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"Merds That Laugh Don't Like Mushrooms": Evidence for Deductive Reasoning by Preschoolers

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The study examines the relationship between the development of logical processes required in deductive reasoning and their occasions of use. Verbal syllogism problems were presented to 4- to 5-year-old children. The problems were systematically varied in content (fantasy premises; premises incongruent with real-world events; premises congruent with real-world events), form, and order of presentation of problem types. Results indicate that young children are capable of making deductive inferences required in solving syllogism problems, and that these abilities are displayed in constrained conditions. The relationship of the problem content to real-world knowledge and the sequence of presentation of the problem types affected the display of logical abilities.

It has become increasingly apparent that cognitive abilities are revealed only in terms of organized contexts of use (e.g., Laboratory of Comparative Human Cognition, 1983). In addition, measurable developmental level is situation-variable as a function of, at least, task materials, goals, and problem context (e.g., Cermak & Craik, 1979; Cole, Hood, & McDermott, 1981; Istomina, 1975; Werner, 1957). This occasioned nature of cognitive ability has important implications for our understanding of cognitive development, particularly as it relates to formal schooling (Brown, 1978; Olson, 1978; Scribner & Cole, 1973, 1981), and for the methods used to understand children's abilities. In this article, we review logical thinking as a contextually embedded performance and define some conditions under which specific logical abilities are used by children (Brown, 1982; Rozin, 1976).

Logical thinking is a key mode of cognitive functioning within a scientifically oriented society. A focus on the pervasiveness of logical functioning has led to views that coherent functioning of *any* sort is based on an explicit or implicit logical organization. For example, Piaget's (1970) influential account of child development proposes that constitutive features of everyday experience (e.g., a stable object world) are not innately given but are derived by progressive logical constructions.

Although theoretical accounts of the role of logic in the organization of experience are persuasive, the methods by which such logical functioning is assessed are controversial. Experimental paradigms typically assume some formulation of logical abilities and aim to reveal an individual's status through their performance on tasks requiring the use of those abilities. For example, verbal syllogism problems are often used to investigate deductive reasoning skills. Osherson (1974, p. 2) notes that "to solve the problem, the child need only recognize the logical validity of the argument's form," and Piaget (1928/1969, p. 32) concurs that "in order to be necessary, a deduction must be formal or hypothetico-deductive, that is, its conclusions must be held to be true only by reason of its premises and quite independently of the empirical truth of these premises." Thus, by these accounts, an important aspect of deductive reasoning skill is the ability to reason only in terms of the formal relations among the premises, without regard to the empirical truth-value of the premises.

Such formulations of verbal deductive inference skills encounter well-known difficulties

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when embodied in research programs. Although logical form (as distinct from content) is an important feature of experience, logical thinking is not the only mode of functioning for dealing with the experimental situation as task. The purposes of an experimental task may be different for the participating individual and the experimenter (Donaldson, 1978; Gelman, 1978; Goodnow, 1972, 1976), at home or cross-culturally (Cole, Gay, Glick, & Sharp, 1971; Cole & Scribner, 1974). Perceived demands of the situation may be met by other types of performances. A few examples will demonstrate these concerns.

A useful distinction has repeatedly been made between occasions when people reason in accord with formal logical procedures, without regard to the empirical truth of problem premises, and occasions when people reason practically or pragmatically. Which mode of reasoning is adopted by adults appears to depend at least on the perceived goal of the task (Henle, 1962) and the nature of the stimulus materials (e.g., Bruner, Goodnow, & Austin, 1956; Wason & Johnson-Laird, 1972).

