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Interpretation and structured learning

Hawkins, Jan, Ph.D.

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INTERPRETATION AND STRUCTURED LEARNING

by

Jan Hawkins

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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January 26, 1988
Date

Executive Officer

Joseph Glick

Harry Beilin

Katherine Nelson
Supervisory Committee

The City University of New York

Abstract

INTERPRETATION AND STRUCTURED LEARNING

by

Jan Hawkins

Adviser: Professor Joseph Glick

An interpretationist perspective is used to developmentally explore how task characteristics and people's interpretations affect the kinds of structured relationships that are learned. The framework for the work is based on three components: knowers constitute the objects of their knowledge; circumstances of engagement affect the construction of knowledge; the notion of multiple rationalities or organizing structures is a way to coordinate the general and the circumstantial through variation in systems of significance. Two experiments were conducted. The same variants of materials and instructions were used in the two studies to orient subjects (7-8 year-olds, 11-12 year-olds, adults) to either formal/analytic or social/thematic organizing structures in the tasks. In the first, implicit learning, study subjects of all ages tacitly learned different structural relationships based on their orientation and interpretive contribution to the task. Subjects with a formal orientation to the task learned a different type of complex rule system that generated a set of exemplars

than did subjects with a thematic orientation. There were no developmental differences. The second, concept learning, study examined whether the same variants of organizing structure similarily affected performance in a different kind of task, and whether the pattern of responses might provide evidence about the kinds of processes underlying implicit learning. Results indicated that the efficiency of performance and strategies used by subjects in explicitly searching for concepts differed as a function of the formal/analytic and social/thematic organizing structures. The developmental differences found in the study indicate that this kind of conscious strategic search does not account for implicit learning. The studies suggest the importance of considering the interpretative framework for understanding the structured learning that takes place in different situations.

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INTRODUCTION

This dissertation is written from an interpretationist perspective. People's participation in any situation is fundamentally interpretive and that our understanding, as analysts, must take account of the interpretive nature of people's functioning. Performance (in this case focussing on some of its cognitive aspects) is not only a function of the abilities or strategies available to participants, but also what the situation means, or comes to mean to them. This developmental study is an investigation of how cognitive performances are linked to the nature of situations, and orientation to the meaning of requested performances. The perspective developed here draws on many literatures, and fits neatly a niche in none.

The nature of the relationship of persons to the material world has been a central question of philosophy since such discussions have been recorded. Briefly and simply, a selection of the material which leads to an interpretationist perspective begins with the posing of two alternatives: the world constitutes the mind through the senses (works, for example of Locke, Berkeley), or the mind of itself makes the world (for example, radical skepticism). The notion of interpretationism can be located with Kant: "mind does not apprehend an object which is given to it in completed form, but through its

activity of providing interpretation or conferring meaning or imposing structure, mind in some measure constitutes or 'creates' the object known" (see Kaplan, undated). Knowledge is possible not because it reflects 'reality' or the object world, but because persons are active knowers through their own experience.

Psychological studies of the development of knowledge, those in particular of Piaget and Vygotsky (as discussed below), grow from commitments to philosophical positions about the origins of knowledge and the nature of knowing. Such commitments are composed with visions of the final form, for which a theory of development is a dynamic account. Anthropological and sociological studies which place the performances of people into specific cultural webs of meaning are also relevant, as is the work of some literary critics who cast human action in dramaturgical/symbolic terms. These works are grounded in the notion of <u>possible</u> meanings, and explore the generative nature of circumstances or perspectives as they relate to peoples' knowledge and performance. A mixture of experimental psychological studies contributes evidence to a perspective about the interpretative nature of human performance.

The studies to be reported here are intended to develop a point of view--that there are multiple answers to a question that is implicitly posed by people in circumstances: "what is going on here?"; to borrow a

phrase from Geertz (1984), `connecting action to its sense rather than behavior to its determinants'. People learn at least partially shared readings about appropriate responses in situations, and these may change developmentally. The goal here is not to lay out a program which systematically documents the different "modes" of organizing thinking or performance (see Bruner, 1986). I believe a viable problem of development is to focus on the nature of the flexibility of responses in situations. These studies are a short voyage into that problem.

This work is an exploration into a point of view, leaving aside for the moment the problem of theory development. There is some indication that this is a justifiable characterization of psychological work, as analyzed for example by Geertz (1984), for the activity of social science and Toulmin (1972), for the nature of post-modern science. There appears to be a trend away from laws-and-instances models of explanation to interpretations-and-cases explanations, recognizing the hermeneutic qualities of scientific understanding--"Not what is true about this, but what can we make of this?" (Toulmin, 1982).

Much evidence, deriving from recent work in psychology, philosophy, anthropology, criticism and common sense understanding (Pepper, 1942; Geertz, 1984) emphasizes the flexibility of human behavior throughout

development. An adequate understanding of development needs to take account of these dynamics--not just with respect to transitions between stable states or stages, but synchronously, the variations in possibility of response as related to the meanings of circumstances for participants. One approach is to try to develop a theory of environments (e.g., Bronfenbrenner), a systematic description of the material circumstances that support and give rise to growth. This appears to be problematic, because what seems missing from such an approach is the notion that participants can transform the meanings of circumstances for themselves. This symbolic flexibility is essential to puzzle over because neither the language of specific circumstances nor the language of specific logics (which must then admit of circumstantial variations) seems adequate to account for these dynamics of interpretation.

The goal of the work reported here is to explore the flexibility of performance, developmentally, for circumstances constructed to offer different kinds of coherence relations to people, and symbolic manipulations of those meanings and relations.

Overview of research problem

This is a developmental study. People learn not only more sophisticated, integrated, and efficient ways of acquiring and using information, they also develop ways of understanding what is required in situations, awareness of

the possibility of ambiguity, and ways of transforming (Goffman, 1974) meanings. Variations in the meaning of an event, and therefore variations in what counts as an appropriate response, can be located as broadly as cultures (e.g. Geertz, 1973 the various meanings of a wink), or more narrowly within cultures (e.g., institutions such as schools, McDermott, 1976 and Goldman, 1982; or very locally, as between pairs of people collaborating on a problem, Hawkins, 1987).

The studies to be reported here were designed to examine the performances of people from different age groups in an experimental situation in which the types of materials they worked with were systematically manipulated as was the purpose of their work (ways in which they were asked to approach the materials), and the meaning of some aspects of the situation (symbolic transformations of the materials).

People abstract systems for dealing with the complexities of individual encounters. Abstraction abilities are visible in a variety of domains--from the mundane and local (discovering a single rule or concept which organizes a number of instances in a psychological experiment) to the sublime and general (learning a language). People "see through" the surface structure of phenomena and understand encounters in terms of some deeper regularities. Descriptions of knowledge of this sort often characterize it as generative (Cassirer, 1923;

claims about language learning, e.g., Chomsky, 1965; Reber 1978); claims about the structure and learning of events (Schank, 1982; Schank & Abelson, 1977; Nelson & Gruendel, 1981; Bransford & McCarrell, 1974). In some cases, the nature of generative knowledge (noting of significant regularities) may be linked to the nature of shared significance among members of a group.

Theories of development address the problem of describing the organized nature of the relationship between mind and particular encounters with the world, and accounting, systematically, for changes in this relationship (Piaget 1962; Vygotsky, 1962; 1978). The goal can be a general account which transcends the variation in the particulars of material engagement. There is considerable evidence, however (see below) that people's understanding and performance in situations may be productively seen as linked to particular characteristics of the material engagement and the significance that has for the participants. Characterizations modelled on purely abstract logics may be inadequate to the problem.

The research reported here attempts to examine the following issues which derive from this line of inquiry:

1. What sorts of regularities do people look for in differently structured environments? That is, do different materials systematically "afford" (Gibson, 1969) different types of organizations?

2. Is there a developmental progression in the environments for which children are able to abstract the systematic relationships from a set of instances? Children may be sensitive to different sorts of material organizations at various points in their growth. In light of evidence of the importance of context to cognitive operations one must consider possible differences in the structural properties of relationships among individual items or events.

In this investigation, context can mean two things:

(a) The nature of the materials and their relationships. This can refer to the characteristics of the object/entities used (in this case, formal abstract materials such as geometric shapes; or real world pragmatic materials such as dogs and bicycles). It can also refer to the nature of the relationships among the objects/entities, the type of rule system governing how individual events "go together" (e.g.. formal logical relationships, event/narrative, social-interactional). These two aspects (materials and relationship rules) are dependent, and probably interact in interesting ways. Developmental findings concerning the effect of familiar materials on children's (and adults) abilities to demonstrate competence in cognitive tasks may be related to the possibilities of relationship among items rather than solely on the materials themselves (see Hawkins, Pea, Glick & Scribner, 1984).

Children may be sensitive to different possibilities of relationship among items at various developmental points. The notion of varying relationships among "objects" in a system or across systems has also been a way of approaching the study of creativity (e.g., John-Steiner, 1985)

(b) The nature of the task and social situation--peoples' interpretations of 'what we are doing here'. This rendering of context can also have at least two readings. The task: what are the explicit agenda for performance with the materials. The task interpretation: what are the materials and the situation taken to mean by participants? People can reinterpret materials or situations in some transform of their announced meaning (Goffman, 1974) The transformation can be governed by what might be called 'social rules' (e.g., acting as a subject in an experiment, or getting a free half hour away from class), or in some symbolic transform of the available meaning (e.g., let's pretend this is a dog, or let's pretend all fish have wings; Hawkins, Pea, Glick & Scribner, 1984). The materials and their relationships are taken to represent something other than their apparent meaning, and responses might vary accordingly. The experimenter can be manipulator and object of these transformations.

Understanding and response can therefore be governed by type of material, relationship among materials, and

nature of engagement with the whole situation. The research reported here follows this line of reasoning: the ability to abstract, or learn, regularities governing sets of objects or events may be developmentally related to particular structural properties of the events. For example, the regularities one looks for in physical events may be quite different from the regularities one looks for in social events (Glick, 1977). These two domains are explored in the current studies, based on evidence that different kinds of information search take place for these domains (Bruner, 1986; Bruner, Goodnow & Austin, 1956). In addition, the perceived regularities in these domains may well be flexible--a function of possible transformations in meaning of the events.

Background

In the next section a subset of this literature is reviewed--that which is most directly relevant to the intent and interpretation of the studies to be reported. A variety of literatures is pertinent, both as sources for the organizing ideas, and as collections of evidence. The evidence is eclectic, as often results are interesting in light of the ideas explored here, but were collected for quite different purposes. The emphasis is local, on work in the psychological tradition. I also borrow from 'visions' in other traditions, believing with Geertz, that the explanatory enterprise may be productively altered by exploring affinities with other scholarly bodies--who

borrows what from whom, placing phenomena in different frames of awareness. The task is to locate this work in the psychological tradition, but also to examine frameworks which take the perspective of understanding human action through analysis of interpreted meaning in a community of knowers.

There are three organizing threads in the segments of selected literature. The selection is illustrative of the main points, as many other works could be interpreted as bearing on this arena.

First, knowers constitute the objects of their own knowledge. Two traditions of work will be used here: the work of Piaget; the psychological work which provides evidence about the constructive nature of inferences.

Second, circumstances of engagement appear to be inextricably linked to our understanding of performances and the construction of knowledge. Aspects of Vygotsky's theory will be briefly reviewed in relation to this thread. In addition, certain psychological studies focussing on the effects of materials and goals will be cited.

Third, the framework of multiple coherences, or 'multiple rationalities'--the necessity of attending to systems of signification or coherence which vary with perspective--may be an (interim) means for organizing the tension between the general and the circumstantial. This is where I do some liberal borrowing.

I. Knowers constitute the objects of their own knowledge

Theories of human development take as their principal problem the analysis of the growing capacities of persons in interaction with their material and social worlds. Theories of ontogenesis focus on either internal or external factors as the emphasized engines of change. Accordingly, the languages of theories are organized by systematic characterizations of cognitive or social/material circumstances of growth that lead to adult forms.

Piaget's theory focusses on the internal dynamics of individual cognitive growth. One definition of reflexive abstraction characterizes cognitive operations as derived from interaction with physical/causal reality. The interplay between material entailments and cognitive operations leads to a system of reversible relations which fully transcends the physical entailments. The system of operations then describes the form of thought applied to any context. Piaget's theory offers a model of development which accounts for the achievement of hypothetico-deductive thought, a form often used to characterize scientific thinking. Children develop progressively more complex structures which enable them to achieve this final form.

One source of difficulty with this theory as it has been used is the evidence which suggests that performances expected by the Piagetian description of operations are,

often, occasionned. For example, not all adults achieve formal operations (documented by, among others, Bovet, 1974), and adults do not appear to be formal operatory thinkers all of the time (e.g., Wason & Johnson-Laird, 1972; Johnson-Laird, 1985; Shakelee, 1979; Kahneman, Slovic & Tversky, 1982). In addition, young children (e.g., Hawkins et al., 1984) and concrete-operational adults perform logical operations some of the time (Cf. Glick, 1977). Much experimental effort has gone into arranging circumstances where children exhibit more sophisticated performances than would be predicted. For example, young children have been shown to possess requisite formal operational skills when tasks are properly arranged to support their display (e.g., Gelman & Gallistel, 1978 with math skills), or when particular cultural practices support their development (e.g., Price-Williams, 1962).

This sort of evidence has generated attempts to accommodate variability. For example, the notion of decalage addresses the problem that consistent operational capacity does not simultaneously emerge for all materials. Piaget and Garcia (1974) explore the notion of bonds between the development of cognitive structures and content in relation to physical causality.

Flavell and Wohwill (1969) suggested an extension of the theory to include performance factors as part of the equation which predicts ability. As noted by Wason and

Johnson-Laird (!972), this makes the claims of the theory untestable.

It is a common finding that the circumstances of experiments or tasks affect the performances of both adults and children. If one begins with the goal or assumption that an underlying logical system is necessary to characterize all performance, then one attempts to fit this evidence to a singular account. Some take these findings as a challenge to develop a `natural logic´ which will encompass all cognitive activity (e.g., Braine, 1959; Osherson, 1974). But it has been argued that no formal calculus will succeed in describing a general theory of human reasoning, or human discovery (Toulmin, 1972; Rorty, 1979), and that a semantic component must be included (Wason & Johnson-Laird, 1972). A candidate means for including this component is through introducing the notion of mental models which are learned and through which people reason about logical problems (Johnson-Laird, 1985). Logic of the sort described by Piaget is in this view a derived ability rather than the central means to characterize the operations of mind.

Cohen (1979), for instance, suggests that the general failure to find correlational thinking in adults (Tversky & Kahnman 1973; 1974; Kahneman, Slovic & Tversky, 1982; Schweder, undated). may be due to the fact that subjects are conforming to a ´Baconian´ model of systematizing their experience rather than a `Pascalian´ model assumed

as the logical standard in these investigations. Briefly, in Baconian reasoning, the adequancy and importance of the evidence available is weighed in making correlational judgments; in Pascalian reasoning it is assumed that all evidence is considered and judgments are based on the laws of statistical probability. In the first system, subjects are evaluating the content of the situations they are reasoning about; in the latter system, content of problems is assumed to be irrelevant. Both systems, it is argued, are available and used on different occasions.

