THE DEVELOPMENT OF REPRESENTATIONAL CHANGE FROM THREE TO FIVE YEARS OF AGE IN TWO DOMAINS OF KNOWLEDGE

by

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ABSTRACT

This study investigated the development of children's understanding of representational change when presented with natural kind and human artifact stimuli. Fifteen three-year-old, 21 four-year-old and 19 five-year-old children were shown four natural kind and four human artifact picture pairs. The initial drawing of each was constructed to suggest the object of interest. Following a story, each child was then shown the second drawing, which showed the true nature of the object. The picture pairs were then put away and the child asked what she had thought the first picture of the pair to be. Following the collection of the representational change data, children were interviewed to gather data on whether or not they distinguished between two domains: natural kinds and human artifacts.

Analysis of the representational change data revealed a significant main effect for age. Post-hoc analysis pointed to a significant difference between the ages of three and four, three and five, but not four and five. No other results were significant. On the domain question significant effects were noted for domain and for age. Post-hoc analysis for domain revealed that children answered the domain question correctly more often for natural kinds than for human artifacts. The post-hoc analysis for age showed significant differences between three and four, three and five, but not between four and five.

The results suggest that four and five-year-olds perform significantly better than three-year-olds on representational change tasks, regardless of domain.

However, there is evidence that at least four and five-year-olds do have some knowledge of human artifacts and natural kinds, though this knowledge is of little value in the successful completion of the representational change tasks.

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My impression is that we mostly bumble and bungle around, thrashing about for some new idea or experiment to keep ourselves busy and out of mischief.

Gordon Bower

I would like to thank my committee, Rita Watson, Harold Ratzlaff and Pat Arlin for their help and guidance in the completion of this thesis.

CHAPTER 1. METAREPRESENTATIONAL DEVELOPMENT IN EARLY CHILDHOOD

1.1. INTRODUCTION

> Our understanding of the world is achieved more effectively by conceptual improvement than by the discovery of new facts even though the two are not mutually exclusive. (Mayr, 1982, p. 23.)

Watch a young child play with a ball. As she becomes increasingly familiar with its features and qualities her play changes. At first the child responds to the ball's bouncing in a seemingly random manner. As the child develops, both mentally and physically, and learns, she comes to realize that it is possible to know how the ball will behave in a given circumstance. The child intuitively uses her growing knowledge of the world to construct mental representations of, say, what happens to the ball when it is thrown against a surface.

Mental representations guide our beliefs, experiences, and judgements of the world: "it is inferred that mental states 'organize' scenes, holding together the disparate elements into which scenes otherwise threaten to dissolve" (Premack & Woodruff, 1978, p. 525). Representations are the contents of mental states, contents which with development become open to explicit manipulation. This study is premised on a view of mind as a symbol manipulation system in which representations carry information of benefit to an individual (Pylyshyn, 1984).

Understanding the nature of the formation and manipulation of

representations assists individuals in effectively functioning within their environment. For example, when dealing with people it is often useful to try and think through a situation from their point of view. Considering another's point of view requires a representation of what the other is possibly thinking, that is a metarepresentation. Metarepresentations are a means of refining knowledge structures, allowing explicit intervention into the process of interpretation. This metarepresentation may then be used in planning a course of action. However, it is readily apparent that young children do not completely understand the subjective nature of representations. Rather, there is a developmental progression leading to an adult-like comprehension of the nature of representations (Bretherton & Beeghly, 1982; Bretherton, McNew, & Beeghly-Smith, 1981; Chandler, 1988). Children gradually come to reflect upon their own mental representations, to form metarepresentations.

Ongoing investigations on metarepresentational development have noted that qualitative changes largely occur between the ages of three and five. Though three-year-olds demonstrate little recourse to overt manipulation of their thoughts, by the age of five most children are able to easily reflect on their representations (Astington & Gopnik, 1988; Chandler, 1988; Perner, Leekham, & Wimmer, 1987; Wellman, 1988). For example, in response to the question "Do you <u>know</u> it's a (name)?", referring to an ambiguous stimulus display, three-year-olds tend to answer positively, whereas five-year-olds tend to admit their lack of knowledge about the object pictured (Olson & Astington, in press). Similarly, when three to five-year-olds were asked "Can X <u>see</u> (object name) with his/her eyes?", after being told that X was only <u>thinking</u> about the named object,

the three-year-olds said yes while the five-year-olds replied negatively (Wellman & Estes, 1986).

Research has focussed on three aspects of the development of metarepresentational abilities: an understanding of representational change, that is, understanding that your representations are open to change (Astington & Gopnik, 1988; Gopnik & Astington, 1988); ascription of false belief, the realization that an individual has had access to incorrect information and therefore must hold a false belief (Olson & Astington, in press; Perner, Leekham, & Wimmer, 1987; Wimmer & Perner, 1983); and the appearance-reality distinction, which considers individual's ability to answer questions about object appearance and nature (Flavell, Green, & Flavell, 1986). While all three areas are concerned with metarepresentational development, Astington and Gopnik have suggested that investigations of representational change will serve to clarify explanations for the developmental progression between the ages of three and five for all three metacognitive areas. This suggests that a further look at representational change may provide general insights into all three processes.

In addition to their view on the importance of representational change, Astington and Gopnik (1988) have noted that the tasks used in representational change experiments do not all produce the same results. While Astington and Gopnik did not specifically investigate this result, it does suggest that children find some representational tasks easier to complete than others. However, to date little has been done to probe links between children's world knowledge and their performance on representational change tasks. This study proposes to investigate

the development of three, four and five-year-olds' understanding of representational change in two domains of knowledge.

1.2. THEORETICAL SIGNIFICANCE OF THE STUDY

Studies of representational change have noted that various stimuli differentially affect the degree of representational change. Three to five-year-olds appear to understand representational change for natural kinds more often than for human artifacts. For example it was noted in passing that the 'cat' task in which children saw a green cat covered by a pink transparency, which made the cat appear to be black was answered correctly more often than the 'Smarties' task, in which children discovered that a Smarties box contained pencils rather than candy as they had expected, by three to five-year-olds (Gopnik & Astington, 1988). However, no study has explicitly considered how a child's knowledge in a particular domain influences his understanding of representational change.

Research indicates that young children often demonstrate a perceptual bias in their observations (Keil, 1986; Kemler, 1983; Smith, 1979; Smith & Kemler Nelson, 1984; Spiker & Cantor, 1983). However, other studies point out that children do not approach all objects in the same manner (Gelman, 1988). In particular children tend to approach human artifacts, such as cars, in terms of their function; while natural kinds, such as animals, are considered in terms of their internal structure or essence (Gelman, 1987, 1988; Keil, 1986, 1987). This is not to say that a child has complete comprehension of either internal structure or function, but that he categorizes based on his naive theories about

such distinctions (Carey, 1982, 1985).

Sugarman (1983), Carey (1985) and Wellman (1988) have pointed out that children act as theory finders; when they face an unknown environment they try to impose some form of order. But children do not approach such tasks in an indifferent manner: they actively process information about the world, using available knowledge to test their conceptual theories. Children first grasp a few characteristics of a concept; development and learning help refine it (Siegler, 1986). Development brings into play new methods for checking the consistency of one's theories. Metacognition, thinking about your thoughts, is one of the tools arising through developmental changes.

It is apparent that children as young as three years of age employ a number of cognitive strategies and incorporate considerable conceptual knowledge during experimental tasks. A child's knowledge of relationships between events and objects in the world needs to be considered if research is to progress beyond investigations considered in isolation. In particular, the qualities which distinguish natural kinds from human artifacts are part of a child's world knowledge. Even young children have an implicit, albeit naive, grasp of some of the restrictions regarding change that natural kinds engender (Carey, 1985; Gelman, 1988; Keil, 1986, 1987): children understand, at a simple intuitive level, that dogs do not change into cats.

Studies on the development of an understanding of representational change reflect varying tacks to comprehend a child's endeavours at ordering her world.

For example, two approaches have been articulated to explain the developmental differences between three and five-year-olds. One is that the three-year-old lacks knowledge of the relationship between the world and the mind (Wellman, 1988; Wimmer, Hogrefe, & Sodian, 1988). This view holds that development of metarepresentational abilities arises as a child begins to realize that representations are formed in concert with information provided taken from the external world. The second approach considers that three-year-olds have a processing deficit (Forguson & Gopnik, 1988; Perner, 1988). Development, on this view, involves the gradual incorporation of mechanisms accounting for the rise of metarepresentational abilities.

Regardless of the merit of either the process or information access approaches, investigation of children's performance on representational change tasks necessitates trying to understand the knowledge structures they use in experimental situations. That is, performance on representational change tasks (Astington & Gopnik, 1988) suggests that younger children may perform better when considering natural kinds than human artifacts. If so, does the development of the understanding of representational change vary between the two domains. Specifically, do the distinctions evident in children's organization of knowledge in natural kinds and human artifact domains have an effect upon the emergence of the understanding of representational change?

CHAPTER 2. LITERATURE REVIEW

This review will focus on a fundamental component of metacognitive development in young children: the understanding of representational change and its relation to developing conceptual theories. Closely linked with the development of representational change is the acquisition of metacognitive verbs. A brief overview of the development of this aspect of language will provide a foundation for investigating metarepresentational development.

2.1. REPRESENTATIONAL CHANGE

In essence, understanding representational change depends upon the realization that what, was at time one, thought to be X is, at time two, known to be Y (Astington & Gopnik, 1988; Flavell, 1988). Understanding representational change thus depends upon the mental comparison of two alternative representations, of which only one is a valid representation of the current state of affairs. A person must be able to hold the two representations in working memory and realize that they did not know at time one, but only thought X to be true. Thus, the study of representational change is related to the comprehension of mental state verbs. Distinguishing between what one knows or thinks is essential for considering the difference between two separate representations and constructing the appropriate metarepresentation for the task situation. For the proposed study the use of the metacognitive verb think is of particular importance. Successful completion of the tasks, in part, depend upon a child's comprehension of this verb.

Three-year-olds' use of metacognitive verbs reflects, at best, a rudimentary knowledge of mental states (Abbeduto & Rosenburg, 1985; Bowerman, 1982; Johnson & Maratsos, 1977; Olson & Astington, 1986; Wellman, 1988): young children quite often do not demonstrate appropriate verb use during experimental situations. In circumstances where they could, at most, think something to be true, younger children tend to answer that they know it to be true; older children admit to lacking knowledge in ambiguous situations (Olson and Astington, in press). While there is disparate use of think and know between the ages of three and five, it is of interest to note that these two verbs are the first to be used appropriately with any regularity by young children (Johnson, 1982; Johnson & Wellman, 1980; Shatz, Wellman, & Silber, 1983).

Interest in metacognitive verbs has lead to investigations in three related areas of metarepresentational development: ascription of false belief, the appearance-reality distinction and, the understanding of representational change. The three themes investigate different, but closely related, issues: Gopnik and Astington (1988), stated that an understanding of representational change underlies success on both ascription of false belief and appearance-reality tasks.

The relation between the ascription of false belief and representational change is clearly shown in work by Wimmer and Perner (1983). Using a story setting, they presented four through nine-year-olds with situations in which an object was hidden, with or without the knowledge of one of the story characters. The results indicated that the youngest children were unable to correctly ascribe a false belief to the character that lacked knowledge about the hidden object;

that is, they could not represent the character as choosing a location where the object no longer was. Rather, the youngest children stated that the character knew where the hidden object was, even when they were specifically told this was not the case. In discussing the results, Wimmer and Perner stated that "representing wrong beliefs requires the construction of two different models of the world and the explicit representation of the falseness relation between propositions in one model and the corresponding propositions in the other model" (p. 124). Their argument is premised on a child's ability to form representations, recognize the discrepancy between representations, and make judgements based upon the resulting metarepresentation. The extra step of then assigning the beliefs to another individual suggests that the ascription of false belief is an extension of understanding representational change.

