnings of the operation . . .[16]

Intuitive thinking still lacks unifying stability. During this time the child uncritically accepts the dictates of whichever aspect of change he happens to perceive. During the intuitive stage, thinking seems to be conspicuously bound by perceptual configurations:

> . . . the limitations are obvious. Intuition being a direct relationship between a schemata of internalized action and the perception of objects, results only in configurations "centered" on this relationship.[17]

An example of the child's "centering" his attention on an immediate perceptual relation is seen when one of two clay balls, acknowledged to weigh the same, is transformed into a long, thin sausage. Bound by perceptual configuration, the child insists that the sausage now weighs more than the ball because it is longer, or less, because it is thinner. Such a performance is to be expected on this typical conservation-of-weight task, where the empirical approach can be seen in the forming of an ad hoc rule.

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[16] J. Piaget. Psychology of intelligence. London: Routledge and Kegan Paul, 1950, p. 129.

[17] Ibid., p. 138.

As thinking evolves from intuitive forms and "perceptual relativity" to the intellectual relativity of the more advanced cognitive forms, a corrective factor appears: "decentralization". It results from the comparisons and transpositions of perceptual activity, and provides flexible supports needed for launching the operational mechanisms.

The rudiments of logical thinking gain primacy during the next phase of cognitive development which is characterized by operational thinking. Perception is subordinated as the child takes into account other sources of information apart from those predominantly perceptual. A reliance on operational thinking can compensate for changes in perception.

As defined by Piaget,[18] "operations are actions which are internalizable, reversible, and coordinated into systems by laws which apply to the system as a whole." They lead to mobile reversibility, stability, and wideness of field that allows the extension of thought into the world far beyond the momentary ranges of the individual's senses or even life span.[19]

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[18] J. Piaget. Logic and psychology. New York: Basic Books, 1957, p. 8.

[19] D. E. Berlyne. Recent developments in Piaget's work. Br. J. Ed. Psychol., 1957, 27.

In both concrete and abstract situations, operations are characterized by their organization into systems of "groupings". The "groupings" depend on five simultaneous laws, the definition of one involving reference to the others. One of them is "transitive combinativity", by which is meant that the combination of two successive operations is equivalent to a third operation. Piaget[20] locates transitivity among the operational groupings as follows:

> In practice, the operational groupings . . . lead to the following structures. First of all they lead to the logical operations of fitting classes together . . . and of serializing asymmetrical relations. Hence the discovery of transitivity which permits of the deductions: A=B, B=C, therefore A=C.21

When applied to judgment of quantity and measurement in general, transitive combinativity can be expressed as: $(A > B)\ \&\ (B > C) \supset (A > C)$, meaning that if A is greater than B, and B is greater than C, then A is greater than C.[22]

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20 J. Piaget. Psychology of intelligence. London: Routledge and Kegan Paul, 1950. p. 143.

21 Ibid.

22 M. D. S. Brain. Ontogeny of certain logical operations. Psychol. Monogr. 1959, 73.No. 5 (Whole No. 475).

In a typical situation where the child demonstrates having acquired transitivity as one aspect of the more general ability to perform logical operations, the following experiment is performed with reference to weight: in front of the subject an object A and an object B are put on a balance scale; the subject is asked to compare their weights; the same is done for the object B now paired with an object C; then without any further actual weighing, the objects A and C are placed in front of the child and he is asked to infer the relative weights of A and C. The deductive approach is reflected in the use of relevant information from previous steps combined with the perceptual configuration, resulting in the final correct judgment about A and C.

Pertinent earlier studies

Piaget and Lambercier[23] showed that perceptual distortions, e.g., in overestimating the size of a stimulus on which attention is constantly focussed, can be automatically corrected by the interaction with logical operations. They found that subjects in the intuitive stage overestimated a nearby rod A when judging its length with reference to a distal, equal sized rod C, even though provided with a movable rod B which could help compare A to C. By

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[23] J. Piaget and M. Lambercier. Transpositions perceptives et transitivité opératoire dans les comparaisons en profondeur. Arch. Psychol., Geneve, 1943-1946, 30-31.

applying transitivity of length, subjects in the concrete operational stage approached the problem deductively; they used logical operations (A = B and B = C, therefore A = C) in order to obtain the correct answer.

Experiments on teaching logical structures demonstrated, according to Piaget,[24] that although not independent of experience, they are acquired only when previous prelogical structures are readily given up. Using transitivity and conservation, experimenters tried to teach children who did not possess concrete operational thinking how to solve problems deductively. On the whole, they found that if learning occurred at all, there was still a great reliance on perceptually bound thinking. Even when correct responses were finally given, they were based on responses to empirical data; the principles were not understood. Smedslund[25] found some learning of conservation-of-weight which indirectly led to improvement in the performance of transitivity-of-weight tasks. He attributed the latter

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[24] J. Piaget. Apprentissage et connaissance. I and II. Etudes Ep. Gen., vol. VII and X. Paris: Presses Universitaires de France, 1959.

[25] J. Smedslund. Apprentissage des notions de la conservation et de la transitivité du poids. Etudes Ep. Gen., vol. IX, p. 125-135. Paris: Presses Universitaires de France, 1959.

result to a cognitive reorganization necessary for the learning of logical operations. In a more extensive study, he found markedly negative results in direct teaching of transitivity:

> The negative results on direct transitivity learning illustrates a situation where no cognitive reorganization occurs and where there is not even empirical learning.[26]

Smedslund[27] considered that the normal development from non-conservation to conservation is also a transition from a perception-bound concept to one less dependent on immediate perception. He therefore tried to improve the teaching by extinguishing responses depending on visual cues, but again had negative results.

In all these experiments, the relation between perception-bound and logical thinking was viewed in relation to one major variable: the absence of concrete operational thinking. Furthermore, the reliance on empirical laws was considered uniform in all children and not independently varied.

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[26] J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959, p. 38.

[27] J. Smedslund. The acquisition of conservation of substance and weight in children. Introduction, Scand. J. Psychol., 1961, 2, 11-20.

Experimental methodology

The methodology of genetic epistemology raises problems about using a purely verbal approach. Piaget's method in the beginning was not only verbal, but also non-standardized, and seldom allowed for replication. His flexible, unstandardized method of inquiring into the reasons for wrong answers is illustrated in his writings from 1921 to 1925.[28,29,30,31] This "methode clinique" has been greatly revised and now allows for replication. It is still a verbal "interrogation" method, and as such has raised certain objections. Brain,[32] in discussing these, points out the diagnostic nature of Piaget's questioning technique, by which he tries to find a process he knows

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28 J. Piaget. Judgment and reasoning in the child. New Jersey: Littlefield, Adams & Co., 1959.

29 J. Piaget. The child's conception of the world. New Jersey: Littlefield, Adams & Co., 1960.

30 J. Piaget. The child's conception of physical causality. New Jersey: Littlefield, Adams & Co., 1960.

31 J. Piaget. The language and thought of the child. New York: Meridian Book, 1955.

32 M. D. S. Brain. Problems and issues in the study of conceptual development. Paper read at the Conference of Intellective Processes Research, Dedham, Massachusetts, April, 1960.

may be there. In this way his results become illustrations and suggestive observations. Furthermore, Brain distinguishes between behavioral and verbal manifestations of a concept, which become obscured in Piaget's technique.

> Vocabulary development may well be a factor in many of Piaget's experiments. Its confounding effects cannot be eliminated unless nonverbal methods of presenting the tasks to the S's are used . . . No theory which postulates levels of conceptual development can be regarded as definitely established when the supporting data are obtained through extensive verbal communication with S's who differ in their ability to verbalize.33

This discrepancy in age norms, for the appearance of different forms of operational thinking, suggests that differences in results may depend upon differences in the loosely defined verbal methods. Brain's non-verbal approach consisted of administering transitivity-of-length tasks by a discrimination method; he thus found that the operation was available at an age at least two years prior to the norm where Piaget located its emergence. The study was inconclusive since a direct comparison to norms obtained by Piaget's method seemed impossible; Brain had no comparison with a parallel control group to which the identical tasks could have been presented.