The effects of different sorts of materials and their transformations have not been systematically articulated in general theories of development. Isolated cases of particular experiences have been widely cited (e.g., potters' children early and singular display of conservation of mass, Price-Williams, 1962), but issues concerning how differently organzied environments may offer different kinds of regularities for learning have not been adequately addressed by a structural account.

Studies of constructive inference. Much recent experimental work has explored what might be termed diachronic processes. That present understanding is shaped by past experience is not a claim peculiar to this work, or necessarily distinct from Piaget's theory (concepts for example of assimilation and accomodation). It is the structure of this knowledge and the impact of the organization on a particular encounter that is

distinct. Whereas Piaget predicts increasing recognition of and operation upon objective reality, one of the properties of 'event structure', 'semantic integration' or 'script' approaches is that the particular organization of knowledge may in some circumstances thwart recognition and manipulation of the objectively described properties of experience.

The importance of diachronic processes has been a topic of increasing interest in recent years. Evidence has recently accumulated that event-structure, or episodic, descriptions may characterize the ways children organize information about the world (Nelson, 1977; 1978). New information, or encounters, are understood and integrated into existing knowledge structures. In some experiments such interpretation and integration processes result in 'distortion' of new encounters (e.g., D'Andrade, 1974; Kahneman, Slovic & Tversky, 1982).

There is an extensive and growing body of evidence that young children as well as adults engage in meaning-rather-than reality-preserving inferences, sometimes referred to as semantic integration. One's organization of knowledge may in fact thwart the recognition and logical manipulation of an 'objective' reality. Pragmatic or meaningful relationships among the materials presented in experiments are understood in terms of world knowledge or belief systems, and are not necessarily reacted to or remembered in terms of their

objective components. With development, the ability to integrate meaningful material may increase (Paris, 1975; Paris & Lindauer, 1977).

The literature concerning functional fixedness in the Gestalt tradition is also interesting in this regard. Scheerer (1963) provides experimental evidence that the degree of cognitive embeddedness of an item in a particular context affects subjects' abilities to disembed, or analyze items for use in a problem solution. For example, the currency of a calendar (this year's or out of date) affected people's tendency to perceive the string which suspended it as a tool for solving they announced problem of putting rings on pegs. Subjects watching the experiment were more able to adopt a reflective attitude and disembed the string. Characteristics of the environment and mode of engagement influence the coherence of the material for subjects.

Experimental evidence demonstrates that both children and adults integrate information presented in sentences (e.g., Prawatt & Cancelli, 1976; short paragraphs (Paris & Carter, 1973); stories (Mandler, 1983; Stein & Trabasso, 1982); spatial descriptions (Johnson-Laird, 1985) with their broader knowledge of the way the world works. Children, like adults, will erroneously judge that they have heard or seen material which was not previously presented to them if the recognition material is congruent with their semantic or episodic knowledge.

Diachronic processes are important to the comprehension as well as the distortion of incoming information. This is the reverse phenomenon to the one described above. Understanding involves contextualizing new information in organized systems of knowledge about the world (Bransford et al., 1982; Bransford & McCarrell, 1977). In addition to affecting memory for meaningful material, such processes can render anomolous material sensible by suggesting a framework which allows a meaningful interpretation (Bransford, Stein, Shelton & Owings, 1982). These sorts of contextualizing processes have been incorporated into instructional strategies that are designed to help children better comprehend and retain text (e.g., Palinscar & Brown, 1984; Brown & Bransford & Ferrera, 1984).

A tradition of work has also developed which characterizes learning and memory processes in both adults (e.g., Schank, 1982) and children (e.g., Nelson & Gruendel, 1981) in relation to some materials by the metaphor of `scripts´. People negotiate situations through dynamic templates which support the recognition of coherence in situations, and facilitate appropriate response. Development of this type of knowledge can be characterized as increasingly sophisticated and integrated event-structural information.

There is considerable evidence for constructive knowing from two quite different traditions--structural

theory and its experimental support for a developmental process which allows knowers to transcend material entailments, and a tradition of work which offers evidence of constructive cognitive processes in learning and remembering material. The second thread explores the effects of circumstances on knowledge construction and performance.

II. Circumstances of engagement

Vygotsky's theory is often offered as a contrast case to Piaget's perspective in that his approach features the social world as a primary source of developmental change. For Vygotsky, complex internal cognitive processes have their source in the social world through the postulated mechanism of the appropriation of socially accomplished tasks/coordinations to the plane of inner cognitive functioning. The contrast is a neat one for easily displaying two approaches distinguished by key emphasis on individual vs. social dynamics. The two are frequently paired because of their contrastive symmetry: two options for motivating developmental change.

There is an interesting aspect of Vygotsky's approach that is only implicitly captured in this contrast. It is a foundation of the theory that is particularly interesting. The theory allows for the fundamental importance of historical/material/contextual circumstances for individual development. A theory which ties the individual to historical processes must give a central

role to the social. While ahistorical processes are used to characterize development--gradual movement of constructions from joint accomplishment to individual competence--the particulars of the context of development can fundamentally affect the nature of individual constructions, and contexts change. It is possible then to link an account of individual development to a theory of social processes and historical change (cf. Wertsch, 1985). This is an option that has been characterized in philosophical work (Lavine, 1951) as `empirical interpretationism'. A system of knowledge has its source in particular factors that are qualitatively different from the mental processes of the individual.

In the Vygotskian tradition, social phenomena are governed by a unique set of explanatory constructs, and these cannot be reduced to intrapsychic phenomena. There is a dialectic between individual growth and the social tools and patterns of activity in the surround (cf. Luria, 1976). The notion of "activity", a socio-culturally defined concept, is the bridge between social and psychological planes of analysis (Leontiev, 1981). This account also offers the analytic categories of "goal-directed actions" (the purpose of an activity), and "operations" (the conditions in which action is carried out).

Another possible move from such a view of development is to emphasize the semiotics of situations. In addition

to a general characterization of social processes that support development, one can productively attend to what circumstances mean, or how variations in significance among communities of knowers affect the development of knowledge. For example, Wertsch examines the differences in interactions between adults and young children carrying out a construction task as a function of adult role and education (teacher vs. mother).

Work deriving from other, though converging, traditions suggests ways in which variations in circumstances and significance may affect performance. Research with children, as well as with adults cross-culturally, indicates that the type of materials, and their familiarity affects the ways in which people perform logical tasks (e.g., Goodnow, 1969; Falmagne, 1975; Scribner, 1975). Pragmatic, or world, knowledge intrudes in situations where a display of 'pure' reasoning is desired. For example, investigations of psychological processes among Liberians (Cole et al., 1971) demonstrated responses quite different from westerners. Instead of concluding that people lacked abilities, the researchers varied the characteristics of the eliciting environment. The environmental rearrangement provided some interesting information about cultural significance as it affected the display of cognitive skills--the meaning of environments for participants. In an experiment designed to assess categorization strategies, Liberian adults at first

performed like western children, using functional groupings of objects as the basis for categorization. When asked, however, to do it as a "dumb" person might, the people produced the sophisticated attribute-based categories characteristic of western adults.

Scribner's work with syllogisms also demonstrates how the cultural meaning of the elicitiation context, and the ways in which subjects chose to make the task 'sensible' were important considerations in understanding performances. More recently, Scribner (1985) has been investigating the ways in which mathematical skills are bound to work situations--how milkmen efficiently organize their mathematical strategies for the tasks at hand.

This research developed into a way of working which emphasized that cognitive skills are bound to occasions of use, and can be productively viewed within the framework of contexts to which they are adapted. In general, the perspective that situations (especially, here, experimental ones) may offer alternative ways of proceeding is supported by a variety of other experimental work. In particular, studies with tasks designed to elicit logical performances are rich in this regard. Briefly:

Effects of problem content. The type of materials used in logical tasks, for example, appears to be complexly related to performance. Abstract material (e.g., geometric forms, letter, word or number strings,

nonsense items) appear to facilitate the use of complex logical strategies in some studies (e.g., Bruner, Goodnow & Austin, 1959, Hawkins et al., 1984), while the same types of materials hinder such performance in others (e.g., Wason, 1968; Wason and Johnson-Laird, 1972). For example, Wason and Johnson-Laird report a series of studies demonstrating that well-educated adults failed to consider disconfirming cases in their evaluation of conclusions drawn from abstract logical problems.

To make the evidence symmetrical, the use of familiar materials (e.g., animals, people, events) can either facilitate logical performance (Wason & Shapiro, 1971; Johnson-Laird, Legrenzi, 1971), or impede it (Bruner, Goodnow & Austin, 1959; Wason & Johnson-Laird, 1972; Tversky & Kahneman, 1973). With respect to facilitation, Wason and Johnson-Laird found that adults readily considered disconfirming cases when a logic task was embedded in a pragmatic situation which made such evidence valuable. In this experiment subjects were cast as postal workers who had to evaluate the conditional: "If a letter is sealed, then it has a 5D stamp on it." While most subjects correctly carried out this exercise, there was no transfer of this "insight" to abstract materials. Logical performance appeared to be facilitated by concrete materials whose logical and causal connectives (natural semantic inference coincided); logical performance was impeded when these two components diverged.

Falmagne (1975) and Osherson (1975) argue that physical or empirical knowledge is often confounded with the logical requirements in situations. Real-world knowledge, for instance, can interfere with adults' (e.g., Scribner, 1978) and children's (Hawkins, Pea, Glick & Scribner, 1984) ability to display logical performance with syllogis material.

Kahneman, Slovic & Tversky (summarized, 1982) have conducted a number of studies investigating subjects' biases in reasoning. They have been interested, for example in the information people attend to in making judgments under uncertainty. In contrast to the above experiments, they report evidence that subjects fail to seek or attend to disconforming cases or evidence when reasoning about concrete materials. Many of their studies use social materials, such as personality descriptions juxtaposed with probability ratings. Subjects tend to rely on the representativeness of the material in the descriptions in relation to their knowledge about people, and ignore the information provided by the mathematical probabilities in making their judgments. The reasoning used to evaluate such claims was not logical in form, making use of all available evidence. Judgments appeared to be guided by subjects' intuitions about likely relationships in the world--their beliefs about the cooccurance of traits in persons. Shweder (1978) likewise argues that western adults can be characterized by the

same processes attributed to 'magical thinking' in cultures such as the Zande. In both instances, people can be shown to rely on resemblance relationships (what goes with what in the world) rather than adopting correlational procedures in making judgments about the likely cooccurence of real-world events. Shweder points out that it is important to recognize that the analysis of behavior is not the same as the understanding of action.

The effects of purpose. The goals of tasks, or their perceived goals affect cognitive performance. The concept of "intention" is becoming increasingly prominent in a variety of fields which have as their purpose some analysis of human activity. It is a major feature, for example, in Bruner's (1986) recent work on the understanding of narrative texts (as an instantiation of a particular mode of thought). Simulations of the knowledge required for both social (Bruce, 1980; Newman, 1986) and cognitive (Simon, 1982; Collins, 198) performances require the creation of `objects' which stand for goal-states or intentions. Recent analyses of how science gets done and the status of its products introduce the notion that knowledge cannot be taken as reflective of a "reality" independent of purpose (Toulmin, 1982; Chaiklin, 1985). Thus one approach to the development of knowledge has as a fundamental component the intentions and situation of those who `design' or use that knowledge.

The present study is more circumspect about evidence for the necessity of considering goals in understanding performance. In psychological experiments which incorporate this variable, performance is often shown to be a function of the shared goals of the task (experimenter communicates intentions); experiments can sometimes be said to go awry when these intentions are not shared (examples in cross-cultural discussion, above).

Understanding of what they are to do is crucial, for example, in adults' memory for both verbal and visual material (e.g., Bransford, McCarrell, Franks & Nitsch, 1977). People appear to be able to adopt a formal, analytic stance toward familiar materials, rather than using real-world inferential knowledge, if they perceive that this strategy is appropriate to the task at hand. Algorithmic procedures are then used rather than natural language connectives; formal analytic descriptions rather than thematic metaphorical ones (Jewson, Sachs, & Rohner, 1981).

Smirnov (1973) has done an extensive and interesting series of studies exploring voluntary and involuntary memory--what is remembered in what kinds of circumstances. He is especially interested in exploring the relationship between mnemonic intention (explicit goal of remembering something), involuntary memory and how variations in the material circumstances affect each of these types of cognitive activity. His broad conclusion is that the most

important factor is the direction and depth of engagement, and mnemonic intention is only one such purpose. The orientation of activity and the "depth" with respect to meaningfulness make the critical difference in what gets remembered.

The nature of the activity engaging subjects powerfully affects what gets remembered. The purpose of activity is of special significance in involuntary memorizing. A study by Zinchenko (in Smirnov, 1973) provides a simple illustration. Subjects were asked to classify pictures that also had a number in the upper corner; in this condition, subjects were able to remember the objects but not the numbers. The reverse condition (requiring subjects to order the pictures by number) demonstrated that the numbers were now the remembered item. Smirnov also asked adults to study pairs of sentences that were related by orthographic rules, and then devise two new sentences to illustrate the rule. When asked on the next day to recall all sentences, subjects could often recall the rule, and the sentences they themselves had composed but not the original sentences. This is interpreted to indicate that people retained products that were the goals of the cognitive activity, but failed to recall those portions of the event that were the means to the goal.

In another type of study, conducted by Istomina, subjects who were asked to notice spelling errors in a

series of sentences were less able to remember the sentences than where required to attend to the meaningful relationships in the material. Likewise with young children, those asked to remember a set of objects did more poorly on a subsequent memory test than those who arranged the objects into an "exhibit". Smirnov reports that the advantage of memorizing meaningful material is smaller at an older age than it is for younger children--adults are better at remembering nonsense material.

The explanation offered uses a kind of depth-of-processing argument to account for the activity-related differences in the studies. Meaningfulness of material is complexly related to voluntary mnemonic orientation, where depth-of-processing (taken as the real-world meaningfulness of the materials/activity composition) can produce better results than instructions to memorize.

But the most useful notion for present purposes is what Smirnov takes to be his real object of study--remembering rather than memory. He is not interested primarily in the <u>weakness</u> of the memory-function, but rather in its dual nature: the preservation of what occurred, and its <u>changes</u>. Changes are a result not of insufficient traces, but of complex mental activity which determines the conditions for the preservation of experience. The source of these changes

is found in the activities surrounding the experience; needs, interests, and goals determine the direction of the preservation, and control the nature of the changes. This type of approach is exemplified by one class of studies Smirnov chose to pursue--how actors remember, how they learn their lines and roles. From interview studies, he concludes that for this professional group, the act of remembering is not the focal goal to be attacked directly; actors do not set for themselves the direct goal of simply memorizing the lines of a play. The act of remembering is embedded in a more complex purposive activity concerning the construction of meaningful performances--meaningful in the sense of understanding the generative system underlying what the characters do and say, and the construction of an image of these moves made through the representational repertoire of the actor.