With regard to the former, Henle (1962) provided qualitative analyses of errors with syllogisms (whose premises were embedded in short narratives of everyday situations). Subjects often refused to reason with only the information provided by the experimenter. And in cross-cultural studies (e.g., Cole et al., 1971; Luria, 1976; Scribner, 1975, 1978), the conditions under which adults correctly solved verbal syllogisms were generally only those in which conclusions were consistent with known factual states of affairs. For example, one syllogism Luria presented to nonliterate, nonformally educated adults in Uzbekistan and Khirgizia was: "Cotton grows well where it is hot and dry. England is cold and wet. Can cotton grow there or not?" After some difficulty, subjects answered correctly, but their responses could have been based only on practical knowledge of the conditions under which cotton typically grows, and not on an inference based solely on the logical form of the problem. The predominance of incorrect answers to subsequent syllogistic problems *beyond* the scope of such individuals' practical knowledge confirmed this interpretation. His subjects often made unfamiliar premise information sensible by embedding it in their knowledge about the world (cf. Bransford & McCarrell, 1974; Schank & Abelson, 1977).

The formal or theoretical mode of reasoning has been speculatively linked to experience with formal educational settings (e.g., Brown, 1977; Bruner, 1973; Cole & Scribner, 1974; Neisser, 1982), or technological development (Luria, 1976). In examining this claim for syllogisms, Scribner (1975, 1977) analyzed response correctness and justifications. Their response justifications indicated that schooled African adults tended to adopt a "theoretical set," and reasoned only in terms of the premises given. In contrast, unschooled subjects tended to adopt a strategy of "empiric bias." In Scribner's terms, the schooled subjects had learned that certain discourse "genres" are coordinated with particular types of settings and adopted a discourse genre appropriate to the situation. People learn cultural readings of task types, as of human performances in general (Goffman, 1974).

With respect to children's performances in experimental tasks, many recent studies have indicated that when task requirements are minimized and materials and task setting made familiar, early competencies with number concepts, social cognition, and other contents may be demonstrated (Donaldson, 1978; Gelman, 1978). It appears likely that the factors described above will also influence the reasoning task performances of young children, yet studies to date have not inquired into the conditions, task organization, and materials that might facilitate the display of deductive reasoning.

There are three possible explanations for the absence of deductive reasoning performance among young children in these types of logical tasks. First, young children do not have the cognitive ability to reason formally in a deductive manner. Second, it is possible that the empirical truth value of the material in premises takes priority over reasoning solely in terms of the formal relationships. Third, children have not yet learned the appropriate relationships among the task and social conditions and the use of reasoning abilities (cf. discourse genres, described above). It is important to understand the contribution each of these possibilities makes to the observed performances of children. In one relevant study, Woodring (1975) presented 4- to 5-year-

old children with complex, quantified syllogistic problems, such as "Some of the windows in the house are open. All of the open windows are dirty. Are some of the windows in the house dirty?" Although the children in this study generally performed at chance levels, on occasion they reasoned deductively (as inferred from their justifications). When they did so, their responses were usually correct. In most instances, however, justifications indicated that the children's responses were based on practical knowledge about problem contents. Because the difficulty of syllogisms with explicit logical quantifiers is well established (Neimark & Chapman, 1975), it is unclear whether the children were deficient in logical abilities or whether poor performances were attributable to the complexity of the stimulus materials.

Hill (1961) demonstrated that somewhat older children (6- and 8-year-olds) can correctly recognize valid conclusions in syllogisms when the problems are relatively simple. O'Brien and Shapiro (1968) replicated this finding with same-aged children but reported that the children had difficulty in recognizing invalid conclusions. Among older children (4th through 8th grades), Roberge and Paulus (1971) found that the correctness of children's class and conditional reasoning performances was related to the type of material presented in the premises. From least to most difficult were concrete/familiar materials, suggestive counterfactual materials, and abstract premises. Although these studies demonstrated that children as young as 6 years of age *may* be able to reason deductively in certain circumstances, the children were not asked to justify their responses. The relationship of their reasoning to the premise information, their empirical knowledge, and the task conditions therefore remains undetermined.