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33 M. D. S. Brain. Ontogeny of certain logical operations. Psychol. Monogr. 1959, 73, No. 5 (Whole No. 475).

Hence a satisfactory experimental design for purposes of direct comparison should include both a Brain discrimination non-verbal type of approach and a Piaget interrogation verbal one.

To recapitulate, experimental attempts to teach a deductive approach to problem-solving fail in the absence of operational thinking; children cling to perceptual centering or at best apply empirical solutions. It is further shown that in the presence of concrete operational thinking, there is an imposition of logical thinking on perceptual organization in a purely perceptual task. What has not been examined is the imposition of perception-dictated thinking on a deductive task once concrete operational thinking has been reached.

Piaget's theoretical, but non-experimental, formulations indicate that once a more advanced level of cognitive development is established, older forms of thinking lose their emphasis. On this same point Inhelder[34] states:

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[34] B. Inhelder. Discussion. Paper read at the Conference of Intellective Processes Research, Dedham, Massachusetts, April, 1960.

> . . . once the child has reached the structure of mental operations characteristic of a given stage, the child need not refer back to the process used in the formation of the prior stage . . . the earlier processes seem abandoned, with the elaboration of newer ones . . . and once he has built a particular structure, he does not seem to go back to any former structure.

It is known that the adult relies on stored information, using premises, even when confronted with perceptual evidence that strongly contradicts it. Do children who have just reached this ability for operational thinking react likewise when faced with the same contradictions?

Within this context, the following issues arise:

1. What is the relation between perceptually bound and logically modeled thinking once concrete operational thinking is apparent?

2. How will children capable of operational thinking, but in some areas still relying on ad hoc empirical laws, respond in situations where perceptual configurations directly contradict logic?

3. If Piaget's verbal interrogation and Brain's non-verbal discrimination techniques are used in parallel procedures, how will the results compare?

CHAPTER III

THE EXPERIMENT

In this chapter a general hypothesis is elaborated into three specific ones. The measures used in the experiment are justified prior to a description of the actual method by which the hypothesis is tested.

Hypotheses and Predictions

From a consideration of the issues raised at the end of the previous chapter, a general hypothesis is stated:

The supremacy of misleading perception is a function of empirical orientation during the concrete operational stage. It is more evident in investigations that use interrogation rather than discrimination methods. This general hypothesis incorporates three specific ones:

In the concrete operational stage, when solving problems that offer both perceptual and logical cues:

1. Children with an empirical orientation err more often than children with a deductive orientation.

2. Children with an empirical orientation make proportionately more of their errors when perception directly contradicts logic, than do children with a deductive orientation.

3. Children rely on logical operations more often when the tasks are presented by a discrimination method than when they are presented by an interrogation method.

Measures

These hypotheses were approached by considering one aspect of misleading perception--the primary reliance on the perception of size, and one characteristic of logical (operational) thinking--transitivity as applied to weight. In addition, the age range was limited to five to seven years. This age range was suggested in the literature as the transition from the intuitive to the concrete operational

stage. According to Piaget[35] ". . . the period from 5 to 7 years marks the transition between preoperational structures and concrete operations. . ." All subjects demonstrated some rudiments of concrete operational thinking by performing correctly on two typical tasks of the concrete operational stage: transitivity-of-weight and conservation-of-weight problems.

Subjects differed in the explanations they gave to their correct solutions on the conservation-of-weight problems. These explanations, categorized as "P" and "S" according to Smedlund's[36] norms, defined the first independent variable: an empirical orientation and a deductive orientation. Two groups, named respectively the P group and the S group, were chosen to represent this variable. The two types of explanations were thus defined:

"P" explanations: all explanations that directly or indirectly referred to observable features in the present situation.

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35 J. Piaget. Apprentissage et connaissance. II. Etudes Ep. Gen., vol. X, p. 165. Paris: Presses Universitaires de France, 1959. Liberal translation by the present author from the following French text: ". . .celle de 5 à 7 ans qui marque la transition entre les structures préopératoire et les opérations 'concrètes' . . ."

36 J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959.

"S" explanations: all explanations that directly or indirectly referred to previous events in the same test item.

Smedslund also reported that in an interjudge reliability test in scoring "P" and "S" explanations, there was complete agreement on "S" type of explanations and 96% to 97% overall agreement. In his studies there was a high positive correlation between correct judgments and "S" explanations, but a number of subjects who gave correct judgments gave "P" explanations. It seemed that these "P" subjects, while able to give correct answers, were still relying exclusively on empirical data, and approached the task empirically.

Using conservation-of-weight in relation to transitivity-of-weight was suggested by Smedslund, who found that they develop closely together, but ". . . do not seem to be symptoms of the same underlying grouping of operations . . ."[37]

The mode of presentation of test tasks--the interrogation and the discrimination methods--represented the dichotomized second independent variable.

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[37] J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959, p.75.

The interrogation method was operationally defined following Smedslund's verbal questioning procedure,[38] in which explicit reference was made to the relative weight of the test objects.

The discrimination method resembled the general discrimination method used in learning experiments, and was the one used by Brain.[39] This method omitted all direct reference to the fact that one of the two objects simultaneously weighed on the balance scale was heavier. The subjects discriminated the heavier object by consistently associating its choice with some sort of "yes" cue. Brain thought that in Piaget's method, and by implication in Smedslund's, motivation was not sustained, therefore he had his subjects find candy when responding correctly. He observed, however, that after a while some subjects lost interest in searching for this comestible. Since the present study required the interest of all children at all times, tokens were provided which could be exchanged for a series of trinkets and hobby materials. This was suggested by Bijou and Sturges;[40] they underlined the advantage of allow-

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38 J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959, p. 47-48.

39 M. D. S. Brain. Ontogeny of certain logical operations. Psychol. Monogr., 1959, 73. No. 5 (Whole No. 475).

40 S. W. Bijou and Sturges. Positive reinforcers for experimental studies with children. Child Develpm., 1959, 30, 151-170.

ing the child to manipulate reinforcers whose effectiveness usually was influenced by age, historical factors and local interests. They also pointed out that this cafeteria style offered variety among reinforcers, which helped to forestall satiation and a decline of motivation.

The quantification of the performance on the experimental transitivity tasks which also allowed for perceptual centering, served as the operational measure of the dependent variable.

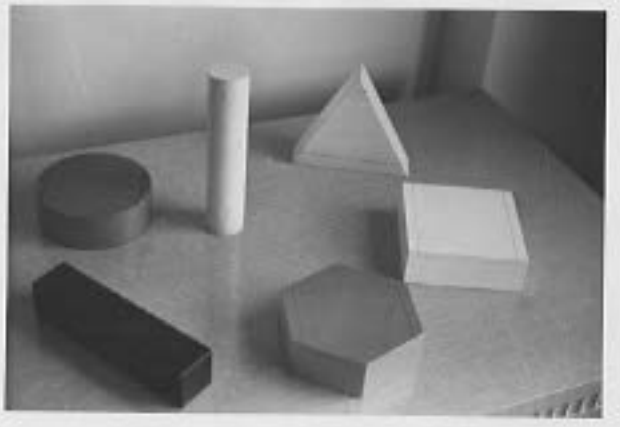
Method

Apparatus

At all steps of the experiment, a precision, avoirdupois, Pelouze R-47 balance scale was used. It had two sides and no calibrated weight readings.

For the conservation-of-weight tasks, eight pairs of colored identical balls, in red, green, yellow and blue, were made out of "Modeline" modeling clay.