Understanding, and thus remembering involves finding what is essential in something. "These processes are the result of reflective reconstruction of perceived material in regular ways." Thus, in harmony with Bartlett (1932), "we do not so much recall as <u>infer</u> what happened." It is the mental activities of composition that are central to remembering rather than merely repeated exposure to materials.

III. Multiple Coherences

Much of the work that either explicily or implicitly criticizes the structural resolution to developmental

problems provides rationale and evidence for variability in predicted formal capacities. The work tends to explore the circumstances that bind performance to context, the supporting conditions (social and material) for skills. Conditions of display can become the theory; organizations of knowledge are isolated in separate domains, and by implication are fully bound to external material circumstances. Theories can be limited to the development of knowledge in particular domains. This approach is currently evident for example in accounts of the development of scientific knowledge. Current accounts of the development of expert knowledge in physics, for example (cf. Larkin 198) analyze how particular concepts and misconceptions develop and are integrated into an expert's flexible conception of the structure of that domain. Carey (1985) takes this tack in developmental studies of science problem-solving skills.

In these examples, and in contextual approaches to development, knowledge is seen as tied to local circumstances. Flexibility is not fully acknowledged: in describing the strategic quality of cognition by locating performances in contexts, the notion that the contexts themselves are interpreted is not considered.

A different strategy is exercised by those philosophers and psychologists who suggest the need to take into account possible multiple rationalities. Logical performance is only one possible organization of

cognitive capacities. While Piaget's theory may account for one sort of developemntal achievement (the final form of hypothetico-deductive reasoning, characteristic of scientific thought), there may be other forms of coherence for operation in the world.

Glick (1978) suggests a different resolution. People find alternate ways of making a situation sensible within the frame of possible "multiple rationalities". This is a structural solution to the problem, different from the predominately functional solution offered by Cole and associates, and those psychologists who weigh heavily circumstantial evidence. Instead of context-skill mappings, this approach assumes cognitive-organizational features that transcend the level of local engagement. There are alternative ways of pursuing meaning, and any particular encounter can be ambiguous with respect to best-course-of-understanding. It may be, for example, that different kinds of materials and circumstances may engage alternate 'rationalities' that change both culturally and developmentally. People may simultaneously see that there are alternative ways of proceeding.

One means of describing this approach has been the 'perspectivist thesis' (cf. Kaplan, undated). Understanding is interpretative and may vary in time and space. It can be located in the "terms" which generate alternate perspectives. The nature of meaningfulness (what counts as information or evidence) is viewed as

relative to perspective. For example, "If the object of knowledge can be defined only through the medium of a particular logical and conceptual structure, we are forced to conclude that a variety of media will correspond to various structures of the object, to various meanings for `objective relations'. Even in `nature' the physical object will not coincide absolutely with the chemical, nor the chemical with the biological--because physical, chemical, biological knowledge frame their questions each from its own particular standpoint and, in accordance with this standpoint, subject the phenomena to a special interpretation and formation" (Cassirer, 1923 Vol. 1).

This position appears principally in disciplines that characterize interpersonal aspects of knowledge (different ways of knowing across socially defined groups). The notion of multiple, legitimate frameworks, indexed to purpose, significance and circumstance is evident in work of a number of philosophers and historians of ideas. The central notion is that of perspective, and that different logics/purposes/forms "see" different types of evidence. Different principles can organize what is taken as evidence.

Some philosophers characterize interpersonal knowledge as structurally, legitimately, multiple. Pepper (1942) offers one formalization of pluralism in developing an hypothesis about world views: systems of explanatory knowledge are multiple, and each is founded in a root

metaphor which generates certain possible descriptions of the material world. The four world hypotheses are mutually incompatible. Each is built not simply from data (multiplicative corroborations), but from the structural corroborations that are the consequences of a particular root metaphor. What can be taken as evidence, and how various types of evidence relate to each other is a function of the selected world view.

Nelson Goodman (1978) develops another approach to a pluralist view of the development of knowledge, one he chooses to term `irrealism´. In this view, persons are engaged in the making of new worlds out of old ones. A constructed world is seen as a `version´ that is related to its context by notions of rightness rather than by notions of truth. The tendency to look "underneath" constructed explanations/versions for confirmation of the truth of that vision through correspondence with a single real-reality is untenable (see also Rorty, 1979). Goodman argues for the necessity of understanding knowledge as characterized by multiple actual worlds, which are the consequences of multiple frames of reference or purposes. These worlds are constructed by means of symbol systems (following Cassirer). Thus incompatible world-versions may be harmoniously maintained because they can be <u>right</u> versions of different frameworks. In his view, "knowing is as much remaking as reporting".

Goodman lists processes through which "worlds" get made, which he points out are only candidates among many possible. They in part derived from psychological evidence concerning inference processes and dynamic memory. Worlds are made, for example: (a) by composing and decomposing materials in which "objects" are sorted into relevant kinds (relevant to the particular frame of reference); (b) differential weighting of particular elements; (c) order of elements for particular purposes; (d) deletion and supplementation processes that allow data to be ignored or fortified in pursuit of pattern; (e) reshaping and deforming processes which select certain properties as meaningful or relevant: "Our capacity for overlooking is virtually unlimited". Goodman stresses that multiplicity does not imply acceptance of all worlds as equally right; the work is to critically select among alternatives the preferred version for a frame of reference. Bruner (1986) has recently adapted this treatment to an argument concerning two different knowledge forms--the paradigmatic and the narrative.

The idea of multiple rationalities is also developed in some analyses of the history and activity of science--problems concerning the status of science as knowledge in relation to other disciplines, and of different schools of thought within a single discipline. For Toulmin (1972; 1982) uses the notion of perspective as fundamental to the understanding of the nature of

scientific knowledge: "Natural sciences are in the business of construing reality...physicists make it their business to discover what aspects of reality/nature lend themselves to interpretation and understanding as considered from any particular standpoint." Scientists engage in interpretation. The difference between humanities and sciences is not whether they engage in interpretation, but in the different modes that characterize them. The adequacy of interpretations is not a personal matter, but arises in relation to the social group with which one communicates. What are taken to be problems, and which available framework is likely to be most productive in a particular case is what matters. With respect to the relation between reasoning and subject matter, "formal reason is not the same as rational soundness".

This class of ideas is articulated among anthropologists, perhaps most forcefully by Geertz (1973; 1983). From his standpoint, the principal program is to characterize the nature of the relationship among knowledge systems and the world. Whether dealing with distant cultures or professional groups within our culture, he seeks to understand how systems of meaning relate to what goes on in the world. Phenomena can be explained by placing them in the local frames of awareness, and these of necessity, are characterized as multiple. There is a "radical pluralism of the product

side of thought"-- it is a matter of finding out how others organize their significative world and what that tells us about the performances we see.

With respect to the intrapersonal side of the multiple rationalities perspective, some evidence is available suggesting that individuals organize encounters in terms of multiple kinds of coherence.

Goffman (1974) directs some of his attention to the necessity of considering that people transform, or change, the surface meanings of materials and tasks (Goffman, 1974, 1984). In his account of action in a social world, people can "reframe", can "thickly interpret" (Geertz) the events in their environments. A certain event, described at a basic or behavioral level, can be given radically different readings by particpants depending on the way it is socially framed (the Vygotskian notion of "activity" is kin to this). For example, an argument between a man and a woman can be a marital conflict, a performance in an acting class, or a professional discussion. The levels of analysis (what are taken to be the units of significance and their relationships) that viewers attend to, given any of these frames, will be quite different. It is also possible to accommodate the recognition that events can be designed to be ambiguous, for certain purposes.

D´Andrade (1974) demonstrates that memory for behavioral events can change, based on how the viewing activity is `framed´. For example, what behavior gets

remembered changes radically when adults are given the opportunity to switch from on-line recording of behavior to descriptive summaries of 5-minute segments of social interaction. Reports done "after-the-fact" were much more subject to distortion from pragmatic expectations for behavior than were the real-time behavioral recordings.

Burke (1969), most often described as literary critic, offers a symbolic-interactional framework to the understanding of human actions and motives. His grammar of motives offers a system to account for people's abilities to find different kinds of explanation in situations involving human actions. It is this part of his vast work that is adopted for the current studies. His form of perspectivism is embodied in a system which generates possible accounts by differently locating the motivation for an event. A pentad of motivational foci is developed to determine the construction of sense in a scene. The five motivational elements include: actor, action, scene, agent, purpose. Any explanation selects one of these loci of motivation and accounts for the event accordingly. Burke's system will be further used in the present studies.

The two studies reported here investigate the ways in which people may multiply interpret two different domains: the abstract-'object' world and the social. Social knowledge may have a different kind of order from that of abstract/objects. As noted by Glick (1978), the physical

world is stable, whereas social reality may be more probablistic. The social may be especially rich, allowing multiple readings depending on purpose and perspective, for which complete specification is not appropriate.

A particular experimental paradigm is well suited to investigate the effects of these kinds of variations in materials and structural relationships on understanding. A number of studies have demonstrated the operation of 'implicit learning' processes in adults, where people learn the systematic regularities or rules governing complex sets of exemplars of a pattern (e.g., Posner, 1967 with statistically generated sets of dot patterns; Reber, 1969, 1987 with letter strings generated by Markov finite state grammer; Franks & Bransford, 1971, with geometrical shapes governed by possible position-movement rules, replicated by Jewson, 1976.). People are neither aware they are learning rules, nor can they commonly verbalize the regularities. In fact, instructions to look for rules seem to hinder performance. People asked to look for rules seem to be learning something different from people who simply learn the examples (Reber & Allen, 1979; Jewson, 1976; Legrenzi, 1971; Lewicki, 1986; Schacter & Graf, 1986; Brooks, 1978).

Subjects in these studies seem to be abstracting knowledge of rule-structure. Recognition responses are better predicted by the rule structure than they are by actual experience with items. People are also able to

detect violations in the system. It is possible that people `implicitly learn` in environments for which they already have some familiarity--they know what kinds of relations to look for. People may have a meta-knowledge about possible organizing principles (restrictions on serial position in letter-strings, for example). Reber & Glick (1979) propose an interesting extension to developmental theory: richly structured environments may be differentially accessible to learning by children, depending on their familiarlity with the embedded relations. Materials and structual relationship available in these environments may interact with children's cognitive sohpistication to constrain the types of rules children can abstract from surface forms. For example, it may be easier for children to learn the regularities in complex environments governed by event-causal relations (cf. evidence of "script" knowledge, Nelson & Gruendel, 1981) than those organized by sequential position or logical rules.

The analysis of differential skill display in context hinges on constrasting formal/analytic (synchronic) organizations with pragmatic/thematic (diachronic) ones. The former requires people to fully transcend material entailments, unless the pragmatic and logical structures of the materials and task coincide. The latter are occasions where material entailments guide responses. This dichotomy may capture something essential about the

possibility of multiple coherences or multiple approaches to situations. The following investigation examines the relationship between people's orientation and interpretation of tasks, and the kind of structured learning that they do.

In sum, the implicit learning paradigm will be used to investigate the perspective offered here, that people actively construct their own knowledge, that this nonconscious constructive activity is influenced by the circumstances of engagement, and that multiple rationalities may be a means of resolving some of the evidence concerning internal and external contributions to the developmental of understanding. The work will extend the inquiry developmentally, examining whether children of different ages can learn different kinds of regularities inherent in materials.

This investigation is based on two related studies. The first study investigates the phenomenon of implicit learning. Thus far, there is considerable evidence that implicit learning of complex regularities occurs. However, relatively little is known about how different configurations of materials and instructions may affect people's performances, or how age may affect the learning of different kinds of organizing structures--in line with the above perspective, are multiple kinds of structures found in the materials? In the second study, a concept learning task using the same variations in materials and

instructions was used to examine the possibility that particular kinds of information scanning strategies may account for the implicit learning of the generative rule systems, and to examine whether multiple approaches to finding regularities are also evident for a different kind of task.

Three age groups took part in the study. They were selected to examine the possibility that different types of organizing structures may be especially salient at different points in development. Thus, following research concerning children's event knowledge (e.g., Nelson, 1977; Nelson & Gruendel, 1981) 7-8 year old children were included to see how formal vs. pragmatic organizing structures affected their performance, with the prediction that pragmatic structures would be more powerful at this age. Eleven-twelve year olds and adult subjects were included to see how the learning of organizing structures changed with development.

This task explores the phenomenon of implicit learning from the framework of multiple rationalities developed above. Variations in the circumstances of learning derived from that framework are systematically examined, and the inquiry is extended developmentally. This paradigm was selected as a promising way to further explore differential understanding as a function of material-properties and interpretative framework. It has been demonstrated in particular and limited conditions

involving abstract/analytic materials. From the perspective developed in the current work one would expect learning of different systems of regularities, based on the surface meanings available and orientation to the situation. The phenomenon has not been explored with respect to different kinds of regularities, its developmental shape, nor have mechanisms underlying these performances been adequately explained.

The perspective underlying the current work suggests three questions about this phenomenon: Do people do this kind of learning only with formal materials, or are other generative patterns acquired? Is the learning solely a function of the properties of the materials and their relationships, or is an interpretative contribution made? What is the developmental shape of the phenomenon? The following predictions were made with respect to these questions:

1. Subjects will demonstrate implicit learning of the rule-systems in their pattern of recognition judgments;

2. There will be developmental differences with respect to the type of rule-system acquired. Specifically, 7-8 year olds will learn the thematic structure but not the formal one. Adults will learn both types of structures, appropriate to the task circumstances. The

11-12 year olds will display an intermediate type of performance.

3. The recognition patterns will be different for subjects in the different orientations to the task (materials and instructions): thematically oriented subjects will learn the thematic structure of the materials, and will not recall the items that are meaningless; formally oriented subjects will not make this distinction.

STUDY 1: IMPLICIT LEARNING

An implicit learning task, adapted from previous research concerning pattern abstraction processes, was used in this study. For this type of task, a set of stimulus materials is generated by a complex rule-governed system. The rule system is too complex to be readily identified by subjects who examine the set of generated exemplars. In previous research, three types of generative systems have been used: sets of perceptual patterns involving spatially organized geometric shapes that are generated from a "core" pattern by applying transformational rules (Franks & Bransford, 1971); finite state grammars, which generate strings of letters or numbers (Reber, 1967); statistically generated dot patterns, where central tendency defines the pattern (Posner, 1969).

The present task makes use of the first method of generating a set of exemplars because it most readily accommodates the possibility of examining the relationship between type of materials and the structural relations among them. There may be ways in which the materials and the characteristics of the generative rule system are interdependent. For example, with respect to the grammars, people appear to learn different regularities with strings of numbers than they do with letter strings that are generated by the same finite grammar (Cantor, ms). Brooks (1976) finds that different strategies are learned at different rates when artifical alphabets (phonetic symbols) are represented 'glyphically' (iconically fused) as opposed to linearly, as in ordinary spelling.