Research Problem

Our aim in this study was to examine the effects of problem complexity, problem content, and task organization on preschoolers' performances with syllogistic problems. We wanted to explore three possible explanations for children's deductive reasoning performance introduced above: to explore (a) whether young children (4–5) can reason deductively by simplifying the reasoning problems; (b) the relationship of empirical truth value to the display of deductive reasoning by varying the problem content; and (c) children's ability to adjust their reasoning performance according to clues about the appropriate discourse genre by varying the sequence of problem presentation.

With respect to (b), the problem content, we hypothesized that if the premises of the syllogisms have no *possible* relationships to practical knowledge, as in the case of "fantasy-world" materials, then premises could not be integrated with practical knowledge. If preschoolers do have access to formal-deductive schemas, we would expect correct responses with appropriate justifications. With respect to (c), the task organization, we hypothesized that varying the sequence of problem types might provide children with different kinds of context cues, and thus affect their judgments about appropriate performance. The problem complexity, problem content, and task organization were thus manipulated in the following ways:

1. *Content.* Three different types of problems were constructed: (a) fantasy problems, in which premises described mythical creatures foreign to practical knowledge, (b) congruent problems, in which premises were compatible with practical knowledge, and (c) incongruent problems, in which premises were in contradiction to practical knowledge.

2. *Complexity.* (a) To simplify problems, quantifiers such as "some" and "all" were made implicit rather than explicit. (b) Both the form of the problems and the presence of negative premises were systematically controlled.

3. *Task organization.* To examine the effects of setting condition on response, the order of presentation of the different types of syllogism described above was systematically varied.

Method

The syllogism problems were designed to be very simple, with some variations in form and polarity (affirmative/negative) of construction. Fantasy problems each describe a world of mythical creatures, such as "purple bangas," and are expected to facilitate the provision of valid responses and "theoretic" justifications by eliminating the influence of practical knowledge. Incongruent problems each describe a world with familiar entities but one that is in violation of practical knowledge (e.g., birds with

Table 1
Construction of Problem Types

Form	Model	Affirmative example	Negative example
A: Universal	A is B	Every banga is purple.	Bears have big teeth.
	B is C	Purple animals always sneeze at people.	Animals with big teeth can't read books.
	A is C	Do bangas sneeze at people?	Can bears read books?
B: Particular	A has B	Pogs wear blue boots.	Rabbits never bite.
	C is an A	Tom is a pog.	Cuddly is a rabbit.
	C has B	Does Tom wear blue boots?	Does Cuddly bite?
C: Action-Functional	A does B when . . .	Glasses bounce when they fall.	Merds laugh when they're happy.
	B is C	Everything that bounces is made of rubber.	Animals that laugh don't like mushrooms.
	A has C	Are glasses made of rubber?	Do merds like mushrooms?

wheels). We hypothesized that premises in such problems might break a set to respond in terms of practical world knowledge. Congruent problems each describe a world compatible with practical world knowledge.

Materials

A set of 24 problems was constructed: 8 fantasy problems, 8 incongruent problems, and 8 congruent problems. Three different problem forms were used (see Table 1) because they are basic yet representative of systematic variation in the relationships among problem elements—the universal form (A), the particular form (B), and problems expressing action/functional relationships (C).

Each syllogistic form was represented in the problem set for each type of content by at least one negative and one affirmative problem, so that a minimum of one "yes" and one "no" response would be required. The effects of problem content and problem complexity (form type; negative vs. affirmative) could thus be explored. Every problem consisted of two premises and a conclusion posed in the form of a yes/no question that the children were asked to answer and then give a justification for.

Participants

Forty children (4.2–5.1 years) from three small, private Manhattan schools took part in the study. There were 21 girls and 19 boys. Children were randomly assigned to one of four presentation groups. Each group received a different order of the set of problems.