For the various transitivity-of-weight tasks, there were eighty-two objects in six basic geometric shapes (Fig. 1: square, cylinder, triangle, oblong, circle and hexagon), of three different sizes, with linear dimension in a one, two, three ratio. They were painted nine assorted colors (white, pink, orange, red, yellow, blue,



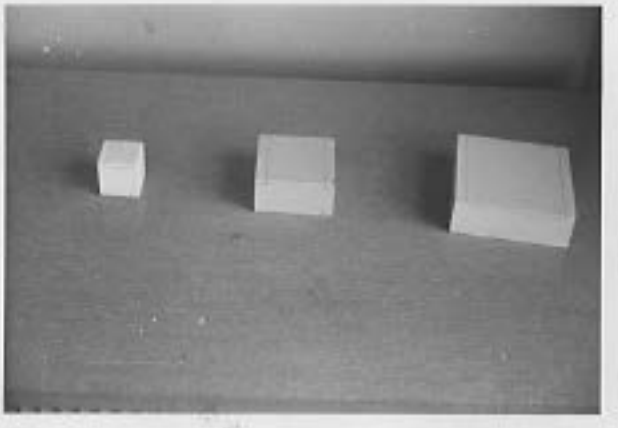


FIGURE #1

TEST OBJECTS IN SIX DIFFERENT SHAPES AND THREE SIZES

green, brown and black) of auto dyes resistent to peeling and dulling. Each geometric shape had hollow compartments covered by sliding doors, in which tokens for the discrimination method could be hidden. The space also allowed for a variation in weight by introducing round, flat, lead weights, uncalibrated.

The reward material used with the discrimination method included tokens: play-money made of thin, shiny, almost weightless material, each with the diameter of a U. S. dime. The tokens could be exchanged for trinkets and hobby materials. These were attached with elastic thread to a 22" by 28" display cardboard, separated into four categories bordered off by red lines, each section identified by the number of poker chips equal to the number of tokens necessary to obtain a prize-object in that section.

Subjects

In order to test the hypothesis, criteria were set in selecting a sample whose ages ranged from five to seven years, who were able to solve typical logical problems and whose orientation could be defined as empirical or deductive.

In the process of selecting the thirty subjects of the experimental sample (N = 30) who met the criteria,

236 children were screened. They all came from a suburban, middle to upper-middle income group; all subjects were attending kindergarten or the first grade in one of three elementary schools at the time of data collecting.

The thirty chosen subjects solved correctly seven out of eight conservation-of-weight problems, showing that they could reliably deal with this aspect of concrete operational thinking (seven out of eight correct solutions reaches significance on the sign test). Subjects also had to show that they could reliably deal with typical transitivity-of-weight problems (six out of six correct solutions reaches significance on the sign test).

The P Group. Operationally defined, subjects were said to have an empirical orientation if they gave a "P" explanation to more than two correct solutions of the conservation-of-weight problems. Actually most subjects gave P explanations to 6 or 7 of the 8 items. Ten subjects (N=10) were assigned to the group in this way and were presented the transitivity tasks by the interrogation method, forming the P group-interrogation.

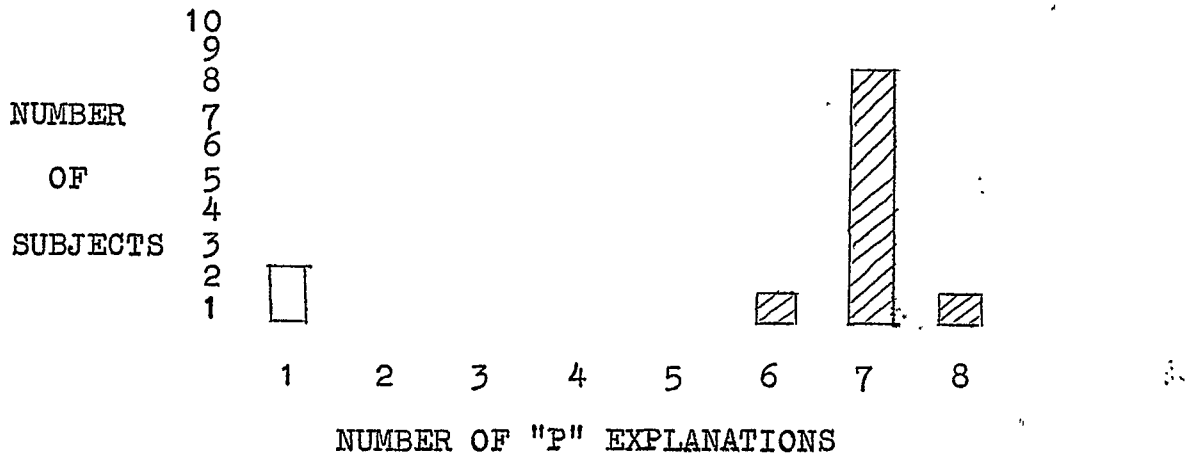
The S Group. Operationally defined, subjects were said to have a deductive orientation if they gave "S" explanations to at least seven of the correct solutions of the conservation-of-weight problems. Twenty subjects (N=20)

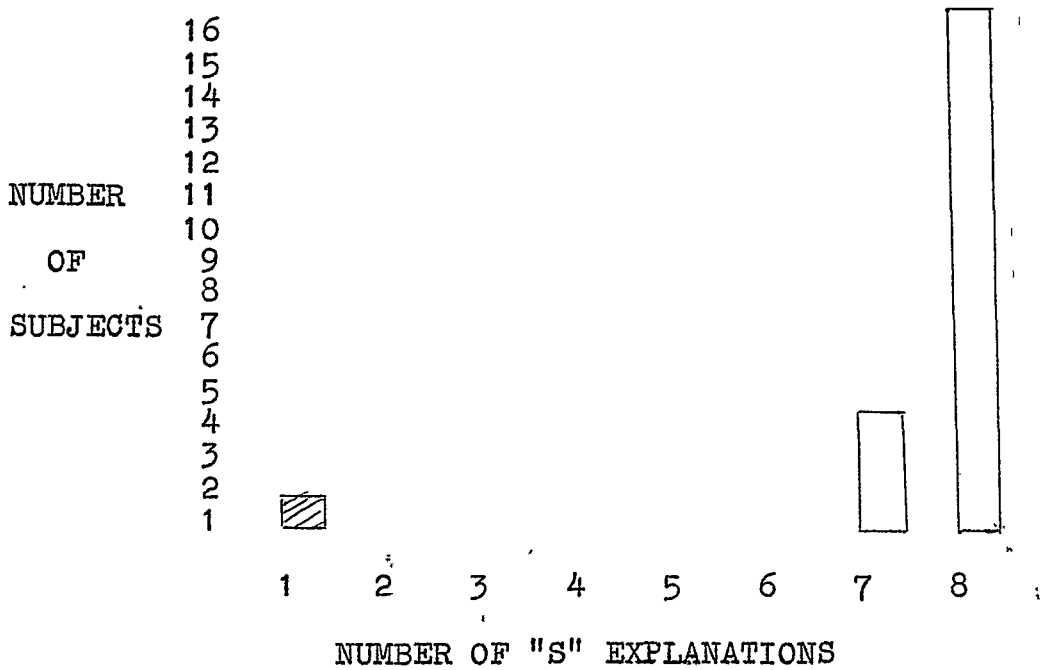
were assigned to the group in this way. Half of these subjects (N=10) were presented with all transitivity tasks by the interrogation method, forming the S group-interrogation. The remaining half (N=10) were presented the transitivity tasks by the discrimination method, forming the S group-discrimination.

Two independent raters, the examiner and a psychologist who had little familiarity with the overall procedure, rated children's explanations for their correct responses on the conservation-of-weight tasks. There were 240 responses to be scored as "S" and "P" in the sample of thirty subjects, and there was 100% agreement between the two raters.

The distribution of "P" and "S" explanations in the two groups (Figure #2) seemed to discriminate between the two populations, P and S; the subjects who gave many "P" explanations, gave few "S" explanations, and conversely.

Random sampling with respect to sex distribution was attempted. On inspection, it appeared that there was a difference in male-female distribution in the three groups. Therefore the null hypothesis that there was no significant difference in sex frequency was tested, comparing the three experimental groups. The Fisher Exact Probability Test,





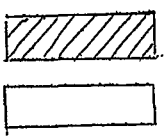


FIGURE # 2

CRITERION EXPLANATIONS DISTRIBUTED BY GROUPS

whose procedure is described by Siegel,[41] was used. The null hypothesis was accepted, since the obtained probability of occurrences of this type of distribution was found to be greater than 0.05 for all comparisons (Table 1). It was concluded that the distribution of male and female was not significantly different in the three groups.

There was an attempt at random distribution of the ages of children who ranged from five to seven years in the experimental groups. In testing whether the ages in the three samples came from a common population, with respect to age, an analysis of variance and a test of significance based upon F distribution were used, as described by Edwards;[42] the value of F was smaller than one, and not significant at the 0.05 probability level (Appendix A). The hypothesis of random sampling from a common population, with respect to age, was regarded as tenable.

