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HIERARCHICAL CLASSIFICATION

IN

KINDERGARTEN CHILDREN

by

Wendy E. Rowe

B.A., Simon Fraser University, 1976

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Abstract

The research described in these studies was designed to investigate whether kindergarten children know that, when categories are hierarchically organized, the principles of mutual exclusion (referred to also as horizontal classification) and class-inclusion (vertical classification) apply.

In the first study, 96 kindergarten children were tested using two hierarchies of natural categories (fruit-vegetable-food and dog-bird-animal). Each hierarchy consisted of three levels (e.g., "collie", ""dog", and "animal").

The results showed that, in a first identification task, 52% of the children with foods and animals, were able to identify specific stimuli (e.g., apple, banana, corn, peas) as members of mutually-exclusive categories (fruit and vegetable) and simultaneously, identify them at both the intermediate and superordinate (e.g., food) level. These children are called "hierarchical identifiers".

In a second sorting task, 71% and 47% of children with animal and food categories, respectively, were "hierarchical sorters". That is, they sorted specific stimuli into two

intermediate-level categories and then combined them into the superordinate category.

In order to clarify results obtained in study 1, study 2 investigated children's understanding of hierarchical organization with an arbitrary three-level hierarchy of meaningless categories. The subjects tested with the food sets in study 1 were used in study 2. They were first taught the links between the first (specific) level stimuli and the second (intermediate) level categories of the arbitrary three-level hierarchy. They were then taught the links between the intermediate and the third (supeordinate) level. Two tests attempted to see whether they had inferred the relationship between first level stimuli and the superordinate categories.

In the first test, subjects were required to identify all specific stimuli belonging to the superordinate categories. In the second test, they were required to sort stimuli at each of the intermediate level categories and combine them into the superordinate category. Eighteen (or 42%) of the subjects (hierarchical utilizers) were judged to have discovered and utilized the principles of hierarchical organization in these tasks.

At the end of study 2, subjects were retested on the hierarchical sorting of the same food categories as study 1.

There was a strong positive correlation between hierarchical sorting of food categories on study 1 and at the end of study 2. However hierarchical utilization with arbitrary categories at the beginning of study 2 was not related to hierarchical sorting of foods on study 1 but was related to hierarchical retest sorting of foods on study 2. This pattern of results primarily reflects the fact that nine children applied principles of hierarchical organization for the first time with the arbitrary categories in study 2 and five of these generalized this ability to hierarchical sorting of the food categories at the end of study 2.

The results of study 1 and study 2 indicate that a significant number of kindergarten children can simultaneously attend to the subparts and wholes of a hierarchical arrangement of categories; that they can integrate or simultanously make use of horizontal and vertical classification. The results of study 2 indicate that training with arbitrary categories may be an effective method to induce children to discover or make use of the principles of mutual-exclusion and class-inclusion of hierarchies.

DEDICATION

To my parents who have provided me
with continuous and unqualified
support and faith

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INTRODUCTION

As a young child acquires knowledge about the world, he acquires knowledge about categories or classes of objects, things and events. He learns what objects are representative or exemplars of a class, what properties or features define a category and in what ways categories are related to each other. This conceptual development is dependent, on the one hand, on the young child's ability to perceptually and conceptually discriminate objects in the world as individually distinct, and, on the other hand, to classify them. In the latter case, he is able to disregard some of the individual differences that exist between the immense number of objects and events he has experienced and group them together into a smaller set of categories or classes, and thus to respond to those objects as if they were equivalent. In this way, the developing child organizes and simplifies his world.

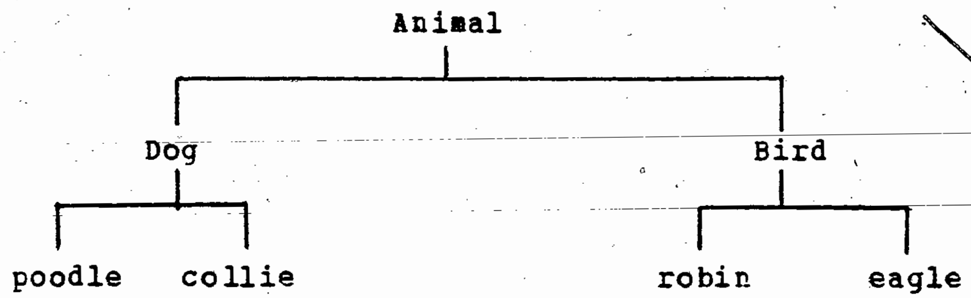
The process by which the young child eventually acquires the ability to categorize things in his world is complicated and poorly understood. It appears that 1- to 2- year old children (Nelson, 1974a; Ross, note 1) respond to certain groups of objects as if they were 'equivalent' and yet also indicate that they perceive the objects as individually distinct. By 2- to 3- years of age, children sort objects on the basis of associative relationships, e.g. dog-bone, (McCauley, Weil, & Sherber, 1976; Mansfield, 1977; Prawat & Cancelli, 1977), functional relationships (i.e. knife + fork) (Nelson, 1974a,b), and perceptual similarities (Clark, 1973).

Thus it is clear that preschoolers possess the ability to group together objects and things on the basis of associative relationships or common properties. This ability appears to rapidly become more sophisticated since 5-to 6-year olds are capable of classifications based on complex combinations of common physical properties as well as on properties that may be more abstract or conceptual. In many instances, a child's classificatory behaviour is, on the surface, similar to that of an adult, yet the young child's ability to put objects or events together according to adult categorical taxonomies does not necessarily mean that he understands the logical principles underlying the classification.

These principles imply, as already mentioned, that while objects or events are perceptually distinct and can be treated as such, they can also be treated as 'equivalent', belonging to a common class or category; that all items organized as a class have a property or set of properties in common. And, that if a category is defined by a common property (or set of properties), these properties are not common to other categories.

The above principles pertain to a "horizontal" aspect of categories, i.e., what defines a category and the relationships of mutual exclusiveness between categories. In addition, there is a "vertical" or hierarchical aspect to categories; namely, that objects or events can be classified at many levels of generality. In organizing objects and events into multiple levels of classification, the young child must learn that a class of objects can be inclusive of another more general class, but exclusive of other classes. Thus, classes that are mutually-exclusive at one level of classification can be 'equivalent classes' of a more general, superordinate category. These principles of mutual-exclusion and of class-inclusion, are represented by a hierarchical tree-like organization of categories or classes, as shown in Figure 1.

Figure 1. Hierarchy of classes



Since it appears that children learn to classify objects into categories at a very early age, at what age or stage do they acquire understanding of the principles of hierarchical classification?

Theoretically, the relationship between the different levels of a hierarchical system of classification has been described in a variety of ways. The progression from lower (more specific) to higher (more general) level has been described by some as concrete-to-abstract (Inhelder & Piaget, 1958). Others (Wright & Vlietstra, 1975) have talked of perceptually-based versus conceptual categorization. Others (Rosner & Hays, 1977) have proposed that the degree of generality is based on the potential number of exemplars within each class defined by a common property.

Finally, Rosch (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) has recently made a number of important distinctions between levels of categorization based on the nction of "cue validity". Each category is assumed to be defined by a number of attributes. Some of these attributes are characteristic of a category. The greater the probability that an attribute is characteristic of one category only and not of another, the higher its "cue validity". According to Rosch, the cue validity of an entire category may be defined as the summation of the cue validities for that category of each of the attributes of that category. Thus a category with a high total cue validity, is more differentiated from other categories than one of lower cue validity. Categories with the highest cue validities (e.g. apple, car, poodle), are called basic level categories, that is, each of these categories possess many high validity attributes, or cues, which are common to most members of the category. Superordinate categories, (e.g, fruit, vegetable, dog) have members that share fewer high valid attributes with each other than do members of basic level categories. At the next, still higher level of categorization (e.g., food, animal), even fewer high validity attributes are shared by all members of the category. An important point to note about Rosch's distinction between basic level categories and superordinates is that it provides, at least in principle, a method of judging the degree to which categories are differentiated from each other, basic level categories being the most differentiated categories.

Empirically, four lines of research are relevant to the issue of categorization in children and these will now be reviewed in detail. Based on the type of tasks used, these four lines of research are referred to in the next sections as categorization research, the use of labels, semantic memory research, and class-inclusion questions.

I. Categorization Research:

In this section, research is considered in which children's knowledge of categorization has been primarily investigated by three types of experimental tasks, (a) children's use of categories in the learning and recall of word lists, (b) the classification of items in free sorting tasks, and (c) the use of category information in problem-solving tasks, such as oddity sorts and matching-to-target tasks.

Several studies have examined the organization of items in free recall when children were presented with lists or sets of categorized words or objects. Rossi & Rossi (1965) presented 2- to 5-year-old children with a list of spoken words, along with pictures, belonging to several first-level superordinate categories (fruits, toys, clothing, and eating utensils). They found that even two-year-olds recalled the members of one category together as a group; that is, they clustered words by category rather than recalling them in the order in which they were originally presented. In this study, the words and pictures used referred to categories in which members of one category were perceptually similar to each other and quite different from members of other categories.

Perlmutter, Myers & Sophian (note 2) presented 3- to 5-year-old children with boxes containing sets of familiar objects which the children were to recall later; one related set was composed of three objects from each of three general categories (mammals, vehicles, dishware), and one unrelated set was composed of nine objects from nine different categories at a similar degree of generality. While none of the children performed very well, more items were recalled from the related than from the unrelated set of objects. In general, conceptual clustering in reporting items occurred above chance levels. Perlmutter, et al. (note 2) also found that recall performance was greatly facilitated by presenting conceptually related items adjacently rather than randomly and by providing category cues at the time of retrieval. As in the Rossi & Rossi study, this study demonstrates that young children could make use of relatedness between items belonging to superordinate, general categories.

Wetherick & Alexander (1977) presented lists of words drawn from eight 'superordinate' categories (body parts, clothing, food, numbers, colors, names, classroom objects, kinds of movement, toys, kitchen objects, and furniture), to children 5- to 9- years of age, for immediate verbal recall. Recall was superior for word lists drawn from one category only, over words drawn from more than one category. This was apparent even in the youngest children. As in the Perlmutter, et al. study, it is apparent that 5-year-olds can make use of general superordinate categories, as shown by their facilitated recall.

In cued or free sorting classification tasks, which require sorting of items into categories, young children also demonstrate considerable knowledge that items can be organized into basic level categories and also into more general superordinate categories (Perlmutter & Myers, 1974; Rosch et al, 1976; Turgeon & Hall, 1977). Rosch, et al. (1976) used items from superordinate categories, such as clothing, furniture, and vehicles which also belonged to basic level categories, e.g.,shoes, pants, tables, chairs, beds, cars, trains, etc.. They found that all their subjects (5- and 6-year-old children) could classify items into basic level categories, and that approximately 50% of the children were able to classify the items into the superordinate categories. Half of their children, therefore, were able to spontaneously classify items at two levels of generality (i.e., an ankle sock was being classified as a sock, and also into a clothing category.) However, this type of sorting performance did not reveal whether the children simply knew that a particular item could be called by different names (e.g., car or vehicle) and could be sorted into separate categories, or whether they possesed a deeper understanding of the principles of hierarchical organization.

Turgeon & Hall (1977) also investigated the ability of subjects 4, 5, 8, and 18 years of age, to sort categories at different levels of generality. The task involved sorting several of a number of sets of eight items each into two piles. Each set contained four items that belonged to one category and four that belonged to another. The two categories in a set differed in degree of generality across sets. Four-year-olds were able to differentiate and classify items belonging to sets containing basic level categories, such as cars-boats, flower-trees, at approximately 65% accuarcy. As the two-category sets became more abstract, the 4-year-olds' accuracy of appropriate classification decreased. Thus, category sets such as landscapes-buildings, toys-tableware, etc. were classified appropriately with approximately 25% accuracy. Eight-year-olds, however, demonstrated a much higher degree of proficiency, as they appropriately classified these superordinate categories at a 96% level of accuracy.

In another study (Margand, 1977), 4- and 5-year-old children were able to differentiate items into the more general "animate" vs. "inanimate" superordinate categories, when cued by the experimenter. In the same study, six-year-olds differentiated animate and inanimate items spontaneously in a free sorting situation.

All of the above studies demonstrate that the ability to classify items into superordinate categories clearly increases with age, with 4- to 5-year-old children demonstrating ability to make use of both basic or concrete levels of categorization and superordinate categorization under cued-sorting conditions; that is, when they are given some guidance or instruction as to the categorization performance required of them. Some 4- to 5-year-old children even demonstrate spontaneous sorting of items according to two or more levels of categorization, and it is apparent that this ability improves or at least becomes more evident with increasing age.

In simple problem-solving tasks, such as oddity sorts and matching-to-target tasks, 3- to 5-year-old children do even better at categorizing items at more abstract superordinate levels than they do in the free sorting or cued-sorting tasks. Rosch, et al. (1976) presented four categories of animals -- cats, dogs, butterflies, and fish -- and four categories of vehicles -- cars, trains, motorcycles, and airplanes -- in groups of three pictures: two related at a basic level or two related at a superordinate level. She had children, 3, 4, 5, 6, 8, and 11 years of age, put the two pictures together that belonged together. For each age, basic level oddity sorts were virtually perfect. Fifty-five percent of the 3-year-olds, 96% of the 4-year-olds, and all of the older children would consistently pair together the items that were related at a superordinate level. This ability of the 4-year-olds to organize items in an oddity sort according to an abstract superordinate relationship was further demonstrated in a task employing animate vs inanimate items (Faw & Wingard, 1977).

The important point of all the above studies is that young children's performance in a variety of tasks indicates that they are making use of conceptual categories, that the categories used vary in level of generality, and that the ability increases between the ages of 3 and 6 years. A point raised earlier is still valid, however. To what extent do these children understand the principles of hierarchical organization: i.e., mutual-exclusion, horizontally, and class-inclusion, vertically?