For the implicit learning task, it was necessary to generate materials that could be interpreted either analytically or pragmatically. Geometric shapes and their relations in patterns (formal materials) allowed the construction of an analogous set of materials where variations in meaning could be rendered by the position of elements in cartoon drawings (thematic materials). These materials allowed more flexibility in the task than the symbol strings of finite state grammars, which are read linearly.

Method

Subjects

The three age groups who took part in the study included: 7-8 year olds; 11-12 year olds; adults. Students from three schools participated: one large public school with a population of average to above-average students as determined by admission tests; 2 private schools with students of average ability and above also determined by tests. Adult subjects were drawn from a population of undergraduate students at a university who volunteered for the experiment.

120 subjects took part in this experiment, 40 from each of the 3 age groups. The youngest subjects had a mean age of 7 years, 6 months (19 boys and 21 girls); the middle students had a mean age of 11 years 4 months (22 boys and 18 girls), and the adults ranged in age from young twenties to late thirties (20 men, 20 women). Individuals from each age and gender group were randomly assigned to 1 of 5 task conditions.

Materials

The task consisted of 2 parts. In the first, learning phase, subjects were shown individual stimulus patterns generated from a prototype pattern by different combinations of transformational rules. In the second, recognition phase of the task, subjects were shown a different set of patterns generated by the same rule system and asked to judge with a degree of certainty whether or not they had seen the pattern previously. The learning and recognition patterns were non-overlapping,

and the recognition set also included examples that were violations of the rule system (Noncases). Accordingly, two sets of stimulus materials (learning and recognition) were developed for this task, for each of the 2 material types (formal, and thematic). Both the formal and thematic materials made use of the same set of transformation rules. The material sets therefore represent instantiations, or surface manifestations, of the structural organization defined by the rule system.

Formal materials. Sets of 3 or 4 spatially arranged shapes were drawn on 5 inch by 8 inch cards. Each card was divided in half vertically by a black line. The patterns were constructed in the following manner:

(1) Prototypes. Two prototype, or central tendency patterns, were constructed. Three shapes (square, circle, triangle) were used, and these shapes were varied by color (red, green, yellow, blue). Each shape could be 1 of 2 colors (different for each of the two prototypes), and two sizes (large or small).

(a) Prototype 1: the left side was a small green square over a large blue square; the right side was a small red triangle over a large yellow circle.

(b) Prototype 2: the left side was a small red circle over a large blue square; the right side was a large green triangle over a large yellow circle.

(2) Movement rules. Four different rules for transforming the prototype patterns were selected. The rules specified particular positional movements for the figures.

(a) Major move. The two figures on one side of the card move as a unit to the other side of the card, adjacent to the center line.

(b) Minor move. The top figure moves next to the figure below it, so that they were horizontally rather than vertically adjacent. Again, it remained next to the center line.

(c) Embedding. A small figure moved inside a large figure.

(d) Deletion. Any of the four figures could be deleted, but this could be applied only once so that there were always at least 3 figures present.

The 4 rules could be applied recursively, so that an exemplar could be from 1 to 4 transformations away from the prototype pattern. The system therefore consisted of two prototype patterns plus a set of allowable-movement rules which could be used to generate a set of exemplars.

These rules were selected for several reasons. Rules of this sort have been successfully used in previous studies (Bransford & Franks, 1971; Jewson, ms.). These sorts of transformations could be given plausible `iconic' interpretations under pragmatic instructions (see below).

The set of learning cards and the set of recognition cards are selected according to the following criteria.

Learning set. Twenty cards were chosen as the learning set. Each type of transformation, and possible combinations were sampled (following Franks & Bransford, 1971). The set was chosen so that the prototype was determined to be the central tendency of the learning set. In order to determine this, the number of transformations presented in the learning set was summed across the 20 cases. When compared with all possible relationships in the set, this sum was less for the prototype pattern for any other configuration of the elements--the prototype was that pattern which represented the least number of transformations for the chosen set of exemplars.

Recognition set. Thirty four cards were selected for the recognition portion of the task. The learning and recognition sets were non-overlapping. The learning set included one of the prototypes, the recognition set included the other. The set contained exemplars of varying transformational distance from the prototype, as well as Noncases produced by illegitimate moves (e.g., substitution of elements from 1 prototype into the other; moving elements counterclockwise, etc.). One additional constraint is explained below, in relation to the construction of the Thematic materials.

Thematic materials. This set of materials was constructed in an identical way to that described above for the abstract materials (two prototypes, and the same 4 movement rules), with the exception that drawings of

people and objects replaced the geometric shapes: children (1 large, 1 small); a bicycle; an apple; a basket; a store counter, (see Figure 2). The prototype cases and the learning set were chosen to represent meaningful representations of relationships among the materials.

Prototype 1. Large child on bicycle, apple on store counter.

Prototype 2. Small child on bicycle, basket on store counter.

Since the study explored how the underlying generative system was learned in various conditions, the recognition cases were chosen to represent 4 possible groups

(1) correct and meaningful: those cases that were both correct according to the rules, and meaningful according to the thematic descriptions;

(2) correct and not meaningful (e.g., the apple is embedded in the bicycle);

(3) incorrect and meaningful: Noncases that were incorrect according to the rule system, but meaningful in terms of the semantic description (e.g. large child on bicycle, basket on store counter, which is meaningful thematically but incorrect because elements from the two prototypes are mixed);

(4) incorrect and not meaningful.

Instructions

There were 3 variants of instructions through which subjects were instructed in the task.

Analytic instructions were used to present the formal materials with their apparent meaning--geometric shapes with varying qualities. The thematic materials were also presented under analytic instructions; subjects were explicitly told that while the drawings represented people and scenes, they were to treat the elements in the cartoons as independent and nonmeaningful items. They were instructed to ignore the ordinary connections among the objects pictured, because this would confuse them in doing the task.

Pragmatic instructions were also used with each set of materials. The formal materials were given thematic interpretations or meanings that corresponded to the event relationships available in the cartoon drawings. As described below in Procedures, subjects in this symbolic condition were presented with the 'abstract' cards, but told to give particular thematic interpretation to each of the dimensions represented. For example, the triangle represented a boy and the circle represented a bicycle.

Silly instructions were used only with the formal materials. These subjects were told that the shapes and dimensions represented particular 'real' things. These were drawn from the same categories as had been used to generate the thematic items, but the meanings assigned formed no coherent 'events'.

Procedure

The youngest subjects (7-8 year olds) were seen individually. The older 2 groups of subjects were tested in groups of 4 to 6, where attention could be maintained in a group setting. Subjects were told this was a memory experiment. They were first familiarized with the materials. Cards that individually pictured each element in the stimulus set were shown serially. Subjects were intructed in a manner appropriate to the experimental condition to which they were assigned. After subjects learned the individual elements they were presented with cards showing combinations of figures, and asked to describe the cards. Mistakes were corrected. The familiarization period ended when each subject correctly described at least 3 consecutive cards.

Small 'books' of blank pages were then distributed to the subjects for the learning phase of the task, along with a set of 4 color markers (red, yellow, green, blue) for the formal materials, and pencils for the thematic ones. Subjects were then told: "I'm going to show you some cards with these pictures on them. You will be able to see the card for a short time, and then I'm going to take it away. After I take it away, I'm going to read a number. Your job is to write down the number, and then to draw the pictures that were on the card". For the thematic materials, subjects are asked to do a brief sketch.

Each of the 20 learning cards was presented individually for 10 seconds. The order of the cards was determined by shuffling them for the first subject of the experimental task; from that point, order remained constant so that subjects viewed the cards in the same order. Following the removal of each card, an 8 digit number was read aloud. This was included as a distractor task, so that subjects were not simply reproducing the card from immediate memory. The number task was not included in the analysis. Subjects wrote down the number as best they could remember, and then drew the picture. When the drawing was completed, feedback was provided by rereading the number, and showing the card again. Subjects were asked to note any mistakes they had made and correct them. The procedure was repeated until all cards had been presented.

Following a break of about 10 minutes, the recognition portion of the task was introduced. Subjects were told that they would see another group of cards. Some of the cards, they were told, were exactly the same as the ones they had just seen and drawn. But some of the patterns were new and they had not seen them before. They were to look at the card, decide whether they had seen it or not, and to indicate how certain they were of their decision. Answer sheets were distributed; subjects circled "yes" or "no" , and then a number from 0 to 4 to indicate degree of certainty (4 equalled absolutely sure;

1 unsure, and 0 don't know). In the case of the youngest group, the individual students were asked to verbally respond to the experimenter's questions, who then recorded their answers.

Results

The main effects for age will be examined first. Subsequently, the most interesting analyses for the above hypotheses will be discussed, the interactions among the variables of materials, instructions, and age. These interactions will be the data used to address the questions. The results for other main effects analyses are available in the Appendix.

Scoring procedure

Participants' responses to each item in the recognition portion of the experiment were coded on a scale from 0 to 8 (0=very sure item had not been seen in learning set; 4=unsure; 8=very sure item had been seen). Thus, following the procedure used by Bransford & Franks (1971), absolute recognition judgments were combined with certainty ratings: scores of 0, 1, 2, 3 indicated that subjects reported they had not seen the item, with diminishing degrees of certainty. A score of 4 indicated that the subject was unsure whether or not the item had been seen. Scores of 5, 6, 7, 8 indicated that the subject judged that the item had been seen, with increasing degrees of certainty.

Composite scores for item categories. To obtain composite scores for each of the recognition item categories (e.g. rule-governed 1 transformation; rule-governed 2 transformations; noncases; etc.), the judgment scores for each subject were summed within each item category, and then divided by the number of items to obtain a mean score for that category.

Composite scores were also calculated for the meaningful and nonsense items within categories. For the purposes of this study, it was important to know how subjects responded to the meaningful rule-governed items (referred to as M items) when compared with the rule-governed items that did not make pragmatic sense (referred to as S items). Likewise, it was necessary to know how the meaningful Noncases (NC-M) and nonsense Noncases (NC-S) were treated?

Mean scores were computed for each subject's responses to the rule-governed transformations that were both syntactically correct and semantically coherent within each of the transformational categories--1 transformation, 2 transformations, etc. Separate mean scores were computed for those items that were only syntactically correct, for meaningful noncases, and for nonsense noncases. Thus, the following categories of mean scores were obtained for each subject:

Overall:

(1) Rule-governed transformations by number of

transformations from the prototype;

(2) Noncases;

Taking meaning into account:

(3) Rule-governed syntactic and semantic (Prototype, M1, M2, M3, M4) vs. syntactic (S1, S2, S3) alone;

(4) Semantic vs. meaningless Noncases.

Following previous research with this paradigm, the mean scores for the categories of interest were ranked. The relationship among the ranked categories was compared with the order predicted by the underlying rule system. It was predicted that the prototype (central tendency) item would be recognized, with the greatest degree of certainty, followed by 1-transformational items, 2-transformational items and so forth. The ranking of the items over all subjects as well as within age, condition and instruction groups and their interactions was examined.

Over All Subjects: Recognition Judgments

When examined for the population as a whole, the rank order of recognition judgments confirmed that predicted by the rule system for the meaningful items. The prototype item received the highest average rating, the one, two, three, and four transformational items were ranked in that order, and the noncases received the lowest average rankings (see Table 1).

One, two and three way analyses of variance were performed to determine the effect of age, condition,

instruction, and gender on the recognition judgment scores. There were no significant sex differences; this variable will not be further discussed.

Age: Recognition Judgments

There were significant differences among age groups for some of the mean scores for categories of items (see Table 2). Age group differences emerged for M1 items $F(2,117) = 5.6$, $p < .005$; M2 items $F(2,117) = 4.1$, $p < .02$; S2 items $F(2,117) = 5.0$, $p < .001$. Post hoc analyses revealed that in all 3 instances the adults' scores were significantly different from one or both of the groups of younger students. The adults' scores differed from both younger groups for the M1 items. Adults and 7-year-olds differed significantly from the 11-year-old group for the M2 and S2 items. There were no differences among age groups for the Noncase items.

Despite these differences, the relative ranking of scores within each age group was the same--all groups generally ranked the item categories in the predicted order. This may indicate that the different age groups differ in the use of the response measure (adults seem to be more apt to use the extreme positive end of the scale than the younger subjects) rather than different recognition patterns for the materials. Thus, the different age groups appear to be implicitly learning the same regularties; there is little evidence of

developmental difference in the structure abstraction that is clearly occurring.

Since this study was centrally concerned with the ways in which orientation toward the task (materials and instructions combined) affected subjects' learning, the interaction analyses are the central data for this study. The comparisons among groups of subjects defined by both material and instructions (referred to as "Group" throughout) will be discussed first, and then the effect of age on these combined variables. The results for other analyses are available in the Appendix.

Group: Recognition Judgments

The responses of subjects in each of the five Groups (Formal analytic-FA, Group 1; Formal pragmatic-FP, Group 2; Formal silly-FS, Group 3; Thematic analytic-TA, Group 4; Thematic pragmatic-TP, Group 5) were examined (see Table 1). One-way ANOVAS were performed using the mean scores of subjects for each of the sets of recognition items. There were no significant differences among Groups for the rule-governed items overall. When examined by transformational distance, there were Group differences in recognition scores for all of the rule-governed but meaningless items (S items): overall S items $F(4,115) = 61.91$, $p < .001$; S1 items $F(4,115) = 26.75$, $p < .001$; S2 items $F(4,115) = 42.37$, $p < .001$; and S3 items $F(4,115) = 19.97$, $p < .001$. Post hoc analyses showed that in all these cases, Groups 3, 4, and 5 were

significantly more certain that they had not seen these items than were Groups 1 and 2. That is, the thematically oriented Groups (3, 4, 5) differentiated the meaningless from the meaningful items in their recognition judgments, judging them to be non-experienced items. The formally oriented subjects (Groups 1 and 2) did not distinguish the meaningful from the meaningless items, treating them all in terms of transformational distance.

There were no Group differences for those rule-governed meaningful (M) items that were prototype, M1, or M2 items. There were significant differences for M3 items $F(4,115) = 3.93$, $p < .005$. Post hoc analyses (Newman-Keuls used throughout) revealed that Group 1 (FA) and Group 2 (FS) differed from Group 3 (FP) and Group 4 (TA) (see Table 1). Groups 1 and 2 had lower recognition scores for these items than did the other groups. They were less likely to recognize the item with certainty than were Groups 3 and 4. Likewise, for the M4 items $F(4,115) = 4.29$ $p < .003$), Groups 1 (FA) and 2 (FS) were significantly less certain that they had seen the item than were Groups 3, 4, and 5 (FP, TA, TP).