Procedure

The experimenter met most subjects in a group for the first time, and was introduced to them by the class teacher. Maximum cooperation was obtained from the school

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41 S. Siegel. Non-parametric statistics. New York: McGraw-Hill Book Company, Inc., 1956. Chapter 6.

42 A. L. Edwards. Experimental design in psychological research. New York: Rinehart & Company, 1950. Chapter 10.

TABLE 1

MALE - FEMALE DISTRIBUTION COMPARED BY THE FISHER EXACT PROBABILITY TEST

	MALE	FEMALE
P GROUP - INTERROGATION	4	6
S GROUP - INTERROGATION	7	3

$p > 0.05$

	MALE	FEMALE
S GROUP - INTERROGATION	7	3
S GROUP - DISCRIMINATION	6	4

$p > 0.05$

system and at all times from the children.

All children were seen individually. When the examining room was at some distance from the classroom, each child was escorted by the examiner. When testing took place in an adjoining room, the teacher sent the children next door to the examiner.

There were four experimental sessions, lasting from fifteen minutes to half an hour, depending on the child's speed in responding, irrelevant chatter, and comments about the examiner. In the first two sessions, the sample of 30 subjects was selected according to the criteria. During the third and fourth sessions, the actual experiment was carried out.

The First Session. This was the pretest session during which the conservation-of-weight tasks were used for the purpose of selecting subjects who could deal with problems involving logic, and in order to assign them to P and S groups. There were three steps:

a. The use of the scale was shown to the subject who then had to demonstrate his understanding of the process of weighing. At no time did the subject weigh things, since care was taken to avoid reliance on kinesthetic sensations. The subject was directed to get his

information entirely from the scales.

b. The eight conservation-of-weight tasks were then administered. In the typical task, the experimenter weighed two clay balls of exactly the same volume, appearance and weight, then transformed one of them into one of four shapes: ring, triangle, basket, star. These were different in shape, although not grossly different in size, from the ball. The eighth task was somewhat irregular, since the transformed ball was shaped into a "snake", which also differed grossly in size from the original ball. Each task was accompanied by these instructions:

> See these two balls of clay; watch me weigh them . . . what do you think . . . yes, they both weigh the same . . . now remember that. (as the two balls were removed from the scale, and one of them was transformed in front of the child) . . . now I'm going to make a . . .(something that looks like a . . .) Do you think that this . . . weighs more than the ball (pointing at both objects alternately), or less than the ball, or the same as the ball?

c. After the subject gave the correct answers, he was asked "Why?" If he did not respond, the following alternatives were used:

> How could you tell that . . .? What is it that makes you think that . . .?

If he still did not respond, the possible burden of responsibility for justification was further relieved by gentle prodding: "Guess . . . you can do that, just

guess . . .?" Ultimately all subjects responded.

At the end of this session, if qualifying for either "P" or "S" samples, the subject was informed about his return to the experiment.

The Second Session. This was the training-screening session, consisting of three steps. During this session further selection of subjects occurred.

a. Five training-to-weigh tasks were first introduced.

With the interrogation method, the five pairs of training-to-weigh tasks were introduced with the comment:

> I'm going to weigh any two of these nicely colored blocks, and I want to see whether you can really tell me each time which weighs more.

With the discrimination method on these same tasks, the subject was shown a token inside a dummy geometric shape and told:

> I'm going to weigh any two of these nicely colored blocks, and this way I can help you find a make-believe penny.

The subject was then led to the prize-display cardboard and shown how many tokens he would need to obtain a prize. He

was encouraged to think of the prize for which he would like to work. A wide variety of reinforcers was provided as the experiment went along. The increased number of opportunities for finding tokens was correlated with a greater variety of trinket-hobby objects of increasingly larger size. After the first pair of blocks was weighed and the subject indicated by pointing, color naming, or whatever procedure he preferred, which one "had the penny", the examiner checked in front of the subject to see if his choice was correct. If the token was found it was given to the subject. If he was wrong he was told:

> There is a way to find out where the penny is each time we weigh; you just watch carefully.

Subjects unable to be trained on this simple discrimination task were dropped from the discrimination method group.

b. This was a screening test consisting of six typical transitivity-of-weight tasks, in which all three objects were of equal size.

With the interrogation method, the tasks were introduced as follows:

> Now, I saw how well you can tell which of two things weigh more. In this next game, you'll have to tell me again, each time I weigh two things, which of the two is heavier, but you'll also have to remember which weighs more. You watch . . .

After A and B, paired, then B and C were weighed, the subject was asked which was the heavier in comparing A and C, which were not weighed together. Following his response, A and C were weighed in front of him, to allow him to check on the validity of his inference.

With the discrimination method, the child was first shown the new variety of toys he could get for playing this game. Then he was told:

> Now, I saw that you know how to find a penny. In this next game, you'll have to think again where you can find the penny each time I weigh two things; but you'll also have to remember where you thought it was, until I can show you if you were right. You watch . . .

Following the transitivity task, the child was shown whether he had actually found the token. The accumulated tokens were then exchanged for one of the prizes.

Subjects who did not succeed on all six tasks were not included in the experimental sample. This was introduced as a control to insure that during the experimental transitivity tasks, where the three objects were also of different size, there existed for all subjects two alternatives in solving each problem: one based on perceptual configurations, the other on the premise of transitive combinativity.

For all transitivity-of-weight tasks, whether in

the experimental sessions or in the screening ones, controls were introduced to avoid position responding by alternating the right-left position of A and C in the last step. To avoid favoring a response to A as always the heaviest, since always presented first, the series A > B > C was alternately reversed. Thus the odd-numbered tasks started C, B, A.

c. In order to get a baseline as to the subject's evaluation of weight according to size, the last step of the second session was carried out, as follows:

Children in the interrogation method group were asked whether, without weighing, they could guess which, in a series of four pairs of objects, of unequal size, was the heavier. Their guesses were then checked on a balance.

Children in the discrimination method group were asked whether, without weighing, they could guess in which of the two unequalsized pairs the token could be found. Then they were permitted to verify their judgments.

The two foregoing sessions allowed for the selection of the 30 subjects out of the 236 screened. Only these 30 were further seen during the third and fourth experimental sessions.

The Third and Fourth Sessions. Eighteen experimental transitivity-of-weight tasks were administered in each of these sessions; instructions similar to those in the typical transitivity-of-weight tasks were used. The subjects were warned, however, that they would not get the opportunity to check, after each item, the validity of their solutions. The examiner made it clear that a record of the performance was being kept.

The interrogation-method group were told that at the end of the session they would be informed of the number of correct answers given.

The discrimination-method group were told that at the end of the session they would be informed of the number of tokens earned.

This procedure was introduced to prevent learning during the experimental sessions.

In these experimental transitivity tasks, the three forms in each of the six geometric shapes were also of three different sizes (L denoted large, M denoted medium, S denoted small size). The dimension of size provided the perceptual-configuration aspect by which the problem could be solved, when the heaviest of the three objects was not also the largest, but medium or small in size: e.g., A-M > B-S > C-L or A-S > B-M > C-L. There were three possible

relations between size and weight. They were all included in order to avoid the direct learning that the smallest of the three objects was either always the heaviest or always the lightest. The three possible relationships between size and weight, where A > B > C, constituted the three types of transitivity tasks. They were included in equal proportion and presented in a mixed succession in the total of thirty-six tasks.

"Incompatible" Tasks. Size and weight were negatively correlated in these tasks. Thus the smallest object, S, was the heaviest; the medium object, M, was medium in weight; the largest object, L, was the lightest. There were twelve incompatible tasks, all consisting of the following size-weight relationship: S > M > L.

"Neutral" Tasks. In these tasks size varied independently of weight, with the following size-weight relationships: S > L > M, M > L > S, L > S > M, M > S > L. There were twelve neutral tasks, and for the purpose of this design, in the following arrangements: 4 were S > L > M; 2 were M > L > S; 4 were L > S > M; 2 were M > S > L.