Perner, Leekham and Wimmer (1987) examined three-year-olds' understanding of their own false belief, rather than the ascription of false belief. Similar work has also been carried out by others (Astington & Gopnik, 1988; Gopnik & Astington, 1988). In all three studies a child was initially presented with a closed Smarties candy box; however, the experiments differed in the manner by which children were led to form a representation of what they <u>thought</u> was inside the box. The experimenter then opened the box to reveal the contents as pencils. The box was closed and put out of sight. The child was then asked what he first <u>thought</u> was in the box; then what he <u>knows</u> to be in the box. To answer correctly the child must choose between what he originally thought, and what he now knows, to be true. Successful completion on such a task was taken as demonstrating an understanding of representational change.

Perner et al. interpreted the results to indicate that while children younger than three can represent alternative models (cf. Wimmer & Perner, 1983) and assign appropriate truth values, they cannot assign conflicting truth values, such as is necessary when ascribing false belief to someone else.

In contrast Astington and Gopnik (1988) and Gopnik and Astington (1988), using a slightly different procedure than Perner et al. (1987), have produced different results than those described above. Where Perner et al. specifically asked children at the start of the experiment what they thought was in the Smarties box, Astington and Gopnik did not ask the children anything about the box, though many of the children stated "Smarties!" spontaneously when first shown the box. The children were then given the box and allowed to discover the pencils inside. At this point the box was reclosed, put out of sight, and the child asked "Now . . . when you first saw the box, before we opened it, what did you think was inside it?" Data analysis revealed significant age effects for the representational change questions. A majority of three-year-olds reported that they originally thought the box contained pencils, in direct opposition to their voluntary exclamations of "Smarties!". Five-year-olds reported their initial incorrect representation. Astington and Gopnik's results can be interpreted as demonstrating that three-year-olds are unable to represent and evaluate alternative models appropriately, which stands in opposition to Perner et al.'s conclusions. These findings are supported by work utilizing modifications to Perner et al.'s experimental procedure to include open-ended questions and a variety of task materials (Astington & Gopnik; Flavell, 1988; Gopnik & Astington).

It is apparent that the study of representational change still has some open questions. For example, the present interest in knowledge versus process explanations of representational change. Perner (1988), views the developmental process as being marked by children coming to represent the process of modelling their representational changes. That is, children come to realize that they not only have representations, but that they can explicitly manipulate them. Knowledge of how to control representations is, for Perner, the deciding factor in determining if a child has an understanding of representational change. Perner does not argue that young children, such as two-year-olds, cannot form representations, including the incorporation of hypothetical conditions; nor that they cannot compare such models to their model of the world. However, in his view, a child has not reached full understanding of representational change until he can represent the process by which such models are constructed. Only at this stage is a child able to understand that phenomena, such as disagreements between people, are often due to individuals having different models of the world.

A second approach considers that development is marked by a child coming to acquire a new understanding of the sources of information about the world (Wimmer, Hogrefe, & Perner, 1988; Wimmer, Hogrefe, & Sodian, 1988). Between the ages of three and six an understanding of the processes by which an individual perceives, communicates and infers develops. Thus as children mature they come to realize that people attend to sources of information in many ways. Young children functionally demonstrate their ability to perceive, communicate, and infer, but only around age six do they begin to reflect upon and understand such processes as varying between people and open to subjective

manipulation. That is, older children are able to understand the causal relation between the world and the mind, and to use this understanding when judging the validity of their representations and in forming appropriate metarepresentations.

The two approaches to explaining the development of representational change bear out that there is need for further research in this area. One unanswered question is the effect of children's prior knowledge on their task performance. Gopnik & Astington (1988) noted that there were differences in performance depending upon the task materials used. The proportion of children answering correctly from ages three to five was 0.69, 0.62, 0.52, 0.49 and 0.39 for the "book", "cat", "rock", "smarties" and "doll" tasks respectively. It should be noted that the "book" task consisted of a booklet of pictures offering restricted views of various animals and flowers. Thus the three tasks with the highest proportion of correctly scoring children fall within the natural kind domain, while the last two can be considered human artifact tasks. All individuals have varying levels of knowledge in certain areas. A physicist recognizes the identifying characteristics of subatomic particles; a child can differentiate between cars and trucks. Both children and physicists bring their knowledge to bear in assessing and acting upon their representations.

The range of correct responses across the various Gopnik and Astington (1988) tasks suggests that previous representational change studies have failed to consider all possible sources of variance. In particular, a child's knowledge about the task materials used in the experiment needs to be considered. Of specific

interest for this study is the manner in which children's knowledge of natural kinds and human artifacts affects their understanding of representational change.

2.2. NATURAL KINDS AND HUMAN ARTIFACTS

Wittgenstein (1958) stated that "concepts lead us to make investigations; are the expression of our interest, and direct our attention" (570, p.151e). New situations promote reflection on possible similarities to previous experiences. By comparing the new with the old, children come to draw conclusions about the nature of reality: they are theorists (Carey, 1985; Sugarman, 1983). Theory building, in turn, leads to ongoing classification of the world. The development of children's categorical hierarchies has provoked considerable interest and study (Garner, 1978; Kemler Nelson, 1984; Kossan, 1981; Rosch & Mervis, 1975). However, much of this research, along with investigations of representational change, has not explicitly investigated the effect of children's extant world knowledge upon their performance on experimental tasks (Murphy & Medin, 1985).

Development of an understanding of representational change is a means for extending and organizing one's knowledge of the world. Learning about the world requires the ability to compare previous with current representations, note any differences, and decide which is a more accurate depiction of reality. But representations do not exist in isolation. Investigations of cognitive processes would benefit by considering the manner in which previous world knowledge, including domain organization, precipitates the development of new processes. Two

domains that have provoked much thought and debate in both psychology and philosophy are natural kinds and human artifacts (Gelman, 1987, 1988; Gelman & Markman, 1986, 1987; Keil, 1986, 1987; Kripke, 1980; Putnam, 1975; Quine, 1969).

Natural kinds and human artifacts differ in a number of substantial ways. Keil (1986, 1987) has stated that natural kind terms do not have anything that approaches what traditionally are regarded as definitions, that is, necessary or sufficient conditions. Instead, natural kinds seemed to be marked out by ostensible definitions; that is, definitions in which individuals believe that a set of things form a kind, and name that kind by pointing out what are thought to be typical members or stereotypes (Putnam, 1975; Schwartz, 1979). Carey (1985) further emphasized that a natural kind term has two components: there is a kind in nature picked out by the term; and the user realizes that the kind referred to has an underlying essence (p. 174). Thus, since the underlying essence is the same, gold may be yellow or it may be white, but it is still considered to belong to the kind "gold". Ostensible definitions are open to falsification at any time if new evidence is brought forth to show that the stereotypes are not homogenous: what is presently considered to be gold may later be shown to be something else, such as fool's gold.

Human artifacts differ from natural kinds in that they are distinguished by their function rather than their inner structure or essence (Keil, 1986): an object may be defined as a stool in one context, or as a small table in another. What to call an artifact is a matter of both situational convention and personal

intention. Children's understanding of the difference between natural kinds and artifacts reflects their knowledge of the context-dependent, conventional, nature of artifacts and the unchanging inner essence of natural kinds.

For young children knowledge of the difference between natural kinds and human artifacts is largely implicit. A number of authors have noted that children just beginning to talk already are able to distinguish between animals, plants and artifacts (Carey, 1982, 1985; Gelman, 1987; Keil, 1986, 1987). Work by Gelman (1987, 1988) and Gelman and Markman (1986, 1987) has looked at the inductions children form about categorically different stimuli. In particular, they investigated the basis for children's categorical distinctions. The question they were interested in answering was whether children would infer properties on the basis of perceptual characteristics or on category membership when the two sources of information were in conflict. For example, a child was shown pictures of tropical fish, a shark and a dolphin. The tropical fish and shark were labeled "fish" and the dolphin, "dolphin". They were then told some characteristics, such as fish stay under water to breathe, but, though the dolphin lives in the water, it pops above the water to breathe. Following the pictures the children were asked "See this fish (pointing to the shark)? Does it breathe underwater, like this fish, or does it pop above the water to breathe, like this dolphin?" The results indicated that by age four children consider a category label a better source of information about an object than its outer appearance. Further research has shown that "categories are a powerful source of information for children, even by age three" (Gelman, 1987, p. 4). Thus in the case of induction young children draw on their knowledge of differences between categories to answer

questions.

While previous work has considered how children form inductions about various natural kinds, there has been little done on whether children differentiate objects into natural kind and artifact domains. In a recent study, however, Gelman (1988) included a small study in which four and seven-year-olds were asked "Do you think people make X's?", where X included both natural kinds and artifacts. The results support the claim that young children do distinguish between natural kinds and artifacts. The analysis showed that children at both age levels stated more often that people make artifacts (84%) than that they make natural kinds (23%). As may be expected, seven-year-olds responded correctly more often than did the four-year-olds. However, the results indicated that four-year-olds also distinguish between the two object domains. Thus, while three, four and five-year-olds may lack complete scientific awareness of natural kinds (Carey, 1985), there is evidence to support the claim that, for four and five-year-olds at least, they do differentiate between natural kinds and human artifacts. The three-year-old's abilities in this area require further investigation.

Carey (1985) has stated that "ontologically important concepts must be viewed in the context of the theories in which they are embedded" (p. 13). That is, childrens' knowledge of the world is linked to the naive theories they hold. Consideration of children as theorists (Carey; Murphy & Medin, 1985; Sugarman, 1983) sets a framework for studying the processes by which young children come to understand the world.

Carey (1985) feels that childhood is a time of conceptual restructuring, in both developing new relations among concepts, and possibly in modifying core concepts themselves. Such restructuring requires a child to be aware both of associations between concepts in the world and the manner in which concepts and relations are mentally represented. Moreover, Gelman's (1987) research on natural kinds suggests that restructuring is also affected by the nature of the concept under investigation: children expect categories to share underlying similarities. A child may not be able to articulate the inner essence of a kind, but he does expect it to exist and be consistent within members of the kind.

Progression towards a fuller understanding of what a natural kind term entails is analogous to the historical delineation of natural kind stereotypes. As young children develop their understanding of what differentiates kinds, they come to reconsider the inclusion of members which are used for pointing out the kind. For example, fool's gold is no longer included as a stereotypical member of the kind "gold" by older children or adults. Development reflects an ongoing process in which theories and prior knowledge serve as a foundation for the more refined theories of adulthood (Carey, 1985; Gelman, 1987; Keil, 1987; Sugarman, 1983).

Previous research on representational change (Astington & Gopnik, 1988; Gopnik & Astington, 1988; Perner, Leekham, & Wimmer, 1987; Wimmer, Hogrefe, & Sodian, 1988) has not expressly considered the nature of the stimuli presented to a child. For example, in the case of the "Smarties" task it is reasonable to hypothesize that children assume that the box contains Smarties, but it is also a conceivable hypothesis that it contains pencils. Three-year-olds, as

well as older children, have experienced boxes that no longer contain their original contents. In such cases childrens' world knowledge is used to determine the contents of a box. If there is no extra information present deciding what a box contains should start with what is normally found in the box, in this case Smarties. However, once it is known that the box actually contains pencils the representation is shifted to illustrate that fact.