The noncase items showed the same pattern of differences among Groups. There were no Group differences when the noncases were analyzed overall. However, when the noncases items are categorized according to meaningfulness, Group differences emerged for the anomalous noncases (NC-S items: $F(4,115) = 3.99$, $p <$

.004, but not for the meaningful noncase items (NC-M items). Post hoc analyses demonstrated that Groups 1 and 2 gave higher recognition judgment scores to the NC-S items than did Groups 3, 4, 5 (see below for discussion).

Group and Age: Recognition Judgments

Two-way ANOVAS and post hoc comparisons (Newman-Keuls) were done to determine how age might affect the recognition judgments of Group members. The Groups by age are identified as follows:

7-8	11-12	Adult
7.Formal analytic	11.FA	A.FA
7.Formal pragmatic	11.FP	A.FP
7.Formal silly	11.FS	A.FS
7.Thematic analytic	11.TA	A.TA
7.Thematic pragmatic	11.TP	A.TP

There were group and age differences for the M1 items $F(14,105) = 2.7$, $p < .002$; M2 items $F(14,105) = 2.0$, $p < .02$; M3 items $F(14,105) = 1.9$, $p < .04$; and M4 items $F(14,105) = 2.2$, $p < .01$. These differences are as follows, and can be accounted for by differences in uses of the response scale.

For the M1 items, group 7.TP differed from A.FP and A.FA, and 7.TA also differed from A.FA. That is, the youngest subjects who worked with the thematic materials tended to have lower certainty ratings for the M1 items than did the adults with the formal items.

For the M2 and M3 items there were differences only between the 11.FS Group and the A.FP and A.TA Groups, with the eleven year old group giving these items higher ratings. For the M4 items, there were differences only between two Groups. The A.FA Group had higher scores than did the 7.TP Group.

There are Group and age differences when the S items are examined: S1 items $F(14,105) = 9.6$, $p < .001$; S2 items $F(14,105) = 17.8$, $p < .001$; S3 items $F(14,105) = 6.3$, $p < .001$. Post hoc analyses for these items revealed differences as follows. For the S1 items, there were no differences by age for the TA and TP groups. These groups were homogeneous and gave the items the lowest ratings. These groups also did not differ from the FP (formal material, but pragmatic interpretation) Groups for all ages. The TA and TP groups differed significantly from all other groups, with the exception of the 11-year-olds in the FS group.

Differences for the S2 and S3 items followed the same general pattern. Groups, regardless of age, oriented toward thematic readings (TP, TA, FP) by either materials or instructions had the lowest recognition scores and differed from the those who were formally orientated (FA and FS), who had the highest scores.

The mean scores for all S items were compiled and compared for all Groups x age, $F(14,105) = 24.3$, $p < .001$. Overall, there was a striking contrast among those Groups

who, regardless of age, were given a thematic orientation toward the materials, and those Groups given a formal orientation (formal materials with analytic or silly instructions). Post hoc analyses showed that the judgment scores for all thematic Groups (TP, TA, FP) differed from all formal Groups, with the thematic groups more likely to give low recognition scores to these meaningless items.

Finally, there were no significant group and age differences for the meaningful Noncases (NC-M). There was only one significant difference among Groups with age taken into account for the anomolous Noncases (NC-S): the 11.FP differed from the A.FS group, with the latter group having a higher recognition score.

Discussion

This study provides further support for the occurrence and power of the implicit learning phenomenon. It offers new evidence concerning its nature and complexity.

First, all three age groups demonstrated that the materials were implicitly learned, and the different age groups showed the same patterns of structure abstraction. The 7-8 and 11-12-year-old subjects demonstrated the same patterns of implicit learning as did adults with both formal and thematic orientations; under instruction they too symbolically interpreted the materials in ways that affected their recall. The effect of Group (see below) was more apparent than the effect of age in this study,

with all FA and FS Groups differing from all TA, TP, FP Groups and with no pattern of developmental differences. Thus, the prediction of developmental differences was not confirmed.

The only age differences apparent for items are best explained as a function of response bias: older subjects tended to use the extremes of the response scale more frequently than younger subjects. This interpretation of age variation seems most plausible because the rank order of judgements in each of the item categories was the same for all age groups; the absolute scores for a few items varied in a nonsystematic way when compared.

With respect to the third prediction, regardless of age, the constructive recall patterns indicate that different systems of regularities were learned based on the materials and instructions. In this case, the abstract/formal or social materials affected performance. The third prediction was confirmed: subjects demonstrated implicit learning of generative rule systems, and that learning varied as a function of the type of materials and relationship structure offered.

But the story is more complex than that. It is not simply the regularities of surface features of the materials at issue; the interpretation given to those surfaces affects the type of regularity "sought" or discovered. The type of materials and the structure of the rule system generating the instances, and the

interpretation given them by subjects is necessary to explain performances in this study.

Recognition judgments were guided by underlying generative rule-systems which were in fact available in the relationships among the items used in the learning phase of the experiment. Yet the type of regularities learned was partially a function of what subjects made of the situation. The primary and striking evidence comes from the judgments of the different groups for the rule-governed but meaningless (S) items in the recognition phase of the experiment. The two Groups of subjects who had a primarily formal orientation to the task (FA and FS Groups) gave much higher recognition judgments to these meaningless items than the three Groups who were thematically oriented (TP, TA, and FP).

There is evidence, however, that the thematically-oriented subjects also responded to the transformational patterning of the rule-governed meaningful items. These subjects did use the meaningful/meaningless dimension (i.e., following the rule: "Have seen if meaningful, haven't seen if nonsense"). They had stronger recognition "boundaries" according the the meaning of items in that they gave higher recognition ratings to the M3 and M4 items than did the formally oriented subjects. But they also judged that they had not seen the noncases, like the formal groups, and their recognitions judgments showed the

transformational pattern of certainty ratings for the rule-governed meaningful items (prototype, M1, M2...). This suggests that the thematically oriented subjects also learned something about the generative rules governing the set of meaningful items.

The performance of the FP (formal materials, pragmatic instructions) Group is especially important because it addresses the question of interpretative contribution on the part of subjects. This Group worked with the formal materials, yet readily symbolically interpreted the materials. Their performances suggested that they attended to the pragmatic relationships in the materials, even though they actually worked with the formal abstract shapes.

In contrast, the Silly instructions did not apparently offer an alternate system of coherent relationship, only individual item meanings. The FS Group was guided by the formal rules. Likewise the analytic instructions for the thematic materials (TA) did not appear to generate an alternate interpretation for the pragmatic situation--not a surprising finding in light of the apparent power of narrative modes in the face of attempts to get people to treat concrete phenomena formally (e.g., Wason & Johnson-Laird, 1972). Unlike the FP condition, TA subjects were not asked to transform the <u>meaning</u> of the materials, but to ignore the available coherence relationships. These instructions appeared to

have little effect on recognition performances. The performances of the FP Group however suggest that "internal" interpretation (what the surface properties were taken to signify by the learner) interacted with the surface regularities of the "external" world.

There is evidence that learning of complex regularities takes place implicitly, and that the knowledge is available to people not directly but through judgments about subsequent encounters. The regularities learned are a function of both surface properties (in this case, formal and pragmatic form and relationship) and interpretative orientation. Children show the same learning patterns as adults.

This study provides some evidence about the conditions of implicit learning and its developmental shape, and about the interpretative nature of implicit acquisition of complex patterned information. The paradigm proves to be an interesting experimental instantiation of the multiple rationalities framework that is developed above. But it is important to know more about the processes involved in implicit learning as well as about how the framework may apply to another, different kind of task. The second study was undertaken for these two purposes.

Little is known about the processes or mechanisms related to implicit learning. Previous studies have examined whether conscious search for the system or rules

is related to performance. Results from this research suggest that this sort of search interferes with acquisition of the generative knowledge. But these studies do not eliminate the possibility that some form of strategic search may be taking place, though such search is not the attentional focus.

STUDY 2: CONCEPT LEARNING

The second study used a different procedure to investigate what kind of processes may account for the implicit learning performances in the first study. The same kinds of differential performance with respect to type of regularities searched for with formal and pragmatic materials have been reported in another situation--the concept formation task used by Bruner et al. (1956). These studies examined the strategies used by college students to scan information in order to discover the "concept" that unified a series of instances. Using this method, are the same performance patterns found when the concept task is structured in the same way as the implicit learning task? In the case of identical performance patterns there would be evidence of similar processes in subjects' information scanning for the two situations. Accordingly the concept study was designed to examine subjects' scanning patterns in concept attainment with materials and interpretation variants that paralleled those in the implicit learning study.

A concept learning task, adapted from an earlier design (Bruner, Goodnow & Austin, 1956, and used more recently, Bruner 1986) was used for this study. Bruner et al. were interested in analyzing the ways in which information is organized into concepts, and the effects of certain stimulus characteristics and dimensional covariations and disjunctions on strategic performance. Most notably for this study, adults use different information search strategies to identify a unifying concept with social-thematic materials than with geometric-abstract ones. Subjects used more complex efficient strategies for eliminating possibilities in correctly identifying concepts with abstract materials (geometric shapes which differed in type, color, size and border) than they did with social-thematic ones (human figures that differed in age, sex, affect and dress).

While this task has been used to examine hypothesis-testing abilities in children (cf. Gholson & Beilin, 1979), it was used in the present study for a different purpose: to investigate how children and adults organize their search for unifying regularities in a set of materials, depending on the characteristics of the materials, the structural relationships apparent or encouraged among them, and the flexibility of response determined by symbolic transformations of the materials. Do performances in the concept task parallel performances in the implicit learning task in a way that suggests

similar processes may account for both kinds of performances?

The following predictions were made about performances in the concept task.

1. Subjects' performances on the task measured by number of trials and strategy use will differ for the formal and thematic orientations. Specifically, subjects in the formal orientation will complete the task in fewer trials, and using more efficient strategies.

2. The kind of strategies used to solve the concept task may provide a an inferential clue as to the type of learning that underlies the observed implicit learning performances. In this case, the same pattern of findings is predicted for the two tasks, with no developmental differences.

Method

Subjects

The subjects in this study were drawn from the same schools and undergraduate populations as those for Study 1, but different individuals participated in Study 2. One hundred twenty subjects took part in this study, 40 from each of the 3 age groups. The mean age of the youngest subjects was 7 years, 4 months, with a range of 7.0 to 8.3 (23 boys, and 17 girls). The middle students had a mean age 11 years 6 months (21 boys, and 19 girls). The adults

were undergraduate students, who ranged in age from early twenties to late thirties (18 men, 22 women). Eight subjects from each age and gender group were assigned to each of the 5 variants of the task organization (see Figure 1).

Materials

Two different types of stimulus sets were constructed. The formal materials consisted of geometric shapes with varying properties. The thematic materials were drawings of people and objects. Each set was done on 4 in. by 6 in. cards. As in the Bruner concept studies, each stimulus set systematically varied along 4 possible dimensions, and had 2 or 3 possible values. The sets were constructed so that each possible combination of the values of each variable occurred once so that the possible values of each variable occurred with equal frequency in the set (see Figure 4).

With respect to the abstract set, the following dimensions and values were used: shape (circle, square, triangle); location (left, right, top); border (large rectangle, large triangle. large ellipse); color of shape (red or blue).

The construction of the parallel thematic set is based on Burke's (1969) analysis of human motivation (see above), and his answer to the question: "What is involved when we say what people are doing and why they are doing it?". Burke argues that there are five elements which

must be considered in any answer: actor, action, scene, agent, purpose. One or more of these elements is always the focus of the understanding of a human event, and this differential emphasis results in a system of alternative accounts. Four of these elements were used for the stimulus set: actor (with the values of boy, girl, teacher); action (making a phone call, running out the door, screaming and yelling); scene (school, store, house); purpose (because actor is late; because there is a fire) (see Figure 4). These values were selected to have reasonably equal plausibility as meaningful combinations of elements. An artist drew each possible set of values as a series of cartoons. For example, one card depicted a boy making a phone call in a fruit store with a clock featured prominantly on the wall; another card showed a teacher running out the door of a school with smoke curling in the background.

Instructions

The same variants of instructions for analytic, pragmatic and silly conditions that were described earlier for the implicit learning study were used in this task. The formal materials were given analytic, pragmatic, and silly interpretations for 3 groups of subjects respectively. The thematic materials were introduced either analytically or pragmatically to 2 other groups.

Procedure

Each subject was seen individually in a private room. In the case of the young students, this was either a library or an empty classroom in the school. The adults were interviewed in an empty classroom or a meeting room. Each session took approximately 30 minutes, varying by 10 minutes in either direction.

Each subject was told that we would be playing a game, using this a set of cards with shapes/drawings on them. Subjects were first familiarized with the materials in the following manner. They were shown a set of cards that represented each value of each dimension individually (e.g., a card with only the mushroom shape, or the little girl). As each card was presented serially, subjects were instructed according to the analytic or pragmatic or silly instructions. After subjects had seen all figures that would be used, individually, they were shown cards representing combinations of the elements. They were asked to describe each of the cards. Any mistakes were corrected. Subject were asked to "read" cards until 3 in a row were correctly read. Even the youngest children had little difficulty learning the "symbolic" readings of the formal materials.

Subjects were then told that they were going to play a game:

Now this is how to play the game. I am going to have an idea in mind about something on these cards. The idea will be one of the things we just talked about or some

combination of those things. I might be thinking about 'outside triangle', for instance (point) or I might be thinking about all the shapes that are at the top like this (point to several) or I might be thinking about 'red'. Your job is to figure out what my idea is. The way to do it is by picking cards, and I'll tell you whether the card has my idea on it or not. By picking cards you can figure out what my idea is; you can tell me any time you think you know, but you can only guess after you've picked a card. You have to try to figure it out as quickly as possible--by picking as few cards as possible. Here, I'll show you what I mean. (A demonstration was made about selecting a card, and showing how it had an idea or not. A complete trial was not worked out so as not to suggest strategies to subjects.) Any questions?

Any confusions were clarified, and another demonstration performed if necessary. When subjects were ready, the first trial began. Subjects were asked to talk about what they were doing as they worked, and probed if the commentary lapsed. All responses (sequence of card selection, 'ideas' guessed, reasons for selections, comments) were noted by the experimenter and the interaction was tape recorded. The recordings were used to correct and elaborate the experimenter's notes.

Six different concepts were used as the targets of inquiry: 3 involved single dimensions (girl, store, because of fire); 3 involved 2 dimensions (teacher running

out door, yelling and screaming at home, boy who is late). These target concepts were selected to represent different values of different dimensions.

Subjects were urged to continue working on an item until they correctly identified concepts. However, the target item was identified for the subject under certain conditions: the subject refused to continue; had completed at least 10 rounds of card selection, and was clearly using a strategy that would not lead to success.