II. The Use of Category Labels:

A parallel line of research, which investigates the cognitive capabilities in young children, comes from interest in language development, specifically, semantic development and concept formation. For example, as the child acquires new words and concepts, he learns to label different objects by the same name (e.g. an apple and a carrot are both labeled as "food"), and one object by two or more different names (i.e. a picture of an apple can be called an "apple" and a "food"). An examination of word frequency lists (Thorndke & Lorge, 1944; Rinsland, 1945) and free association responses to category names, in children, (Nelson, 1974a,b; Rosner & Hays, 1977) suggest that there are considerable developmental differences in the use of category names at different levels of generality.

Woodrow & Lowell (1916) found in a free association task that young children produced fewer superordinate responses than adults (e.g., they were more likely to respond "eat", or " red" to the word "apple" than "food", as an adult would do). In a study designed to compare the vocabularies of children and adults directly, Brown (1976) selected the first thousand most frequent words used by adults from the Thorndike-Lorge (1944) list and the first thousand most frequent words from the Rinsland (1945) list for children of the first grade. Nouns found in the list for adults but not in the list for children were often superordinate to those in the first thousand words of children. For example, frequent words in a child's vocabulary would include "apple", "car", "shirt", and "milk", but not "clothing", "food", or "vehicles", whereas these superordinate words would be found in lists of the most frequent words of adults. This suggests that adults are more likely to use superordinate terms to refer to things than are children. However, this does not imply that the young child does not comprehend the meaning of superordinate words nor make use of them at all, just that the young child more frequently uses specific or "basic level" words.

Anglin (1977) directly investigated the young child's ability to use category labels at different levels of generality to refer to a group of objects or things. He used the following 3-level hierarchies: boys-children-people; apples-fruit-food; roses-flowers-plants; volkswagen-cars-vehicles; dimes-coins-money; collies-dogs-animals; and sharks-fish-animals. For each hierarchy he made up posters each of which contained four pictures. The children (2- to 3-year-olds and 4- to 5-year-olds) were first asked to name each object depicted in the four pictures and then tc give a class name for all the pictures in a given poster (What are they all?). For example, when shown a poster containing a picture of a collie, a bulldog, a poodle, and a german shepherd, the child was required to first provide each specific name and then to produce a superordinate name (in this case, "dog" or "animal") that would refer to all fcur picture. This task was repeated with posters of animals and objects that could be labeled by the child at three different levels of generality. For example, the child was presented with four pictures of collies, which could be called all "collies", or all "dogs", or all "animals"; four pictures of dogs, which could be called all "dogs" or all "animals"; and four pictures of animals, which could be called only all "animals". In the analysis of the results, Anglin calculated, for each age group, the percentage of posters for which subjects in that age group were capable of giving some class name at each of the levels of generality, which were superordinate to all of the objects depicted on a given poster (e.g., "dog" or "animal" to the poster of four collies, and "animal" to the poster of four dogs).

It was clear that while adults produced an appropriate class name for all posters of pictures, children had much more difficulty. Generally, children were better at giving some appropriate class name (not necessarily the most immediate superordinate class label) for the posters which corresponded to the lowest level in the hierarchy than to posters corresponding to higher levels. For example, in a poster showing pictures of four different kinds of apples, 67% of the subjects produced an appropriate class name ("apple" or "fruit" or "food"), but only 47% of the subjects produced the class name "fruit" or "food" for the poster containing four different kinds of fruit, and 40% produced the class name "food" to the poster containing four different kinds of food. It was also apparent that while adults would generally provide the most immediate superordinate class label to classify the pictures, the children would often use a higher level superordinate or none at all. For example, pictures of collies were labeled as "dogs", not "collie", pictures of roses were labeled as "flowers", not "roses", and pictures of "monkeys" were labled as "animals", not "monkeys". At the same time, approximately half to two-thirds of the children were unable to produce the highest level superordinate class label for most of the category sets. For example, where an adult would label the pictures of the rose, tree, cactus, and rubber plant as "plants", the child would label them by their individual names or reply they didn't know. No child produced the superordinate "'transportation" and "people" labels. A child's ability to produce a superordinate label was clearly dependent on the type of stimuli used.

These results suggest that most young children are not very proficient at producing class labels for groups of objects at superordinate and specific levels. However, Anglin notes that the child's ability to comprehend these class labels may be superior and also, that the children in the study may not have understood the question, "What are they all?". They often produced the appropriate class label when identifying individual pictures (e.g. a picture of a collie is called a dog) but did not produce it to refer to a set of four pictures (e.g., label "dog" to refer to all of the dog pictures). Also, the fact that in many cases one category label is dominant, whether it be the intermediate or superordinate level, does not preclude the possibilty that the young child may comprehend the use of the less dominant label.

Dunn (note 3) found that when 2- to 3-year-old children were given items belonging to the categories of food, animal, and clothing, and asked them to identify all items belonging to each of these categories as labeled by the experimenter, all the subjects answered correctly. In a subsequent task, subjects were also all able to produce a label for the items.

In a production task (Rosner & Hayes, 1977), preschool and grade school children were given category labels (animals, furniture, clothes, and food), and asked to verbalize instances of the category. All responses were judged for their category approriateness. It was found that among preschoolers, the mean number of responses were as follows: animals - 12.19; furniture - 9.22; clothes - 9.78, and food - 10.79. Of these responses, most of the responses for all category sets were appropriate. Thus, these five-year-olds were able to produce appropriate names of items belonging to semantic categories, and could appropriately refer to things by at least two class labels.

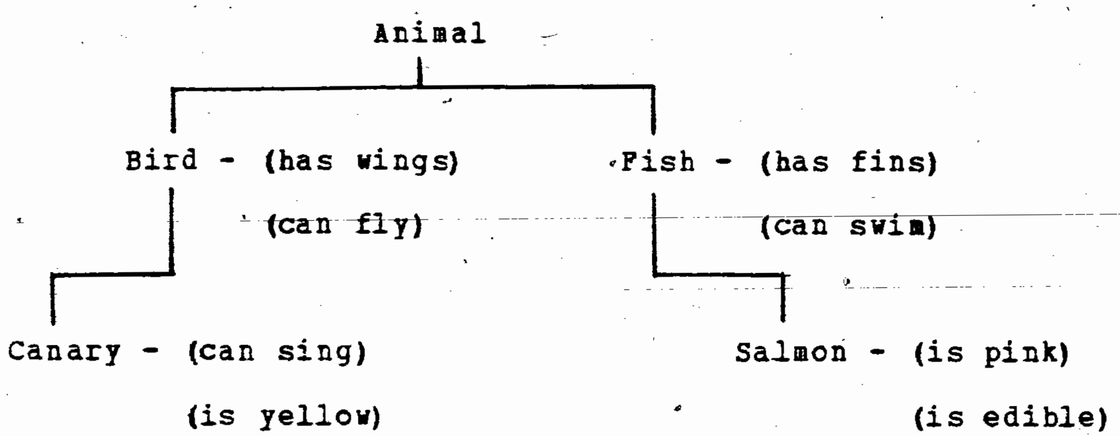
Nelson (1974a) provided 5- to 8-year-old children with the category labels of furniture, clothes, tools, insects, animals, flowers, vegetables, and colours and required them to produce names of things belonging to these classes. Most 5-year-old chilren were able to name things belonging to the categories of vegetables, tools, furniture, clothes, colours, and animals. Approximately a third of the children were unable to provide names of things belonging to the categories of flowers, fruit, and insects.

The research reviewed in this section, just as that reviewed in the previous section, suggests that a majority of 2- to 5-year-old children can classify various objects or things at two or more levels of generality but that the level of generality of particular class labels spontaneously used by children varies depending on the particular objects being categorized. As before, the question remains as to whether children have simply learned multiple labels for the same objects, or whether they have an understanding of class-inclusion and mutual-exclusion in hierarchically organized categories.

III. Semantic Memory Research:

While the previous sections dealt with young children's direct use of category labels, the line of research considered in this section is concerned with how more direct performance measures, e.g. reaction time, can be used to reveal a hierarchical organization of concepts in memory. A concept in memory is indexed by a word and, for this reason, "word" and "concept" are typically used interchangeably in this research. For the same reason, one speaks of semantic organization instead of conceptual organization. There has been a considerable amount of research and writing on sematic memory and organization in the past ten years (see Smith, 1976, for a review), most of it done with college students. Recently, there has been a developing interest in semantic organization in children. This research can be understood in terms of Quillian's hierarchical network model of memory (Quillian, 1969; Collins & Quillian, 1969). According to this model, semantic information is stored in a hierarchical network such as that shown in Figure 2.

Figure 2. Quillian's Hierarchical Network Model (Quillian, 1969)



We are concerned here with only one of the major properties of this model, namely, that different words at different levels of generality occupy different levels in the hierarchy. Thus "canary" is at the lowest level, "bird" at the next highest level, and "animal" at the highest level in the hierarchy shown in figure 2. The implications of this model for certain types of tasks, on the assumption that "canary" and "bird" are closer than "canary" and "animal", are straightforward. In a reaction time task, for example, it is predicted that the verification of the sentence, "A canary is a bird," would be quicker than the verification of the sentence, "A canary is an animal." Verification is quicker because there is only one relational link between "canary" and "bird" and two links between "canary" and "animal."

While not everybody agrees with the details of Collins & Quillian's model (see Anderson & Bower, 1973; Norman & Bobrow, 1976, and Smith, Shoben, & Rips, 1974), it is generally agreed that semantic concepts are organized in hierarchical class relations. One property of such an organization would be that there should be more retrieval confusion between closely related subset-superordinate terms (e.g. bird-to-canary) than between distantly related subset-superordinate terms (e.g. canary-to-animal).

Thus, Steinberg & Anderson (1975) attempted to determine whether the semantic organization of kindergarten and first grade children could be understood in terms of a hierarchical network model. They presented 5- to 6-year-old children with a series of target pictures. After each target picture (paired with a distractor picture), the child was given a retriveal cue, and asked which picture made them think of the 'retrieval cue' word. The retrieval cue consisted of the target noun (the picture label) and four related words. The related words were a close superordinate (CS), a remote superordinate (RS), a close cohyponym (CC), and a remote cohyponym (RC). Cohyponyms were words which name members of a common class. For example, for the target picture 'dog', the close cohyponym was 'cat', the remote cohyponym was 'hippopotamus', the close superordinate was 'pet', and the remote superordinate was 'animal'. Target pictures and related words were chosen from the categories of animals, clothes, eating utensils, food, measurement, people, toys, and vehicles.

Steinberg & Anderson found that there was almost perfect recall of pictures when the retrieval cue was the noun naming the target picture. 85% of the pictures were recalled as a function of the close superordinate cue and approximately 70% as a function of both the remote superordinate cue and the close cohyponym word. Only 40% of the pictures were recalled as a function of the remote cohyponym cue. In all categories, except the people category, the close superordinate led to better recall than the remote superordinate. Both the close and the remote superordinate are seen as more closely related to the target picture than the close or remote cohyponym.

These results suggest that 5- to 6-year-old children have organized words in terms of subordinate-superordinate, semantic relations or, rather, that these types of relationships are stronger than other types of semantic relationships.

Mansfield (1977) employed a false recognition task to determine the extent to which young children encode words along the same semantic dimension used by adults. Mansfield reports that studies of false recognition in kindergarten children have found that words strongly associated with target words are more likely to be falsely recognized than are unrelated words. Mansfield studied 5-year-olds , first-grade, and third-grade children. A child was presented with a sentence, followed by an additional (probe) word, and asked to decide whether the probe word following the sentence had also been present in the previously presented sentence. Target-probe word pairs were related in a number of systematic ways, among which were superordinate-subordinate (e.g., tools-hammer) relations, subordinate-superordinate (e.g., horse-animal) relations, and no relations (e.g., apple-clothes).

Mansfield found that the superordinate and subordinate relationships elicted highly significant recognition confusion in the kindergarten, first grade and third grade children. Recognition confusion was stronger if the target-probe relationship was subordinate-superordinate than if they were in the reverse order.

Heidenheimer (1978) also used a false recognition task to compare the respective roles of exemplar (subordinate), action coordinate, and superordinate relation in the semantic processing of young children. Four- and five-year-old subjects were read a list of words and then read the words on a second list. After each word on the second list, the child was asked to indicate whether they had heard that particular word on the first list. The probe words were related to a word in the first list in one of four ways: exemplar (e.g. first list word "fruit, probe word "apple"), action ("dog"-"bark"), coordinate ("couch"- chair"), and superordinate ("shirt"-"clothes"). Heidenheimer found that more false recognition errors occurred to the exemplar probe words than to any other words, but that the number of errors caused by the superordinate probe word was very low. Although Heidenheimer concluded from the latter results that 4 and 5 year old children do not make use of the superordinate, class-inclusive relations when they are encoding information, the fact that there was considerable confusion when the children were first presented with a superordinate word and then presented with an exemplar of that superordinate word (a subordinate word), suggest that the superordinate-exemplar relationship is in fact evident among 4- and 5-year-olds, but not in the direction expected by Heidenheimer.

The semantic memory research just reviewed is important in that it shows that children possess subordinate-superordinate relational links between specific concepts. This can be taken as indirect evidence for the existence of class-inclusion. In this sense, this research goes beyond the research reviewed in the previous two sections since all that that research showed was an ability to use multiple labels, but not the existence of subordinate-superordinate links. Still, the semantic memory research has not addressed the question of mutual-exclusion, nor has it addressed the question of class-inclusion in a direct way; that is, it has not examined the situation in which the links between several subordinate categories and one superordinate category are considered simultaneously.