Procedure

The 24 problems were arranged into four different presentation sequences. We were most interested in determining the way in which the initial type of problem in the sequence acted as a setting condition. Fantasy, congruent, or incongruent problems appeared in initial position and in one random order sequence. The order was systematically varied in three different blocks: (a) FIC—fantasy, incongruent, congruent; (b) IFC—incongruent, fantasy, congruent; (c) CIF—congruent, incongruent, fantasy; and another sequence (d) jumbled—consisting of a random scrambling of all 24 problems.

In a quiet room, participants were individually presented with one of the four sequences. One practice problem was used in order to ensure that participants understood the task. If the child answered incorrectly or appeared confused, the problem was explained by the experimenter. The instructions were as follows:

> I am going to read you some little stories. Some of them are about make-believe animals and things and some of them are about real animals and things. Some of the stories are going to sound sort of funny. I want you to pretend that everything the stories say is true. Here, I'll show you what I mean.

After the initial practice story, each problem was read, one at a time. The child was asked to respond and to justify his or her response. Two questions were used as probes: After the child responded to the concluding question of each problem with either "yes" or "no," he or she was asked "How come?" Following the justification offered, the child was asked "How do you know that?" This procedure was followed for each of the 24 problems. If the child interrupted the experimenter in the course of reading a problem, if no response was given, or if the child asked to hear the problem again, it was repeated. All problems were presented in a single session of about 30 min duration, which was tape recorded and later transcribed for analysis.

Results

Response Coding

All responses were coded in two ways: (a) for response correctness and (b) for type of justification given for the response. The type of justification used is particularly important for determining whether the child's reasoning is "theoretical" or "empirical" in nature, as earlier discussed. Justifications were classified as either:

1. *Theoretical.* The response only referenced information presented in the problem in the valid deductive manner. For example, in response to: "Bangas are purple animals. Purple animals always sneeze at people. Do bangas sneeze at people?," a justification of this type would invoke the premise information, for example, "yes, because bangas are purple animals."

2. *Empirical.* The response was justified by reference to practical world knowledge. For example, in response to: "Birds can fly. Everything that can fly has wheels. Do birds have wheels?," an empirical justification would refer to practical world relationships, for example, "No, birds have wings!"

3. *State.* The response simply restated the identity of the creature in question. In response to the "purple banga" problem above, an example of a state response was "yes, because he's a banga."

4. *Authority.* The response referenced someone who might be relied on as an authority in the matter. For example, in response to the "purple banga" problem, one justification was "yes, because my mommy told me that."

5. *Other or uninterpretable.* The response could not be coded according to the above categories. The responses were coded by two independent raters. Interrater agreement was 95%.

Data Analyses

The data were analyzed for (a) effects of variations in problem complexity (thus for problem forms A, B, C, and presence of negation); (b) effects of variation in problem content (fantasy, congruent, incongruent); (c) effects of setting condition (the four sequences); and (d) sex differences. No significant sex differences were found for any of the analyses.

Interaction of Problem Content With Presentation Sequence

The effects of problem set organization had a large impact on the strategies children adopted in response to different problem contents. As evidenced primarily in the justifications for their responses, children were quite sensitive to variations in problem content and task organization. Analyses of variance (ANOVAS) were performed for Sequence × Problem Type.

Table 2
Mean Number Correct Responses by Problem Type and Sequence Group

Sequence group	Problem type: Fantasy (N = 8)	Incongruent (N = 8)	Congruent (N = 8)	Total (N = 24)
Group 1 (F/I/C)	7.5	1.6	7.4	16.5
Group 2 (I/F/C)	4.4	0.7	7.2	12.3
Group 3 (C/I/F)	5.7	0.50	7.8	14.0
Group 4 Jumbled	5.7	1.3	7.5	14.5
Averages	5.8	1.0	7.5	14.3

Significant differences were found among sequence groups (*F*antasy, *I*ncongruent, *C*ongruent—FIC; IFC; CIF; and jumbled) for both the (a) correctness of the response (see Table 2) and (b) types of justifications offered for the responses (see Table 3). Because the most interesting information concerning the children's facility with reasoning with these materials is revealed by their patterns of response justification, we present these analyses first.