"Compatible" Tasks. Size and weight were positively correlated in these tasks. Thus the largest object, L, was also the heaviest, and only one size-weight arrangement was possible: L > M > S. Twelve compatible tasks were used.

The six different geometric shapes for a set of tasks combined with nine possible colors for each of the objects further guarded against exact perceptual replication.

In this experiment the heaviest object has always been designated as A and the lightest as C; the correct solution was the judgment that A was heavier than C. Any other solution was considered incorrect. The total score was expected to be different for subjects who relied on the premise that A was heavier than B and that B was heavier than C, as opposed to those who were bound by the perceptual configuration of the immediate situation, that since C might be larger than A, it would also be heavier. However, while all thirty-six tasks allowed for correct and incorrect solutions, it was expected that if subjects were consistent in all answers, there would be most variability in the scores of the eighteen tasks (all twelve "Incompatible" and six "Neutral" tasks) where solutions based on perceptual configurations would be different from solutions based on premises.

CHAPTER IV

THE RESULTS

This chapter includes the experimental results bearing on the three hypotheses, as well as the rational for the use of statistical analysis chosen.

Hypotheses

Method of Analysis

The original design allowed for an analysis of variance with a parametric F test of significance. The data (Appendix B) were therefore examined towards this end.

Departure from normality and heterogeneity of variances was suggested by the fact that standard deviations in each group tended to be proportional to the corresponding means (Table 2). A transformation to logarithmic scale was therefore performed, and the newly transformed

TABLE 2

MEANS AND STANDARD DEVIATIONS OF INCORRECT SCORES

	I* TASKS		N* TASKS		C* TASKS	
	$\bar{x}$	S	$\bar{x}$	S	$\bar{x}$	S
P-GROUP INTERROGATION	8.2	3.65	5.2	2.09	2.4	3.84
S-GROUP INTERROGATION	0.9	1.20	0.8	0.87	1.2	1.40

* I=INCOMPATIBLE N=NEUTRAL C=COMPATIBLE

data were tested for homogeneity of variance. The Bartlett test as described by Edwards[43], was used. The obtained value of x^2 of 11.47 with three degrees of freedom was significant at the 0.01 probability level. The hypothesis of sampling from a common population with homogeneous variance was rejected. The samples were therefore thought to be heterogeneous in variance and departing from normality. The data failed to meet the requirements of an analysis of variance, and therefore a non-parametric statistical analysis was used.

Since non-parametric techniques could not use all available data, an attempt was made to have only two major task categories: "Incompatible" and "Compatible". This was made possible by collapsing half of the "Neutral" tasks with the "Incompatible" tasks, those neutral tasks whose size-weight relationships were incompatible, and the other half with the "Compatible" tasks, since their size-weight relationship was compatible. The incorrect scores on the original and on the revised "Incompatible" and "Compatible" tasks were then compared. Inspection suggested that the incorrect scores were in similar proportion in the original and revised task categories (Appendix D).

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[43] A. L. Edwards. Experimental design in psychological research. New York: Rinehart & Company, 1950. Chapter 11.

Results of statistical analysis

The first hypothesis tested in this experiment stated that:

In the concrete operational stage, when solving problems that offer both perceptual and logical cues, children with an empirical orientation err more often than children with a deductive orientation.

In terms of the operations performed to test it, the prediction was that subjects in the P group have more incorrect scores than subjects in the S group in solving transitivity-of-weight problems that offer perceptual cues in addition to logical cues. This prediction was confirmed; the P group made 158 errors, while the S group made 29 errors.

The significance of this difference was tested using Wilcoxon's Test of Significance for Unpaired Replicates.[44] On the basis of the number of incorrect scores, the sum of ranks for the P group=152 was compared to the sum of ranks for the S group=58. The value of T=58.0 was significant at the 0.01 probability level. This indicated that the difference in the number of incorrect responses given by the two groups cannot be attributed to chance, but rather to the independent variable.

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[44] F. Wilcoxon. Some rapid approximate statistical procedures. New York: American Cyanamid Company, 1949.

The second hypothesis tested further stated that:

Children with an empirical orientation make more of their errors where perception directly contradicts logic than children with a deductive orientation.

Again, in terms of the operations performed, it was predicted that in solving transitivity-of-weight problems, subjects in the P group would give proportionately more incorrect responses on "Incompatible" tasks than on "Compatible" tasks, when compared to subjects in the S group. This prediction was confirmed; the P group gave proportionately more incorrect scores on these tasks, with a sum of ranks = 135, as compared to the sum of ranks for the S group = 75. The significance of this difference was tested using Wilcoxon's Test of Significance for Unpaired Replicates.[45] On the basis of proportion scores of "Incompatible" incorrect scores to the total incorrect scores, the obtained value of T=75 was significant at the 0.05 probability level. This indicated that the difference in the kinds of mistakes the two groups made cannot be attributed to chance, but rather to the independent variable.

The third hypothesis which was tested stated that:

Children rely on logical operations more often

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[45] F. Wilcoxon. Some rapid approximate statistical procedures. New York: American Cyanamid Company, 1949.

when the tasks are presented by a discrimination method than when they are presented by an interrogation method.

In terms of the operations performed, it was predicted that subjects of the S group who were presented with the experimental tasks by a discrimination method would have fewer incorrect responses than those of the S group who were presented with these tasks by an interrogation method.

This prediction was not supported by Wilcoxon's Test of Significance for Unpaired Replicates.[46] The value for T=102.5 was not significant at the 0.05 probability level.

Additional Findings

Descriptive Results

In the process of assigning the thirty subjects to the three experimental groups, observations on the 236 screened subjects, were collected and are of interest. These children came from six kindergarten classes and five first grade classes in three different schools (Appendix E).

The experimental sample of 30 children (N=30) represented 12.12% of the total sample which was screened. Of these, the N=10 in the P group made up 4.02%, while the N=20 in the S groups represented 8.10%.

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[46] F. Wilcoxon. Some rapid approximate statistical procedures. New York: American Cyanamid Company, 1949.

Of the 236 subjects screened, 152 were eliminated on the basis of failing the conservation-of-weight tasks (65.3%). Of the 83 who passed the tasks (34.7%), 23 were assigned to a P group (9.3%) and 60 were assigned to an S group (25.5%).

Qualitative Results

In seven of the eight conservation-of-weight tasks, the transformation of the plasticine ball led to a difference in shape. However, in the eighth task the transformation also resulted in a more dramatic change shape. It was surmised that for subjects who solved the first seven tasks, giving either "P" or "S" explanations, the eighth task would present a special case. The responses were therefore examined in the 83 subjects who had succeeded in the conservation-of-weight test. Only 13 of these showed a change in the response to item 8. Ten subjects failed this last item following seven successes, and one subject gave a "P" explanation following four consecutive "S" explanations. There were only two subjects who improved their performances on this eighth item, by giving an "S" explanation following seven consecutive "P" explanations.

CHAPTER V

DISCUSSION

In an attempt to clarify the relation between perceptually bound and logically dictated thinking, this thesis focussed on the supremacy of misleading perception in the concrete operational stage. A general hypothesis was formulated in terms of a functional relation between perception and an empirical orientation:

The supremacy of misleading perception is a function of empirical orientation during the concrete operational stage. It is more evident in investigations that use interrogation rather than discrimination methods.

Positive Findings

Two aspects of the general hypothesis were verified:

Children in the concrete operational stage, although having demonstrated the ability to use logic, still

persisted in their reliance on perceptual configurations if they were empirically oriented. This reliance on perception became increasingly evident where perception contradicted logic.

Within the limitations of one study and its operational definitions, a number of implications emerge:

The dominance of misleading perception continues into areas where concrete operational thinking is already evident. This interaction between perception and cognition has two aspects. First, logical thinking does not always correct deceiving perception, although it may do so, as shown by earlier studies. Secondly, in the presence of operational structures, perception can govern thinking.

In emphasizing that more advanced modes of thinking integrate previous ones, Piaget has been explicit primarily about one dimension in cognitive development: its forward movement. The progression from one mode of thinking to the next can now be considered to proceed alomg various dimensions. There is the possibility of a residue of former modes of thinking which are still used in certain situations. Inhelder's theoretical speculation that older modes of thinking are abandoned in favor of newer ones also has to be modified. Further research might examine whether

older modes of thinking persist together with newly acquired ones at all phases of cognitive development.