Gopnik & Astington (1988) have suggested that three-year-olds' difficulty in remembering their original representation of "Smarties" is possibly due to there being no immediate benefit in remembering a false belief. But this argument ignores the benefits inherent in being able to recall an incorrect representation. Immediate benefits need to be balanced against future possibilities. Success in novel situations depends to some degree upon holding an appropriate representation. Piaget's (1973) object permanence experiments, in which infants tracking a moving object passing behind a screen look ahead to where it will emerge, highlights that even infants are aware of more than the instantaneous condition created when the ball passes behind the screen; there can be a benefit in ignoring the immediate situation.

Gopnik & Astington's (1988) explanation also fails to consider that expectations about natural kinds differ significantly from those about artifacts. As Gelman (1987) stated, "categories differ tremendously as to whether they tie into richly organized world knowledge. By second grade, natural kind and artifact categories have distinctly different structure for children" (p. 8). A cat does not change into a dog, but boxes can contain many different things; it is not

inconceivable that three-year-olds are aware of such facts. While the proposed study is concerned with children younger than those in grade two, the domain distinctions demonstrated by older children are present from an early age (Gelman, 1988). Investigations of children's understanding of representational change must consider how their domain structures, and accompanying naive theories, affect performance on the tasks presented.

2.3. RATIONALE FOR THE STUDY

Previous studies of representational change have evinced a developmental shift between the ages of three and five. While three-year-olds demonstrate limited ability to understand representational change, five-year-olds show much greater understanding. However, the situation is not as clear as this synopsis suggests. Specifically, studies to date have not considered the nature and extent of the world knowledge that even three-year-olds possess and bring to the tasks they face. There is evidence to suggest that children do not consider all tasks in the same way, but make reference to their knowledge of the nature of the task materials in responding to the questions they are asked (Astington & Gopnik, 1988; Carey, 1985; Gelman 1987, 1988; Gopnik & Astington, 1988; Keil, 1986, 1987). In particular, Gopnik and Astington's results suggest, though they did not specifically address the issue, that, for three through five-year-olds, the degree of understanding of representational change may vary depending upon whether the stimulus is a natural kind or a human artifact.

Keil (1987) stated that "concepts do not develop in isolation but rather

develop in a relational system with important interdependencies" (p. 177). Children are not passive recipients of information. Rather children, as adults, function as theory builders (Carey, 1985), integrating their new knowledge of the world with what they already know. It is important to consider children's current theoretical knowledge of the world, including domain distinctions, when investigating representational change. Children's division of the world includes natural kind and human artifact groupings, albeit with limited and possibly erroneous criteria for domain membership (Carey; Gelman, 1987, 1988; Gelman & Markman, 1986, 1987; Keil, 1986, 1987). It is hypothesized that three, four and five-year-olds refer to their knowledge of natural kind and human artifact terms when forming metarepresentations; and that their naive theories of natural kinds and human artifacts are linked to their ability to understand representational change. This study proposes to investigate the manner in which children respond to natural kind and human artifact stimuli during representational change tasks.

The following research questions will be addressed within the body of this study:

1. Is there a developmental trend between the ages of three and five on representational change tasks?
2. Is there a difference on performance on representational change tasks for natural kinds and human artifacts?
3. Are there age group differences on representational change tasks for natural kinds and human artifacts?
4. Is there support for the argument that subjects group the world into natural kinds and human artifacts?

CHAPTER 3. METHODOLOGY

3.1. DESIGN

The design for the present study was a 3 x 2 (AGE x DOMAIN) fixed factorial design, with repeated measures on the domain factor. To control for possible order and practice effects, stimuli were combined using a latin square to form eight different presentation orders, each consisting of four natural kind and four human artifact drawings. Subjects were then randomly assigned to one of the presentation orders. Following presentation of each stimulus, a question similar to that used by Gopnik and Astington (1988) was asked. Secondly, to evaluate the premise that children do distinguish between natural kind and human artifact domains, subjects were interviewed to determine their knowledge of the origins of various objects, following the procedure outlined in Gelman (1988). Participation for all subjects was voluntary and no child was forced to complete the tasks.

Astington and Gopnik (1988) noted that initially asking a child what he thought was true of a situation (cf. Perner, Leekham, & Wimmer, 1987) may lead him to later recall what he said rather than what he thought. While two presentation formats, one in which half the children are asked during the initial display of the stimulus what they think the object is and the remainder are simply shown the stimulus, would control for the possibility of a confound, the size of the available sample group was insufficient for this purpose. The methodology followed requires knowledge of a child's original representation in

order to determine whether or not the subject has correctly answered the representational change question. Therefore I followed Perner et al.'s procedure and explicitly asked subjects during the presentation of the stimuli what they thought the first picture in each pair to be.

3.2. EXPERIMENTAL HYPOTHESES

The following experimental hypotheses were proposed:

H1 AGE - A main effect for age is predicted across domain type. Older children will answer the representational change question correctly more often than younger children.

H2 DOMAIN - A main effect of domain is predicted across age groups. Subjects will answer the representational change question correctly more often for natural kind stimuli than for human artifact stimuli.

H3 AGE x DOMAIN - Younger subjects will provide more correct responses to the representational change question for natural kinds than for human artifacts.

3.3. SUBJECTS

Subjects were 22 three-year-old (3;01 - 3;11, mean = 3;06) 25 four-year-old (4;01 - 4;11, mean = 4;05) and 19 five-year-old (5;00 - 5;11, mean = 5;05) children currently attending the U.B.C. Child Study Centre, a pre-school drawing most of its students from the surrounding upper-middle class

community. Each child was given an initial screening task, such as that used by Astington and Gopnik (1988). This task was used to exclude subjects who failed to distinguish between past and present, a necessary skill for answering the representational change test question. During the screening task children were shown a doll's house. A door was opened and an apple inside the house shown to the children. The apple was then removed, a doll placed inside, and the door closed. Children were then asked "What is in the house now?", followed by the question "When you first saw the house, before we opened it up, what was inside it?" As Astington and Gopnik noted, for a child to answer "the apple" to the last question he must understand the question, understand the concept of events happening in a temporal sequence, recall the first event, and be able to ignore the present state of the apple. Thus this procedure models, using physical objects, the mental events necessary for successfully completing representational change tasks (Astington & Gopnik; Gopnik & Astington, 1988)

Five three-year-olds failed the screening task, and a further two three-year-olds, while successfully completing the screening task, failed to respond to every instance of the representational change question leaving 15 three-year-olds (3;01 - 3;11, mean = 3;07) in the final analysis. Four four-year-olds also failed the task leaving 21 four-year-olds (4;01 - 4;11, mean = 4;06). All the five-year-olds successfully completed the screening task. During the second portion of the study only the children failing the screening task were excluded. Thus there were 17 three-year-olds, 21 four-year-olds and 19 five-year-olds in the Domain Question portion of the study.

3.4. TASK DESCRIPTION

The materials used were similar in nature to the task used by Chandler and Helm's (1984) restricted view task in which subjects viewed cartoons presented in such a manner as to obscure the true nature of the object portrayed. Rather than using cartoons four pairs of natural kind line drawings and four pairs of human artifact line drawings, similar to those used by Keil (1986), were constructed (see Appendix). Pairs of stimuli were chosen in which there was a physical similarity between the two objects portrayed. The first line drawing of each pair was constructed to suggest, rather than explicitly show, the object of interest by partially obscuring it with the background details. The second drawing, the true form of the object of interest, was constructed to be flipped over the initial drawing. The final overlay was a black-out sheet which covered the two previous drawings.

The natural kind stimulus pairs were:

1. horse and zebra.
2. cat and skunk.
3. flower and tree.
4. plum and grapes.

The human artifact stimulus pairs were:

1. ship and bus.
2. bicycle and car.
3. table and chair.

4. broom and vacuum cleaner.

3.5. TASK PILOT

The eight pairs of drawings were pilot tested on six children, three three-year-olds, two four-year-olds and one five-year-old, to determine if the items functioned in the manner predicted. None of the children in the pilot were able to correctly identify the obscured member of any stimulus pair.

It is important to note that the actual name supplied for the first of each stimulus pair by the subject may not match the object the drawing was meant to suggest. In the pilot study some children provided alternate names for the first, obscured, picture of some of the pairs, though they had no difficulty in correctly identifying the second, the complete form, of each pair. Further, no child supplied a natural kind name when viewing the first of a human artifact pair, or a human artifact name for the first member of a natural kind pair. The purpose of the study was to investigate children's ability to reflect on their representations. Consequently it is not important that a child correctly label the first picture, as long as he is able to supply the same label when asked the representational change question. Thus if a child refers to the drawing of the plum as a "blueberry" he will need to supply "blueberry" in order to answer the representational change question correctly.

3.6. PROCEDURE

Children were individually tested on the screening task, and final selection for the study based on their performance on this task. Children successfully completing the control task were the subjects used in the representational change tasks. Approximately one week after the screening task, subjects were presented with the representational change task. Prior to this phase of the study each child was randomly assigned to a presentation order combining both domains. Each subject was individually presented with four natural kind and four human artifact stimulus pairs. The following story was used to introduce the task:

> I have got a story to tell you. A boy named Bobby liked to go for walks. When Bobby went for walks he liked to look at many different things, and he always took his camera with him. Bobby's camera helps him to see things better when he isn't sure what something is. As Bobby was walking along one day he took a look to the side and this is what he saw (show first member of stimulus pair and ask: "What do you think this is?"). Bobby wasn't sure what it was so he looked through his special camera. When Bobby looked through the camera this is what he saw (flip second member of stimulus pair over the first). Bobby walked a little further and then he couldn't see any more (flip over the black-out sheet).

Rather than repeating the story for each stimulus pair the remaining drawings were introduced by continuing the story as follows:

> A little further on Bobby saw this (show first member of stimulus pair and ask: "What do you think this is?"). Bobby wasn't sure what it was so he took out his special camera. When Bobby looked through the camera this is what he saw (flip second member of stimulus pair over the first). Bobby walked along a little further and then he couldn't see any more (flip over the black-out sheet).

Following presentation of each stimulus pair the child was asked the following:

1. "When you saw the first picture, what did you think it was?"

In order to correctly answer the representational change question children needed to supply the label that they had previously given for the first member of the picture pair under consideration. Children were given a score of 1 for each correct answer, incorrect responses received a score of 0 for the question. The question of how to treat "I don't know" responses is difficult in that it is hard to determine if a child really doesn't know, doesn't understand the question, or is simply providing a formulaic response. Thus "I don't know" is neither a correct answer nor an incorrect response, but rather a non-answer. For the purpose of this study it was decided that children answering "I don't know would be statistically treated as having supplied an incorrect response. Children not responding to the representational change question were scored as non-responding. The items they failed to respond to were excluded, for those subjects, from the analysis.

After completing the representational change questions for all eight pairs of pictures, subjects were interviewed to determine if young children do distinguish between natural kinds and human artifacts. This portion of the study, taken from Gelman (1988), was introduced in the following manner. Subjects were randomly assigned to one of the eight presentation orders used in the representational change portion of the study. Children were then told "I am going to ask you a few questions without any pictures. Do you think people make

X's?" Where X is the second member of each pair of pictures used in the representational change tasks. Children answering "Yes" were then asked "How?" Children answering "No" were asked "Why not?" As Gelman points out, this approach allows for the determination, at a fairly simple level, of whether or not children divide the world into man-made things, human artifacts, and objects not made by man, natural kinds.

Responses to this portion of the study were tape recorded for later transcription and analysis.