Results

Subjects' performances in this study were analyzed in several ways. The measures include: (1) number of trials (selection of cards to accumulate information) required for correct problem solution--a measure of efficiency of strategy that has been a key component of similar studies; (2) the type of strategy used--the method subjects used to proceed toward solution. Previous research provides candidate strategies but it was necessary to modify these in order to characterize performances in this study; (3) subjects' verbal comments and rationales they developed as they worked were coded in ways that provide some insight into what subjects thought they were doing. In some cases, this talk situated work on a problem in the context of the whole task.

Measures

Number of selections. The number of card selections subjects made in order to accumulate enough information to

reach a correct choice were analyzed. A limit of 10 selections had been set by the pilot testing of the procedure; after 10 selections, subjects often became frustrated, and could not continue productively with the task. After subjects had made their 10th selection, work on that particular problem was ended and they went on to the next. Thus, subjects who did not achieve correct solution received a score of 10 for the purposes of this analysis.

Strategy. The information scanning strategies were coded for each problem. As noted above, it was necessary to modify the coding system used in other studies. In the Bruner et al. studies, four strategies (with modifications) were identified: focus gambling; conservative focussing; simultaneous scanning; successive scanning. The subjects in the present study did not use the two most cognitively taxing of these strategies: focus gambling or simultaneous scanning--successful use of either of these led to quick solution, but required careful mental maintenance of information. None of the present subjects engaged in these practices. This may be due to the characteristics of the adult population used in the study; they were a less academically sophisticated group than was used in the Bruner et al studies.

Strategy use was determined by examining each subject's protocol for each item of the task. Sequence of selections and accompanying justification were analyzed.

Two of the strategies identified in the Bruner studies were used by the subjects, and three new strategies were added to characterize the performances of these subjects.

(1) Conservative focussing. The person finds a card containing the concept, and makes a sequence of choices, altering only one attribute value at a time. Those values that remain positive when changed are excluded from the correct concept. A negative card selection reveals features of the concept.

(2) Successive scanning. One hypothesis at a time is tested. For instance, an hypothesis that the concept is `ellipse´ is tested by systematically selecting cards to confirm or eliminate that possibility. Particular features of this strategy differentiated it from the two other types of scanning described below. In this type, subjects systematically tested their ideas by sequencing card selections to eliminate hypotheses in regular ways. Subjects commonly tested a dimension with its various values, and combinations of dimensions (e.g. "I think it´s got to do with color so I picked this one--so no it´s not red"). Subjects using this approach accumulated information as they worked to narrow down possibilities.

(3) Attribute scanning--examination of the protocols indicated that while many subjects engaged in scanning strategies, they were of qualitatively different types in terms of their systematicity of approach, and the accumulation of information. Attribute scanning was

identified as another sort of scanning. In this case, subjects selected specific attributes of the shapes or objects to test. For example, a subject might determine whether school, or blue, was part of a positive instance. Selection sequence and comments indicated that she was only interested in the testing this specific idea, and it was not part of a plan to accumulate information and isolate the answer. If it were a positive instance, they would tend to say they knew the answer, and guess that attribute. If it were not correct, they would move on to a new, and usually unrelated, idea. The next selection would be another specific attribute or configuration.

(4) Object scanning. This strategy was similar to attribute scanning in that information provided in choices was not efficiently accumulated. Subjects using this strategy however focussed their choices on whole objects (with several attributes), and did not easily disembed attributes from their relations in objects (e.g., selecting the teacher making a phone call at the school). After testing that particular object, subjects went on to a similarly local and unrelated choice.

(5) Scene. Some subjects in the thematic orientation invented stories or scenarios about the events represented. Selections were made according to an event-sequence being evolved (e.g., "I think it's the teacher running away from the fire because in the last one

the smoke was coming out of the building and I think they were putting all the kids on the bus").

The work of each subject on each problem was coded according to these strategy types. Interrater reliability for strategy use was 98%. Subjects were consistent about the strategy used within a problem, with some minor modifications. Most modifications were of two types. In successive scanning subjects sometimes showed redundancy in selecting more cards than they needed to eliminate an hypothesis. Subjects were coded according to the dominant strategy that characterized their performance. There was one exception to this consistency: occasionally a subject switched from attribute scanning to object scanning strategy or the reverse mid-problem. In these cases, performances were coded according to which strategy was dominant for that problem. It was always the case that one strategy was more frequently used than the other.

Context Comments. As a further clue about what people were doing as they worked on the task, the comments made by subjects in the experiment were transcribed and analyzed. Subjects were encouraged to talk aloud as they proceeded. This side-talk became part of the inquiry since this study could help to shed light on how subjects were scanning the information. The remarks were examined and a set of categories developed.

(1) Guided by previous problem (GUIDE): some subjects used the solution to the previous problem as a

guide for the answer to the subsequent problem (e.g., "It was a girl the last time so it's probably not that but maybe it had boys in it).

(2) INTENT: subjects referred to the experimenter's intent in making selections (e.g., "I'm trying to figure out what your favorite thing is", "It was one thing last time so you're probably not going to do that again--I think I should check out 2 things at a time").

(3) Repeated use of same dimension or object (SAME): some subjects repeatedly used the same dimension or object in their discussions of their moves, even though the hypothesis they were examining might not include this dimension (e.g., always referring to the Actor when talking about any of their choices);

(4) Identifying common dimension(s) or value(s) for current and prior selected cards (DIMS): some subjects examined both cards for what they had in common as the basis for a rationale (e.g., "Both have a red circle");

(5) Making up a story (STORY): some subjects invented stories as they worked through the task, selecting cards and incorporating them into a narrative they developed about the card sequence;

(6) Fracturing dimensions (FRAC): some subjects (only those working with thematic materials), used elements or objects on the cards to make selections other than those introduced as the focal dimensions (e.g., the flagpole, smoke, fruit);

(7) Abstract language (ABST): some subjects offered strategic rationales in `abstract´ language that described their strategies for working with the task (e.g., "I was checking out whether it was the cards with red circles and it´s not and I´ll check that one off, so next I´m going to find out about triangles");

(8) Different task (DIFF): some subjects made comments that revealed they were doing a different task in some way from the one that was described. For example, some decided to simply guess the answer repeatedly rather than selecting cards to eliminate possibilities. Others selected a sequence of cards in order to tell a story, even though they might also have an hypothesis about a concept.

One, two and three-way analyses of variance and post hoc comparisons (Newman-Keuls) were performed to determine the effect of age, condition, instruction, and gender on the number of trials to criterion, the strategies used by subjects, and their context comments. There were no significant gender differences for these measures; this variable will not be further discussed.

Main Effects for Age

Number of trials to criterion. Over all problems, there were no significant age differences in the total mean number of selections made by subjects to achieve the correct choice (mean number for 7=6.1; 11=4.8; adult=5.0) (see Table 3). Examination of individual problems

revealed age differences for two of the problems: Problem 3 $F(2,117) = 8.4$, $p < .001$--mean scores for 7=5.9; 11=3.5; adult=4.4) and Problem 4 $F(2,117) = 7.2$, $p < .001$--mean scores for 7=5.1; 11=3.8; adult=2.9. In each case, the 7s had significantly more trials than either the 11s or adults. The problem differences did not correspond to the number of dimensions used in a problem (1 vs. 2). In the case of the adults this difference may be related to the types of strategies used in these problems--a larger percentage engaged in successive scanning for these two problems than they did for the others (adults 60% and 62.5% successive scanning for 3 & 4 compared with 45%, 40%, 35% and 37% for Problems 1, 4, 5, 6 respectively). This kind of strategy difference does not account for the performance of the 11s however.

Strategies. There were significant age differences in the mean scores for the strategies used by subjects overall problems for 4 of the 5 types of strategies. Successive scanning $F(2,117) = 3.7$, $p < .03$ was used more frequently overall by adults and 7-year-olds. The focus strategy $F(2,117) = 3.5$, $p < .03$ was used more frequently by the 11 year olds. Object scanning $F(2,117) = 6.1$, $p < .003$ characterized the 11's. The scene strategy $F(2,117) = 8.7$, $p < .001$ was used more often by the 7's when compared with the other two groups. There were no significant differences among age groups in their use of the attribute scanning strategy.

Materials and Instructions (Group)

As with the implicit learning study, a central purpose was to examine responses of subjects under different orientations to the experimental situation--comparisons among the groups of subjects defined by both material and instructions (Group), and the effect of age on these different task orientations.

Group and number of trials to criterion. The number of selections required to achieve correct choice was examined by Group. The Groups will be referred to as follows:

Group 1: Formal analytic (FA)

Group 2: Formal silly (FS)

Group 3: Formal pragmatic (FP)

Group 4: Thematic analytic (TA)

Group 5: Thematic pragmatic (TP)

There were significant differences among groups in the mean number of selections made over all problems $F(4,115) = 11.9$, $p < .001$ (see Table 6). Post hoc analyses (Newman-Keuls) revealed that Groups 1 (mean=3.8) and 2 (4.6) required fewer selections than did Groups 3 (mean=5.6), 4 (5.7), 5 (6.7). Group 5 also differed from Groups 3 and 4 (see Table 3).

When examined by individual problem, the same overall pattern can be seen for 4 of the 6 problems, with the formal orientation (formal materials with analytic or silly instructions) resulting in fewer selections than the

thematic orientation (thematic materials with analytic or pragmatic instructions, formal with pragmatic instructions). Only problems 2 and 3 showed no difference in number of selections among the Groups, and this again was not related to number of dimensions used in the problem.

For Problem 1 $F(4.115) = 4.1$, $p < .004$, Groups 1 & 2 required fewer selections than Groups 3, 4 & 5. Problem 4 $F(4,115) = 4.1$, $p < .004$ had a slightly different configuration, with Groups 1 & 2 requiring fewer selections than Groups 4 & 5, with Group 3 intermediate between them. There was considerable difference among Groups for Problem 5 $F(4,115) = 12.64$, $p < .001$. This was apparently a particularly difficult problem, requiring formal subjects to combine the dimensions of color and position, and the thematic subjects to isolate and combine `action' and `location'. The combination proved especially difficult for the thematically oriented Groups. This problem required the most selections to achieve correct choice for all Groups. Post hoc analyses showed that Group 1 (mean=3.9) differed significantly from Groups 4 (8.2) and 5 (9.4). Mean scores for Groups 3 (6.7) and 2 (7.0) also differed from Group 5.

Problem 6 also showed significant Group differences $F(4,115) = 14.6$, $p < .001$, with Groups 1 (mean=3.4), 2 (4.7), and 3 (5.4) differing significantly from Groups 4

(7.3) and 5 (8.5). Group 3 also required significantly more selections than did Group 1.

Thus, over all problems, differences in number of selections required for correct choice indicated that the formally oriented subjects (formal materials, analytic and silly instructions) tended to require fewer selections than did the thematically oriented subjects (thematic materials, analytic and pragmatic instructions). The subjects who had formal materials with pragmatic instructions tended to fall between these two groups, although overall were grouped with the thematic subjects as significantly different from those who were formally oriented.

Group and strategy. As discussed above, each problem protocol was coded for strategy use. The number of times each subject used each strategy was summed across the 6 problems, resulting in a composite score for strategy use for the task. ANOVAS were calculated to examine Group differences in strategy (see Table 7). Significant differences were found for four of the strategies as follows.

The successive scanning strategy, by which subjects systematically tested hypotheses was differentially used by the Groups $F(4.115) = 9.9$, $p < .001$. Group 1 (mean=4.1), the formal analytic subjects used this strategy significantly more frequently than any of the other Groups. The remaining groups did not differ from

each other (Group 2=2.7; Group 4=1.5; Group 3=1.3; Group 5=.75), with the exception that Group 2 used the strategy significantly more often than did Group 5.

The focus strategy was used rarely by any subjects, but when it did appear, it was almost always used by subjects in Group 1 $F(4,115) = 5.34$, $p < .001$. Group 1 (FA, mean=1.1) differed from all other Groups, and the latter did not differ from each other.

The object scanning strategy was also differentially used $F(4,115) = 5.68$, $p < .001$ Group 1 almost never used this strategy (mean=.1), and differed significantly from all other Groups whose scores clustered around 2. These groups did not differ from each other: Group 2 (FS, 1.7); Group 3 (FP, 2.1); Group 5 (TP, 2.3); Group 4 (TA, 2.4).

Finally, the scene strategy was used almost exclusively by one Group: Group 5 (TP, mean=1.7). Groups 1 and 2 did not use it at all, and Groups 3 (.9) and 4 (.5) used it rarely. Group 5 differed significantly from all other Groups, who did not differ from each other.

Group and context comments. There were significant Group differences for 4 of the categories of context comments (see Table 8). Group 5 (TP) differed from all other Groups in their use of the GUIDE category, where responses were guided by previous problem solutions $F(4,115) = 2.54$, $p < .04$ and the SAME category, where the same dimension or value was used repeatedly $F(4,115) = 3.89$, $p < .005$.

Group 1 (FA) differed from all other Groups $F(4,115) = 6.30$, $p < .001$ in never making STORY comments. All other Groups did not significantly differ from each other in this regard, with Group 5 (TP) having the highest mean score (2.3) for this category.

Finally, Groups 1 (mean=2.6) & 2 (3.0) differed from all other Groups in the use of ABSTRACT comments $F(4,115) = 10.7$ $p < .001$. The other groups made these comments rarely, and did not differ from each other.

Group and Age

Since these studies were also conducted to examine the possible effects of age on task orientation, two-way analyses of variance and post hoc comparisons were done to examine differences among Groups when age was taken into account. The Age Groups will be referred to as follows:

7-8	11-12	Adult
7.Formal analytic	11.FA	A.FA
7.Formal pragmatic	11.FP	A.FP
7.Formal silly	11.FS	A.FS
7.Thematic analytic	11.TA	A.TA
7.Thematic pragmatic	11.TP	A.TP

Given the large number of comparisons required, only those differences of significant interest will be discussed in the body of the text. Results of other comparisons appear in the Appendix.

Number of trials to criterion. When examined for the problems overall, there were significant differences for Groups with age taken into account $F(4,115) = 6.6$, $p < .001$. The adult & 11-year-old Formal Analytic Groups had the lowest mean scores (3.4 & 3.6). The 7 year-old-Thematic Analytic Group, and the adult Thematic Pragmatic Group had the highest scores (7.6 & 7.4 respectively).

The Formal Analytic Groups of all 3 ages tended to use fewer selections than did the Pragmatic and Thematic orientations for materials and instructions. The Formal Silly Group was intermediate between these two. The one exception to this was the 11-year-olds: the 11.TP Group made relatively few selections, differing only from the A.FA in this regard. The 11.TA group also made fewer selections than their counterparts in other age groups; scores for these groups did not differ from 11.FA, 11.FS, A.FS, or 7.FA.

Strategies. There were significant differences in 4 of the strategies when examined by Group and Age, the same 4 as for Group alone.

The successive scanning strategy $F(14,105) = 6.0$, $p < .001$ was used most frequently by the groups that were formally oriented: A.FA (4.75), 7.FS (4.25), 7.FA (3.87), A.FS (3.87) and 11.FA (3.75), who did not differ from each other. This strategy was least used by 11.FS (0), 7.TP

(.25), 11.FP (.29) and 7.TA (.75). These Groups did not differ from each other.