In his description of the establishment of operational thinking in one concrete area at a time, Piaget actually talks about a gradual taking over of logical thinking. The change from perceptual to operational thinking in one specific concrete area also appears to be gradual. This is indicated by the interaction between perception and logic where there is an alternating dominance of the older and newer modes of thinking. Future research might examine whether in other areas of the concrete operational stage (e.g. weight, volume) there is this same type of gradual change to logical thinking.

Smedslund[47] classified "P" explanations of solutions to conservation-of-weight problems as failures. The present study suggests that these "P" explanations, designating an empirical orientation, may not be real failures, since they are found in the context of operational thinking. However, the empirical orientation, which was functionally related to misleading perception in the stage of concrete operations may itself represent an intermediate step to the acquisition of logical thinking. It appears similar to Smedslund's[48] empirical learning, which was qualitatively

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47 J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959.

48 J. Smedslund. Apprentissage des notions de la conservation et de la transitivité du poids. Etudes Ep. Gen., vol. IX. p. 85-124. Paris: Presses Universitaires de France, 1959.

different from normally acquired logical ways of solving problems. Future research could elucidate whether the empirical approach represents an intermediate level in the acquisition of operational structuring. Or it may be that the empirical orientation, as defined by this experiment, is itself a variable, representing an excessive reliance on perception, which continues in a subtle manner throughout cognitive organization and is functionally related to other variables.

Negative findings

The interrogation method was compared with the discrimination method in deductively oriented children, and there was no difference in the results. This shows that the uncontrollable factors in the interrogation method, to which Brain refers, do not conceal the reasoning ability involved in the transitivity tasks.

The generality of these findings is limited because:

a. A real significance of the findings might have been concealed by a ceiling effect. There was no room for either method to show superiority, since the subjects tested by both methods performed close to perfection.

b. Brain used the discrimination method in a normative study in detecting an earlier age level for the emergence of an ability. However, the present experiment went a step further in predicting that the method would also facilitate the use of an already existing ability in a complex situation. It is possible that the discrepancy can be expected only in normative studies.

c. This study provided no comparison between the use of candy as a reinforcer, as Brain did, and the present cafeteria type of reward. Future research should also include a direct comparison of these two types of reward in the discrimination method.

Brain's discrimination method may also be suited to investigations similar to those in the present experiment, but carried out on a population with uneven verbal development.

Additional findings

The present study, having scanned 236 subjects between the ages of 5 years 3 months and 7 years, also included some normative data in the area of conservation-of-weight. This data was collected by Smedslund's[49] stan-

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[49] J. Smedslund. Learning and equilibration. Unpublished manuscript. Oslo, 1959.

dardized verbal method, allowing for a direct comparison with his findings. On closer inspection, of the 34.7% of the children who performed correctly (beyond chance), only those who gave "S" explanations could be contrasted with Smedslund's findings, since he considered as failures those who gave "P" explanations. With a smaller sample (N=135) than the one used in this study (N=236), his findings of 20% successes between the ages of 5 years 6 months and 7 years compared favorably to the 25.4% figure in the present study. In the light of previous objections to verbal methods as being too vague, such findings would indicate that Smedslund's standardization of Piaget's procedure is precise enough to allow for communication and replication.

Also pointing to future research are some of the qualitative findings. The change which occurred on the eighth conservation-of-weight task was mostly a shift from conservation to non-conservation. However, two subjects shifted from "P" to "S" explanations on the last item, in which the transformed ball was radically discrepant from the unaltered one. The previously consistent reliance on empirical data in explaining that the two balls still weigh the "same" because "they look alike", did not operate in giving the explanation during the eighth item. One may question whether a "P" explanation was too incongruous with

the reality of the eighth transformed ball, and the conflict in the situation led to a "deductive", "S" explanation. The aspect that could be further studied is whether this shift in the face of conflict is a function of a progression in cognitive development.

Another question was raised, this time about the subjects who failed the typical transitivity tasks during the screening sessions. Would the P and S groups still differ on the experimental tasks, according to the predictions made in the hypothesis, after the training on typical transitivity problems? A possible experimental design was thus considered in a pilot study (Appendix F).

CHAPTER VI

CONCLUSIONS

This thesis examined the relationship between thinking dominated by perception and thinking guided by logic. It was suggested by Piaget's theory of cognitive development, which defines modes of thinking in terms of logical forms as models of operation of the mind. Thus thinking unfolds in several stages, each characterized by a precursor of logic.

Within this theoretical framework, the present study focussed on the supremacy of misleading perception at the onset of the concrete operational stage. The relationship between perception and logic was examined in a situation where they were incompatible.

Thinking is bound by perception up to and during the intuitive stage, just preceding the concrete operational stage. Piaget's view is that perception with its "centering"

effects--inconsistencies and distortions--tends to hinder early forms of thinking, which lack unifying stability. In problem-solving it is reflected in an empirical approach. As the rudiments of logical--concrete operational--thinking gain primacy, the child takes into account other sources of information apart from those predominantly perceptual. A reliance on operational thinking can compensate for any change in perception, and a deductive approach to problem-solving becomes possible:

The intuitive and the concrete operational modes of thinking, perceptually and logically guided, have been investigated in studies on children lacking operational structures. Attempts to teach the subjects to solve problems involving logic led, at best, to empirical learning. Although the newly acquired skill was correct for the particular situation, it lacked the underlying logical principles. The empirical approach to problem-solving was found to persist throughout the intuitive stage, being replaced by deductive problem-solving in the concrete operational phase of thinking.

These experiments considered only one variable: the absence of operational thinking. Furthermore, they showed that in the presence of concrete operational thinking, there is an imposition of logic on the perceptual

organization in a purely perceptual task. What has not been examined is the imposition of perception-dictated thinking on a deductive task once concrete operational thinking has been reached. Also, in these studies, the alternative perceptual and logical cues were not simultaneously present.

Piaget's early, flexible, verbal method of research had been systematized and allowed replication. It was still a verbal method, and as such, raised certain objections. Brain, in discussing these, distinguished between behavioral and verbal manifestations of a concept, which were obscured in Piaget's technique. Brain therefore used a discrimination method in an experiment finding concrete operations available at an age at least two years prior to the norm where Piaget located their emergence. However, this comparison is not entirely satisfactory, for Brain used no directly parallel interrogation method in the same experiment.

The relationship between perceptually dominated and logically guided thinking was therefore examined in a situation where perceptual configuarations and logic competed. The investigation was carried out during a period in the child's development which Piaget had described as transitional between intuitive and operational thinking, five to seven years.

The subjects, however, demonstrated having the rudiments of operational thinking, but differed in their reliance on empirical laws in problem-solving.

The following general hypothesis was stated:

The supremacy of misleading perception is a function of empirical orientation during the concrete operational stage. It is more evident in investigations that use interrogation rather than discrimination methods.

In this study, one aspect of perception--primary reliance on perception of size, competed with one characteristic of operational thinking--transitivity as applied to weight (in the weight relationship of three objects, A was heavier than B and B was heavier than C; it was therefore inferred that A was heavier than C). In the experimental transitivity tasks, the largest object was heaviest, lightest or medium in weight, providing the perceptual cues.

The explanations given for successful performances on the conservation-of-weight tasks operationally defined the first independent variable: an empirical orientation and a deductive orientation. Two groups were chosen to represent this variable: the P group (empirically oriented) and the S group (deductively oriented).

The mode of presentation of the test tasks, an interrogation method and a discrimination method, represented the dichotomized second independent variable. Two groups, the S group-interrogation and the S group-discrimination, represented this variable.

The quantification of the performance on the experimental transitivity tasks, which also allowed for a reliance on perceptual cues, served as the operational measure of the dependent variable.