CHAPTER 4. RESULTS

4.1. REPRESENTATIONAL CHANGE

During the data collection phase of the study it was noted that one of the human artifact pairs, that of the bicycle and car, failed to function in the manner predicted. Sixteen children, three three-year-olds, seven four-year-olds and six five-year-olds, thought the first drawing of the stimulus pair was a car, rather than a bicycle. Since the second drawing was a car a child could develop a second representation of a car or keep the original representation. Regardless, it was impossible to tell which representation a child was referring to when answering the representational change question. Probes at the conclusion of the task revealed that children thought the initial drawing was a car because of two characteristics of the drawing: there were tires; and the way in which the pictured boy's hands were placed suggested he was holding a steering wheel. Given the ambiguity the inclusion of this item would cause, the picture pair was dropped for all subjects. Thus four natural kind and three human artifact pairs were included in the analysis.

Accordingly the raw score means for the three age groups by the two domains are shown in Table 1. The natural kind (NK) means were 0.87 for the three-year-olds, 2.62 for the fours and 2.74 for the fives. For the human artifacts (HA) the means were 0.33 for the three-year-olds, 2.14 for the fours and 2.10 for the fives. As the means reflect, there is an increase in the number of correct responses between the ages of three and four, with a

plateauing between four and five. This leveling off will be further explored below. However, as Table 1 reflects, the maximum possible mean score in the two domains was not the same, due to the dropping of the one human artifact item.

Table 1

Mean Raw Scores for Age and Domain on the Representational Change Question

	Age			
	3	4	5	Maximum
NK	0.87	2.62	2.74	4
HA	0.33	2.14	2.10	3
Mean Total	1.20	4.76	4.84	7

Since the two domains had an unequal number of items an analysis based on raw score means was difficult. Therefore the data were transformed to produce a proportional score for each subject in each of the two domains. The transformed scores were determined by calculating each subject's mean score for each domain. In the natural kind domain each subject's total score, the sum of the four items, was divided by four; similarly for the human artifacts, though the number of items was three. Thus the maximum possible transformed subject score in either domain was 1.0. In this manner the effect of having unequal numbers of items in the two domains was negated. The subject means were then used as the data for further analysis. The transformed mean scores (see Table 2) for the natural kinds were 0.217, 0.655 and 0.684 for the three, four and five-year-olds respectively. For the human artifacts the means were

respectively 0.111, 0.714 and 0.702.

Table 2

Mean Transformed Scores for Age and Domain on the Representational Change Question

	Age			
	3	4	5	Marginal
NK	0.217	0.655	0.684	0.545
HA	0.111	0.714	0.702	0.545
Marginal	0.164	0.685	0.693	0.545

Children's transformed scores were subjected to a 3 (Age) X 2 (Domain) analysis of variance, with repeated measures on the Domain factor. Domain was the within-subjects' factor, and Age the between-subjects' factor. There was a significant main effect of Age ($F(2, 52) = 17.24$ $p < 0.05$) (see Table 3). A visual inspection of the transformed means indicated that the number of correct responses on the representational change question, holding domain constant, increased between the ages of three and four, but not between four and five years of age. A Tukey post-hoc comparison (alpha = 0.05) revealed a significant difference in performance between the three and four-year-olds, and the three and five-year-olds, but not between four and five-year-olds. It is of interest to note that the three-year-olds had mean transformed scores well below what would be expected by chance alone.

Neither the main effect for Domain nor the Age by Domain interaction were significant ($F(1, 52) = 0.08$ $p > 0.05$; $F(2, 52) = 1.93$ $p > 0.05$).

Table 3

Age by Domain Repeated Measures ANOVA for the Representational Change Question

Source	SS	df	MS	F
Age	6.007	2	3.004	17.24 *
Error	9.057	52	0.174	
Domain	0.002	1	0.002	0.08
DxA	0.124	2	0.062	1.93
Error	1.668	52	0.032	

* $p < 0.05$

4.2. ITEM ANALYSIS

The above results suggest that there is no difference between domains for all ages. Between the ages of three and four, however, there is an increase in performance on representational change, with domain held constant. The validity of such results depend to some degree on whether or not domain items functioned similarly. Consequently Cronbach's alpha, a measure of internal consistency, was calculated for each domain. For the natural kind stimuli, alpha was 0.79; for the human artifacts it was 0.74. Nelson (1974) has stated that, while an acceptable alpha value depends upon the purpose of the study, it should be at least 0.70. It can be concluded that each item within the two domains was functioning in a manner similar to its fellow members.

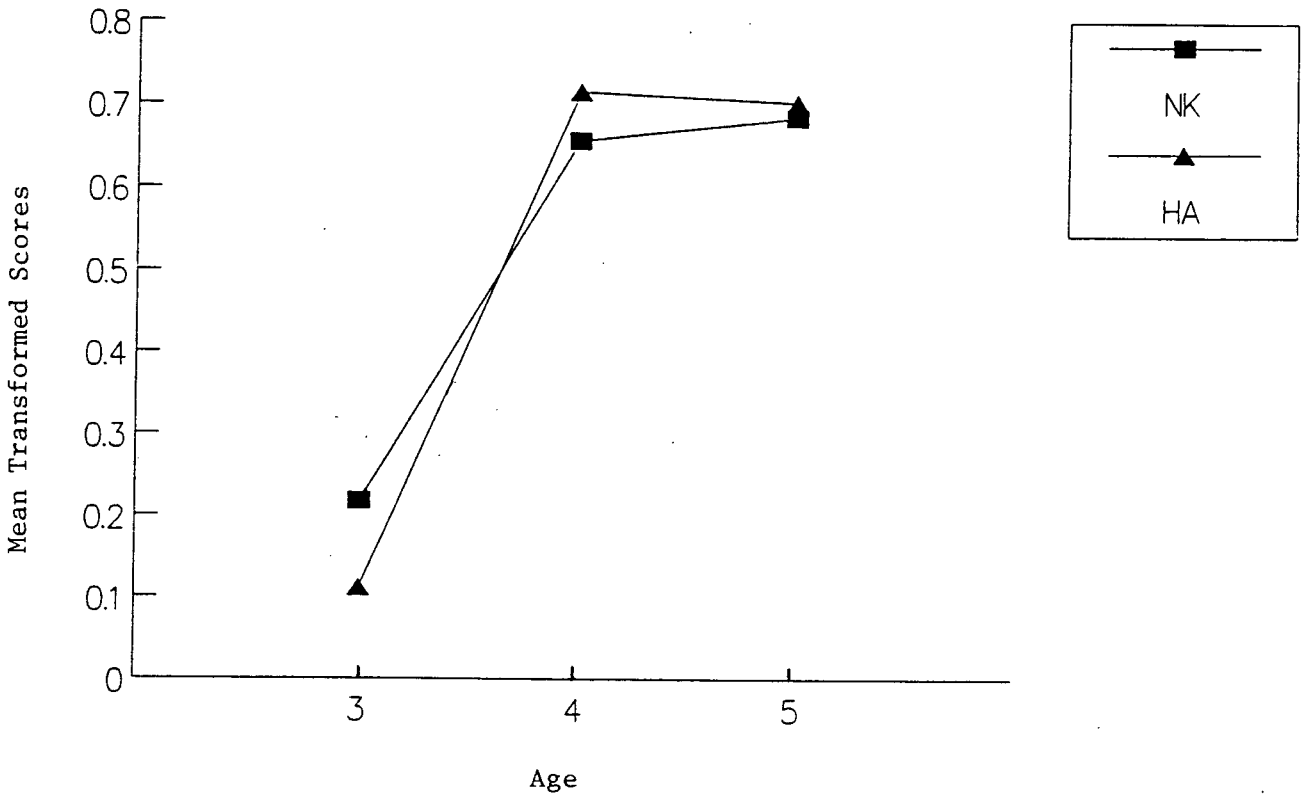

Figure 1. Mean Transformed Scores by Domain and Age for the Representational Change Question

The coefficients of reliability provide evidence for a degree of commonality within each domain. However the shape of Figure 1 indicates the possibility of a ceiling effect for four and five-year-olds across both domains. A ceiling effect occurs when most items are answered correctly, thus reducing variance. If one item within each domain was consistently eliciting incorrect responses the possible maximum would be depressed, increasing the likelihood that the plateau between the ages of four and five was due to a ceiling effect. In order to investigate such a possibility an item analysis was conducted for the four and five-year-olds (see Table 4). Correct responses for each natural kind item ranged from 55% to 80%, and 63% to 80% for each human artifact item. The analysis suggests that no one item within either domain is consistently eliciting incorrect responses, that is, errors appear to be spread across all items for the four and five-year-olds.

Table 4

Proportion of Four and Five-Year-Olds Answering the Representational Change Question Correctly for Each Item

	Domain						
	NK				HA		
Item	1	2	3	4	1	2	3
	0.60	0.73	0.80	0.55	0.70	0.80	0.63

4.3. KNOWLEDGE OF NATURAL KINDS AND HUMAN ARTIFACTS

A major premise of this study was that children as young as three years of age do group objects into two domains: natural kinds and human artifacts. To determine whether these children make such a distinction data were collected for children's response to the domain question "Do you think people make X?" where X was one of the eight natural kind or human artifact stimuli. The intent of this portion of the study was to gather general information regarding children's knowledge of domain awareness.

Table 5

Domain Appropriate Mean Scores by Age and Domain for the Domain Question

	Age			
	3	4	5	Marginal
NK	2.12	3.24	3.53	3.00
HA	1.94	2.05	2.47	2.16
Marginal	2.03	2.64	3.00	2.58

The correct answer, that is, domain appropriate, mean scores on the domain question (see Table 5) for the natural kinds were 2.12, 3.24 and 3.53 for the three, four and five-year-olds respectively; and 1.94 for the threes, 2.05 fours and 2.47 for the fives for the human artifacts. For both domains the maximum possible mean score was four. It is interesting to note that three-year-olds answered at approximately chance levels for both domains, while

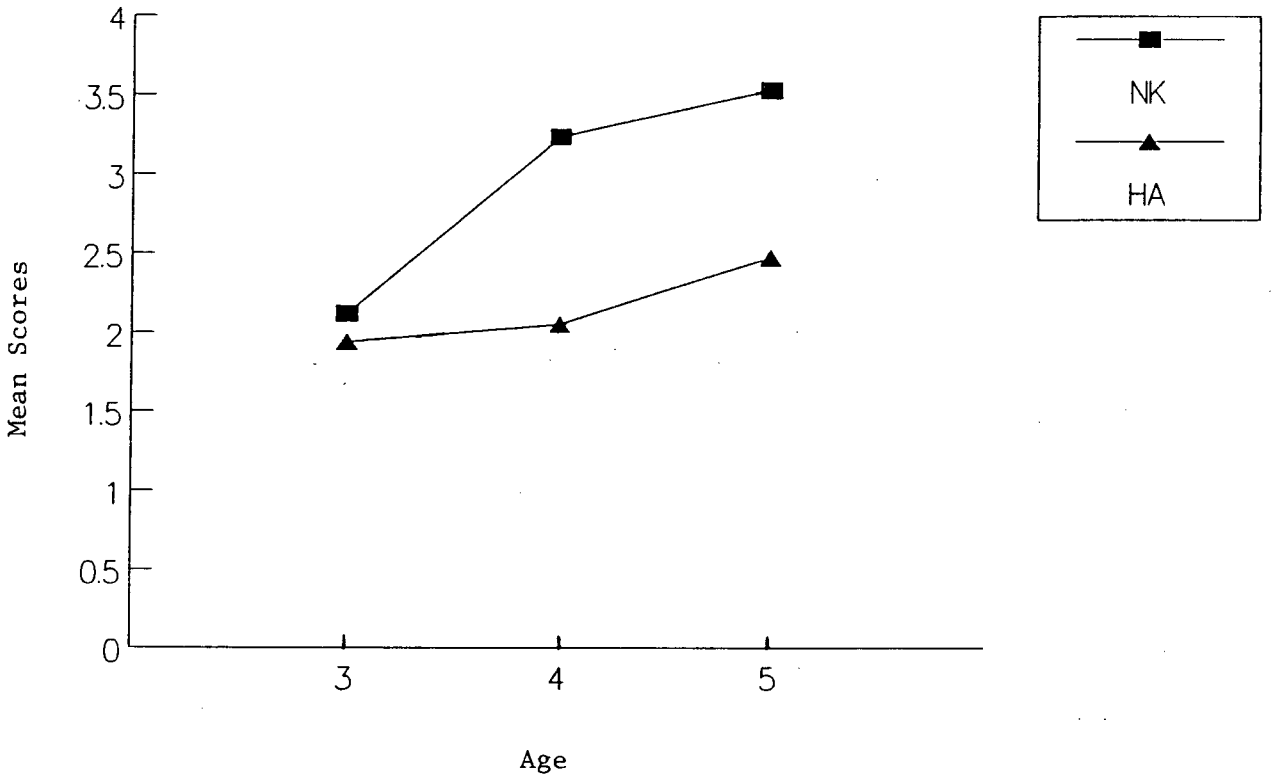

Figure 2. Domain Appropriate Mean Scores by Age and Domain for the Domain Question

the four and five-year-olds were considerably above chance for the natural kinds (see Figure 2).