Analysis of Patterns of Response Justifications

The group who received fantasy problems first (FIC) give many more theoretical justifications for their responses than any of the other groups, for fantasy problems, $F(3, 36) = 40.38$, $p < .001$; for incongruent problems, $F(3, 36) = 2.95$, $p < .05$; for congruent problems, $F(3, 36) = 4.26$, $p < .01$. Although the differences among groups in the numbers of theoretical justifications produced for these problem types are statistically significant, children who first received fantasy problems gave far more theoretical justifications for fantasy problems than they did for any other problems (see Table 3). This FIC group offered 52 theoretical justifications (out of 80 possible; M = 4.6 per child for the eight problems) for the fantasy problems, but only 20 out of 80 possible (M = 2 per child) for congruent problems, and 10 out of 80 possible (M = 1 per child) for incongruent problems. Such results

indicate a powerful effect of empirical problem content on the response strategy children used for this reasoning task.

Furthermore, the FIC group produced significantly more theoretical justifications overall to the set of 24 problems: 7.6 per child, as compared to 1.0, 1.8, and 0.7, respectively, for the IFC, CIF, and jumbled sequence groups. This difference among groups is largely accounted for by the difference in response strategy for the fantasy problems. All 10 subjects in the FIC group produced at least some theoretical responses (range: 3–19). In addition, approximately half of the children in the remaining three groups produced at least one theoretical justification (IFC, 5 children; CIF, 5 children; jumbled sequence, 4 children). No child in these three groups produced more than three theoretical justifications.

There were no significant differences among groups in the number of "authority" justifications, or uninterpretable responses for any of the problem types. An interesting difference did occur, however, for the "state" justifications (see "state" definition for an example). The FIC group produced significantly more "state" responses than did the remaining groups—an average of 2.1, 0.2, 0.6, and 0.2, respectively, for FIC, IFC, CIF, and jumbled sequence groups, $F(3, 36) = 5.12$, $p < .005$. The FIC group produced more "state" justifications for all three problem types. This might suggest that these children were approaching the task differently from the other groups. The sequence in which they received the problems (i.e., fantasy first) may have suggested to them that empirical reasoning was not an appropriate form of response in this situation. This difference provides further support for the interpretation that they were approaching the task in a manner quite distinct from the other groups.

Analysis of Correctness of Responses

Fantasy problem response correctness. The group who received fantasy problems first (FIC) also produced significantly more correct (i.e., valid in terms of logical form) responses for the set of eight fantasy problems than did any of the remaining groups, $F(3, 36) = 7.69$, $p < .0004$. Although these other three groups answered a number of fantasy problems correctly (IFC, 4.4; CIF, 5.7; jumbled sequence,

Table 3
Mean Number of Justification Types for Problem Types and Sequence Groups

	Fantasy ($N = 8$)					Incongruent ($N = 8$)					Congruent ($N = 8$)					Totals ($N = 24$)				
	Theoretical	Empirical	Authority	State	Other	Theoretical	Empirical	Authority	State	Other	Theoretical	Empirical	Authority	State	Other	Theoretical	Empirical	Authority	State	Other
Group 1 (F/I/C)	4.6	1.9	0	.9	.6	1	5.9	.1	.5	.6	2.0	5.1	.1	.7	.10	7.6	12.9	.2	2.1	1.3
Group 2 (I/F/C)	.67	5.2	.3	.2	1.6	.10	7.3	0	0	.55	.22	7.0	0	0	.777	1.0	19.5	.3	.2	2.93
Group 3 (C/I/F)	1.0	4.7	.2	.6	1.5	.10	7.7	0	0	.20	.70	6.7	.1	.1	.50	1.8	19.1	.3	.7	2.2
Group 4 jumbled	.30	5.6	.3	.5	1.3	0	7.2	.4	.1	.30	.40	7.1	.2	.1	.20	.7	19.9	.9	.7	1.8

5.7), such responding did not exceed chance levels for correctness. Both correct and incorrect fantasy problem responses tended to be justified with empirical reasons by these three groups, even in lieu of practical knowledge about fantasy materials.