The focus strategy was seldom used except by one group, the formal analytic 11-year-olds (2.25). This group differed significantly from all other groups $F(14,105) = 4.9$, $p < .001$, who seldom used it. The next most frequent user was the A.FA group, with a mean score of .87.

The object scanning strategy was used most frequently by 11.FS (3.5), 11.FP (3.4), 11.TP (3.4) and A.TP (3.1) groups, apparently evoked by a thematic orientation. It was used least frequently by the 11.FA (0), 7.FA (.1), 7.TP (.4), and A.FA (.4), and 7.FS Groups. The 11FS Group appears to be doing something differently from their counterparts in the other age groups. This group was the most frequent user of the object scanning strategy and differed from the 7s and adults in never using the successive scanning strategy.

The scene strategy differentiated the 7-year-old thematic pragmatic group from all other groups $F(14,105) = 7.4$, $p < .001$. This may explain why these children seldom used the object-scanning strategy, which was used by both 11 year old and adults in thematic orientations. Instead of focussing on objects, they were making stories out of the material. The 7.TP group had a mean score of 3.8, whereas all other groups did not differ from each other, with mean scores ranging from 7.FA (0) to 7.TA (1.6).

While some 11 year olds did engage in this strategy--11.TP (1.4) and 11.FP (1.4), no adults did.

Context comments. There were group and age differences in 6 categories of context comments. For SAME (making use of the same dimension or value repeatedly), the 11.TP (mean=2.0) differed from all other groups whose scores ranged from 0 to .75.

For FRAC (focussing on different aspects of the cards than the announced relevant dimensions), the 7.TA (mean=1.9) differed from all others, whose scores ranged from 0 to .6. Likewise for DIFF (doing something other than the announced task), the 7.TA group (mean=1.0) differed from all others, with a range of 0 to .8. These groups of 7-year-olds, who were given analytic instructions with thematic materials, thus seemed to be doing something different from their pragmatically oriented counterparts. They seemed to be attempting to reorient the task, but were not fully successful at reorganizing the thematic materials.

Examination of DIMS (justifying selections by referring to dimensions and their values) revealed that four of the adult groups--A.FA (4.), A.TP (3.1), A.TA (3.1) and A.FP (2.9)--made these comments most frequently whereas the younger groups were less likely to do so--4 of them not at all: 7.TA, 7.TP, 11.FA, 11.TP.

There were differences in the use of STORY comments. Formal analytic groups regardless of age made no comments

of this type. They were most frequently made by 11.FS (3.4), 11.FP (3.3) and 7.TP (2.9). Mean scores for the remaining groups ranged from .25 (A.FS) to 2.0 (11.TP & 7.FS).

Finally, ABSTRACT comments tended to be made by all Formal analytic groups regardless of age: 7.FA (3.4), 11.FA (2.5) and A.FA (2.0). They were also frequently made by two of the formal groups with silly instructions: A.FS (4.4) and 7.FS (3.3). Abstract comments were made very infrequently by the thematic pragmatic groups, regardless of age: 7.TP (0), A.TP (0), 11.TP (.25), and by the 7.TA group (.1).

Discussion

Do the performance patterns in the concept learning study correspond to those found in the implicit learning study in a way that provides clues about strategies underlying rule acquisition in the implicit learning task?

At the first level of analysis, results of Group (materials and instructions combined), performances with the concept task are similar to those in the implicit learning task. Subjects used different kinds of strategies to search for concepts that unified the different materials, confirming the first prediction about the effects of formal and thematic materials. The formally oriented Groups (FA and FS) worked differently from the pragmatically oriented ones (FP, TA, TP), requiring fewer selections to obtain correct solution.

The FA Group also used different kinds of strategies than the others. As with the implicit learning task, it was not only surface properties that affected performance, but the ways in which the subjects interpreted the material. The critical Group for this analysis, the FP group, was indistinguishable in their performance from the Groups who worked with thematic materials. This parallels the implicit learning findings.

Three of the Groups were asked to do some kind of transformation of the surface of the materials or situation they were initially presented with. The FP subjects were asked to transform the meaning of the formal materials in a way that invited coherent narrative relationships. Of the other two Groups who were asked to transform the surface forms they were given, the FS Group (silly instructions) transformed only item meaning, with no implied coherence relations, and the TA Group (thematic materials, analytic instructions) was asked to think differently about the task, to treat thematic materials analytically.

In the concept task, the FA Group was distinguished by the successive scanning and focus strategies; members of the other four Groups engaged in some successive scanning although significantly less frequently than the FA Group. These latter groups engaged in object scanning (FS, FP, TA, TP) and scene strategies (TP). In the implicit learning task, the FS and FA Groups performed

similarly; in the concept task, FS Group appeared to be a "hybrid". While they were not distinguished from the FA Group in the number of trials required, the way they went about the task appeared different. They looked more like the pragmatic performers in their strategy use.

Group 5 (thematic materials, pragmatic instructions) also differed from the other Groups in their tendency to use the scene strategy and to make "story" comments as they worked, particularly the younger subjects. This Group thus seemed to be operating in a narrative mode that distinguished them from the other thematically oriented Groups.

When the performance of the Groups is more closely examined with respect to age, different response patterns for the concept study from the implicit learning study are apparent. The prediction of identical response patterns for the concept and implicit learning tasks are therefore not confirmed. No evidence of age difference was found in the implicit learning study. Subjects in all age groups similarly intuited underlying rule-generated patterns in the case of the formal orientation, and primarily meaning-governed patterns in the case of the thematic orientation.

In contrast, there were age-group differences in performance in the concept task. The FA subjects in all age Groups performed the task most efficiently in terms of number of trials, although the adults and the 11s did

better than the 7s. Thematically oriented adults (TP) and 7s (TP and TA) performed the worst. The 11 year old TP group, however, performed quite well and were not distinguished from the formally oriented Groups (see below for further discussion).

There were age differences in use of strategies. The FA Groups, primarily adults and 7s, made most use of the successive scanning strategy. It was used by all ages, but least often by the 11s who were distinguished from all others in their use of the focus strategy. The 7s TP Group differed from all others in the extent of use of the scene strategy (a few 11s also used it but no adults). These subjects were in part creating another task in that their verbal explanations were of a different sort (narrative descriptions relating the cards in a ongoing story) than what they were asked to do in the instructions. These subjects made selections as they were invited to do, yet their justifications were unrelated to the information scanning task they were given. One had the impression they were doing two different things in the situation.

The "scene" approach seems to be replaced by the object scanning strategy for older subjects in the thematic orientation. The 11TP, AdultTP and 11FP groups used this strategy, organizing their search around whole objects. The 11FS group also used this approach. The 11FS group was doing something unique; they did not

perform in the same way as their counterparts of other ages. While they used the object scanning strategy--not an especially efficient procedure--they had relatively few trials for solution. They also tended to make a particular sort of comment ("same"), picking the same object repeatedly just to have the opportunity to guess.

The comments analysis offers a few more clues about the age differences. The 7TA group differed from all others in their tendency to make use of other attributes on the stimulus cards than the announced relevant ones ("frac"), and to engage in a different task ("diff"). The former suggests they were attempting to follow instructions in decomposing the meaningful items, but couldn't keep the correct critical attributes in mind. The latter suggests that the combination of meaningful materials and analytic instructions set up a conflict about the task that they couldn't resolve. The use of "story" comments by 7TP, 11FP and 11FS further supports the conclusion that these groups were at least partially interpreting the task as a narrative one.

References to the particular dimensions of the stimulus items were made most frequently by adult subjects (AFA, AFP, ATA), even in thematic orientations. This type of comment was never made by the 7TA, 7TP, 11TP or 11FA Groups. Abstract comments were made most often by all of the FA Groups, and by the AFS and 7FS Groups.

To summarize briefly, there were systematic differences in performance in the concept task that were different from those seen in the implicit learning task. The 7-year-old subjects seemed to be most easily drawn to a narrative orientation to the task. The performances of the 11-year-olds suggests that they were responding differently from the other groups in attempting to transform the task variants into a formal orientation. For example, the 11TP group performed much more efficiently than the adults and 7s in the same circumstances and the 11FS group was distinguished from their counterparts in how they approached the task. This may also be affected by the populations used in this study. The 11 year-old subjects came from a selective and highly academically oriented school; the adult population consisted of volunteers from a less selective college. The adults can be characterized as the most flexible group, modulating their performances to adapt to the variants offered of the task circumstances. These performance differences, not observed in the implicit learning task, suggest that the sort of information scanning observed here cannot account for the intuitive learning taking place in the former situation.

GENERAL DISCUSSION

The implicit learning and concept studies were done to experimentally explore aspects of a particular

framework for analyzing interpretative understanding developmentally. In these studies, the idea that identically structured materials can afford different kinds of coherences--different kinds of organizing structures for understanding--as a function of the relationships available and how they are interpreted by people, was examined. The main conclusions of the two studies are reviewed below, followed by considerations for future research directions.

First, the implicit learning study provides further evidence that people implicitly abstract complex structural regularIties from material encounters.

The second, and striking, finding was of no developmental differences in the occurrence or patterning of implicit learning. The performances of 7-8 year-olds, 11-12 year-olds and adults did not significantly differ in this study. While this may indicate that the task was less "difficult" in some sense than the concept task, it is interesting that subjects of all ages demonstrated learning of different kinds of underlying organizing structures. All age groups demonstrated implicit learning of the generative rule systems in analytic, pragmatic, and transformational conditions. The study demonstrates the early and seemingly powerful ability to tacitly learn regularities governing instances of complex patterns.

Third, both studies demonstrated that performance is affected by the type of materials used (in this case,

abstract/analytic vs. social/thematic and the implied relationships) as well as the instruction-based transformations of their meanings. The results of the implicit learning study indicate that people abstract different types of "rules"/regularities when the surface form of the stimulus materials differs on the analytic/thematic dimension. But rule-learning performance is not entirely dependent on the surface form that is presented to subjects. An interpretative contribution is also made; subjects in the study readily symbolically transformed the analytic surface form into pragmatic meanings, and their recognition performance indicated they were guided by pragmatic "rules".

The results of Study 1 thus contribute to understanding the material conditions and developmental shape of the implicit learning phenomenon. It did not address the processes that may account for these performances

Relatively little is known about how this kind of learning takes place, so a further goal of the two studies, taken together, was to see if the kinds of strategic performances observed in Study 2 might provide some clue or inferential evidence about possible candidate processes underlying implicit learning performance. By using identical variations in materials and instructions in the two studies, it was possible to examine their relationship.

Thus, Study 2 examined whether a particular kind of strategic information search could help to explain implicit learning. The concept study investigated the strategic performances of subjects who worked with analytic, pragmatic and symbolically transformed materials that paralleled those in Study 1. The developmental results of the concept study indicate that the strategic regularities used in explicit concept search do not appear to underlie implicit learning. Group by age differences were found that were not observed in the implicit learning study. The context comments that subjects made in this study provide additional clues concerning the ways subjects worked, often not in pursuit of the kinds of regularities that would have to be the center of the "rule" learning necessary to implicit learning.

The processes underlying implicit learning remain largely a mystery (see Reber, 1987). A straight-forward notion of strategic search cannot account for this phenomenon. This finding is supported by and extends previous work with adults which suggested that directing subjects to search for rules consciously in the learning phase of the implicit learning paradigm interferred with grammatical judgment. The concept study further demonstrates that strategic, though not directedly conscious, search is not likely to be the central learning process involved in implicit learning. This lack of correspondence in the results of these two studies

further, inferentially, strengthens the case that implicit learning subjects are not strategically searching for regularities as they "acquire" the generative rule system governing the materials.

The concept learning study did, however, produce results concerning the effect of surface form and transformation of materials on subjects performances. As with the earlier Bruner et al. study, the analytic materials elicited different patterns of performance than did the pragmatic materials. Subjects also readily symbolically transformed the analytic materials to pragmatic meanings when asked to do so, and changed their performances in expected directions.

Taken together, these two studies demonstrate some features of the multiple rationalities perspective developed above. But more needs to be known.

The lack of developmental differences is striking: what kinds of structure abstraction processes are these? How early are they displayed and in what circumstances? It is unlikely that the design used in the current study can be used with children much younger than 7, but other methods for examining when children display these abilities need to be devised and tested. How early do children demonstrate implicit learning of these kinds of generative systems, and how can the relatively early appearance of this ability be explained?

In addition, more research is needed to further determine the characteristics of the knowledge, and how it is acquired. Since we cannot collect direct information concerning how subjects implicitly learn as we can for the strategies in the concept study, the processes accounting for implicit learning are largely a mystery. There are several possible steps to take to address these queries. Thus far, the `existence' of the generative system is seen only in its application, not in conscious articulation. Analyses of what is retained in the learning trials as subjects sequentially encounter items may provide some clues about how the systematic knowledge is built up. What kinds of errors do subjects make as they learn the sequence of items? Further studies might also investigate long term retention of the generative rule system; the recognition phase has taken place relatively soon after the learning phase in studies thus far.

The present study found different patterns of learning for different types of situations. The particular materials used were selected as likely candidates because of evidence of differential performance in other tasks. It is important to explore further this aspect of implicit learning documented in this study. What are the characteristics of generative rule-systems that subjects implicitly learn--which "systems" get learned, which don't, how does prior knowledge relate to what is acquired (see Reber & Lewis, 1977)?

It may be that some different way of characterizing the knowledge will be needed, one not based on a static conception of rules, procedures, strategies, representations that get applied, but one which may have more to do with generative 'configurations' that are articulated with contexts. For example, as noted above Smirnov (1973) describes the memorization process of professional actors in learning their parts; rather than consciously memorizing words/lines, the actors he worked with developed a generative conception of the role or character and only then, obliquely, acquired the material in relation to this intellectual/emotional configuration of the context in which the material was played. There may be an analogy worth exploring here concerning the nature of the generative knowledge in implicit learning experiments. Studies can be designed to vary the properties of the materials and the conditions of acquisition.

Another line of research is suggested by the notion of examining the acquisition of other kinds of generative rule systems. This concerns the situations in the everyday world where implicit learning might operate or play a role. This interesting and powerful phenomenon found in the present study to be characteristic of young children (7 year olds) as well as adults likely has many applications in the world. Another set of questions therefore concerns how implicit learning articulates with

contexted activity--where can we identify learning occasions where implicit learning accounts for some of the performances for both adults and children, and what can these contexts tell us about the phenomenon? What are other kinds of rule-systems that characterize implicit learning processes in everyday life? Conversely, how might this ability be better utilized in learning situations?