Children's answers for the domain question were analyzed with a 3 (Age) X 2 (Domain) repeated measures ANOVA (see Table 6). Note that this analysis includes the two three-year-olds who were excluded from the representational change analysis since they failed to respond to any of the stimulus items. There was a significant main effect for Age ($F(2, 54) = 7.41$ $p < 0.05$). A Tukey post-hoc comparison (alpha = 0.05) revealed a significant increase in the number of correct answers between the ages of three and four, and three and five, but not between four and five.

Table 6

Age by Domain Repeated Measures ANOVA for the Domain Question

Source	SS	df	MS	F
Age	17.180	2	8.588	7.41 *
Error	62.613	54	1.160	
Domain	18.401	1	18.401	18.29 *
DxA	5.461	2	2.731	2.71
Error	54.328	54	1.006	

* $p < 0.05$

There was also a significant main effect for Domain ($F(1, 54) = 18.40$ $p < 0.05$). Inspection of the two means, 3.00 and 2.16 for the natural kinds and human artifacts respectively, revealed that, holding age constant, children answered the domain question correctly more often for natural kinds than for

human artifacts. However, the Age by Domain interaction was not significant ($F(2, 54) = 1.01$ $p > 0.05$).

Children answering "Yes" to the domain question were then asked "How?"; those responding "No" were asked "Why not?". Since this portion of the study was designed to gain some indication of whether or not the subjects, at the cognitive level, had knowledge of differences between natural kinds and human artifacts only justifications for correct responses to the domain question were tabulated. Justifications for incorrect responses are definitely of interest in most developmental studies; however, there is considerable difficulty in interpreting an appropriate domain justification for an incorrect response to the the domain question. Further, it was felt that the ambiguity of any such interpretation would not help clarify whether or not children do group the world in terms of the two domains of interest. Consequently justifications for incorrect responses were not tabulated. Responses were classified in a manner similar to that used by Gelman (1988). Children's answers for natural kind terms were judged suitable if they mentioned some characteristic of a living thing, for example, "Grapes grow", "Zebras come from a mother zebra"; or if children stated that the item was made by God. Answers for human artifacts were judged appropriate if they mentioned the use of tools, for example "You use a hammer to make a chair"; or specified specific parts, such as "You put wheels on a bus".

For natural kind terms seven (21%) of the three-year-olds' justifications were judged to be suitable, compared with 66 (88%) of the four-year-olds' and 53 (77%) of the five-year-olds' (see Table 7). For human artifacts the number of

appropriate responses was 30 (68%), 43 (77%) and 56 (88%) for the three, four and five-year-olds. All age groups had varying degrees of difficulty in justifying responses to the domain questions. There is a noticeable increase between the ages of three and four, but a drop between the ages of four and five, on the number of appropriate justifications for the natural kind stimuli. Further, it is interesting to note that three-year-olds were able to provide considerably more suitable justifications for human artifacts than for natural kinds.

Table 7

Justifications for Correct Answers to Domain Question by Domain and Age

	Age					
	3		4		5	
	NK	HA	NK	HA	NK	HA
Justifications						
Suitable	7	30	66	43	53	56
Unsuitable	27	14	9	13	16	8
Total	34	44	75	56	69	64

CHAPTER 5. DISCUSSION AND CONCLUSIONS

The analysis of the data suggests that there is an overall developmental trend in the understanding of representational change, which is robust over the two domains. This result is in line with a wide body of research which notes that representational change increases between the ages of three and five (e.g., Astington & Gopnik, 1988; Flavell, 1988; Perner, Leekham, & Wimmer, 1987; Wimmer & Perner, 1983). While three-year-olds' performed at considerably less than chance across domains, both four and five-year-olds answered the representational change question correctly at least 66% of the time. It is interesting to note that in the present study there was no significant difference in performance between the four and five-year-olds on the representational change question. Previous studies (Astington & Gopnik, 1988; Gopnik & Astington, 1988) have indicated that performance on representational change tasks improves significantly between the ages of four and five as well as between three and four. However, the present study suggests that the understanding of representational change occurs mainly between the ages of three and four.

It is possible that by the age of four children have developed the necessary cognitive skills for successfully completing the representational change tasks presented. That is, the results imply that the largest developmental jump occurs between the ages of three and four; cognitive growth beyond the age of four gradually refines a child's facility over the next few years. Unlike Gopnik and Astington (1988) the present study purposely restricted the stimuli to drawings of human artifacts and natural kinds with which it could reasonably be

expected all children would have basic knowledge of. Previous findings demonstrating a significant developmental progression between four and five may be a reflection of the wide range of domain materials used in such experiments.

5.1. DOMAIN EFFECTS

No support was found for the hypothesis that children answer the representational change task correctly more often for natural kind stimuli than for human artifact stimuli; neither was there evidence of a significant age by domain interaction. Visual inspection of Figure 1 reflects the lack of difference between the two domains for the four and five-year-olds, though three-year-olds did have a mean transformed score for natural kinds twice as large as that for human artifacts.

Both Carey (1985) and Sugarman (1983) have pointed out that young children have intuitive knowledge about the world. This knowledge is used by a child to make decisions about possible actions in a given situation. In light of this it is of interest to consider the nature of the three-year-olds' results. Though the two domains were not significantly different, the difference between the three-year-olds' mean scores points to possible dissimilarities in their ability to answer the representational change question across domains. The mean for the natural kinds was twice as large as that for the human artifacts. The pattern of the results suggests it would be worthwhile to further investigate the nature of three-year-olds' knowledge of the two domains and the link between this cognitive skill and an understanding of representational change. At present any

domain difference is masked to some degree by the overall lack of three-year-olds to cope with the representational change task. Further, any domain differences appear to disappear by the time children, around the age of four, begin to master representational change.

The lack of an overall significant domain effect is interesting to consider in light of the data gathered on subjects' domain knowledge. Collapsing across ages, mean scores on the domain question for both domains are above chance, though not by large degree for human artifacts. These results would seem to indicate that children do group the world into two domains.

However, further analysis of the domain question data revealed that three-year-olds differed significantly from four and five-year-olds on the domain question across the two domains. Inspection of the means (see Table 5) shows that the three-year-olds performed at chance regardless of the domain considered. This suggests that the younger children do not have a solid grasp of whether or not something is man-made; that is, three-year-olds do not understand the special nature of natural kinds. This is somewhat out of line with previous research (Carey, 1982, 1985; Gelman, 1987; Keil, 1986, 1987) that has pointed out that children just beginning to talk already are able to distinguish between natural kinds and human artifacts.

If, as Carey (1985) feels, childhood is a time of conceptual restructuring it would appear, that the ability to report on such is not evident until the age of four, at least in the two domains under consideration. Three-year-olds'

performance indicates that they have little reportable understanding of the two domains of interest. Interestingly Gelman (1987) found that children as young as three used categories as sources of information for drawing inferences. That is, children used their knowledge of natural kind terms to organize and expand their knowledge. But the results of the present study indicate that, while children may be aware of commonalities underlying various natural kind terms, three-year-olds do not consistently report that natural kinds are not made by man.

Though the ANOVA for the domain question did not reveal an interaction between age and domain, there is an interesting pattern within the data. Four and five-year-olds had higher mean scores on the domain question for natural kinds than for human artifacts. Mean scores for human artifacts across the three age groups reveals that three through five-year-olds range from slightly below chance to above chance. Three-year-olds performed at chance regardless of domain. That is, four and five-year-olds appear to be more aware of natural kinds as not man-made than they are of human artifacts as man-made, while three-year-olds have little awareness of the distinction between the two domains. Gelman (1988) found that four-year-olds and second-graders answered a similar domain question correctly approximately as often for human artifacts as for natural kinds, with both domains having means considerably above chance levels. The difference between Gelman's results and the present study are interesting. The present four-year-olds did not do as well as those in Gelman's study, and had almost as much difficulty as the three-year-olds in answering the domain question correctly for human artifacts. Yet their performance when considering natural kinds was much better, and is not significantly different from that of the

five-year-olds. Thus the present results suggest a similarity with Gelman's work in the natural kind domain, but are discrepant with Gelman's results using human artifacts.

The domain differences across the ages on the domain question suggests it is worthwhile to consider how children approach the task. To some degree answers to the domain question reflect children's interpretation of what it means to "make" something. It would be interesting to probe children's understanding of the domain question. Do children understand the question as referring to people in general, or do they interpret it with reference to an individual's abilities? As one child stated, "Cars are too hard to make"; suggesting that he interpreted the domain question as referring to his ability, or that of any non-expert, to make a car. It is possible that the abstract nature of the question leads to a misinterpretation, thus confounding children's true domain knowledge, at least for three-year-olds.

Justifications for the correct answers to the domain question also provide some interesting results, though no inferential analysis was conducted on these data. Both three and five-year-olds answering the domain question correctly offered a greater proportion of appropriate justifications for human artifacts than for natural kinds. However, the four-year-olds had the reverse pattern. Thus while the data indicate a developmental increase across the three age groups for the human artifacts, the natural kind data is harder to generalize, since there is a drop in the proportion of appropriate justifications between four and five years of age for natural kinds. Further investigation is called on to see if this result

is a chance artifact or a true indication of the general nature of the difference between four and five-year-olds. Regardless, the results suggest that, collapsing across age groups, children answering the domain question correctly are able to appropriately justify their answers more often for human artifacts than for natural kinds.

Given that the domain question was answered correctly more often for the natural kinds than for human artifacts, the pattern of justifications is especially interesting. It would appear that being able to distinguish between whether or not something is man-made is a separate consideration from knowing, or reporting, why this may be so. Carey (1982, 1985) has pointed out that young children, and adults, for that matter, lack complete scientific awareness of natural kinds. Explaining why something is not man-made requires explicit knowledge of natural kinds. If, as has been argued, young children largely have a rudimentary, intuitive knowledge of natural kinds it may not be possible for them to articulate their correct response to the domain question for natural kinds. In contrast, explaining how human artifacts are made requires only knowledge of parts or processes.

