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HIERARCHIES IN CLASSIFICATION AND LANGUAGE: EVIDENCE FROM PRESCHOOL CHILDREN

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ABSTRACT

Hierarchies in classification and language: Evidence from preschool children

Sandra R. Waxman

Rochel Gelman

Hierarchical systems of organization (e.g., apple, fruit, food) are fundamental to human cognition. They provide a powerful foundation for reasoning and are woven into the fabric of language. The experiments reported here examine preschoolers' appreciation of hierarchical systems in classification and language.

In Experiment I, preschoolers classified materials at four levels (superordinate, intermediate, basic, subordinate) within two hierarchies (animals and food). Overall preschoolers performed well, suggesting that they appreciate hierarchical systems. The most intriguing results involved the role of language. Previous work suggested that children honor an implicit bias to interpret nouns taxonomically. Therefore, novel nouns

(e.g., **suikahs**) were expected to have a uniform effect, facilitating classification at all levels. Instead, the nouns facilitated superordinate classification, but made subordinate classification more difficult. This specific effect may be related to the conceptual status of classes at different hierarchical levels.

In Experiment II, preschoolers' labels for these classes suggest that they do not yet appreciate categorical distinctions at subordinate levels. For example, children labelled the TERRIERS and COLLIES identically (as 'dogs'), with no semantic contrast. Children labelled subordinate classes contrastively only when they were explicitly encouraged to do so. Most children ultimately marked subordinate level contrast using adjectival phrases (e.g., 'big dogs'), with the head noun honoring the basic level class. Introducing novel nouns at subordinate levels (Experiment I) may have made it more difficult for children to discover subordinate level distinctions. The noun may have highlighted the inclusive, and especially salient basic level class (e.g., DOGS).

In Experiment III, a multiple-level classification task, novel words were presented in two linguistic contexts -- either as nouns (e.g., **suikahs**) or as part of adjectival phrases (e.g, **suk-ish ones**). Children were very sensitive to linguistic context. As predicted, nouns made subordinate classification more difficult; adjectival phrases facilitated subordinate classification, but made superordinate classification more difficult.

These experiments point to a powerful link between conceptual and linguistic organization. Labels do more than highlight taxonomic relations. The linguistic form of the label may provide information regarding hierarchical level. Children's early sensitivity to the relations between linguistic and conceptual information guides them as they establish hierarchical systems of organization.

Chapter 1

Introduction

Conceptual organization is a powerful and fundamental cognitive process. We are capable of organizing a great deal of information efficiently and with remarkable flexibility. Any particular item may be considered a member of several different groups or classes, depending upon the task at hand. Taxonomic classification systems represent one type of conceptual organization. In taxonomic classification, items are grouped together on the basis of a similarity or 'equivalence' relation. For example, an apple simultaneously belongs to the classes APPLE, FRUIT, FOOD, and PHYSICAL OBJECT. These classes vary considerably in their scope or breadth. Taken together, they form a hierarchical system, in the which lower-order classes are nested within subsequently higher-order classes. Taxonomic classification systems such as these figure centrally in our philosophic tradition and have been adapted to studies of human conceptual organization (See Smith & Medin, 1981; Anderson, 1983).

However, not all systems of organization are taxonomic. We also can form 'ad hoc' or idiosyncratic groupings that cut across taxonomic class boundaries. Consider, for example, the class BIBLICAL SYMBOLS, which includes APPLES and SNAKES, but not all FRUITS and ANIMALS. Another example is the class SIGNS OF AUTUMN, which includes FALLING LEAVES, APPLES, and PUMPKINS. In addition, we can group objects on the basis of functional or thematic relations. For example, an apple and a knife may be grouped together since a knife is often used to cut an apple.

In this dissertation, I will restrict my focus to the development of hierarchical taxonomic classification systems (e.g., APPLE, FRUIT, FOOD). These systems provide a powerful foundation for much of our logical reasoning and are intimately woven into the fabric of human language. Scholars from a wide range of disciplines (including philosophy, linguistics, anthropology, computer science and psychology) acknowledge the essential role of hierarchical systems in human cognition. However, questions regarding the development of hierarchical systems have been more controversial.

At what point in development are children able to organize information hierarchically? Since children acquire a great deal of information in the first few years of their lives, and since hierarchical systems are so efficient in organizing information, one might expect young children to use hierarchical systems of organization early in development. Further, given the rapid pace at which young children acquire language, and the close relation between language and classification, one also might expect that language serves as a tool for organizing hierarchical relations. In this dissertation, I propose that very young children are capable of organizing information hierarchically, and that an intimate and powerful link between language and classification guides their early conceptual development.

In this chapter, I discuss several characteristics of hierarchical systems, including their underlying logical principles, the linguistic conventions used to describe them, and the importance of modification and reorganization within hierarchies. Turning to developmental issues, I then provide a general outline of theoretical concerns, followed by a review of the literature on young children's appreciation of hierarchical systems of organization.

I adopt the following notation throughout: lower case (e.g., apple or dog) indicates a particular instance of a class (e.g., an individual apple or an individual dog). Upper case (e.g., APPLE or DOG) refers to that entire class of objects. A hierarchy refers to a set of nested classes in an inclusion relation. (See Figure 1.1 for a schematic representation of an animal hierarchy.)

Characteristics of Hierarchical Systems:

Hierarchies and Logic:

Hierarchical systems are governed by two organizing principles: the hierarchical and contrastive principles (Inhelder & Piaget, 1964; Miller & Johnson-Laird, 1976; Horton, 1983). The hierarchical principle is concerned with logical inclusion relations among classes at different levels of abstraction. It is based upon two underlying logical principles: transitivity and asymmetry. Transitivity captures the fact that if a

class C is included in class B, and if class B is included in class A, then class C is included in class A.