Additional research should address the question of how prior knowledge may interact with the implicit learning that occurs. In this design, a generative rule-system would be held constant and the knowledge individuals bring to the experimental situation systematically varied. In the present study, the thematic materials were selected to minimize this possibility, based on Burke's analysis of human action. However, other research concerning expert/novice understanding of complex domains such as chess (e.g. Chase & Simon, 1973) and physics (e.g., Chi, Feltovich & Glaser, 1981; Larkin, McDermott, Simon & Simon, 1980) suggests that differential knowledge may lead to differential structure abstraction. This line of inquiry would thus explore how variations in knowledge interact with implicit learning of complex rule systems.

Finally, in addition to being of interest in their own right as cognitive performances, the implicit learning and concept paradigms were used as tools to explore

further the notion of multiple rationalities--the relationship between surface forms of materials that may afford different kinds of generative regularities, and how interpretation plays a role. This is a very large set of issues that crosses many fields of inquiry, but based on the results of these studies, further investigative steps independent of the experimental paradigms used here seem warrented. In particular, the ability of people to symbolically transform materials and their relationships seems especially important to investigate further. The goal of simply mapping the kinds of generative systems that are available, their occasions of use and conditions of learning ignores the tranformational ability people displayed in the studies. Indeed, according to the perspective developed here, it would not be possible to fully capture a system of materials and relationship rules, because they are being continually invented. Further work is thus suggested which pursues not simply how the world <u>is</u> as the basis for analyzing interpretative understanding, but how people go about transforming it, <u>making</u> something of it--in Goodman's terms, those processes through which people are continually changing and inventing worlds; in Goffman's the generative ability to reframe phenomena. What are these processes, how are they used, and what is their developmental course?

Table 1

Implicit Learning
Recognition Judgments: Mean Score by Group

Group	1 (FA) *	2 (FS)	3 (FP)	4(TA)	5(TP)
N=	24	24	24	24	24
Proto	7.8	7.9	7.7	7.8	7.8
M1 (meaningful)	5.8	5.6	6.0	5.6	5.2
M2	4.8	5.1	5.2	5.1	4.9
M3	4.6	4.6	5.1	5.2	5.0
M4	2.5	2.9	3.7	3.8	4.7
S1 (meaningless)	4.9	4.7	2.3	.1	.2
S2	3.7	4.2	.8	1.0	.8
S3	2.8	3.6	.9	.8	.1
NC-M (Noncase)	1.7	2.0	1.9	1.9	2.1
NC-S	1.6	1.8	1.2	1.0	1.0

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 2

Implicit Learning
Recognition Judgments: Mean Score by Age

Age	7-8	11-12	Adult
N=	40	40	40
Proto	7.9	7.8	7.7
M1 (meaningful)	5.2	5.6	6.2
M2	4.9	4.7	5.3
M3	4.7	4.7	5.1
M4	4.0	3.0	3.4
S1 (meaningless)	2.4	1.8	2.8
S2	2.0	1.6	2.8
S3	1.5	1.7	1.7
NC-M (Noncase)	1.8	2.3	1.9
NC-S	1.3	1.2	1.4

Table 3

Concept Study
Number of Trials to Criterion: Mean Score by Age

Age	7-8	11-12	Adult
N=	40	40	40
Mean no.	6.1	4.8	5

Table 4

Concept Study
Strategy Use: Mean Number of Times Used by Age

Age	7-8	11-12	Adult
N=	40	40	40
Scanning	1.0	1.4	2.8
Focus	.1	.6	.4
Attribute	1.3	.9	1.0
Object	.9	2.4	1.7
Scene	1.4	.7	0

Table 5

Concept Study
Context Comments: Mean Number of Times Used by Age

Age	7-8	11-12	Adult
N=	40	40	40
Guide	.5	.2	.1
Intent	.5	.3	.08
Same	.1	.5	.3
Dims	.4	.8	2.9
Fracture	.7	0	0
Story	1.6	2.0	.9
Abstract	1.4	1.5	1.7
Diff	.4	.02	.07

Table 6

Concept Study
Number of Trials to Criterion: Mean Score by Group

Group	1 (FA) *	2 (FS)	3 (FP)	4 (TA)	5 (TP)
N=	24	24	24	24	24
Mean no.	3.8	4.6	5.6	5.7	6.7

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 7

Concept Study
Strategy Use: Mean Number of Times Used by Group

Group	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
N=	24	24	24	24	24
Scanning	4.1	2.7	1.3	1.6	.8
Focus	1.1	.3	.2	0	0
Attribute	.7	1.3	1.3	1.4	.7
Object	.1	1.7	2.1	2.4	2.3
Scene	0	0	.9	.5	1.7

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 8

Concept Study
Context Comments: Mean Number of Times Used by Group

Group	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
N=	24	24	24	24	24
Guide	.1	.2	.1	.2	.6
Intent	.3	.1	.4	.3	.4
Same	.3	0	0	.3	.9
Dim	1.5	.7	1.7	1.8	1.0
Fracture	.2	0	.1	.6	.2
Story	0	1.9	2.0	1.2	2.3
Abstract	2.6	3.0	1.0	.9	.1
Diff	0	.1	.1	.3	.3

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 9

Concept Study

Number of Trials to Criterion: Mean Score by Group and Age

Age	Group				
	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
7-8	4.2	5.5	6.1	5.3	7.6
11-12	3.6	4.3	5.4	4.5	5.8
Adult	3.4	3.9	5.3	5.0	7.4

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 10

Concept Study
Scanning Strategy: Mean Use by Group and Age

Age	Group				
	(FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
7-8	3.9	4.3	1.3	.8	.3
11-12	3.8	0	.3	2.3	.8
Adult	4.8	3.9	2.4	1.8	1.3

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 11

Concept Study

Focus Strategy: Mean Use by Group and Age

Age	Group				
	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
7-8	0	0	.1	0	0
11-12	2.3	0	.7	0	0
Adult	.9	.8	0	.1	0

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 12

Concept Study

Object Strategy: Mean Use by Group and Age

Age	Group				
	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
7-8	.1	.5	1.0	2.6	.4
11-12	0	3.5	3.4	2.4	3.4
Adult	.4	1.0	1.9	2.3	3.1

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Table 13

Concept Study
Scene Strategy: Mean Use by Group and Age

Age	Group				
	1 (FA)*	2 (FS)	3 (FP)	4 (TA)	5 (TP)
7-8	0	0	1.4	1.6	3.8
11-12	0	0	1.4	0	1.4
Adult	0	0	0	0	0

* 1 FA: Formal analytic
2 FS: Formal silly
3 FP: Formal pragmatic
4 TA: Thematic analytic
5 TP: Thematic pragmatic

Figure 1

Design for Studies

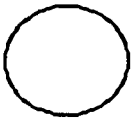
Each of the two studies (Concept Task and Implicit Learning Task) used the same variations of materials and instructions, adapted to the context of the particular study. These variations are diagrammed below. Independent groups participated in each of the two studies. Each cell (variant of materials, instructions, age group) was composed of eight subjects. Thus, 120 subjects participated in each of the two studies for a total of 240.

Materials

	Formal									Thematic					
Instructions	Analytic			Pragmatic			Silly			Analytic			Pragmatic		
Age	7	11	A	7	11	A	7	11	A	7	11	A	7	11	A
N =	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)

Figure 2

Materials: Implicit Learning

Formal Element		Thematic Meaning (Drawing)
GREEN		large child
RED		small child
YELLOW		bicycle
BLUE		store counter
RED		apple
GREEN		bicycle basket

Movement Rules:

Major move:	elements on right move to left of center line, adjacent ot it;
Minor move:	top element moves to bottom, adjacent to center line
Embedding:	a small element is embedded in a large element
Deletion:	any element is deleted; this can be applied only once

Figure 3

Problems: Concept Study

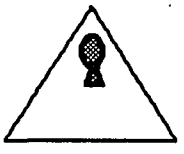
	Formal	Target Concept	Thematic Meanings (Drawings)
1.		girl	Girl yelling in the store because she's late
2.		teacher running out door	Teacher running out door of store because there's a fire
3.		fire	Boy making a phone call at home because there's a fire
4.		school	Teacher making a phone call at school because she's late
5.		yelling at home	Girl yelling at home because there's a fire
6.		boy who's late	Boy making a phone call at store because he's late

Figure 4

Materials: Concept Study

Formal Elements			Thematic Meanings (Drawings)
Shape		Actor	Girl
			Boy
			Teacher
Border		Scene	School
			Store
			Home
Location	top	Action	Yelling
	left		Making a phone call
	right		Running out the door
Color	RED	Purpose	Because there's a fire
	BLUE		Because he/she is late

APPENDIX

Implicit Learning Study

Main Effects: Materials and Instructions

One, two and three-way analyses of variance were performed to determine the effect of age, condition, instruction, and sex on the recognition judgment scores. There were no significant sex differences; this variable will not be further discussed. The main effects for Age, and the interactions for materials X instructions (Group) and Group X Age are discussed in the Results section of the text. The effects for Materials and Instructions aree presented below.

Materials. The kind of materials subjects worked with (formal or thematic) was significantly related to their responses to the recognition items. ANOVAS revealed that there were no differences for the Prototype, M2, M3 or the composite of M items overall. There were differences for the M1 items $F(1, 118) = 5.4$, $p < .02$. Higher recognition scores characterized subjects who used formal materials for these items.

There were also differences between the thematic and formal groups for S1 items $F(1,118) = 8.7$, $p < .001$; S2 items $F(1,118) = 24.21$, $p < .001$; S3 items $F(1,118) = 10.9$, $p < .001$; and for the S items compiled overall $F(1,118) = 61.6$ $p < .001$. Subjects using formal materials had higher

recognition scores for these items than did subjects using thematic materials. There were materials differences for the noncase anomolous items (NC-S) $F(1,118) = 8.6$, $p < .004$, but not for judgments about the meaningful Noncase items. Again subjects using formal materials had higher recognition scores to the NC-S items than did those with thematic materials.

Instructions. The same pattern of differences is found when recognition judgment scores are examined according to the instructions given to subjects (analytic, pragmatic, or silly). ANOVAS showed no differences in response according to instructions for any of the M item categories (prototype, M1, M2, M3, M4). There were significant differences for S1 items $F(2,117) = 6.2$, $p < .003$); S2 items F2,117) = 39.2, $p < .001$; and S3 items $F (2,117) = 24.1$, $p < .001$ items, and for the compiled S items $F(2,117) = 39.7$, $p < .001$. Those subjects receiving analytic or silly instructions were more likely to give higher recognition scores to these items than were those receiving pragmatic instructions. Analyses of the Noncase items revealed differences for the NC-S items $F(2,117) = 3.2$, $p < .04$, but not for the NC-M items, with the same pattern accounting for these differences.

It is important to note that when the interactions of these two variables (materials and instructions) are examined (see Group analysis in Results) it appears that those aspects of the experience that orient subjects to possible thematic coherence (either thematic materials, or

pragmatic instructions with formal materials) seem to have a more powerful effect than analytic or silly instructions do on reinterpreting formal or thematic materials.

Concept Study

Main Effects for Materials and Instructions.

Results for these variables will be reported separately for each of the measures.

Number of selections.

Materials. There were significant differences over all problems when the total mean scores are examined by material (formal/thematic). Subjects using the thematic materials required significantly more selections overall problems $F(1,118) = 25.54$, $p < .001$ to reach a correct solution than did those using the formal materials. The differences are accounted for by peoples' performances in 4 of the 6 problems (Problem 1 $F(1,118) = 5.0$, $p < .03$; Problem 4 $F(1,118) = 12.5$, $p < .001$; Problem 5 $F(1,118) = 26.9$, $p < .001$; Problem 6 $F(1,118) = 45.5$, $p < .001$). There were no differences in performance for problems 2 and 3.

Instructions. Again, there were significant differences over all in subjects' performances when examined by the instructions they received (analytic/pragmatic/silly instructions, $F(2,117) = 10.3$, $p < .001$). Those individuals operating under analytic (mean=4.7) or silly (mean=4.6) instructions required signficantly fewer selections to solve

the problems overall than did those in the pragmatic instructional group (mean=6.2). When examined by individual problem there were differences for 4 of the 6 (Problem 1, $F(2,117) = 4.9$, $p < .009$; Problem 2, $F(2,117) = 3.2$, $p < .04$; Problem 5, $F(2,117) = 5.7$, $p < .004$; Problem 6, $F(2,117) = 5.7$, $p < .004$). No significant differences emerged for two of the problems: 3 and 4.

Strategies.

Materials. There were significant differences for 4 of the 5 strategies when total mean scores over all problems were examined by materials. Subjects using formal materials were more likely to use the successive scanning $F(1.118) = 13.6$, $p < .001$ and focus $F(1,118) = 8.2$, $p < .005$, whereas subjects with thematic materials more frequently used object scanning $F(1,118) = 8.8$, $p < .004$ and scene $F(1,118) = 7.5$, $p < .007$ strategies. There were no differences by condition in the use of the attribute scanning strategy.

Instructions. Examination of the instructional variable (analytic/pragmatic/silly) revealed significant differences in 2 of the 5 strategies. Successive scanning was used more frequently by people under analytic and silly instructions $F(2,117 = 9.0$, $p < .001$, whereas the scene strategy was used more frequently by people under pragmatic instructions ($F(2,117) = 9.9$, $p < .001$.

The analysis of the context comments that people used as they were doing the task are were comprehensible and interesting when discussed as a function of the interaction

of all three variables (Materials, Instructions, and Age). Accordingly this discussed in the Results section.

Interactions

Age x materials. There were age by condition interactions in the number of selections subjects made for the total mean score $F(4,115) = 9.6$, $p < .001$. The subjects with formal materials required fewer selections than the adult and 7 year olds with the thematic materials. The 11-year-old thematic subjects, however, did not differ from the adult, 11 and 7 year old formal groups.

There were age by material interactions for 4 of the strategies: successive scanning $F(4, 115) = 6.5$, $p < .01$--the thematic 7s, 11s, adults were less likely to use this than the formal adults and the formal 7s; focus $F(4,115) = 4.5$, $p < .001$ which was used most frequently by the formal 11s; object scanning $F(4,115) = 4.9$, $p < .001$ which was used most often by the thematic 11s and adults when compared with the formal 7s, adults, and thematic 7s; scene $F(4,115) = 10.9$, $p < .001$ where the thematic 7s differed from all others in their frequency of use.

Age x instructions. There were significant interactions for the total mean score overall problems $F(5,114) = 5.4$, $p < .001$. The adult and 7s pragmatic groups required more selections that the adult and 11s analytic and silly groups.

There were significant interactions for four of the strategies. The analytic (11s and adults) groups used

successive scanning more often that the pragmatic 7s and 11s $F(5,114) = 5.9$, $p < .001$. The focus strategy was used signficantly more frequently by the analytic 11s than by the others $F(5,114) = 2.8$, $p < .001$. The objects scanning strategy differentiated the silly and pragmatic 7s from the silly and pragmatic 11.s $F(5,114) = 4.4$, $p < .001$. Finally the scene strategy was used more frequently by the pragmatic 7s than by all other groups $F(5,114) = 8.2$, $p<.001$.

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