The fact that there were no significant differences between domains on the representational change question suggests that domain knowledge is perhaps a secondary consideration. That is, by the time a child is developmentally able to consider the ontological nature of a stimulus, he already possesses the necessary cognitive mechanisms to deal successfully with representational change tasks. Whether these mechanisms consist of the ability to represent the modelling

process, as Perner (1988) feels, or the awareness of sources of information (Wimmer, Hogrefe, & Sodian, 1988), or some combination of the two approaches is open to speculation. It is worth noting that the present four and five-year-olds demonstrated an understanding of representational change, but did not have complete comprehension of the domain question. Moreover, children's knowledge about whether or not an item is man-made apparently develops around the same time as they begin to master representational change. This suggests that successful completion of the representational change question may not depend on knowledge of information sources for children above the age of four.

5.2. EDUCATIONAL IMPLICATIONS

The present study has some basic implications for educational practices. First, the results appear to indicate that four and five-year-olds do have some knowledge of domain differences; that they do not consider natural kinds and human artifacts to be fundamentally the same. Three-year-olds, however, do not give evidence in their verbal reports that they have a grasp of the differences between the two domains. Educationally, this suggests that the declarative knowledge base of young children is limited. Further, while young children can answer simple questions their lack of knowledge hinders their ability to differentiate between domains in a manner similar to one that adults may use.

The difference between natural kind and human artifact means on the representational change question for the three-year-olds may indicate that for very young children an understanding of representational change is linked somewhat to

their domain specific knowledge. Naive domain theories may affect the type of activities such children are capable of successfully performing. This, too, may be worth considering when introducing concepts to children below the age of four.

Four and five-year-olds' domain knowledge appears not to have an effect on their understanding of representational change. However, the developmental progression of representational change is important to educational practices. Much of education deals with organizing old knowledge and incorporating new knowledge into existing knowledge structures. These knowledge structures are then used for dealing with both typical and novel situations. Representational change is one means by which individuals come to manipulate their knowledge base when dealing with novel situations. Programs attempting to promote knowledge restructuring at an early age need to be aware of the limitations young children have.

Activities in which very young children are expected to reflect on changes, or to predict future occurrences, require a child to construct at least two different representations and notice differences between them. That is, the child must have an understanding of representational change. Yet as the present study indicates early preschool children do not have a grasp of representational change, nor of domain specific knowledge. Teachers of preschool children need to be aware of not only the cognitive abilities of children, but also of their metacognitive abilities.

5.3. CONCLUSIONS

In summary, the results suggest that four and five-year-olds perform significantly better on representational change tasks than do three-year-olds, which is in general accordance with previous research. That is, they are able to construct two different models of the world, recognize the discrepancies between the two and act upon the resulting metarepresentation (Wimmer & Perner, 1983).

Further, there is support for the argument that children, at least four and five-year-olds, can distinguish between the two domains of knowledge considered, though this knowledge is limited in all three age groups. It would appear, though, that the knowledge children have about natural kinds and human artifacts is of little consequence in their successful completion of representational change tasks. Success in the representational change task was independent of domain.

There is a need to consider some of the limitations of the present study. The deletion of an item from the human artifact domain highlights the unpredictability of children's perception of stimuli. A more extensive pilot study may have been of benefit in the final selection and development of the stimulus items used in the present study.

Generalizability of the results is somewhat constrained by the properties of the sample used. The U.B.C. Child Study Centre is the source of subjects for many developmental studies. Many of the four and five-year-old children used for

this study have participated in a number of experiments over the last two years. It is not inconceivable that such exposure has had an impact on their performance in all experimental situations. Further, the children attending the centre are primarily from upper middle-class backgrounds. Still, the similarity of the overall results with other studies in the literature suggests that these limitations are minimal.

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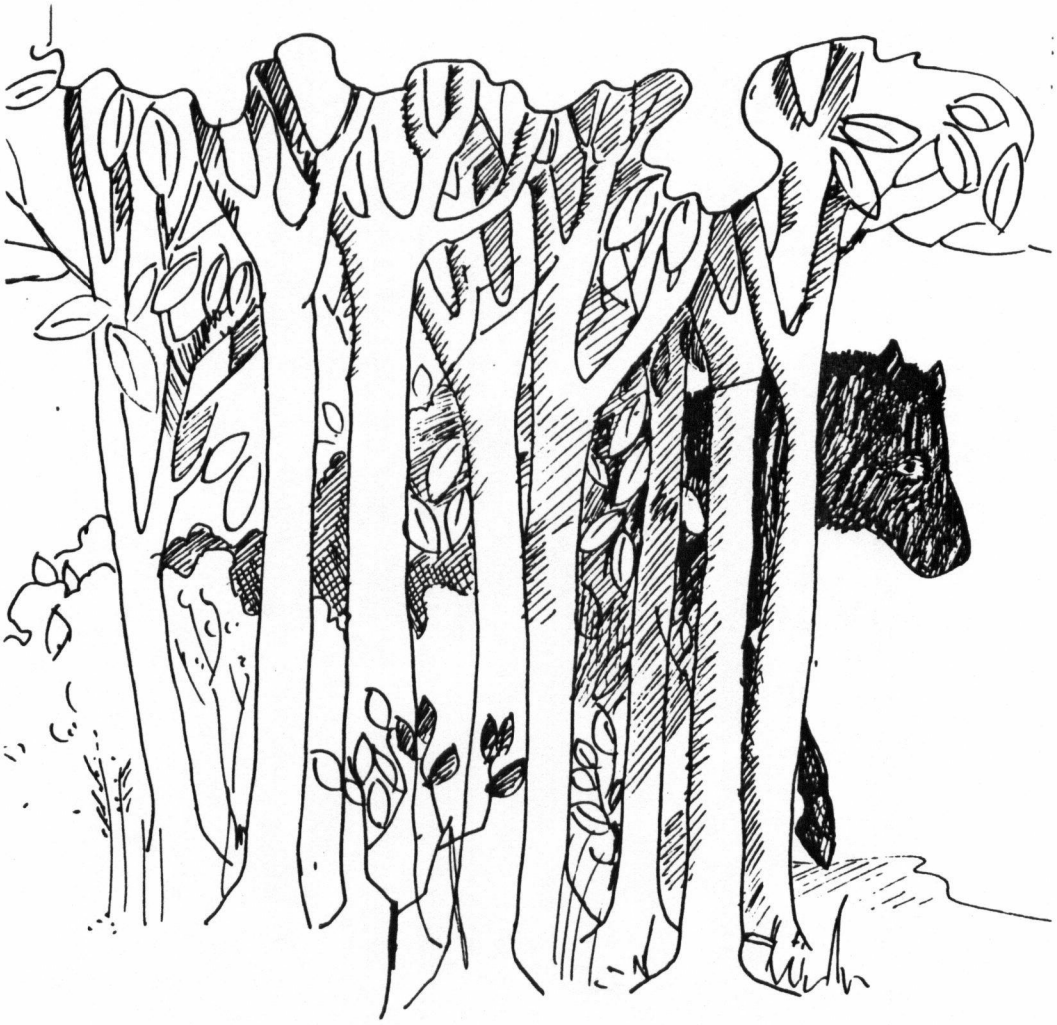
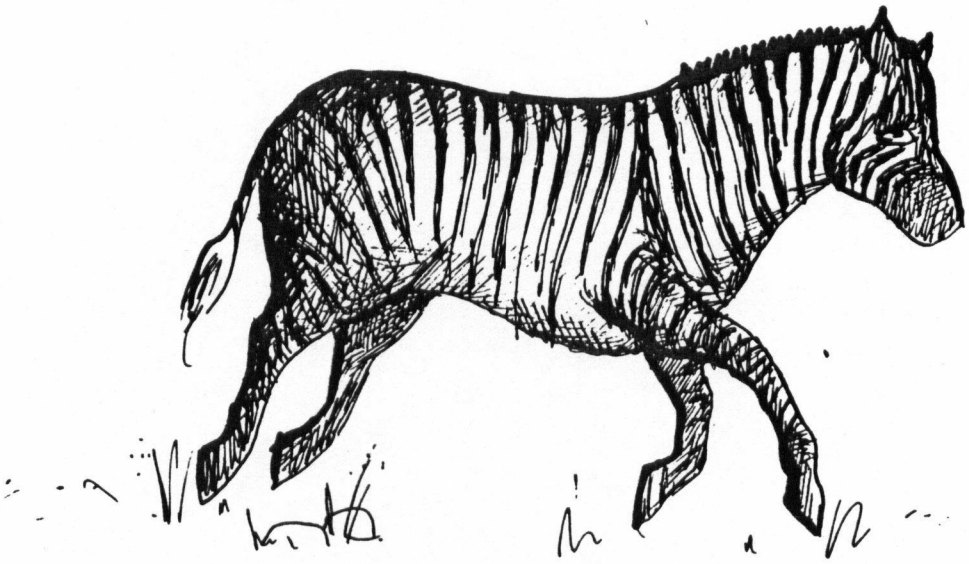
APPENDIX

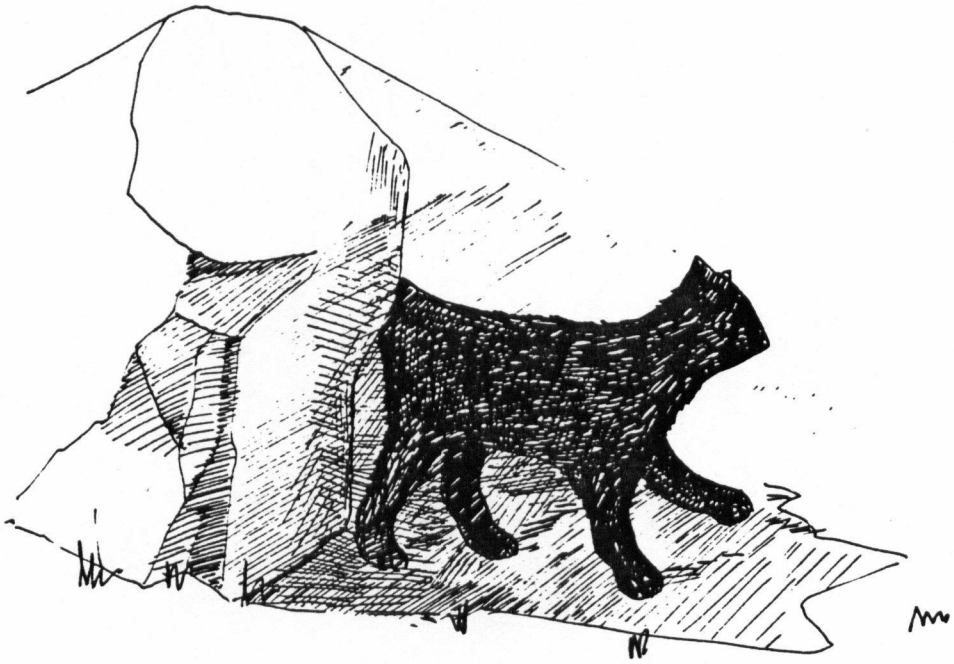
The following contains copies of the four natural kind pairs followed by the four human artifact pairs. The initial member of each pair is indicated by the letter A; the second member by the letter B. Additionally, the pair excluded from the analysis are marked with an asterisk.