Out of the 236 children who were screened, 30 subjects qualified during the first two sessions as possessing some rudiments of concrete operational thinking, and were categorized as having either an empirical or a deductive orientation. They also showed the ability to rely on logical premises in the successful solution of typical transitivity tasks, where the three objects were of the same size. During the following two sessions in solving the experimental transitivity-of-weight problems, they were given the opportunity to rely either on perception or on logical premises. The subjects were thus assigned to the three experimental groups: empirically oriented - interrogation method, deductively oriented - interrogation method, and deductively oriented - discrimination method. Statistical tests showed that chrono-

logical age and male-female distributions were not significantly different for the three experimental groups.

The Wilcoxon Test of Significance for Unpaired Replicates was the statistical analysis used for the three specific hypotheses (incorporated in the general hypothesis).

1. In the concrete operational stage, when solving problems that offer both perceptual and logical cues, children with an empirical orientation err more often than children with a deductive orientation.

This first hypothesis was confirmed; in analyzing the data a T value of 58 was obtained, significant at the 0.01 probability level.

2. In such problems, children with an empirical orientation make more of their errors where perception directly contradicts logic than children with a deductive orientation.

This second hypothesis was confirmed a value for T=75 was significant at the 0.05 probability level.

3. In problems which offer both perceptual and logical cues, children rely on logical operations more

often when the tasks are presented by a discrimination method than when they are presented by an interrogation method.

This hypothesis was not confirmed; the value for T=102.5 was not significant at the 0.05 probability level. Here a real significance of the findings might have been concealed by a ceiling effect. There was no room for either method to show superiority, since the subjects tested by both methods approached the maximum possible score.

Within the limitations of this study certain generalizations emerge. In the concrete operational stage, perception may mislead even in areas where logical thinking is already manifest. Though logic may correct deceptive perception, it does not necessarily do so.

Piaget has emphasized only one dimension in cognitive growth, with more advanced modes of thinking integrating previous ones. This progress is now seen along various dimensions, with the possibility of a residue of former modes of thinking being used in certain situations.

The interaction between perception and logic

with an alternating dominance of the older and newer modes of thinking indicates that the change to operational thinking in at least one concrete operational area is gradual. Future research might examine whether in other areas of the concrete operational stage there is the same type of gradual change to logical thinking, and whether this alternating dominance of older and newer structures may mark all phases of cognitive development.

The empirical orientation, which was functionally related to misleading perception in this stage, may itself represent an intermediate step in acquiring the concrete operational structure.

A P P E N D I C E S

APPENDIX A

SUMMARY OF THE ANALYSIS OF VARIANCE OF AGES

APPENDIX A

SUMMARY OF THE ANALYSIS OF VARIANCE OF AGES

SOURCE OF VARIATION	df	x^2	s^2	F
BETWEEN GROUPS	2	18.07	9.035	----
WITHIN GROUPS	27	881.30	30.389	
TOTAL	29	889.37		

not significant

APPENDIX B

NUMBER OF INCORRECT SCORES

APPENDIX B

NUMBER OF INCORRECT SCORES

P GROUP - INTERROGATION

	I* TASKS	N* TASKS	C* TASKS	TOTAL
Male F. F. Subj. #1	5	7	7	19
Female N. C. Subj. #2	7	6	7	20
Female S. D. Subj. #3	11	5	0	16
Female J. G. Subj. #4	12	6	0	18
Male J. W. Subj. #5	12	4	0	16
Female S. S. Subj. #6	6	7	7	20
Male L. B. Subj. #7	3	1	0	4
Female V. P. Subj. #8	7	5	6	18
Male J. S. Subj. #9	11	4	0	15
Female R. W. Subj. #10	8	4	0	12

* I - INCOMPATIBLE N - NEUTRAL C - COMPATIBLE

APPENDIX B

NUMBER OF INCORRECT SCORES

S GROUP - INTERROGATION

	I* TASKS	N* TASKS	C* TASKS	TOTAL
Male K. K. Subj. #1	1	0	0	1
Male R. L. Subj. #2	1	0	3	4
Male R. d'A. Subj. #3	0	1	0	1
Female E. R. Subj. #4	0	2	2	4
Female S. C. Subj. #5	3	3	1	7
Male L. B. Subj. #6	3	0	0	3
Male S. B. Subj. #7	0	0	1	1
Male B. C. Subj. #8	1	1	4	6
Male H. D. Subj. #9	0	1	1	2
Female R. S. Subj. #10	0	0	0	0

* I - INCOMPATIBLE N - NEUTRAL C - COMPATIBLE

APPENDIX B

NUMBER OF INCORRECT SCORES

S GROUP - DISCRIMINATION

	I* TASKS	N* TASKS	C* TASKS	TOTAL
Male R. C. Subj. #1	0	0	0	0
Female J. S. Subj. #2	0	3	0	3
Female E. J. S. Subj. #3	2	2	1	5
Female L. B. Subj. #4	1	1	0	2
Male R. W. Subj. #5	0	1	0	1
Male B. W. Subj. #6	0	1	0	1
Female A. B. Subj. #7	0	2	1	3
Male R. Y. Subj. #8	0	0	0	0
Male B. A. Subj. #9	2	0	1	3
Male G. R. Subj. #10	0	2	3	5

* I - INCOMPATIBLE N - NEUTRAL C - COMPATIBLE

APPENDIX C

BARTLETT'S TEST OF HOMOGENEITY OF VARIANCE FOR P GROUP - INTERROGATION AND S GROUP - INTERROGATION

APPENDIX C

BARTLETT'S TEST OF HOMOGENEITY OF VARIANCE FOR P GROUP - INTERROGATION AND S GROUP - INTERROGATION

GROUPS	d.f.	s^2	log s^2
P group - I* tasks	9	31,007.96	4.4914
P group - C* tasks	9	291,682.49	5.4496
S group - I* tasks	9	86,285.34	4.9359
S group - C* tasks	9	75,049.82	4.8753
Sum		484,025.61	19.7522

X^2 COMPUTATIONS

1. $\frac{\Sigma s^2}{r} = \frac{484,025.61}{4} = 121,006.4$; $\frac{\log \Sigma s^2}{r} = 5.0828$

2. $r \left[\log \frac{\Sigma s^2}{r}\right] = (4)(5.0828) = 20.3312$

3. Diff.$= r \left[\log \frac{\Sigma s^2}{r}\right] - \log s^2 = 20.3312 - 19.7522 = .5790$

4. $X^2 = (2.3026)(n-1)(\text{Diff}) = (2.3026)(9)(5790) = 11.997$

5. Correction $= \frac{1+r+1}{(3)(r)(n-1)} = \frac{1+4+1}{(3)(4)(9)} = 1.046$

6. Corrected $x^2 = x^2/\text{correct.} = 11.997/1.046 = 11.469$

$x^2 = 11.47$ $\quad p < 0.01$

* I - INCOMPATIBLE C - COMPATIBLE

APPENDIX D

INCORRECT SCORES ON ORIGINAL AND REVISED TASK CATEGORIES

APPENDIX D

INCORRECT SCORES ON ORIGINAL AND REVISED TASK CATEGORIES

P GROUP - INTERROGATION

INCOMPATIBLE TASKS		COMPATIBLE TASKS	
ORIGINAL	REVISED	ORIGINAL	REVISED
5	10	7	9
7	8	7	12
11	16	0	0
12	18	0	0
12	16	0	0
6	11	7	9
3	4	0	0
7	8	6	10
11	15	0	0
8	12	0	0
TOTAL 82	118	27	40

APPENDIX D

INCORRECT SCORES ON ORIGINAL AND REVISED TASK CATEGORIES

S GROUP - INTERROGATION

INCOMPATIBLE TASKS		COMPATIBLE TASKS	
ORIGINAL	REVISED	ORIGINAL	REVISED
1	1	0	0
1	1	3	3
0	0	0	1
0	0	2	4
3	6	1	1
3	3	0	0
0	0	1	1
1	2	4	4
0	1	1	1
0	0	0	0
TOTAL 9	14	12	15

APPENDIX D

INCORRECT SCORES ON ORIGINAL AND REVISED TASK CATEGORIES

S GROUP - DISCRIMINATION

INCOMPATIBLE TASKS		COMPATIBLE TASKS	
ORIGINAL	REVISED	ORIGINAL	REVISED
0	0	0	0
0	2	0	1
2	3	1	2
1	2	0	0
0	1	0	3
0	1	0	0
0	1	1	2
0	0	0	0
2	1	1	1
0	0	3	5
TOTAL 5	9	6	14

APPENDIX E

SCHOOL SOURCE OF THE TOTAL SAMPLE

N = 236

APPENDIX E

SCHOOL SOURCE OF THE TOTAL SAMPLE

N = 236

School	Kindergarten	1st Grade	Total
S	72	36	108
M	65	--	65
B	45	18	63
Total	182	54	236

APPENDIX F

PILOT STUDY ON TRAINING IN TRANSITIVITY-OF-WEIGHT

APPENDIX F

PILOT STUDY ON TRAINING IN TRANSITIVITY-OF-WEIGHT

Additional data was collected in keeping with questions raised during the reported experimental study.