Congruent and incongruent problem correctness. No significant differences among the four groups occurred in numbers of correct answers for the congruent or incongruent problems (see Table 1). All children tended to produce very few correct responses for the eight incongruent problems (FIC, 1.6; IFC, 0.7; CIF, 0.5; jumbled sequence, 1.3). Conversely, all children tended to produce mostly correct answers for the eight congruent problems (FIC, 7.4; IFC, 7.2; CIF, 7.8; jumbled sequence, 7.5). Thus as with Luria's (1976) subjects, answers to reasoning problems for these two problem types were biased toward congruence with practical knowledge, irrespective of logical form.

Correctness of responses overall. When the total number of correct responses is examined, the FIC group also produced more correct responses than any other group, $F(3, 36) = 4.81$, $p < .006$. The success of this group with the fantasy problems is a major contributor to this effect; not only were the responses often justified theoretically, they were often correct. Such success had but a mild transfer to the remaining problem types for the FIC group (see Table 2).

IFC group idiosyncracies. Children who received incongruent problems first (IFC) also behaved differently from the other sequence groups. These children tended to answer more problems incorrectly overall, $F(3, 36) = 5.36$, $p < .004$. This decrement in the number of correct responses produced was most striking for the eight fantasy problems (IFC, 4.4; FIC, 7.5; CIF, 5.7; jumbled sequence, 5.7). We may speculate that children starting a session with incongruent problems might have inferred that the experiment involved some "trickiness," because their practical knowledge would lead them to answer exactly opposite to what the logical form of the problem called for. They may have then been led to more frequently contradict the answer to fantasy problems that valid reasoning would have required. Further evidence for this speculation is suggested by the increased tendency among this group to respond "no" when a "yes" response was correct in comparison to the other groups (see below).

Relationship between response correctness and justification type. As in Scribner (1977), it was found that if the response to a problem was given a theoretical justification, it was nearly always answered correctly. For the 115 problems to which children gave theoretical justifications, 112 were answered correctly. Empirical justifications were associated with both correct and incorrect responses (365 problems were correct and empirically justified; 320 problems were wrong and empirically justified). It is a potent finding that, even for 4- and 5-year-olds, theoretically justified reasoning is virtually always deductively correct reasoning. If children constrain their judgement to the information presented in the problem, then they are almost invariably correct in response. By contrast, when information other than that supplied by the problem is marshaled in justifications, responses may be either correct or incorrect, depending on the (mis)match between practical knowledge and the relations posed in the problem premises.

Patterns of responses to individual items. An interesting finding concerns the particular problem formulations that tended to receive (the relatively rare) theoretical justifications by children in the IFC, CIF, and jumbled sequence groups. Twelve of the 16 theoretical responses offered by children in these groups for the fantasy problems were given to the following two problems: (a) Godes have skinny legs. Animals with skinny legs can't dance. Can godes dance? (b) Daggles have ugly toes. Animals with ugly toes can't jump. Can daggles jump?

The interpretation of this finding must be speculative. This item effect reflects a variable in problem construction that was discovered post hoc. The relationships among premises in these two problems are semantically nonarbitrary, as opposed to, for example, the "banga" problem, where "being purple" has no pragmatic connection with "sneezing." Having skinny legs, however, can be plausibly related to limited dancing ability (i.e., legs that are too wobbly will not hold up a dancer). Similarly, "ugly toes," if the imagined deformation is extensive, might be expected to con-

strain jumping abilities. So for these two fantasy problems, the theoretical justification covaried with a plausible empirical justification. (This sort of correlation is also noted by Wason & Johnson-Laird, 1972, as the covariation of logical and causal relationships in logical problems.)