A. Horse

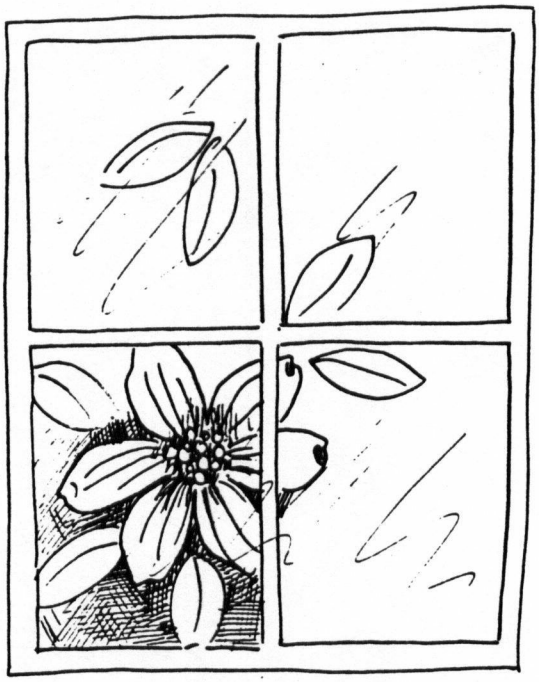


B. Zebra



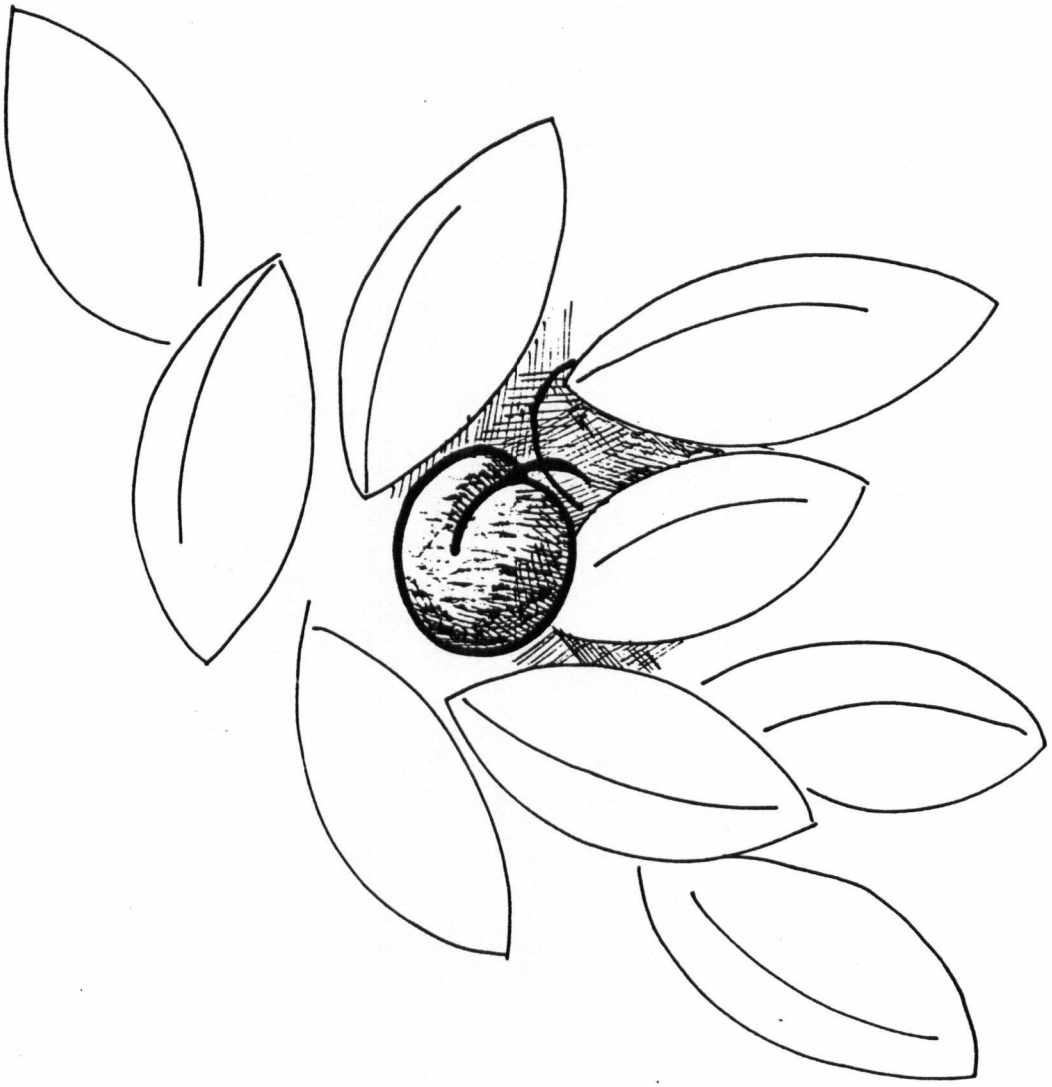
A. Cat

B. Skunk

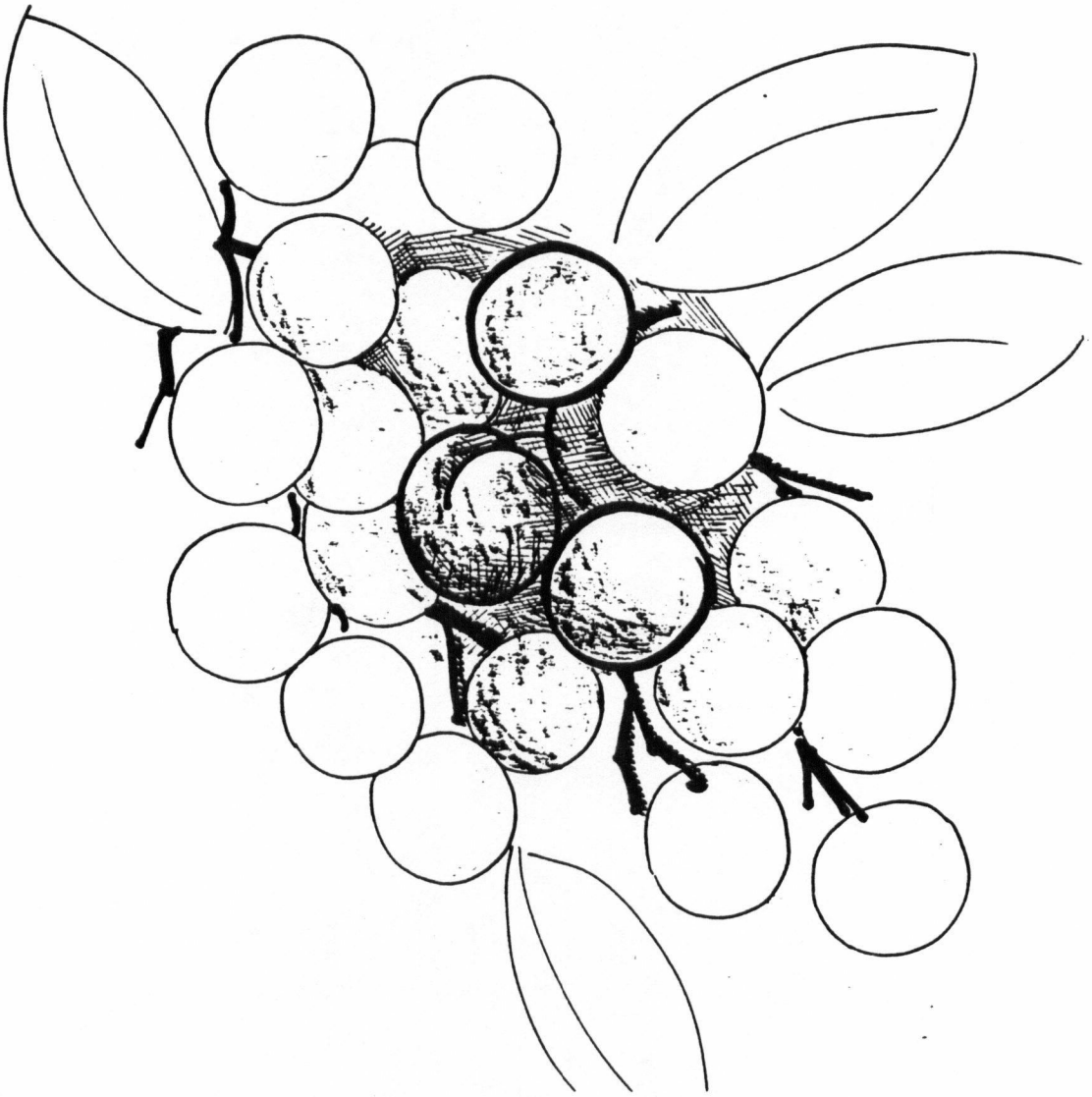


A. Flower

B. Tree

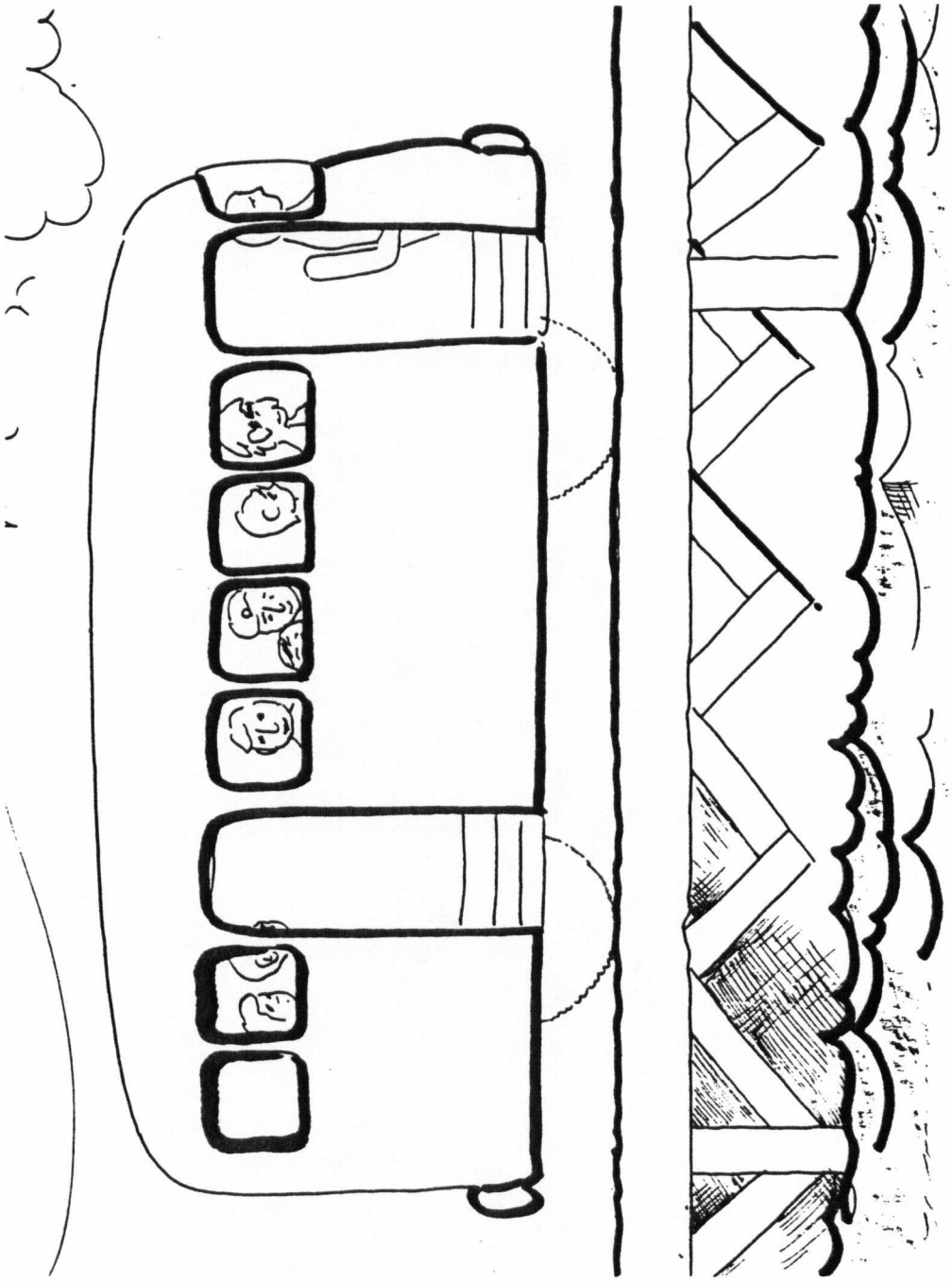


A. Plum