More specifically, a question was focussed on the subjects who originally failed on typical transitivity tasks (during the screening session). Would the P and S groups differ on the experimental tasks according to the predictions made in the hypothesis following training on typical transitivity-of-weight tasks?

The procedure was similar to that described in the main experiment. The P and S groups formed four subgroups according to the method of presentation: P Group-Interrogation, P Group-Discrimination, S Group-Interrogation and S Group-Discrimination. Following their failure on the screening tasks, they were trained on nine typical transitivity-of-weight tasks. Another try at the six screening tasks determined whether they were to continue in this pilot study. If they met the criterion of complete success (six out of six tasks passed), they returned for two additional sessions and performed on the experimental transitivity tasks.

Of the nineteen subjects in this additional sample, thirteen failed to meet the criterion. Of these, four belonged to the P group and nine to the S group. Of the six subjects accepted in the final pilot sample, two were of the P group and four of the S group.

The results on the experimental transitivity tasks for this N=6 were inspected and not statistically analyzed (Appendix F - Form 1). The proportion of incorrect responses was higher in the P group than in the S group. This trend was in the same direction as the statistically significant results of the main study in which the empirically oriented group made more mistakes than the deductively oriented group. It would therefore be interesting to enlarge this pilot study.

APPENDIX F - FORM 1

INCORRECT SCORES FOR SIX SUBJECTS IN THE PILOT-STUDY

P GROUP		S GROUP	
INTERROGATION	DISCRIMINATION	INTERROGATION	DISCRIMINATION
Subj. T. L.	Subj. S. R.	Subj. S. E.	Subj. J. H.
20	10	3	1
		Subj. K. B.	Subj. C. B.
		1	11

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EFFECTS OF INCOMPATIBILITY BETWEEN PERCEPTION AND LOGIC IN PIAGET'S STAGE OF CONCRETE-OPERATIONS

Abstract of a Dissertation

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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ABSTRACT

This thesis examined the relationship between thinking dominated by perception and thinking guided by logic. It was suggested by Piaget's theory of cognitive development which defines modes of thinking in terms of logical forms as models of operation of the mind. Thus thinking unfolds in several stages, each characterized by a precursor of logic.

Within this theoretical framework, the present study focussed on the supremacy of misleading perception at the onset of the concrete operational stage. The relationship was examined in a situation of incompatibility between perception and logic.

Thinking is bound by perception up to and during the intuitive stage, just preceding the concrete operational stage. Piaget's view is that perception with its

"centering" effect--inconsistencies and distortions--tends to hinder early forms of thinking, which lack unifying stability. In problem-solving it is reflected in an empirical approach. As the rudiments of logical--concrete operational--thinking gain primacy, the child takes into account other sources of information apart from those predominantly perceptual. A reliance on operational thinking can compensate for any change in perception, and a deductive approach to problem-solving becomes possible.

In unsuccessful attempts to teach children to solve logical problems, investigations on the relationship between perception and logic considered only one variable: the absence of concrete operational thinking. In the presence of operational thinking, studies had focussed primarily on purely perceptual tasks and the extent to which logic imposed on the perceptual organization. What had not been examined was the imposition of perception-dictated thinking on a deductive task once concrete operational thinking had been reached. Also, in these studies, the alternative perceptual and logical cues were not simultaneously present.

Discrimination methods in experiments on operational thinking detected the ability to use logic prior to

the period when it was found to emerge in experiments using Piaget's verbal-interrogation method. However, this comparison is not entirely satisfactory since these studies did not directly parallel interrogation and discrimination methods.

The relationship between perceptually dominated and logically guided thinking was therefore examined in a situation where perceptual configurations and logic competed. The investigation was carried out during a period in the child's development which Piaget had described as transitional between intuitive and operational thinking, five to seven years. The subjects, however, demonstrated having the rudiments of operational thinking, but differed in their reliance on empirical laws in problem-solving.

The following general hypothesis was stated:

The supremacy of misleading perception is a function of empirical orientation during the concrete operational stage. It is more evident in investigations that use interrogation rather than discrimination methods.

In this study, one aspect of perception, primary reliance on perception of size, competed with one characteristic of operational thinking, transitivity as applied

to weight (in the weight relationship of three objects, A was heavier than B and B was heavier than C; it was therefore inferred that A was heavier than C). In these experimental transitivity tasks, the largest object was heaviest, lightest, or medium in weight, providing opportunity to rely on perceptual cues.

The Wilcoxon Test of Significance for Unpaired Replicates was the statistical analysis used for the three specific hypotheses (incorporated in the general hypothesis).

1. In the concrete operational stage, when solving problems that offer both perceptual and logical cues, children with an empirical orientation err more often than children with a deductive orientation.

This first hypothesis was confirmed; in analyzing the data, a T value of 58 was obtained, significant at the 0.01 probability level.

2. In such problems, children with an empirical orientation make more of their errors where perception directly contradicts logic than children with a deductive orientation.

This second hypothesis was confirmed a value

for T=75 was significant at the 0.05 probability level.

3. In problems which offer both perceptual and logical cues, children rely on logical operations more often when the tasks are presented by a discrimination method than when they are presented by an interrogation method.

This hypothesis was not confirmed; the value for T=102.5 was not significant at the 0.05 probability level. Here a real significance of the findings might have been concealed by a ceiling effect. There was no room for either method to show superiority, since the subjects tested by both methods approached the maximum possible score.

Within the limitations of this study, certain generalizations emerge. In the concrete operational stage, perception may mislead even in areas where logical thinking is already manifest. Though logic may correct deceptive perception, it does not necessarily do so.

Piaget has emphasized only one dimension in cognitive growth, with more advanced modes of thinking integrating previous ones. This progress is now seen along various dimensions with the possibility of a residue of former modes of thinking being used in certain situations.

The interaction between perception and logic with an alternating dominance of the older and newer modes of thinking indicates that the change to operational thinking, at least in one concrete operational area, is gradual. Future research might examine whether in other areas of the concrete operational stage, there is the same type of gradual change to logical thinking, and whether this alternating dominance of older and newer structures may mark all phases of cognitive development.

The empirical orientation, which was functionally related to misleading perception in this stage, may itself represent an intermediate step in acquiring the concrete operational structure.

BIOGRAPHY

I am the second daughter of Antoinette and Baruch Halpern, born the 6th of November, 1929, in the small port town of Braila, Rumania.

World War II was instrumental in the move of our entire family to Bucharest, and resulted in my attendance at seven different schools between 1941 and 1947. In 1947 we left my native land and wandered through several countries before settling in Canada, in 1948.

That year we took up residence in Montreal, where I entered McGill University. In 1952 I received a B.Sc. with Honors in Psychology, and in 1954, a Masters in Psychological Sciences, specializing in clinical psychology.

In 1951 and 1952 I was a psychological intern in a hospital for adults, then in a children's hospital. From 1953 to 1956 I was staff psychologist at the Montreal Children's Hospital. I joined the Montreal Mental Hygene Institute as chief psychologist in 1956; in 1958 I left on a three years' leave of absence, in order to enrol at Boston University's Psychology Department. I was helped in this endeavor by a Canadian Dominion-Provincial Mental Health Grant.

As part of my training in Boston, I worked as a Psychology intern at Putnam Children's Center and at Judge Baker Guidance Center. I returned to Montreal and my position at the Mental Hygene Institute in the fall of 1961, continuing to work in absentia on my dissertation.