Relation of syllogistic form to response correctness. To review briefly, there were three forms of problems, each represented in the 24-problem set by at least one exemplar of all the problem types (see Table 1); universal (A), particular (B), and action/functional relationship between terms (C). Within each of the four sequence groups, there were no significant differences in the numbers of correct responses for any of the three syllogistic forms. There were, however, significant differences *among* the groups in the number of correct responses to Form A and Form C problems. The FIC group tended to perform better than the other groups with these syllogistic forms, but such superior performance was largely confined to fantasy problems. Hence, such differences appear to be better accounted for by problem *type*, as discussed, rather than by problem *form*.

Relation of negation to response correctness. Likewise, an analysis of response correctness according to whether the problem contained a negative construction (e.g., "animals with skinny legs can't dance") revealed no significant differences among groups for the negative problems (see Table 4). But there were significant differences among the groups for the correctness of affirmative problems (see Table 5). Again, the FIC group performed better with the affirmative problems than the remaining groups. Furthermore, the IFC group responded incorrectly more often to the affirmative problems than other groups (i.e., responded "no" when a "yes" response was correct). Such differences for the IFC group again suggest that these children suspected "tricks" from the experimenter.

Table 4
Negative Constructions: Percentage Correct by Problem Type and Sequence Group

Sequence group	Problem type			
	Fantasy	Incongruent	Congruent	Total (N = 24)
Group 1 (F/I/C)	90	17.5	90	65.8
Group 2 (I/F/C)	66.7	25.0	86.1	59.3
Group 3 (C/I/F)	82.5	10.0	100	64.2
Group 4 (jumbled)	75.0	20.0	97	64
Total (averages)	78.6	18.1	93.3	63.3

Table 5
Positive Constructions: Percentage Correct by Problem Type and Sequence Group

Sequence group	Problem type			
	Fantasy	Incongruent	Congruent	Total (N = 24)
Group 1 (F/I/C)	97	22.5	95	71.5
Group 2 (I/F/C)	19	8.3	75	34.1
Group 3 (C/I/F)	52	5.0	95	50.7
Group 4 jumbled	65	12.5	90	55.8
Total (averages)	54	12.1	88.8	53.0

Because the added difficulty of negation in reasoning tasks is well documented for both adults (Wason & Johnson-Laird, 1972) and children (Falmagne, 1975), it is surprising that, overall, the children tended to respond correctly to more negative problems than affirmative ones. There are at least two plausible explanations for this finding: (a) because the premises contain a negative construction, children may readily supply a "no" response (as in the "atmosphere effect" discussed by Woodward & Sells, 1935) and (b) an item analysis suggests that individual problems are treated differently, depending on the particular semantic relations among premises. Children, on this account, may be relying on the content of the problems to guide responses rather than being subject to the complexity of negation. The test problems supporting the second interpretation are the two fantasy problems described above, which not only contained plausible empirical relations (and resulted in more correct responses and theoretical justifications among children), but also contained a negative construction.

Discussion

In this study, two findings have particular prominence: Young children were shown to be able to perform verbal deductive reasoning with theoretical justification, and they demonstrated such reasoning only in highly constrained circumstances. Thus possibility (a), that children can perform deductive reasoning, has been confirmed. In addition, there is evidence that both (b), the empirical truth-value of the problem content, and (c), the task organization in terms of problem sequence, affected the use of this skill. A theoretical or abstract attitude toward the verbal problems appears to have been made possible because the fantasy problems were constituted of premises isolated from practical knowledge. These preschool children reasoned in terms of logical form when the task was constrained in such a way as to most effectively eliminate the intrusion of practical world knowledge. There was no empirical truth value information that interfered with the use of logical reasoning. However, performance with the fantasy problems by the FIC group demonstrates that it is not necessary for the correct conclusion to be supported by empirical truth.