IV. Class-Inclusion Research:

A more direct attack on the question of whether children understand the logical implications of conceptual hierarchies with regard to class-inclusion was originated by Piaget. Inhelder & Piaget (1958) tested young children's understanding of the priciples of class-inclusion by presenting 5- to 10-year old children with pictures of flowers consisting of yellow primulas and other color primulas. The child was then questioned as to whether there were "more primulas or more flowers". In many cases, after answering this direct question, the child would be asked for a verbal explanation of his answer. The type of verbal explanation given was crucial for Inhelder & Piaget to decide whether the child had or had not mastered class-inclusion.

Based on this method, Inhelder & Piaget concluded that not until approximately eight years of age, did the child understand formal class-inclusion and that "the whole retains its identity although it is conceptually separated into its component parts" (p. 109). Interestingly, Inhelder & Piaget found that subjects did much poorer on questions relating birds to animals, and subsequently concluded that, since classes of animals are more abstract than classes of flowers, the ability to manipulate more abstract classes lags behind the ability to manipulate concrete, familiar classes.

Since this original research, much additional research has been generated attempting to discern why children fail on the class-inclusion questions, and what are the implications for assessing the child's knowledge of class-inclusion.

Smedslund (1965) investigated the idea that the removal from sight of the stimuli defining the classes would facilitate the task of comparing subclass to total class. Smedslund (1964) used pieces of linoleum, consisting of round white pieces and square white pieces. The stimuli were actually present, then covered immediately prior to the class-inclusion question, and then uncovered and the question repeated. Smedslund found that there was a rapid onset of the ability to pass the class-inclusion question, from total failure before age five to almost total mastery after age seven. 50% of the six year olds were able to answer the questions correctly. He also found that almost 15% of the youngest children could pass the questions with the objects covered up, but failed when the objects were visible.

Wohlwill (1968) followed up Smedslund's ideas by using natural categories (e.g. owls and other birds; roses and flowers, dogs and animals) and found that 4- to 5-year-old children did signficantly better when questions were asked without reference tc actual pictures than when pictures were available. Wohlwill found that instructions to count the elements of the superordinate class and then those of the subordinate class, also facilitated performance, although not as much as the pure verbal questioning did. These results led Wohlwill to suggest that the traditional class-inclusion question, presented with two contrasting subclasses, resulted in a strong perceptual set to translate the class-inclusion question into a subset comparison question. He also noted that class-inclusion performance did not correlate with other types of Piagetian logical reasoning tests and suggested that class-inclusion responses should be related to the performance of children on tasks "involving a hierarchical organization among subclass, class, and superordinate class" (p. 464).

Ahr & Youniss (1970) used paper cutouts of cats and dogs, and red and yellow flowers, and varied the proportions between the subclasses (e.g, from four dogs and four cats to eight dogs and no cats) and the relational term used in the class-inclusion question (more A or more B, versus fewer A or fewer B). They found that the subclass ratio had a very strong effect: the greater the inbalance between subclasses, the more frequent the errors. Errors were also generally in favor of the larger subclass. Peformance was greatly facilitated on tasks in which equal size subclasses were used, in tasks in which the class-inclusion question was expanded to facilitate a subclass-superordinate interpretation of the question rather than a subclass comparison, and on tasks in which corrections were provided. Ahr & Youniss concluded that the "primary reason for children's failure is their persistent comparison of subclasses to the exclusion of considering one subclass in relation to the supraordinate class" (p. 141). The format of questioning biases subjects to focus on the numerical difference between subclasses. "That the same children who focused on the subclass difference initially could with non-information giving correction immediately refocus on the inclusion relation suggests that they had understood inclusion, but failed to perform appropriately. (p. 142)"

Recent experiments by Markman (1973; 1978) have shown that first grade children are much more successful in answering class-inclusion type questions when classes and subclasses are designed without using exact natural language labels. Markman (1973) made use of the concept 'family' and asked questions, such as; "Here is a picture of a family of dogs, here are mother and father dogs, and here are baby dogs. Now, who would have more pets, someone who owned baby dogs or someone who owned the family?" In another experiment, Markman (1978) manipulated part-whole comparisons involving classes. In two conditions, one in which the display was hidden from the child, so that empirical (counting) means of making a judgment was withheld, and the other in which the child was given information about a novel class and was told it was subordinated to a familiar class, she found that subjects manipulating collections had superior performance. Many children manipulating classes were not able to answer the class-inclusion problem correctly when 'empirical' means of quantification were unavailable. Markman thus concluded that initial success in class inclusion type questions is achieved by an emprical (object counting) approach to the problem rather than the use of logical principles. She states, however, that the relatively young child does have at least a rudimentary ability to appreciate logical principles.

In a review of the class-inclusion research, Klahr and Wallace (1972) note that the failure on the traditional class-inclusion task can be characterized either as a processing failure or as an encoding failure. A processing failure arises when the child is unable to appreciate the relationship of a subclass to a superordinate, and make the appropriate size-comparisons. An encoding failure results from a misinterpretation of the class-inclusion instruction, leading to a comparison between two related subclasses. This latter explanation seems to be the position taken by most researchers. Wohlwill notes that "even to an adult there apprears something tricky about a question such as "are there more pears or more fruits?"" (p.462)

None of these researchers, however, discard the notion that the child's conceptual and classification abilities go through stages of development, but only contend that the traditional class-inclusion question is not a very precise means of determining the young child's true knowledge and use of subclass-superordinate relationships, nor of hierarchical classification structures in general.

Thus it has been well documented that young children can not verbalize knowledge of a hierarchical organization of categories, and yet they demonstrate surprising ability to classify objects and things at different levels of generality, to make use of part-whole relations or subordinate-superordinate relations and to provide category labels for items at the different levels of generality. Yet none of the research reviewed has simultaneously addressed the two fundamental principles necessary for a hierarchical organization of categories: the mutual-exclusiveness of categories at the horizontal level, and class-inclusion of categories at the vertical level.

The present thesis attempted to do just this. Study 1 used natural categories. Study 2 used arbitrary categories. The purpose of the first study was to measure whether 5- to 6-year-old children understood and made use of the hierarchical organization of familiar categories, employing both the principles of class-inclusion and mutual-exclusion of categories. In this study, an identification and sorting task were used as the main means of addressing the basic issues. However, in order to explore every aspect of a child's behaviour in classifying objects, particularly hierarchical organization, two additional tasks were included: Piaget's class-inclusion questions and multiple-label questions. Multiple-label questions either asked subjects whether objects could be labeled by two names (e.g., "Is this (picture of apple) called a fruit and a food?"), or asked them to find objects that were labeled by two names, (e.g., "find a picture that is called a fruit and a food").

The main purpose of study 2 was to teach some of the same 5- to 6-year-olds tested in study 1 a hierarchy of arbitrary (artificial) categories. In the first phase of study 2 children were taught the 'vertical' links between the first and second level, and between the second and third level of a three-level hierarchy. The question was, could they infer the entire hierarchical structure from having learned the separate links? A second question concerned whether the children could show that the 'horizontal' level-2 categories were mutually-exclusive, as well as demonstrate understanding of the class-inclusive 'vertical' structure. The second phase of study 2 consisted of a replication of the sorting experiment of study 1, with one of the original sets of natural categories. Since the same subjects were utilized in study 1 and study 2, it was possible to determine (a) whether those subjects who had shown knowledge of hierarchical organization of natural categories in study 1 also learned a hierarchy of arbitrary categories, and (b) whether those subjects who had not shown knowledge of the hierarchical organization of the natural categories in study 1, but who had learned the arbitrary hierarchy in the first phase of study 2, would also show knowledge of hierarchical organization of the natural categories in the repeated sorting task (in the second phase of study 2).

STUDY 1

METHOD

Subjects:

Ninety-six subjects, 48 boys and 48 girls, were randomly chosen from the kindergarten classes of five elementary schools within the Coquitlam School Board District. Approximately 20 children, half female and half male were selected from each class. The children ranged in age from 5 years 4 months to 6 years 8 months, and the mean age was 5 years 10 months.

Stimuli:

Two sets of pictorial stimuli were used in the study. Pictures were cut out from magazines and pasted on 10 x 15 cm cards. One set, called the food stimulus set, consisted of 16 pictures. Four stimuli exemplified the subordinate category 'fruit' (apple, banana, strawberries, and grapes), four exemplified the category 'vegetable' (carrots, corn, tomato, and peas), four pictures were 'other food' (roast chicken, salad, eggs, and a piece of pie), and four pictures were 'nonfood' (mouse, frog, horse and cat). Figure 3 presents the hierarchical organization of these stimuli. The second set, called the animal stimulus set, consisted of 16 pictures, four pictures representing the category 'bird' (owl, seagull, eagle and duck), four representing the category 'dog' (collie, german shepherd, poodle and bulldog), four pictures representing additional 'other animals' (mouse, frog, horse, and cat) and four pictures representing 'non-animals' (tomato, eggs, banana, and roast chicken). Figure 4 presents the hierarchical organization of these stimuli.

Figure 3: Hierarchical organization of food category stimulus set

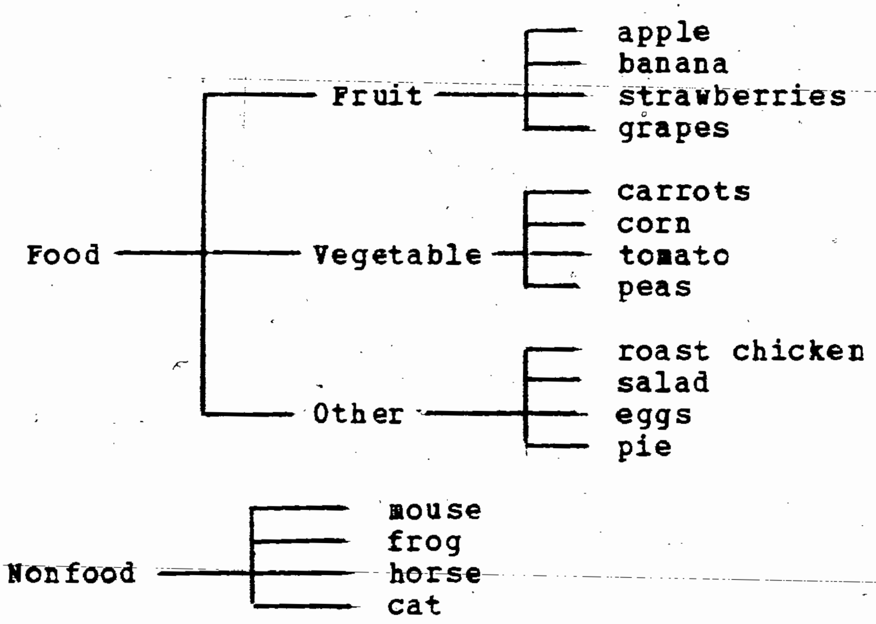
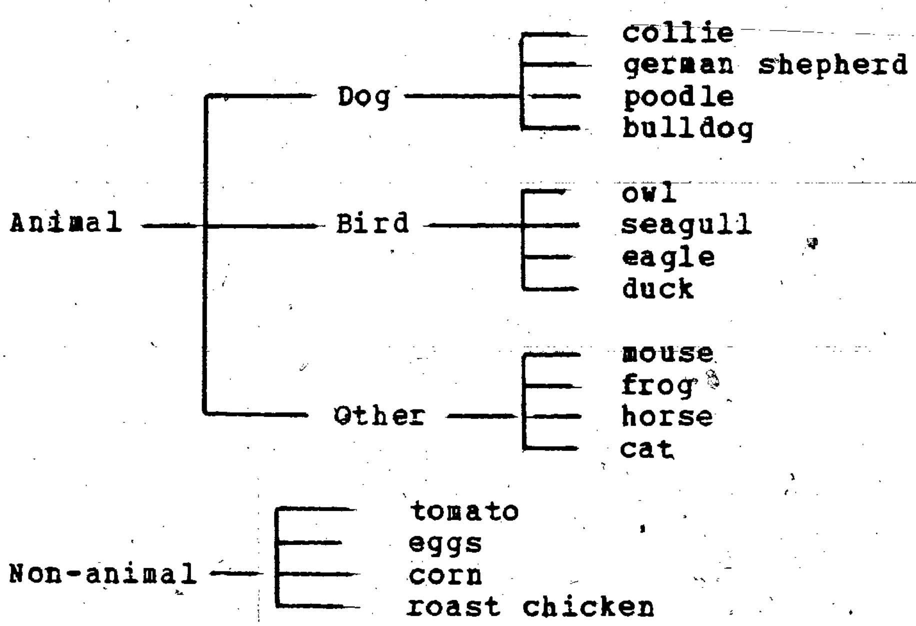


Figure 4: Hierarchical organization of animal category stimulus set



These items and these categories were chosen because previous research (Rosch, 1975; Turgeon & Hall, 1977; and Anglin, 1977) indicated that 5- to 6-year-old children can classify such items correctly into categories such as fruits, vegetables, foods, birds, dogs, and animals. Therefore, the categories are highly familiar to young children, the items are typical exemplars of the categories and, in most cases, the children can distinguish and label the specific objects. The specific names of the stimulus pictures are also common words appearing on the word frequency lists of young children (Rinsland, 1945).

Procedure:

Each child was individually tested by a single experimenter in an isolated room. Twenty-four boys and 24 girls were randomly assigned to the food stimulus set and 24 boys and 24 girls to the animal stimulus set.