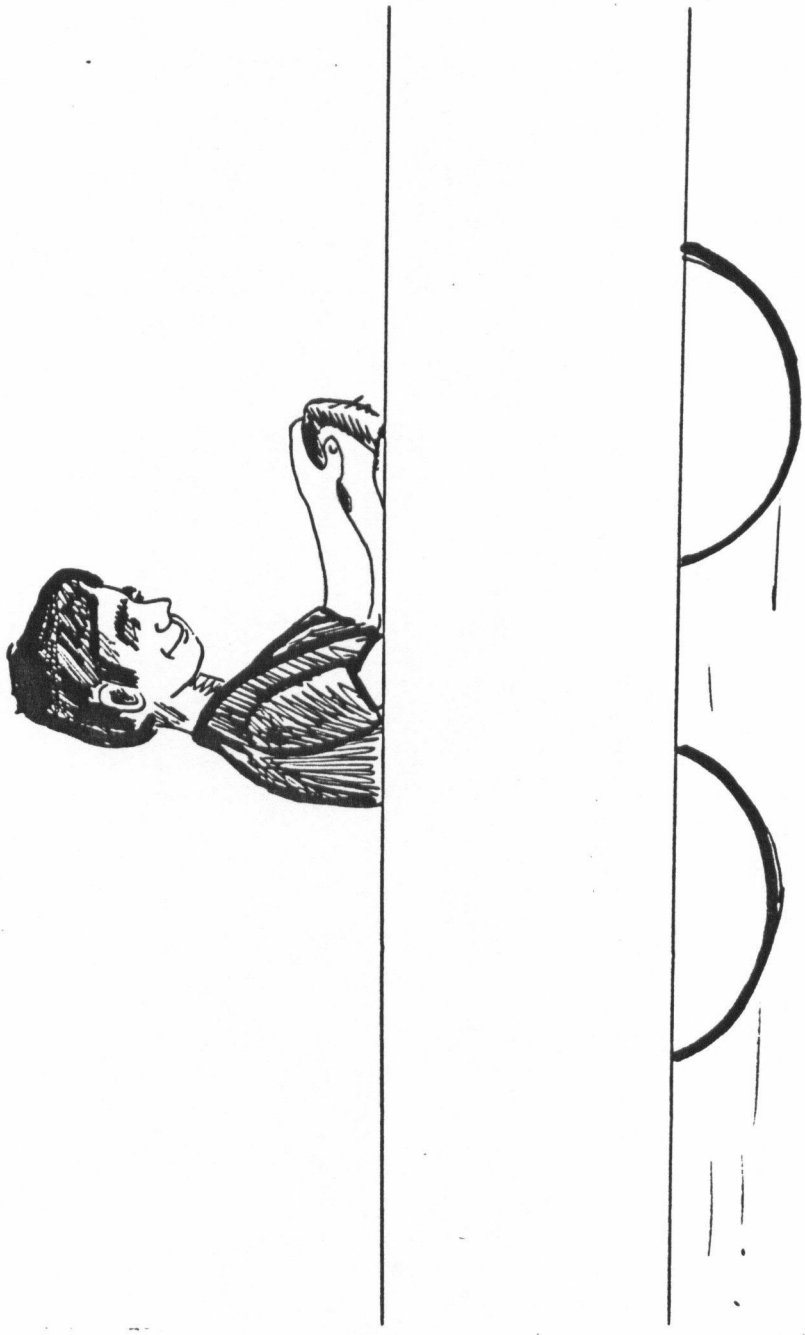


B. Grapes

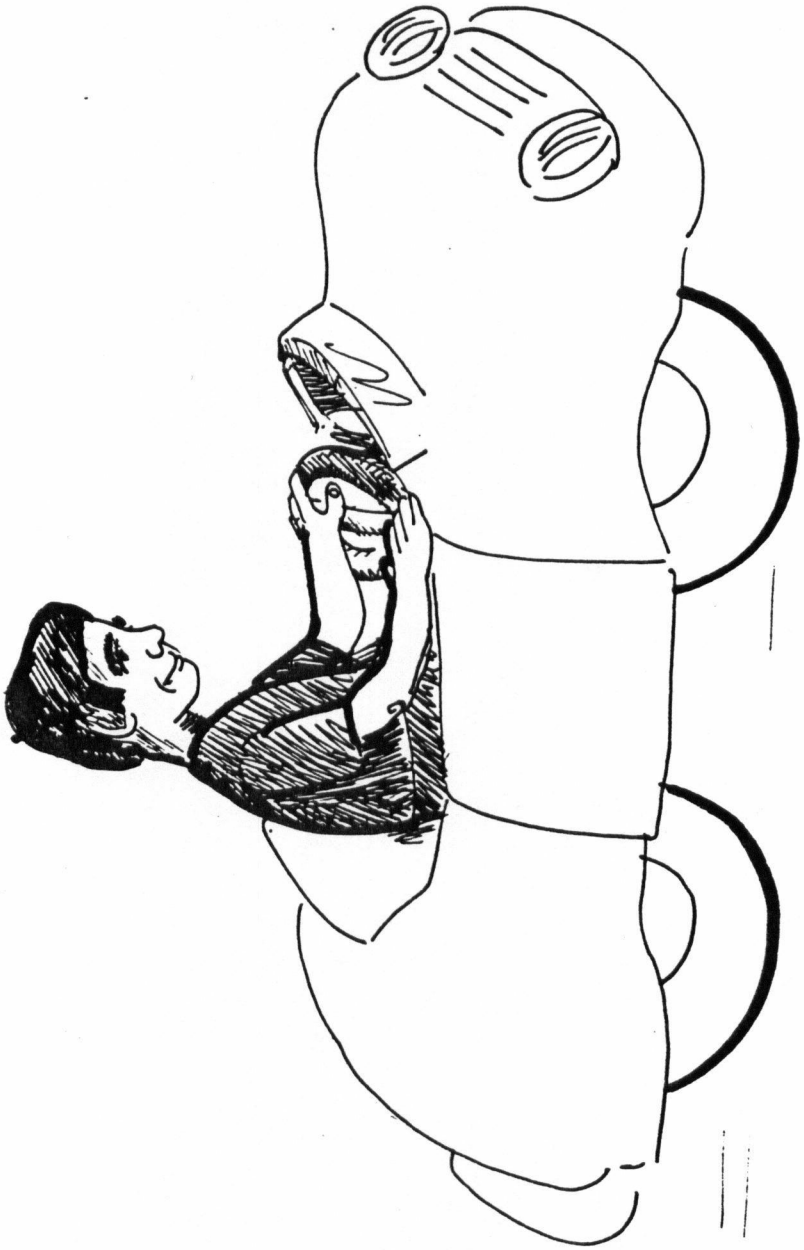
A. Ship



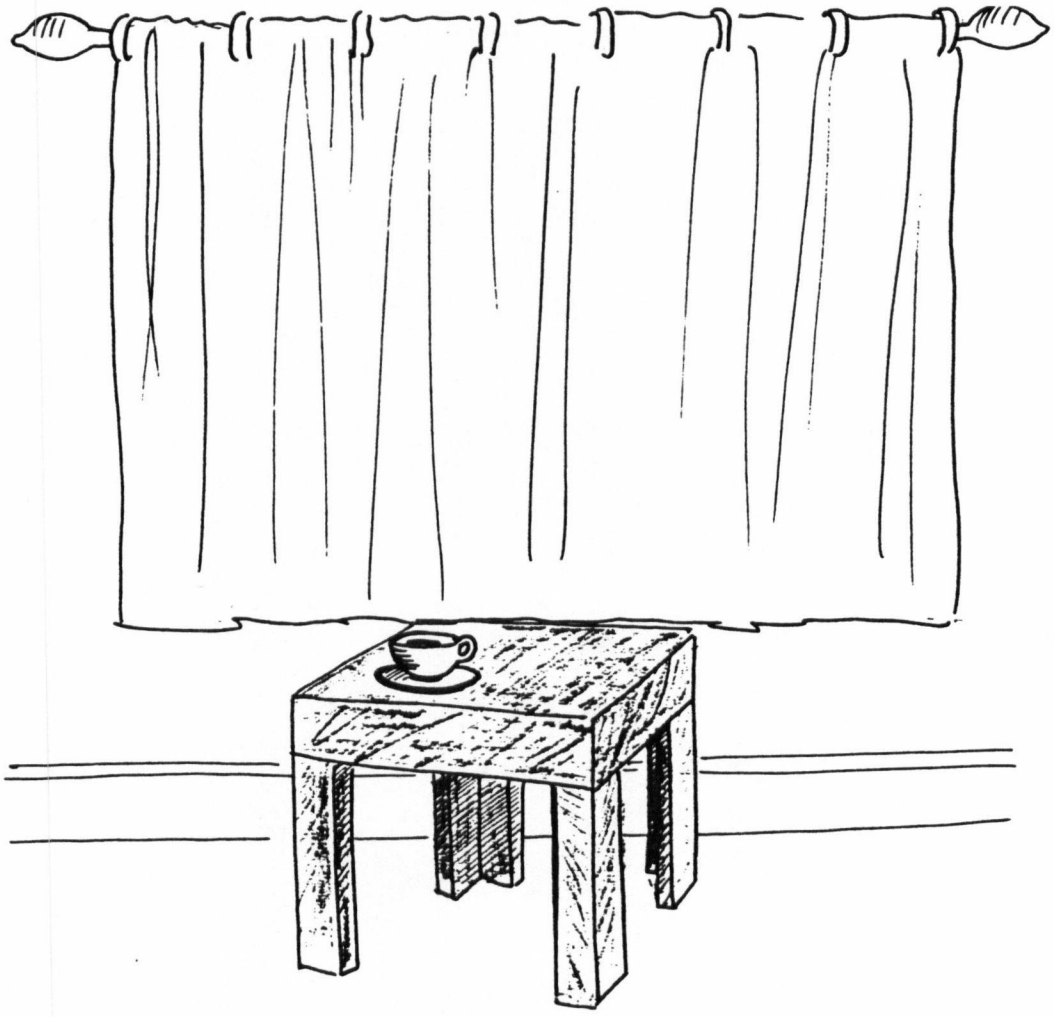
B. Bus



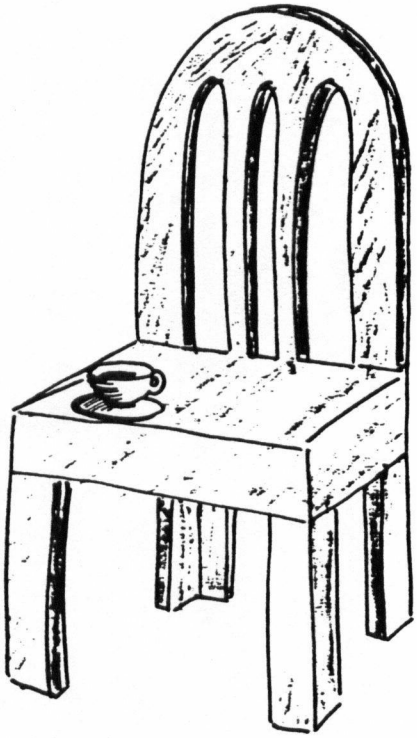
A. Bicycle *



B. Car *



A. Table



B. Chair

A. Broom

B. Vacuum Cleaner