Thus, the results suggest that the task context affects children's reasoning performances in at least two ways. First, the problem content affects reasoning as discussed above, but second, the problem sequence also affects reasoning. Children appear to have some ability to use their reasoning strategies in terms of their interpretations of task requirements. For example, initial presentation of either the congruent or incongruent problems appears to act as a setting condition, and the entirety of the problem set tends to elicit empirically biased reasoning. When fantasy problems were presented in initial position, however, children could use unfamiliar information in premises in deductively correct ways and used some different response strategies than the other groups of children in the remainder of the task.

In their work among the Vai, Scribner and Cole (1981) report similar effects of task sequence on subjects' use of theoretic justifications for syllogistic reasoning, providing converging support for the effects of task context on subjects' interpretations of appropriate responses in that situation. The participants in their studies engaged in a variety of tasks during a single session. The task series was designed to investigate metalinguistic knowledge. Subjects who received syllogism problems *last* in the sequence of tasks (which included such tasks as defining words and judging grammatical acceptability) responded with a significantly higher rate of theoretic justifications than subjects who received the syllogism task early in the session.

These findings bring us to two key points. First, it appears likely from these findings, as well as from studies of reasoning among adults (see discussion in Cohen, 1981), that the pragmatic form of reasoning, which incorporates any relevant knowledge into a reasoning situation, may be more pervasive, more "natural," in most situations. This is particularly true for meaningful as opposed to formal materials, such as logical formulae. The children in our study generalized this empirical response strategy to fantasy problems, which are foreign to practical knowledge, when these problems appeared in any other than first position in the organization of the task. In contrast, the formal, theoretical strategy was largely confined to fantasy problems at the outset of the problem set. Only one child showed evidence of consistent formal generalization on most problems of the experiment.

Second, the highly limited conditions under which formal reasoning was displayed by these children suggests that this is not a logical schema over which they have complete control, nor are they fully conversant with the conditions in which formal reasoning is appropriate. That is, these children do not yet display the ability to manipulate "content-free schemas of relations" (Flavell & Wohlwill, 1969; Piaget, 1972; Scribner, 1977) independently of problem type. But the children will perform valid logical deductions when practical knowledge is irrelevant and when the task conditions support this form of reasoning.

Children's responses appeared to be constrained by systematic knowledge about possible kinds of structural relationships among the materials. In displaying sophisticated empirically biased reasoning, we do not wish to underemphasize that the children revealed an organized system of practical knowledge that they bring to the task. The structure of such knowledge and the processes by which it is

accessed in such a task is ultimately of key importance for an understanding of the development of formal reasoning from a predominantly empirical orientation.

To fully succeed in this task, knowledge of the possible arbitrariness of material entailments is required (i.e., that it is possible to hypothetically reason about birds with wheels). A strategy that allows people to juxtapose possible (not necessarily meaningful) connections under the constraints only of the logical connectives and not of the semantic relationships is necessary. In such a task, the demonstration of a consistent theoretical strategy requires that the child attend only to the configuration of logical form in the premises *and* that the child know that this approach is appropriate to the discourse engaged in with the experimenter.

Although the 4- and 5-year-olds in this study did not demonstrate this level of skill, the striking sequence effects indicate that certain aspects of the task context influenced the response strategies adopted by the children. The strategy of empirical bias generalized to the fantasy problems when they appeared in the second and third position in the sequences. Further, the group receiving incongruent problems first seemed to suspect "trickiness" on the part of the experimenter and adjusted their response strategies accordingly.

In summary, these results indicate that at least two situational variables affect the display of logical reasoning in task performances: (a) the structure of the materials, with respect to both type of content and the semantic relationships among the premise information and (b) the structure of the task as it affects the formulation of strategies to handle the *experiment* as a setting. The children demonstrated that they were capable of deductive reasoning and were sensitive to aspects of the task context in their responses. Although the children were not fully able to use deductive reasoning where appropriate, the results suggest that 4- to 5-year-olds are beginning to acquire information about selective application of these reasoning skills.

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