Identification Task:

Each child was presented with all 16 pictures, in two sets of eight pictures each. In the first set, two of the eight pictures were randomly chosen from the four that belonged to the category being tested, and the other six were randomly selected from the remaining twelve stimuli. The second set consisted of the 8 remaining items. Each child was asked to identify pictures belonging to, say the category 'fruit' (i.e., show me the fruit pictures?) for each set. Then, all pictures were scrambled, again presented in two trials of eight pictures each, and the child was asked to identify pictures belonging to the category 'vegetable'. Pictures were again scrambled and the child was asked to identify the pictures belonging to the 'food' category. The same procedure was followed for children presented with the animal pictures, and they were asked to identify all pictures belonging to the categories, bird, dog, and animal. Each child was asked to point out pictures and not to sort or put them together. The experimenter felt that any sorting or grouping of the pictures might result in associations between pictures because they were perceptually similar, and might not indicate a direct association between a particular picture cf an object and a referent (category) name. Only eight pictures were presented at one time as it was discovered that children could not attend to all pictures in a display consisting of 16 pictures.

This procedure allowed the child to select any of the sixteen pictures as belonging to the category labeled by the experimenter. Since all sixteen stimuli were used in each identification task, the procedure did not demand that the child identify mutually-exclusive catgories, nor that each item be identified by both an intermediate category name and a superordinate category name. The child could potentially identify the stimuli by none, one, two, or three different names. And the categories could potentially overlap in any idiosycratic pattern chosen by the child, as he identified the pictures by the category label available on any particular trial.

For each stimulus set the three category conditions were presented in six possible presentation orders: food-vegetable-fruit; food-fruit-vegetable; fruit-food-vegetable; fruit-vegetable-food; vegetable-food-fruit; vegetable-fruit-food; and bird-dog-animal; bird-animal-dog; animal-bird-dog; animal-dog-bird; dog-bird-animal; bird-animal-dog. Four boys and four girls were randomly presented with each category presentation order.

Sorting Task:

In this task, the same stimuli were used as in the identification task. Each child was presented with all the items in the stimulus set and asked to sort the pictures belonging to, say the category 'fruit', into a single pile (e.g., "put all the pictures of fruits into a pile.") Then, while leaving the pile of fruits pictures intact in front of the child, the child was asked to "put all the pictures of vegetables into a pile." The above procedure was likewise followed for children sorting the bird and dog categories. All children were asked to sort the fruit, then the vegetable category; and in the case of the animal pictures, the bird, then the dog pictures. Finally, while retaining both piles of pictures in front of the child, with all remaining pictures also in view, the child was asked to "put all the pictures of food into one pile". Likewise, children presented with animal pictures were asked to "put all the pictures of animals into one pile". The particular sorting strategy utilized by the child to create the superordinate category was specifically noted.

Class-inclusion and Mutiple-Label Questions:

In addition to the two formal experimental tasks, each subject was asked two Piagetian class-inclusion questions: "Are there more fruits than food?", and, " Are there more vegetables than food?" Animal stimulus set children were asked, "are there more birds than animals", and "are there more dogs than animals?" The children were alsc prompted to provide an explanation for their answer. In addition, the childen were asked a series cf mutiple-label questions. Children with food pictures were shown a picture of a fruit (e.g. an apple), and asked, "Can this be called a fruit and a food?". If the child replied, "Yes" he was encouraged to provide an explanation. Then the child was asked to locate other pictures on the table that were both fruit and food ("Find me other pictures that are both fruit and food"). If the child replied "No" to the first question, he was asked for an explanation. Then additional pictures were presented to the child with the same questions being asked. The purpcse of these questions was to elicit the child's thoughts on whether the pictures could be called by two names, and why they could be so named. The above multiple-label questions were repeated with the vegetable items; similar questions were asked of children tested with animal pictures.

STUDY 1

RESULTS

Preliminary analysis of the data revealed that there were large, consistent differences between children classifying stimuli belonging to the animal stimulus set, and children classifying stimuli belonging to the food stimulus set. Therefore all additional analysis and discussion of results undertaken differentiate between the two groups of children.

Additional preliminary analysis revealed that there were no differences on any performance variables between children from different school populations, and between children with different presentation orders in the identification task. This was true for both stimulus set groups. There were no consistent sex differences on any performance variables for children with the food stimulus set, or the animal stimulus set.

Identification Task:

Peformance on the first identification task was analyzed in terms of the following dependent measures. In all cases, appropriate performance means adult-like behaviour. For example, a child was scored appropriate when asked to identify items belonging to the category fruit, if he pointed to the pictures of the apple, banana, grapes, and strawberries, and nothing else.

(1) Specific Identification:

This variable was measured in terms of accuracy at identifying each specific stimulus (labeled by the experimenter). For example, "Find the picture of a collie?" This variable was scored: all 4 correct; 3 out of 4 correct in each intermediate category set, (e.g., dog and bird); and less than 3 identifications correct within each intermediate category set.

(2) Intermediate Identification:

This variable was a measure of the degree to which children appropriately identified stimuli at the intermediate category level, as labeled by the experimenter. For example, "find all the pictures of dogs" For each category, this variable was scored: all appropriate stimuli only; all appropriate plus additional inappropriate stimuli (overgeneralized); appropriate but less than the possible total set, i.e. 3 stimuli or less (overdiscriminated); and a mix of some but not all appropriate stimuli and some inappropriate stimuli (mixed).

(3) Superordinate Identification:

This variable was concerned with the degree to which children accurately identified all appropriate stimuli at the superordinate level, as labeled by the experimenter. For example, "Find all the pictures of animals" For each category, foods and animals, this variable was scored: all appropriate stimuli identified correctly; one missing stimulus; and 2 or more 'misses'. (No child included non-category stimuli in the superordinate category, e.g,. identifying the roast chicken as an animal.)

(4) Intermediate and Superordinate Identification:

This variable is a measure of the degree of consistency in which the stimuli identified at the intermediate level are also identified at the superordinate level, e.g. a picture which is identified as a dog is also identified as an animal. This variable was scored: complete consistency, in which all stimuli correctly identified at the intermediate level are all identified at the superordinate level; one error, in which one intermediate stimulus is not identified at the superordinate level; and two or more errors. In scoring for consistency, the appropriateness of the stimuli with regard to the category label was not considered.

(5) Specific, Intermediate and Superordinate Identification:

This variable measures the degree to which stimuli identified at the specific level, are consistently identified at both the intermediate and superordinate levels, e.g., a picture which is identified as an apple, is also identified as a fruit, and also as a food. This variable was simply scored: all stimuli identified consistently at the three levels; or not all stimuli consistently identified at the three levels. Again, appropriateness of category-stimuli identification was not scored here.

(6) Mutual-exclusion:

This variable measures the degree to which the two intermediate level categories (i.e. fruit and vegetable) are mutually-exclusive. For example, pictures initially identified as fruit, are not later identified as vegetables and similarly pictures identified as vegetable. are not later identified as fruit. This variable was simply scored: both categories are mutually-exclusive or they are not mutually-exclusive.

Table 1 presents the percentages of subjects within each of the two stimulus sets who had completely adult-like 'appropriate' classification behaviour on each of the performance variables. Inappropriate classification or error patterns are examined later. Chi-square analysis was performed on all differences in percentages of children appropriately identifying animal pictures versus children appropriately identifying food pictures.

Table 1. Percentage of animal set children vs food set children with appropriate classification behaviour.

	Animals		Foods	
1. Appropriate specific identification		2		96
2. Appropriate intermediate identification	both	56	both	31
	bird	56	fruit	61
	dog	96	veg	38
3. Appropriate superordinate identification		81		88
4. Intermediate-Superordinate Identification		52		71
5. Specific-Intermediate-Superordinate I.D.		2		67
6. Mutual-exclusion		100		71

As shown in Table 1, children with the food set performed better than children with the animal set in the specific identification task (χ^2=84.8, df=1, p<.000). Only 2.1% of the children could correctly identify all the animal pictures by their specific label. Although identification of stimuli at specific name levels was significantly poorer for children with animal pictures, intermediate level identification tended to be better with the animal pictures (56% appropriate performance across both dog and bird categories) than with the food pictures (31% appropriate performance across both vegetable and fruit categories). However, this difference was not statistically significant. An examination of the individual intermediate categories revealed that performance with the vegetable category was significantly lower than with any other intermediate category, but that there were no statistically significant differences among the other three categories.

A high percentage of children were able to identify all appropriate pictures at the superordinate level (81% and 87%, in the animals and foods sets, respectively). There was no difference between the food set and the animal set in terms of children's ability to identify items at the intermediate and superordinate level. With regard to the ability to classify stimuli at three levels of generality (specific, intermediate & superordinate), performance with the food set (66%) was significantly superior to that with the animal set (2%), (χ^2=41.55, df=1, p<.001).

Finally, the results show that all children with the animal set could identify pictures into appropropriate mutually-exclusive bird and dog categories, whereas only 71% of the children could classify the food pictures into mutually-exclusive fruit and vegetable categories. This difference between the two groups was statistically significant ($\chi^2=14.3$, df=1, $p<.001$). The patterns of inappropriate classsifications are examined later.

The most significant information contained in Table 1 concerns variables 4 and 6, intermediate-superordinate identification and mutual- exclusion of identified categories. It has been argued that knowledge and use of the hierarchical organization of categories is dependent on knowledge and use of both principles of mutual-exclusion and class-inclusion. Implicit in the notion of class-inclusion is the notion that objects can be labeled at two or more levels of generality. Therefore this study was concerned with determining the extent to which children would identify stimuli as belonging to two intermediate level mutually-exclusive categories, and simultaneously identify all intermediate level stimuli at a common superordinate category level. As illustrated in table 2, approximately half (52%) of the children identified pictures into mutually-exclusive intermediate level categories, and simultaneously appropriately identified all stimuli at both the intermediate and superordinate level. This pattern of identifying pictures would be what would be expected from knowledge of hierarchical organization and is thus referred to as 'hierarchical identification', and the children using it 'hierarchical utilizers', in further discussion of the data.

Table 2. Percentage of children identifying stimuli into mutually-exclusive categories and also at intermediate and superordinate category levels as a function of stimulus set.

Stimulus Set	Intermediate Identifying	Intermediate-Superordinate	
		all correct	not all correct
Animals	mutually-exclusive	52%	48%
	not mutually-exclusive	0	0
Foods	mutually-exclusive	52%	19%
	not mutually-exclusive	19%	10%

There were differences between the two stimulus sets in the type of errors that occurred. As illustrated in Table 2, all children classified specific stimuli into the mutually-exclusive dog and bird categories, but 48% of them failed to identify some of the stimuli as both dog and animal, or both bird and animal. Most often, the error occurred as a failure to label a particular picture of a bird (e.g. owl) as an animal, altough it typically was labeled as a bird along with other pictures of birds; some subjects identifying the food stimuli failed to identify the stimuli into mutually-exclusive categories (19% + 10%), some failed to identify the stimuli at both the intermediate and superordinate level (19% + 10%), and some (10%) of the children failed to appropriately identify the stimuli on both principles.

Sorting Task:

Peformance on the sorting task was analyzed in terms of the following dependent variables.

(1) Intermediate Sorting:

This variable is a measure of the accuracy with which stimuli were appropriately sorted into the intermediate level categories, labeled by the experimenter. For each category, this variable was scored in the same manner as the intermediate identificaticn variable: appropriate category scrt; overgeneralized category sort; overdiscriminated category sort; and mixed category sort.

(2) Superordinate Sorting Strategy:

This variable measured the type cf sorting strategy used by each child to produce the superordinate category, as labeled by the experimenter, ("put all the foods in one pile"). This variable was scored in terms of four sorting strategies. The first 'appropriate-spontaneous' sorting strategy consisted cf grouping the two previously created intermediate categories into one pile and adding all additional 'superordinate category' stimuli to create one large superordinate category, consisting of all 12 appropriate pictures. The second 'appropriate-prompting' sorting strategy, was the same as the first, but the children utilized it only under experimenter's prompting. In the third 'horizontal' sorting strategy, the child simply grouped together the remaining four appropriate superordinate category stimuli, excluding the previously created intermediate categories and their stimuli. The fourth 'other' sorting strategy was simply any sorting strategy not defined above.

Table 3 presents the percentage of children who correctly sorted the pictures of animals and foods, at the intermediate level and who appropriately sorted the intermediate categories into a superordinate category.

Table 3. Percentage of children correctly sorting at the intermediate level and the superordinate levels as a function cf stimulus set.

Sorting Level	Animals	Foods
1. Intermediate sorting	both 63% bird 65% dog 96%	both 10% fruit 46% veg 10%
2. Superordinate (Appropriate, spontaneous + prompting)	71%	47%

As can be seen from table 3, 47% of the children with the food set and 71% of the children with the animal set created the superordinate category following a completely appropriate strategy, i.e., by grouping together the two previously created intermediate level categories, and adding the remaining four stimuli that belonged to the superordinate category. For example, they combined the pile of bird pictures with the pile of dog pictures, and added all other animal pictures to produce the superordinate category, 'animal'. The difference between stimulus sets was significant (χ^2=4.3,df=1,p<.05). Of the children who did not show the appropriate superordinate sorting strategy 15% with the animal categories and 31% with the food categories showed the 'horizontal' sorting strategy, i.e., they put into the superordinate category only the four stimuli left after sorting the intermediate categories. The remaining children (15% with animal and 22% with the food, respectively), demonstrated idiosyncratic superordinate sorting strategies.

Performance across Identification and Sorting Tasks:

The performance of the children across the identification and sorting tasks, was first analyzed in terms of the consistency with which specific stimuli identified by a category label in the identification task, were sorted into the same categories in the sorting task. For example, whether 'apple' is identified as a fruit in the identification task, and also sorted into the fruit category in the sorting task. Both appropriate and inappropriate stimuli were scored for category consistency across tasks. For example, if 'corn' is identified as a fruit in the identification task and also sorted into the fruit category in the sorting task, this would be scored consistent categorization. This variable was simply scored: either all stimuli were consistently classified within categories across tasks or they were not. Whereas 85% of the subjects were consistent in classifying animal stimuli into intermediate level categories, only 56% of the subjects with food stimuli were consistent. This was significant ($\chi^2 = 8.5, df=1, p<.01$).