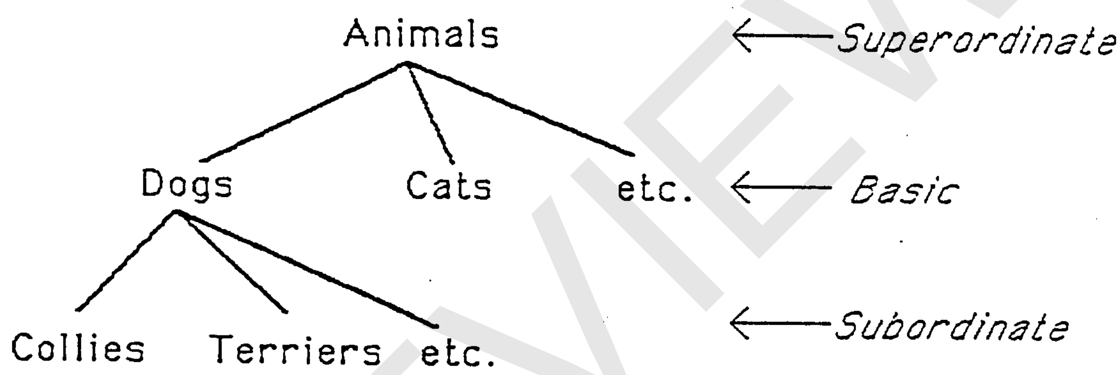

Figure 1.1. A schematic representation of an animal hierarchy.

For example, if the class TERRIERS is included in the class DOGS, and the class DOGS is included in the class ANIMALS, then the class TERRIERS is included in the class ANIMALS.

Asymmetry captures the fact that the inferences drawn from hierarchical structures are unidirectional. Inferences regarding class membership are licensed only as one ascends within a hierarchy. Any member of a lower-order class (e.g. a terrier) is, by definition, included in each of its higher-order classes (e.g., TERRIERS, DOGS, ANIMALS). This inference cannot be made in the opposite direction: All members of a higher-order class (e.g, ANIMALS) are not included in the lower-order classes (e.g., TERRIERS). The principle of asymmetry insures that higher-order classes are, by definition, larger than their subsets. The direction of the asymmetry is reversed when considering class properties rather than class membership. Properties are 'inherited' as one descends within a hierarchy. Any property which can be predicated of a higher-order class can also, by definition, be predicated of its subclasses. For example, because we know that all fruits have seeds, we can infer that bananas, kiwi and papayas have seeds.

The _hierarchical principle_ governs vertical relations among classes at different levels of abstraction; the _contrastive principle_ maintains horizontal relations among classes at a given level of abstraction. At any particular level within a hierarchy, the classes are contrastive or mutually exclusive. For example, while an object can be included in a myriad of vertically-related classes (e.g., TERRIERS, DOGS, ANIMALS), it can be included in only one class at each level of abstraction. If it is included in the class TERRIERS, it cannot be included in the contrastive class COLLIES; if it is included in the class ANIMALS, it cannot also be included in the class FURNITURE. (See Inhelder & Piaget (1964), Keil (1979), Horton (1983), Markman (1984), and Shipley, Kuhn, & Madden (1985) for discussions of the role of contrast in hierarchical systems.)

These principles provide the structural framework for hierarchical systems and make possible a rich set of inferences. By placing an object in a category, we open up "... a whole vista of possibilities for "going beyond" the category by virtue of the ... relationships linking this category to others." (Bruner, Goodnow, & Austin, 1956, p. 13). For example, if we encounter a novel item and are told that it is an animal, we can infer that it is alive and that it eats. Similarly, if we encounter a novel item and observe that it eats, we can infer that it is an animal and shares other properties with members of that class. Further, when we discover a new property of a single item (e.g., Fido bites if I pull his tail), we tend to attribute that property to other class members as well. In this way, hierarchical systems "...give us the greatest command over our knowledge already acquired, and lead most directly to the acquisition of more." (Mill, 1843, p. 432.) Researchers have proposed that hierarchies serve as the 'natural domain of induction' (S. Gelman, 1984; Shipley, et. al., 1985). For example, we do not have to learn that dogs bite through first hand experience with all individual dogs; knowing that Fido is a dog may license the induction.

Hierarchies and Language:

In addition to their unique logical structure, there is a linguistic characteristic that distinguishes taxonomic classes from groups based on other relations. Taxonomic classes tend to be lexicalized or nominalized (e.g., APPLE, FRUIT, FOOD), while groups based on idiosyncratic and thematic relations tend to be described by phrases or sentences (e.g., BIBLICAL SYMBOLS or APPLE AND KNIFE). This linguistic convention is common across languages, both spoken (Berlin, 1978) and signed (Newport & Bellugi, 1978). Further, nouns tend to be organized differently in the lexicon than the other grammatical form classes. Nouns are hierarchically organized, while verbs and adjectives are not (Huttenlocher & Lui, 1979). Thus, there are fascinating parallels in the organization of natural object hierarchies and the language we use to describe them. These parallels suggest that our conceptual and semantic groupings may be closely related.

Modifications within hierarchical systems:

Like language, our hierarchical systems of organization are dynamic. This is an essential feature for any fundamental cognitive capacity, for we need conceptual systems that are flexible enough to incorporate new knowledge. Modifications within hierarchies go hand-in-hand with changes in our knowledge and our theories (either naive or scientific) within a particular domain. (See Carey, in press, for a discussion of naive and scientific theories.) Quine (1969), Chi (1982), and Siegler and Klahr (1981) have paid particular attention to this fluid relationship