In order to more fully compare children's performance across tasks, response patterns on both intermediate identification and intermediate sorting were examined in detail. As mentioned earlier (see page 42), in addition to the completely appropriate classification pattern, classification patterns were judged as to whether subjects had overgeneralized the category (i.e. including inappropriate stimuli in addition to the appropriate ones); overdiscriminated the category (e.g. identifying less than 4 pictures available); or had produced a mixed structure (e.g. some appropriate stimuli and some inapropriate stimuli). The results showing the classification patterns in the identification and sorting task are presented in Table 4. It can be seen from this table that about half of the children appropriately identified and sorted the fruit category, with some of the remaining children overgeneralizing and some overdiscriminating the category.

Subjects were not sc clear about the category vegetable, and many of the children (64% & 90% in the identification and sorting tasks respectively) had inappropriate classification patterns. Most subjects in both the identification and sorting tasks appropriately classified the dog and bird categories. All children who inappropriately classified the bird and dog categories overdiscriminated the categories.

Table 4. Percentage of children identifying (I) and sorting (S) stimuli at the intermediate level as a function of completely appropriate, overdiscriminated, overgeneralized and mixed patterns of respondng

Type of classification	Fruit		Vegetable		Bird		Dog	
pattern	I	S	I	S	I	S	I	S
completely appropriate	60	46	38	10	56	65	96	96
overdiscriminated	8	21	13	27	44	35	4	4
overgeneralized	15	19	33	31	0	0	0	0
mixed	17	15	17	31	0	0	0	0

By dummy coding each classification pattern, 1 or 2 (the child either performed in that manner or not), it was possible to determine whether there was a correlation between the classification pattern utilized by a child in the identification task and the classification pattern utilized by the child in the sorting task. All correlations are Pearson r product-moment correlations done on dichotomous variables.

Although, typically, this kind of relationship is reported as a phi coefficient, in this thesis they will be referred tc simply as correlations. The results indicate, as shown in Table 5, that there were significant correlations between the classificaticn patterns exhibited in the identification task and those exhibited in the sorting task. As can be seen from Table 5, children who classified all items appropriately for all categories in the identification task, generally classified stimuli appropriately in the sorting task (r =.74,.44,.75,.48 for the fruit, vegetable, bird, and dog categories, respectively). Children who cverdiscriminated the dog and bird categories in the identification task, did the same in the sorting task (r=.48,.75). It can be noted that children were much less consistent across tasks when dealing with the vegetable category. Confirming previous analysis, this indicates that these five year cld children did not have a clear understanding of the category vegetable.

Table 5. Correlations between type of classification pattern in the identification and sorting tasks.

Classification Pattern	Fruit	Vegetable	Bird	Dog
completely appropriate	.74***	.44***	.75***	.48***
overdiscriminated	.40**	.19	.75***	.48***
overgeneralized	.56***	.29*	no cases	no case
mixed	.61***	.42**	no cases	no case

*** p<.001
** p<.01
* p<.05

The next question was to determine whether there was any relation between the intermediate-level classification pattern utilized by the children and their ability to make use of the hierarchical organization of categories. That is, do young children need to be able to classify items appropriately at the intermediate level before they are able to produce, or simply make use of a hierarchical organization of these classes.

The results of the analysis were (a) that hierarchical identification (see page 45) was not consistently related to appropriate intermediate sorting, (b) that intermediate sorting was not related to hierarchical sorting, and (c) there was no significant correlation between hierarchical identification and hierarchical sorting of the food stimuli. There was a significant, though small, correlation between hierarchical identification and hierarchical sorting of animal stimuli ($r=.30$, $p<.01$).

On the whole these results do not indicate any consistent significant relationship between the classification patterns (or even the classification of specific pictures) that a child may employ in classifying items at an intermediate level and their use and knowledge of hierarchical organization. Even children who were consistent in utilizing an appropriate intermediate level classification pattern, generalizing from one task to another, did not seem to understand, or at least make use of the hierarchical organization of categories.

Class-Inclusion and Multiple-Label Questions:

Peformance on class-inclusion and the multiple-label questions was examined to determine whether answers were related to the child's classification behaviour in the identification and sorting tasks. The four Piagetian class-inclusion questions, one for each intermediate level category, (e.g. Are there more animals than dogs?) were initially scored all correct, inconsistent (some correct and some not), and all questicns incorrect. Explanations that the subjects provided for their answers were scored as (a) correct class-inclusion type reason, (e.g., "There are more animals than dogs, because dogs are animals") (b) counting or pointing explanation, and (c) other explanations or no explanations at all. Children providing counting explanations simply counted the pictures of, e.g., dogs, and then counted the pictures of the remaining animals. As there were four pictures of dogs, and eight other non-dog animal pictures, the child could arrive at a correct answer to the Piagetian questions, without any understanding of class-inclusion. The data are shown in Table 6 There was no relationship between a child's ability to answer correctly a yes/no class-inclusion question and his ability to give a class-inclusion explanation.

Table 6. Percentage (number) of children anwering class-inclusion questions, and the type of explanations provided.

Answers to Class-Inclusion Questions	Explanation	Fruit-Food and Vegetable-Food	Bird-Animal and Dog-Animal
Correct	Class-inclusion	2.1(1)	2.1(1)
	Counting	27.7(13)	53.2(25)
	Other or None	14.9(7)	6.4(3)
	Total	44.7(21)	61.7(29)
Inconsistent	Class-inclusion	2.1(1)	0.0(0)
	Counting	14.9(7)	6.4(3)
	Other or None	29.8(14)	17.0(8)
	Total	46.8(22)	23.4(11)
All Incorrect	Counting	6.4(3)	8.5(4)
	Other or None	2.1(1)	6.4(3)
	Total	8.5(4)	14.9(7)

When performance on the class-inclusion questions was correlated with performance on the hierarchial identification, no relationship emerged. Similarly, there was no relationship between performance on the class-inclusion questions and that on the hierarchical sort. With regard to class-inclusion explanations, only two subjects, one each for each stimulus set, were able to provide an acceptable class-inclusion explanation.

In summary, while about one half of the subjects were able to give correct class-inclusion yes/no type responses, they were not able to provide adequate explanations for their responses. Often they counted or pointed to items. Also, there was no relationship between a subject's class-inclusion responses and his performance with hierarchical identification and sorting tasks.

After the class-inclusion questions, children were asked mutiple-label questions (e.g., "Is this (picture of apple) a fruit and a food?" "Find me all the pictures that are fruit and food."). Their answers to these questions were scored as all correct, incorrect or mixed responses, for each intermediate-level class. The explanations that the subjects provided for their initial answer included: (1) mutiple-label (A 'banana' is a fruit and a fruit is a food) , (2) common feature (e.g., "You can eat them both") (3) answering "It's called that way" or "Because it's a food," (4) answering that only one label could be given to the item, or, (5) giving no explanation at all. The results are shown in Table 7.

Table 7. Percentage (number) of children answering mutiple-label questions, and the type of explanations given.

Anwers to Multiple-label Questions	Explanation	Fruit Food	Vegetable Food	Bird Animal	Dog Animal
All Correct	mutiple labels	12.5(6)	22.9(11)	4.2(2)	12.5(6)
	common feature	16.7(8)	4.2(2)	8.3(4)	14.6(7)
	"called that way"	8.3(4)	20.8(10)	4.2(2)	16.7(8)
	other	10.4(5)	16.7(8)	14.6(7)	10.4(5)
	Total	47.4(23)	64.6(31)	31.3(13)	54.2(26)
Inconsistent	multiple labels	2.1(1)	0.0(0)	4.2(2)	0.0(0)
	common feature	2.1(1)	0.0(0)	12.5(6)	0.0(0)
	"called that way"	12.5(6)	6.3(3)	16.7(8)	8.3(4)
	other	14.6(7)	6.3(3)	14.6(7)	12.5(6)
	one label only	2.1(1)	6.3(3)	0.0(0)	6.3(3)
	Total	33.4(16)	18.9(9)	48.0(25)	27.1(13)
All Incorrect	common feature	0.0(0)	0.0(0)	2.1(1)	2.1(0)
	one label only	18.8(9)	14.6(7)	18.8(9)	12.5(6)
	other	0.0(0)	2.1(1)	0.0(0)	4.2(1)
	Total	18.8(9)	16.7(8)	20.9(10)	18.8(7)

Overall, children tended tc perform better with the food than with the animal set. With regard to the relationship between a subject's ability to answer the multiple-label questions and his ability to hierarchically identify them, there was a significant correlation between subjects' answering that all fruit items could be called both 'fruit and food' and their ability to hierarchically identify all the food items ($r=.42, p<.001$). This relationship was also true for dog stimuli ($r=.46, p<.001$). However, although hierarchical identifying was related to the correctness of the mutiple-label questions, it was not related to the child's ability to explain why an object can be called by twc names. There was no relationship between hierarchical sorting and the child's ability to answer all the mutiple-label questions correctly.

STUDY 1

DISCUSSION

The performance of children in identifying and sorting pictures into categories suggests that a significant number of 5- to 6-year-old children understand and can make use of the hierarchical organization of categories. That is, in the identification task, 52% of the children with animal stimuli and 52% of the children with food stimuli were able to maintain mutual-exclusiveness at the intermediate level and, at the same time, correctly classify stimuli at the intermediate and superordinate levels (see Table 2, page 46). 71% of the children with animal categories and 47% of the children with food categories (see Table 3, page 48), utilized a sorting strategy that also suggests understanding of hierarhical organization, as shown by the fact that they first formed two mutually-exclusive intermediate categories, and combined then and added the four additional pictures to form the superordinate category.

There was a significant tendency for children to generalize their use of a particular intermediate level classification pattern (whether it was appropriate, overgeneralized or overdiscriminated) across different identification and sorting tasks. However, even children who were completely consistent across tasks, did not necessarily make use of the hierarchical organization of the categories.

There were considerable differences in behaviour depending on the stimulus set. Children had a much higher degree of proficiency in classifying animal categories than in classifying food categories. For example, all subjects with animal categories were able to create mutually-exclusive intermediate categories but only 71% of those with the food set were able to do so (see table 1, page 43). Also, not only did the children with animal pictures tend to classify the intermediate level categories better, but they also were much more likely to use a hierarchical organizational strategy in the sorting task than the children with food pictures.

The results of study 1 are significant as they appear to demonstrate, contrary to the notions of Piaget and others, that many children 5- to 6-years old understand and make use of the hierarchical organization of categories. Not only did this study use simpler, more direct performance measures to elict the child's use of a hierarchical classification behaviour than most other studies investigating these questions, but it also investigated the child's knowledge of hierarchical organization through the use of its two fundamental principles, mutual-exclusion and class-inclusion. As pointed out in the introduction, other studies investigating hierarchical classification behaviour in children have failed to consider the fact that both principles must be employed simultaneously in order for categories to be hierarchically organized.

This study showed that the child's ability to identify pictures in response to labels at several levels of generality may not be related to any underlying conceptual understanding of the hierarchical organization of the categories involved. Some children who could identify pictures according to labels provided by the experimenter in ways consistent with hierarchical principles, did not make use of hierarchical sorting strategies. Other children, who did make use of a hierarchical sorting strategy, were not necessarily able to identify pictures in ways consistent with hierarchical organizing principles. These results suggest that language, at least as a set of names which refer to objects in real world, is independent of conceptual development in which information acquired by the child is increasingly classified with greater proficiency at several levels of generality, and eventually organized hierarchically.

Piaget (Inhelder & Piaget, 1958) would certainly support, this contention, that children who have mastered use and understanding of verbal concepts, would not necessarily understand principles of class-inclusion. "Inclusion, in this sense, has not been acquired merely because the child talks correctly and uses verbal concepts which reflect the inclusion implicit in the language of adults" (p.117).

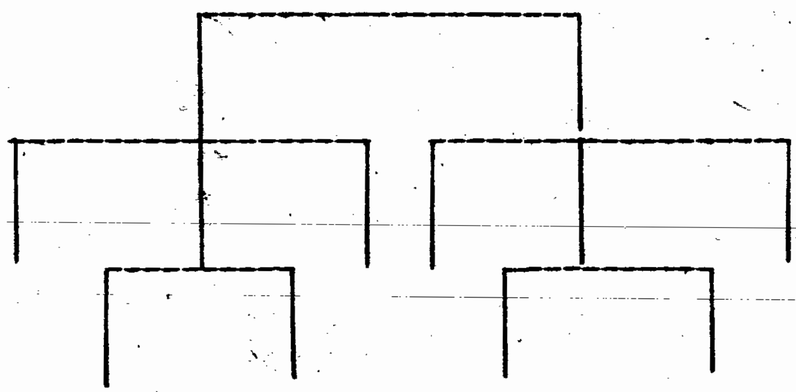
There are a number of puzzling results in this study. First, it is unclear why children, who in the sorting task, appear to have mastered the complex operation of hierarchically organizing a set of pictures, would in the identification task, fail either to identify or label the pictures properly into mutually-exclusive categories or to label the pictures at the two levels of generality. Second, children were remarkably consistent in employing the same pattern of classifying pictures at intermediate levels across different tasks, but not in employing hierarchical organizing principles across different tasks. Thus, an important question to pursue is one of consistency across tasks and transfer of learning from one task to another. Two recent studies seem to shed more light on these questions as they examined the use of principles of hierarchical organization across different tasks.

Storm (1978) attempted to discern whether third and seventh graders could acquire the principles of hierarchical semantic organization using two different training procedures, and then transfer these principles to a new sorting task. One of the training procedures controlled visual presentation of a hierarchy of animal terms with their category labels. Six classes of 18 animals were first grouped on the basis of function (animals for pets, for fur, for game), and then on the basis of abstract features (meat eaters vs plant eaters). The second training procedure was a list presentation demonstrating first, how all animal terms could be classified acccrding to the values of one of the dimensions in the hierarchy and then according to the values of the other dimension in the hierarchy. The transfer sorting task involved sorting the same item set, spontaneously, and then having them sort the items into six groups, three groups, and then twc groups. Two other groups of subjects were trained with a random presentation of items or had no training. Storm found that in the spontaneous free recall sorting task, the hierarchical organization trained subjects transferred this structural organizaticn to the free recall task. Individual subjects in the presentation and no-training groups sorted the items hierarchically, but for the most part used different dimensions (i.e. size and ferocity) to determine sorting strategy. In the fixed sorting tasks, all trained subjects maintained the 6-category classificationn provided in training. All trained subjects, but grade sevens more than grade threes utilized the 3-category classification, and also the 2-category classification.

Storm thus concluded that, through emphasizing and training a particular hierarchical structure, subjects of at least 8- to 9-years of age could grasp the principles of hierarchical organization and use (or transfer as Storm suggests) these principles acquired in a given task to a new task.

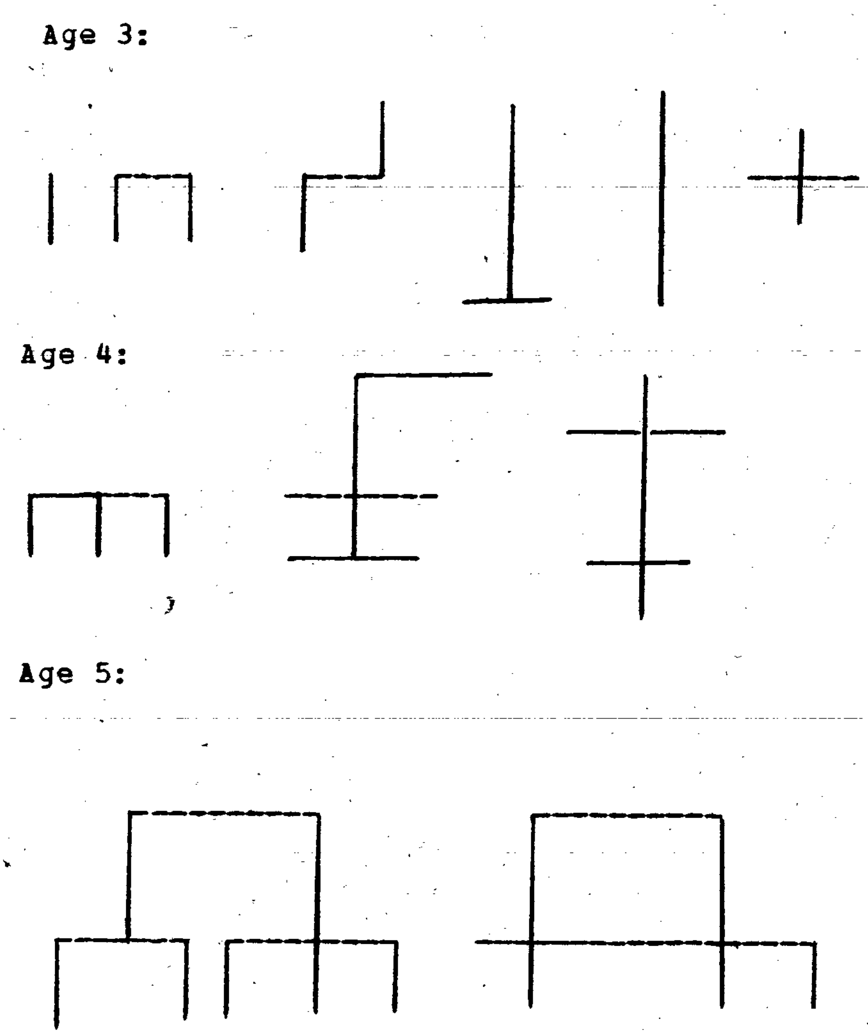
In an another study, Greenfield & Schneider (1977) tried to determine the degree to which 3- to 9-year-olds could understand a hierarchical arrangement of non-meaningful elements and transfer the principles of this hierarchical structure in a reconstruction task. Greenfield & Schneider presented the children with a tree-like hierarchically organized 'mobile', and had the children construct a mobile of their own to look just like the one hanging in front of them (see Fiqure 5).

Fiqure 5. Structure of Mobile (Greenfield & Schneider, 1977)



The investigators found a clear developmental progression between ages three and six toward greater complexity. By age six, only one child out of ten failed to copy the model exactly. The three-year-olds tended to produce simplified mobiles often consisting of isolated and repetitive unit pairs (Figure 6), failing to integrate these separate units into a more complicated structure. Four-year-olds were more likely to integrate some of the units, reproducing parts of the hierarchical model. Some four-year-olds, like three-year-olds, considered these incomplete parts to be complete units, in and of themselves, totally unrelated to any large, more hierarchical plan of action. Other four-year-olds, although not able to recreate the complete hierarchical model, indicated that their incomplete units were only parts of the total structure. They thus demonstrated an ability to compare the structures and to analyze the whole into its component parts.

Figure 6. Example of structures produced by 3, 4, and 5-year-old children (from Greenfield & Schneider, 1977).



Most five-year-olds, unlike four-year-olds, were able to form double-branched structures, in which a superordinate component joined two substructures. Whereas four-year-olds could integrate simple units into a chainlike form with complex nodes, the five-year-olds could form two such chains and integrate them into a hierarchical double-branched structure.

The five-year-olds appear to understand the principles of a hierarchical arrangement of units, but they frequently were inaccurate in the exact type of units present in the original mobile. By age six, though, the children were able to reproduce the exact same units and the complex hierarchical structure.

These two pieces of research are significant, as they demonstrate that young children were able to perceive and make use of hierarchical structure, presented directly to them, or taught to them, and then apply this principle in a new classification (Storm, 1978), or reconstruction task (Greenfield & Schneider, 1977). The Greenfield & Schneider study is particularly significant because, although the children were in fact copying the mobile, this reproduction of the mobile was not possible unless the child was able to maintain the entire integrated structure in his mind, as well as in visual field. While this study does not explicitly address the question of children's use of the hierarchical principles of mutual-exclusion and class-inclusion, it does address the question of whether young children can understand and attend to the entire integrated organization of a hierarchical structure sufficiently well to reproduce the entire integrated structure without error. The fact that the 3-year-olds merely attended to the parts of the structure and not the entire structure is supportive of Piaget's contention that young children can not understand class-inclusion, because they can not think of the parts simultaneously with the whole.

Study 2 was designed to test young children's understanding and use of principles of hierarchical organization, using an arbitrary hierarchy of artificial categories. The children tested in study 2 were the same (though not all) as those tested in study 1. It was hoped that comparison of performance across the two studies would reveal whether children who had made use of principles of hierarchical organization with familiar natural categories could also make use of them to discover the hierarchical organization of the artificial categories.

In addition, after they had been tested on the arbitrary hierarchy the children in study 2 were tested again on the sorting task of study 1. This permitted examination of whether their classification behaviour of natural categories was stable over time and, more importantly, whether the child's ability to infer the hierarchical organization of the artificial categories affected his classification strategies with the natural categories. If subjects who had not made use of hierarchical organization of categories in the first study were able, after being successful with the arbitrary hierarchy in study 2, to make use of such a hierarchical organization to sort the natural categories in the repeated study 2 task, this would be an indication of their ability to generalize principles of hierarchical organization learned in one context to another.

STUDY 2

METHOD

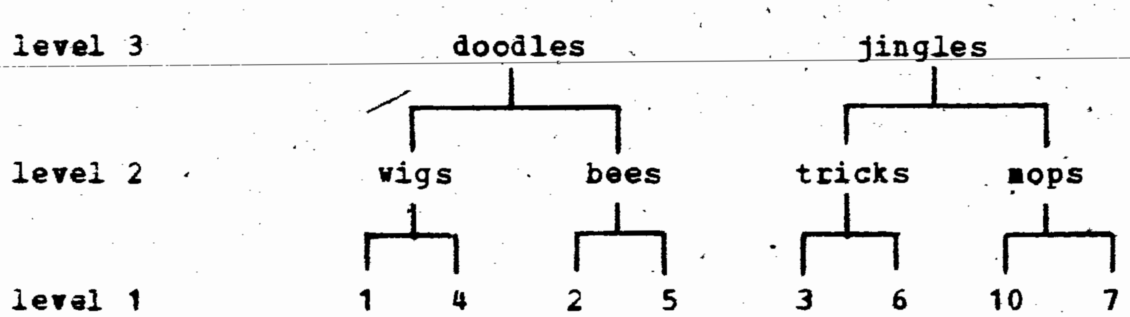
Subjects:

The forty-eight subjects from study 1 who had completed the identification and sorting tasks with food stimulus pictures were selected to take part in study 2.

Stimuli and Procedure:

The arbitrary hierarchy shown in Figure 7 was the focus of study 2. The hierarchy consisted of three levels. The bottom level consisted of numbers 1,4,2,5,3,6,10 and 7. These numbers were grouped two to a group, into four level-2 categories (wigs, bees, tricks, and mops). The four level-2 categories were then grouped into two superordinate (level 3) categories (doodles, and jingles). In addition to these eight (training) numbers, two distractor numbers (12, and 8) were also used. Each number was written on an 10 x 15 cm card.

Figure 7. Hierarchical organization of artificial categories



In stage 1 training, children were taught the level-1 level-2 links by using a step-by-step additive procedure. Each level-2 category was first taught individually and then rehearsed progressively (relearned) as each other level-2 category was learned, until all four categories were learned. At each step, all numbers, the 8 that belonged to the hierarchy as well as the two distractors, were on display for the child.

As an example, in step 1, the child was shown the card depicting '1' and the card showing '4', and told that they were 'wigs', pointing to each one and saying "This is a wig", and then emphasizing, "They are both wigs". The child was then immediately asked to produce the category label for the numbers. The numbers were then placed back in the total array of cards the cards were scrambled and the child was asked to identify all the "wigs". If the child indicated only one 'wig', he/she was asked to find another one. After the child had selected two cards, he/she was told whether they were right or wrong; and if wrong, which two cards were the correct ones and belonged to the category 'wigs'. Again the display was scrambled and the child was asked to find the "wigs". In each substep, the correct or incorrect identification of numbers belonging to the category were recorded. The above substeps were repeated until each number belonging to the category had been correctly identified four times consecutively. Then the experimenter went onto step 2.

Step 2 training was exactly the same as step 1 training, except that subjects were taught that numbers '2' and '5', belonged to the category "bees".

In step 3, the two categories 'bees' and 'wigs' were relearned together. The child was asked to identify a number belonging to the category 'wig', (Show me a wig.), corrected if wrong, then asked to find another 'wig' and also corrected if wrong. Next, the child was asked to find a 'bee', corrected if wrong, to find another 'bee', and also corrected if wrong. This procedure was repeated as many times as necessary, until the child was able to correctly identify the four numbers belonging to the two categories, four times consecutively for each number.

Step 4 was the same procedure as step 1 and step 2, and the child was taught that the figure '3' and '6' belonged to the category 'tricks'.

Step 5 was similar to step 3, but in this case, three categories, 'wigs', 'bees' and 'tricks' were rehearsed in contrast with each other. For example, the child was asked to find a 'wig', and corrected if wrong, then to find another 'wig', and corrected if wrong. Next he was asked to find a 'bee', corrected if wrong, and then find another 'bee', and corrected if wrong. Finally, he was asked to find a 'trick', corrected if wrong, and to find another 'trick' and corrected if wrong.

Step 6 procedure was like step 1, 2 and 4. The child was shown the numbers '10' and '7', told that they were 'mops' and then asked tc correctly identify numbers belonging to the category 'mops', four times consecutively.

In step 7, all four categories were rehearsed (relearned) in contrast with each other. The procedure was like that in step 3 and step 5.

In stage 2 training, the children were taught that the four level-2 categories could be organized into two level-3 categories. In the first step, the child was told that 'a wig' is a 'doodle', and then the child was asked the question "What is a doodle?". If the child did nct understand or replied incorrectly, the child was provided with the correct response and the question was asked again. Next, the child was told a 'bee' is a 'doodle', and asked "What is a doodle?" If the child could name a 'wig' and a 'bee' as both 'doodles', then this was accepted as a correct response. The child was told that both a 'bee' is a 'doodle' and a 'wig' is a 'doodle', and asked to name "What is a doodle?" If at this point, both categories were not identified, the question was repeated by asking "What else is a doodle?" As the criterion of learning for the category 'doodle', the child was required to correctly name the category 'wig' and the category 'bee' both four times consecutively.

In step 2, the child was taught by the same procedure as in step 1, that a 'trick' and a 'mop' were 'jingles', until the child could correctly identify the categories 'trick' and 'mop' as belonging to the superordinate category 'jingles', four times consecutively.

In step 3, the child was asked "What is a doodle?" and "What is a jingle?", successively until criterion was reached. When errors were made, step 1 or step 2 was repeated until the child could clearly identify the intermediate categories belonging to the superordinate categories 'doodles' and 'jingles', four times correctly, without making any confusions between the two categories.

Once criterion was reached for step 3 of training stage 2, a post-test was conducted for all categories, to assess the degree to which the child could still remember the previously learned categories. All numbers were displayed and in a single trial, the child was asked to identify numbers belonging to the four level-2 categories. If the child made an error, the correct response was provided, but no rehearsal and retesting was undertaken. The numbers were removed from sight and the child was again asked "What is a doodle?" and "What is a jingle?" The child was prompted to name two categories which belonged to each level-3 superordinate category. If the child made errors, the experimenter provided the child with the correct response but did not retest the child again.

The children were tested on two tasks, one of which was an identification task comparable to the identification task in study 1 and the other a sorting task, comparable to the sorting task in study 1, to determine whether they had discovered or inferred the hierarchical structure of the artificial categories.

In the 'hierarchical-utilization identification' test the child was presented with all the level-1 cards and asked to select those numbers belonging to the category 'doodle'. If the child made less than four choices, he/she was asked if there were other numbers belonging to the category 'doodle'. This was repeated, until the child indicated that they had selected all the cards. This procedure was repeated with the category 'jingles'.

In the 'hierarchical-utilization sorting' test, the child was presented with all the numbers and asked to put all the 'wigs' into one pile, then all the 'bees' into one pile, next all the 'tricks' into one pile and then all the 'mops' into one pile. (Note. At this point, if the child has performed this task correctly, there will be two remaining distractor items.) Finally, the child was asked to put all the 'doodles' into one pile, and next to put all the 'jingles' into one pile. The particular manner in which the child grouped the cards together according to intemediate (level-2) and superordinate (level-3) levels of classification was carefully noted.

In the second phase of study 2, the child was retested on the study 1 sorting task, with the categories of fruits, vegetables, and food. As in study 1, the child was simply asked to put all the fruit into one pile, then all the vegetables into one pile and finally, to put all the foods into one pile.

STUDY 2

RESULTS

Of the original 48 children in the food category set of study 1, 2 were unavailable and 3 refused to complete the learning phase of study 2. Forty-three subjects reached criterion in the category learning phase of study 2, and were subsequently tested on the hierarchical-utilization identification and sorting tasks. Thirty-nine of the forty-three children were tested on the repeated food categories sorting task in study 2. The performance of children in the category learning phase, on the two hierarchical- utilization tasks, and on the food categories sorting task was analyzed in terms of the following dependent measures.

Intermediate Category Learning Trials:

Intermediate level categories were initially learned in isolation and then relearned (or rehearsed) in the context of 1, 2 or 3 other categories. Due to the additive step-wise procedure of the training task, the category "wig" was first learned alone (1-category set), then relearned with the category "bee" (2-category set), then with the categories "bee" and "tricks" (3-category set), and finally, once more with "bee", "trick", and "mop" (4-category set). Similarly "bee" was first learned alone then relearned with "wig", then with "wig" and "trick", and finally, with "wig", "trick" and "mop". The category "trick" was learned alone, then relearned with "wig" and "bee" and then with "wig", "bee", and "mop". And finally, the category "mop" was learned alone, and then relearned with "wig", "bee", and "tricks". The mean number of trials to learn each intermediate level category (bee,wig,tricks,mop) in each learning context was calculated. In all cases, the mean number of trials include the four minimum number of trials required for the subject to reach the learning criterion.

Table 8 provides the mean number of trials and standard deviations of children to reach learning or relearning criterion for each of the intermediate categories. Means are based on total number of trials (including criterion trials) per subject. T-tests revealed that mean number of trials to learn the categories alone (in 1-category learning sets) were significantly fewer than mean number of trials to relearn those categories in the 2-category sets ($t=2.03, df=42, p<.05$), although the magnitude of the difference was small. They were also signficantly fewer than the mean number of trials to relearn them in the 3-category set, (t-=3.02,df=42,p<.005), and the 4-category set (t=4.53,df=42,p<.001), the magnitude of the difference being higher in this case. There were no differences in mean learning trials between 2-category sets, 3-category sets and 4-category sets. Only the overall mean (5.1 trials) will be considered further, since there was no interest in the relatively small differences shown in table 8.

Table 8. Mean number of trials (including criterion trials) to learn and relearn intermediate level categories, as defined by the number of categories in the learning set, (1-category set, 2-category set, 3-category set, and 4-category set.

Intermediate categories	Number of Categories in Learning Set								overall
	1-category		2-category		3-category		4-category		
	X	S.D.	X	S.D.	X	S.D.	X	S.D.	mean
wig	4.5	1.0	5.6	2.4	5.4	2.1	5.3	2.0	5.1
bee	4.5	1.1	4.5	1.3	5.5	2.5	5.5	2.4	5.0
tricks	4.7	1.0			4.8	2.0	6.0	3.0	5.2
mop	4.2	.7					4.8	1.2	4.5
All Categories	4.5	.9	5.0	1.7	5.3	1.8	5.6	2.1	5.1

Superordinate Category Learning Trials:

Table 9 provides the means, ranges, and standard deviations of the number of trials to reach the learning criterion of the superordinate level categories. There was no significant difference between "doodle" and "jingle" learning trials.

When the performance of children learning the intermediate categories, (i.e. the level-1 to level-2 links) was compared to their performance in learning the superordinate categories (level 2 to level 3 links) there were significant differences between the mean number of trials to learn the superordinate categories ($\bar{X}$=10.0), and the mean number of trials to learn the intermediate level categories ($\bar{X}$=5.1), (t=6.39, df=42, p<.001).

Table 9. Average number of trials to learn superordinate categories

Superordinate Level Category	Mean	S.D.	Range
doodle	10.9	7.2	4-28
jingle	9.2	4.7	4-20
both categories	10.0	5.3	4-28

Post-Test: Learning of Intermediate Categories:

The one-trial post test was designed to determine the degree to which children retained the level-1 to level-2 (intermediate categories) and the level-2 to level-3 links (superordinate categories) just learned.

Each intermediate category (wig,bee trick,mop) was scored as correct or incorrect on the one-trial learning post-test. The total number (from 1 to 4) of categories, for which all items were correctly identified, was calculated. The results are shown in Table 10, middle column. 72% (n=31) of the subjects correctly identified all items belonging to all four intermediate level categories (wig,bee,mop,tick), 19% (n=8) correctly identified 3 out of 4 categories, and the remaining 9% (n=4) correctly identified two of the categories. All subjects who made errors corrected their errors when informed that they had made an error. The errors were randomly distributed across different categories.

Post-Test: Learning of Superordinate Categories:

Each superordinate category (doodle,jingle) was scored as correct or incorrect on the one-trial learning post-test depending on whether the child identified both appropriate intermediate category labels or not. The data are shown in Table 10, rightmost column. 67% (n=29) of the subjects were correct on both superordinate categories, 23% (n=10) of the subjects were correct on one superordinate category and 9% (n=4) of the subjects were correct on both. Most of the children corrected their errors when informed that that they had made an error.

Table 10: Percentage (number) of children who correctly identified all intermediate categories and all superordinate categories. Performance on identifying categories is reported in terms of 75% correct, 50% correct, 25% correct, and 0% correct.

Percent of Categories Correctly Identified	Intermediate Categories	Superordinate Categories
100%	72% (n=31)	67% (n=29)
75%	19% (n=8)	N/A
50%	9% (n=4)	23% (n=10)
25%	(n=0)	N/A
0%	(n=0)	9% (n=4)

Hierarchical-Utilization Identification Task:

Task 1: Doodle Category:

In this task, in which subjects were asked to identify (by pointing) all the numbers belonging to the category "doodle", responses were scored in the following manner: (i) all four numbers correctly identified (ii) any three of the four numbers correctly identified (iii) one number each from each of the two intermediate categories (wigs and bees), (iv) two numbers from one category only (e.g. bee only), (v) two numbers from one category and any other incorrect items, (vi) one number from one category and any other incorrect numbers, (vii) any other combination of two stimuli, (viii) one stimulus only, (ix) no stimuli identified.

Task 2: Jingle Category:

Same scoring as for doodle.

The results are shown in Table 11. Response patterns (i),(ii) and (iii) were accepted as evidence that the subjects had discovered the hierarchical structure. Pattern (i) is, of course, perfect performance. Pattern (ii) was accepted to allow for minor lapses in attention. Pattern (iii) was accepted on the basis that the experimental procedure, on the whole, probably biased the subject toward assuming that each category, regardless of the level of generality, could contain only two items. By these criteria, the results shown in table 12 indicate that 44% (n=19) of the subjects for "doodle" and 46% (n=20) for "jingle" had utilized the hierarchical structure of the artificial categories. In addition, 40% of the children were hierarchical utilizers for both of the superordinate categories. Since classification of the doodles and jingles were done successively, these subjects consistently utilized the principles of hiearchical organization across the two superordinate identification tasks.

tasks.

Table 11. Number of subjects identifing numbers as members of the superordinate categories "doodle" and "jingle" as a function of response pattern.

Response Pattern	Superordinate Category	
	Doodle	Jingle
(i) all numbers correct	16	16
(ii) all numbers + or - 1 number	2	3
(iii) 1 number from each intermediate	1	1
Hierarchical Utilizers	19 (44%)	20 (46%)
(iv) 2 numbers from one category only	9	9
(v) 2 numbers from one category + more	5	3
(vi) 1 number from each category + more	0	0
(vii) any combination not above	8	7
(viii) one number only	0	0
(ix) no numbers selected	2	4
Non-Hierarchical Utilizers	24 (56%)	23 (53%)

Hierarchical-Utilization Sorting Task:

Subjects' performance in sorting the intermediate categories was scored for each category (wigs, bees, tricks, and mops) as correct or incorrect depending on whether they made no errors or one or more errors. Performance in this task was reasonably accurate. 88%, 86%, 79%, and 81% of the children correctly sorted numbers belonging to wig, bees, tricks, and mops, respectively.

Task 3: Doodle Category:

The subject's performance in sorting together the previously created intermediate categories into the superordinate category "doodle", was scored : (i) both intermediate categories grouped together as belonging to the the superordinate "doodle", (ii) both intermediate categories combined together, with one extra or one missing number, (iii) one intermediate level category only selected as belonging to the superordinate, (iv) remaining numbers (not previously sorted into the intermediate catgory) selected, usually the two distractor cards, (v) no numbers selected, (vi) other sets not defined above.

Task 4: Jingle Category:

Same scoring as for "doodle".

The results on task 3 and 4 are shown in Table 12. Children who showed sorting patterns (i) and (ii) were characterized as having utilized the hierarchical structure of the arbitrary categories. By this criterion, 33% (n=14) and 30% (n=12) of the children for the doodle and jingle category, respectively, did so. In addition, 30% (n=12) of the children did so for both superordinate categories.

Table 12: Number of children sorting numbers belonging to superordinate categories, "doodle" & "jingle", in the hierarchical-utilization sorting tests, according to type of response pattern.

Sorting Pattern	Superordinate Category	
	Doodle	Jingle
(i) all numbers correctly sorted	12	12
(ii) all numbers correct + 1 more	2	1
Hierarchical-Utilization Sorters	14 (33%)	13 (30%
(iii) 2 numbers from one intermediate category only	6	9
(iv) remaining numbers not sorted before into intermediate categories	13	12
(v) some other set not listed above	8	8
(vi) no numbers	2	1
Non-hierarchical-utilization sorters	29 (67%)	30 (70%

The peformance of children in all four superordinate tasks, the two indentifications, and the two sorting tasks, is summarized in Table 13. This table shows that 25% (n=11) of the subjects demonstrated complete mastery of the artificial hierarchy by being completely correct on all four tasks. Five subjects utilized the hierarchical structure on both identifications tasks, but failed to utilize it on the sorting tasks. Six subjects utilized the hierarchical structure on only one task. Nineteen subjects demonstrated no understanding or use of the hierarchical structure on any of the tasks. One could argue that reasonable evidence of a child's understanding of the principles of hierarchical organization if he performed correctly in two out of four of the tasks. By this criterion 42% (n=18) of the subjects would be judged to have discovered (or previously understood) the principles of hierarchical organization. In further analyses, these 18 subjects will be referred to as 'hierarchical utilizers'.

Table 13. Number of children exhibiting different patterns of hierarchical utilization across identification and sorting task. 'Hier' means that a child was 'hierarchica in that task, 'No Hier', that he was not.

Identification Task		Sorting Task		Number of Children
Doodle	Jingle	Doodle	Jingle	
Hier	Hier	Hier	Hier	11
Hier	Hier	No Hier	Hier	1
Hier	Hier	No Hier	No Hier	5
Hier	No Hier	Hier	Hier	1
Hier	No Hier	No Hier	No Hier	1
No Hier	Hier	No Hier	No Hier	3
No Hier	No Hier	Hier	No Hier	2
No Hier	No Hier	No Hier	No Hier	19
all other patterns				0
				Total 43

Relationship between Learning, Identification, and Sorting:

The next analysis looked at the correlations between performance on the learning, the identification, and the sorting tasks. A step-wise multiple regression revealed that overall performance in learning the intermediate and superordinate categories moderately predicted (MC=.68) whether subjects would be hierarchical utilizers or not. This analysis also revealed that subject's learning performance on the intermediate-to-superordinate categorization accounted for most of the variance predicting hierarchical utilization. In addition, children who made use of the hierarchical structure in at least two of the tasks (the 18 hierarchical utilizers), had learned the superordinate categories more quickly (mean #trials=6.8), than children who were not hierarchical utilizers (mean #trials=12.4). A one-way analysis of variance revealed that these two groups were significantly different ($F=15.2$, $df=1,41$, $p<.001$).

Further analysis revealed that subjects who performed poorly in the learning post-tests (performance variables 3 and 4), were less likely to be hierarchical utilizers. That is, hierarchical utilizers were significantly better than non-hierarchical utilizers on the intermediate categories post-test ($F=8.5$, $df=1,41$, $p<.005$), and on the superordinate categories post-test ($F=7.7$, $df=1,41$, $p<.01$).

Sorting Strategy on Repeat Food Categories Sorting Task:

This variable was scored in the same manner as it was scored in Study 1. A sorting stategy in which subjects combined the two previusly created intermediate categories into the superordinate category "food" was scored as appropriate (i.e., hierarchical), with or without prompting. As before, two other sorting strategies were noted. In one the subject selected all the remaining pictures not previously sorted and created another horizontal category called food. The remaining sorting strategy included any other sorting.

Of the 43 subjects who were tested in the identification and sorting tasks, only 39 could be retested on the food categories sorting task. Of these 39 children, 43% (n=17) hierarchically organized the fruit and vegetable pictures into the superordinate food categcry.

Through the following set of analyses, an attempt was made to determine the relationship between a subject's use of hierarchical structures in sorting food categories in study 1 (FC1), the use of the hierarchical structure with the artificial categories (AC) in study 2, and the second sorting of food categories (FC2), in study 2. The first analysis examined the relationship between subjects' sorting of the food categories in study 1 and their sorting of the food categories in study 2. The data are shown in Table 14. In this table a strict definition of "hierarchical" is used, that is, only those children who spontaneously (without prompting) organized the categories hierarchically are called "hierarchical sorters". As can be seen from Table 14 there was a significant relationship between children's hierarchical sorting in the first study and hierarchical sorting of the food categories in study 2 ($r=.53$, $p<.001$). 83% of the subjects who hierarchically sorted the food categories in study 1, did the same in study 2, and, likewise, 74% of the non-hierarchical sorters in study 1, were also non-hierarchical sorters in study 2. Seven of the non-hierarchical scrters in study 1 became hierarchical scrters in study 2.

Table 14: Number of children showing hierarchical sorting of the food categories in study 1 and study 2

Study 1	Study 2	
	Hierarchical	Not Hierarchical
Hierarchical	10	2
Not Hierarchical	7	20

The next analysis examined the relationship between hierarchical sorting of food categories in study 1, and the child's subsequent performance with the arbitrary hierarchy of study 2. First of all, there was no relation between subjects' sorting performance in study 1 and the mean number of learning trials to learn either the intermediate or the superordinate arbitrary categories. Next, as can be seen in Table 15, there was no relation between hierarchical sorting on the first food categories sorting task, and the child's use of the hierarchical structure in study 2.

Table 15: Number of children showing hierarchical sorting of of food categories in study 1 and hierarchical utilization in study 2.

Natural Categories Study 1	Artificial Categories - Study 2	
	Hierarchical	Non-hierarchical
Hierarchical	8	6
Non-hierarchial	10	19

The next step of analysis examined the relationship between subjects' performance with the arbitrary hierarchy in study 2 and their performance with the food categories in the repeat sorting task in study 2. First of all, there was no relation between mean learning trials to learn the intermediate or superordinate categories, and performance on the sorting of the food categories in study 2. However, the results indicated a positive correlation between subjects' ability to utilize the principles of a hierarchical structure with artificial categories and their subsequent ability to hierarchically organize familiar food categories ($r = .47$, $p < .001$, $n = 39$). The data on which this correlation is based are shown in Table 16.

Table 16: Number of children showing use or non-use of the hierarchical structure with the artificial categories in study 2, and hierarchical performance with the food categories in study 2.

Food Categories Study 2	Artificial Categories - Study 2	
	Hierarchical	Non-hierarchical
Hierarchical	11	6
Non-hierarchical	4	18

In an attempt to clarify these results, a fourth level of analysis examained all three tasks together; that is, the pattern of subjects' performance on each of the two food categories sorting tasks and on the learning and use of the hierarchical structure of the artificial categories.

Table 17 lists each combination of hierarchical versus non-hierarchical performance with each of the two food categories and the artificial categories, and the number of children demonstrating each type of performance pattern across the three tasks. This analysis includes the 4 subjects who were tested on the first food category sorting task and were trained and tested on the artificial categories, but were not retested on the study 2 food sorting task. Included in this table are the mean number of trials to learn the superordinate categories for each performance pattern across the three tasks. The performance patterns across the three tasks have been grouped in ways that suggests a meaningful interpretation of the results.

Table 17: Number of subjects demonstrating use of hierarchical organization across each of the three tasks, with food categories in study 1(FC1), with artificial categories (AC) in study 2 and with the food categories in study 2 (FC2). 'Hier' means hierarchical organization and 'No Hier' means no use of hierarchical organization. Mean number of trials to learn the superordinate categories in the artificial hierarchical structure are reported.

	Hierarchical Performance			Number of Children	Mean Trials to Learn the Superordinate Categories Doodle and Jingle
	FC1	AC	FC2		
1.	Hier	Hier	Hier	6	6.6
2.	Hier	Hier	not tested	2	4.3
3.	No Hier	Hier	Hier	5	8.4
4.	No Hier	Hier	No Hier	4	7.3
5.	Hier	No Hier	Hier	4	14.2
6.	Hier	No Hier	No Hier	2	17.3
7.	No Hier	No Hier	Hier	2	16.3
8.	No Hier	Hier	not tested	1	4.0
9.	No Hier	No Hier	not tested	1	4.0
10.	No Hier	No Hier	No Hier	16	10.9
11.	Hier	Hier	Nohier	0	
12.	Hier	No Hier	not tested	0	
	total # of subjects			43	

First of all, an examination of Table 17 indicates that 38% (n=18) of the children appeared to make use of principles of hierarchical organization on at least two of the tasks (patterns 1,2,3, and 5). Of these 18 children, 6 children clearly indicate understanding across all three tasks (FC1-AC-FC2). (The two subjects who were not retested on the food categories would have probably belonged to the hier-hier-hier group as their overall pattern of responding was more similar to that of this group than of any other group, and there were no subjects who hierarchically organized on both the first food categories task and the artificial categories, and then failed on the second food category sorting task.) Five children used hierarchical principles with the artificial categories and the second food categories task (AC-FN2); and four children used hierarchical principles with the first and the second food categories task, but not with the artificial categories (FC1-FC2).

DISCUSSION

The purpose of the present studies was to investigate whether young children's knowledge of familiar categories was hierarchically organized into a tree-like structure; more specifically, whether young children could make use of the principles of mutual-exclusion (referred to also as horizontal classification), and class-inclusion (vertical classification) implicit in hierarchically organized categories.

Study 1 was designed to test children's understanding of hierarchical organization by observing their performance in the identification of familiar natural categories. Study 2 examined their ability to integrate separately learned links of an arbitrary hierarchy.

In the identification task of study 1, approximately half of the children could identify pictures in such a way that (a) all pictures were identified into two mutually-exclusive intermediate level categories (horizontal classification), and (b) pictures were also identified by a common superordinate label (vertical classification).

In the sorting task in study 1, the children were directed to create two mutually-exclusive categories. After they did that, they were then required to produce a superordinate category, as labeled by the experimenter. In the latter case, the children had available two already sorted intermediate-level and mutually-exclusive categories of four stimuli each as well as four other stimuli belonging to an 'other category'. That is, the latter four stimuli were mutually-exclusive to the last sorted categories, but belonged with them to the superordinate category (refer to Figures 3 and 4, pages 33-34). About half of the children with the food stimuli vertically created a superordinate category by grouping together all 12 stimuli belonging to it (hierarchical sorters). One third of them horizonally created a third mutually-exclusive category by grouping under 'food' only the four 'other stimuli' but not any other. About two-thirds of the children were able to sort animal categories into a hierarchical structure and only 15% of them created a third horizontal animal category.

According to Piaget (Inhelder & Piaget, 1958; see also Ginsburg & Opper, 1969), children between 5- to 7-years of age can not understand the relations among the different level of a hierarchy of classes, that is, the relation of the parts to the whole, of the whole to the parts, and the parts to the parts. In his original class-inclusion research, Piaget observed that once the child has subdivided a collection or class into two sub-parts, he can not think simultaneously in terms of the whole collection and the subdivided parts, which he has contructed.

According to Piaget this is but one indication of a young child's inability to attend to several dimensions simultaneously in order to solve a problem. For example, with regard to children's understanding of conservation of amount, Piaget observed that 4-to 5-year-old children can not attend to both width and height simultaneously. They generally attend to the height dimension. Piaget observed that the slightly older 5- to 6-year-old child , vacillates in his response, sometimes attending to the width dimension, sometimes attending to the height dimension, but generally still not attending to both dimensions simultaneously. Only around 7- to 8-years of age are most children capable of using two dimensions simultaneously in order to solve a problem. This is the age at which Piaget suggests children now have the cognitive capacity to understand class-inclusion.

If the Piagetian position is interpreted to mean that 5- to 6-year-old children are incapable of simultaneously thinking of the horizontal (mutual-exclusion) dimension and the vertical (class-inclusion) dimension, or of the parts and the whole simultanecusly, then the present results contradict this interpretation; at least half of the present children exhibited identification and sorting behaviours that suggest they were able to comprehend the integrated hierarchial organization of the categories.

Greenfield & Schneider (1977) provide strong support for the findings in this study, namely that some 5- to 6-year-olds can simultaneously attend to the horizontal and vertical dimensions of classification. It may be recalled that they investigated this question by having children reproduce a stick mobile hanging in front of them. They found that three-year-olds could only attend to and reproduce individual horizontal or vertical units. Four-year-olds were able to attend to and reproduce limited vertical and horizontal subunits, but they could not integrate these subunits into an integrated hierarchical strucuture. Five-year-olds could integrate some of the horizontal and vertical subunits, but were not quite able tc integrate the entire structure into a hierarchial arrangement exactly the same as the one hanging in front of them. And six-year olds were fully able to attend to and reproduce the entire (horizontally and vertically) integrated hierarchical structure.

Despite all of the above, it is still possible that children in the sorting task could have produced the supeordinate category, say, animals, by attending only to the category animals and paying no attention to the subclasses previously formed. Likewise, children (particularly with food pictures) who horizontally sorted only the 'other' pictures into the category, food, may in fact have been attending to the horizontal aspect of classification only. Since the identification or sorting of pictures intc intermediate level categories, and then into a superordinate category were sequential, the tasks of study 1, in fact, did not demand that the child simultaneously attend to parts and wholes, or to the horizontal and vertical aspects of the hierarchy. All that was required is that children have stable and consistent knowledge of the various category labels that an object or thing can be called by, e.g., that a picture of an apple is sometimes called an apple, sometimes called a fruit, or sometimes called a food. The child does not need to know the relationship of an apple to all other fruits or to all other food.

The problems of adequately interpreting the results in terms of the original question of whether children could make use of the hierarchical organizational principles of class-inclusion and mutual-exclusion, was further compounded by the fact that identification of pictures consistent with these principles was not related to the type of sorting strategy used by the children in the second task of study 1.

Study 2 was therefore designed tc more clearly address these original questions. Subjects were trained on an arbitrary hierarchy of categories and taught the classification links between the first (most specific) and second level, and between the second and third level of a three-level hierarchy, but not taught the first to third linkages. A child would need to employ principles of mutual-exclusion and class-inclusion in order to discover the hierarchical structure of the categories, that is, tc appropriatelly link all stimuli at the first level with the appropriate third level category. Further, a child who had discovered the hierarchical structure would be able to, first, form mutually-exclusive intermediate categories and then group them into the superordinate category. Based on these notions, 25% of the children (first row in Table 13, page 85) definitely discovered the hierarchical structure of the arbitrary categories and another 18% (2nd, 3rd, and 4th rows in Table 13) are also likely to have done so, for a total of 42%, or almost half of the children.

Additional, though indirect, support for this conclusion comes from the fact that subjects who later utilized the hierarchial structure had learned the intermediate-to-superordinate links in a highly significant fewer number of trials than subjects who later did not show understanding of the hierarchical structure (see page 86). It may be that the ability to understand hierarchical organization facilitated both the learning of intermediate-to-superordinate links as well as performance in the tasks directly testing for knowledge of hierarchical organization.

Hierarchical performance in the sorting of the food categories in study 1 was correlated (but not perfectly) with the same performance in the repeated sorting of food categories in study 2 (Table 14). However, performance with food categories in study 1, did not predict ability to make use of the hierarchical structure of arbitrary categories in study 2 (Table 15). Finally, ability to make use of the hierarchical structure of arbitrary categories did predict later ability to hierarchically sort food categories (Table 16). Something may have changed as a result of the child's training on the arbitrary hierarchy. Subjects did not simply make use of principles of hierarchical organization across all three contexts.

Hierarchical performance across all three tasks (see Table 17 revealed interesting patterns. However, since the numbers are small, it is sufficient to note the patterns and suggest possible interpretation of the child's understanding and use of hierarchial organization.

First, there were six children who did make use of hierarchical organization across all three tasks. Two more children who were not tested the third time probably would also have been 'hierarchical' in all three tasks. These children had also been able to learn the artificial categories very quickly. Second, there were nine children who appeared to acquire the principles of a hierarchical structure for the first time when learning the artificial categories in study 2. It is interesting that these subjects also took a little longer than the previous group to learn the superordinate artificial categories. It is also interesting that approximately half of these children exhibited hierarchical performance on the second sorting of food categories. Third, the above must be contrasted with the fact that only 2 out of 18 children who did not show hierarchical performance in either the first food sorting or in the arbitrary category tasks, showed hierarchical performance in the second food sorting. Thus, it is suggested that performing hierarchically (for the first time) on the arbitrary categories generalized to the second food sorting task. Interestingly, this would imply that one effective way to teach children knowledge of hierarchical structures is to do it with arbitrary categories. More research is certainly needed here. Fourth, about one-third of the children did not show any understanding of hierarchical organization.

CONCLUSIONS

The results of study 1 and study 2 suggest that a significant number of 5- to 6-year-old children have some knowledge of the principles of mutual-exclusion and class-inclusion underlying hierarchical organization and can make use of it in a variety of different contexts, either to classify familiar categories, or to learn new arbitary categories, cr both. An important outcome of the present studies is that they show it is possible to study the principles of hierarchical organization using methods other than Piagetian-type questioning. In fact, the results of study 1 cast some doubts on the reliability of results obtained with such questioning procedures. Nevertheless, and in accord with Piagetian theory the fact that one-third to one-half of the children had no understanding of hierarchical organization under any context clearly suggests that the 5- to 6-year-old is in a transition stage, needing to acquire greater understanding of conceptual organization.

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