Chapter I

A Rich and Quick Theory of Lexical Organization and Access

Isabel Beck and her colleagues at the University of Pittsburgh describe word meaning as having structure that varies from shallow to deep. Shallow knowledge refers to word meaning that has a low degree of structure. These words tend to be highly unfamiliar and difficult to retrieve. When we encounter unfamiliar words in a text, comprehension is interrupted and attention is consciously directed to lexical retrieval. Deep word knowledge refers to meaning that has a high degree of structure. These words are "rich" in meaning, highly familiar, and fluently accessed in a variety of contexts. Readers with a rich lexicon that is quickly accessed can direct their attention to comprehension processes and encounter fewer interrruptions in lexical access. From this point of view, vocabulary knowledge is considered "instrumental" to reading comprehension (Stahl, 1983).

Beck et al. claim that the development of a "rich" and "quick" vocabulary knowledge requires intensive and extensive practice under conditions that convey word meaning in varied ways, including exercises that require speeded responses. Their instruction presented more exposures per word than found in the typical classroom in order to establish the high degree of structure. These exercises were varied to insure that the structure formed a "richly" connected network of interrelations. Exercises that required learning about words under speeded conditions were considered necessary to facilitate fluency in word knowledge retrieval. Presumably, Beck et al. thought that fluency

in word knowledge retrieval could be promoted by speeded exercises and that number of instructional exposures effects its structure independently. As will be discussed in the next section, there are problems with assuming that word knowledge structure is independent of access to that knowledge and that the latter is not affected by number of instructional exposures.

Teaching unfamiliar words in their semantic category and employing exercises that emphasize semantic groupings were the hallmarks of the Beck et al theory of pre-reading vocabulary instruction. They presented lists of 8 to 10 unfamiliar semantically related words to fourth graders in a 5-day instructional cycle. Along with traditional definitional and context use exercises, subjects were required to evaluate items in terms of the conceptual category to which each belonged. They thought that definitional exercises (teaching dictionary definitions and synonym knowledge) and exercises that varied word meaning in different sentence contexts were important, but insufficient in themselves to promote the deep understanding of word knowledge needed to affect reading comprehension. They concluded that exercises that require students to distinguish between the "critical features of word meanings" and the semantic relations between different concepts must accompany the traditional tasks in order to establish a network of word relations (Beck et al., 1980).

Beck et al. consider number of instructional exposures a factor that influences level of lexical structure: The more exposures, the higher the degree of structure. They argue that one reason that results of studies seeking to establish a relation between vocabulary knowledge

and reading comprehension are equivocal may be due to insufficient amounts of instructional exposures. They manipulated word familiarity by dividing a corpus of 104 words into two levels of frequency of encounters, many and some. Both levels provided amounts of instruction that were considerably greater than is commonly found in vocabulary instruction. The many exposure words were treated differently by including them in a review cycle, consisting of an additional 2 to 3 days of instruction, interspersed between cycles at various points throughout the entire set of instructional cycles. Some words were restricted to the 5-day cycle in which they were introduced and practiced.

Their instructional approach resulted in significant posttest effects for vocabulary knowledge in one study (Beck et al., 1980) and reading comprehension in a follow-up study (McKeown, Beck, Omanson, & Perfetti, 1982). Posttest scores for the many exposure words were higher than for some and none (i.e., words that were unfamiliar and excluded from the instruction). The results suggested that other basal reading programs may provide inadequate amounts of instructional intensity and exposure.

As mentioned above, one problem with the Beck et al. study was that number of exposures was confounded with speed of instructional exercise. They employed a couple of different speeded exercises. One was presented on the fourth day of instruction. The exercise was a definition knowledge task that required subjects to match instructional words with their definitions under time constraints. A second speeded exercised was presented at the end of the review cycle only and each

subject's goal was to answer as many true/false questions as possible about the review words. Since many exposure words were the only words reviewed, they received additional instructional exposure and an additional speeded exercise. Without a clear specification of the role of number of exposures and speeded exercises in fluency in word knowledge access, it could be argued that more trials or exposures led to the instructional gains, rather than the inclusion of the speeded lexical decision tasks. It will be shown in the next section that number of instructional exposures could also account for the Beck et al. results.

A second potential problem relates to their use of words that were "loosely organized" around a semantic categories. Beck et al. used words that were included as a class on the basis of some category label. All but a few of these words were adjectives (e.g., eating was the category label for obese, glutton, devour, appetite, fast, wholesome, nutrition, famished, edible). Perfetti (1983) claims that had they used more tightly defined word list, their instructional effect may have been greater.

While they have shown that loosely defined categories can be used effectively in vocabulary instruction, tightly defined categories can take on a variety of forms and it is not clear how these differences will affect word knowledge structure or its access. For example, words can be classified on the basis of their taxonomic relations (e.g., apple, orange, banana, pear, etc.) or according to some thematic knowledge (e.g., stove, timer, recipe, mixer, ingredients, etc.). As will be discussed in more detail below, taxonomic (e.g., types of fruit)

and thematic categories (e.g., what is needed to bake a cake) differentially constrain what we consider prototypical exemplars of the category and although each can be decomposed into a hierarchical set of interrelations, the coordinate level processing potential varies across the two in ways that are important to the structure and retrieval of the individual word level units. We know little about how these differences influence learning new vocabulary or their instruction.

Classification practice in a basal reading program. An informal observational study was performed by the author to determine the extent to which classification practice was employed in a basal reading program. The study was conducted in a fourth grade classroom located in a southeast San Diego elementary school. The reading program is a local version of the Ginn reading curriculum, called the Achievement Goals Program (AGP). The program focuses on vocabulary building, as opposed to reading comprehension. As in many other basal reading programs, children are taught the difficult words from a story they are currently reading in their text. The ability to attack words (i.e., pronounce and spell words) is the overall objective of the set of exercises. There are instructional exercises that provide practice in the use of words in different sentence contexts, but unlike many basal reading programs there is less emphasis on developing dictionary definition knowledge.

The reading instruction took place in one half hour daily lessons. The classroom observations indicated that classification practice was virtually nonexistent during the reading period. This should not be surprising, since the words identified for instruction were taken from the current story in the text. Identifying instructional

words in this way results in a semantically unrelated list. Teaching words in semantic categories requires a list of words that share meaning on the basis of some conceptual relation. It was apparent from this study that the district's program was, at the very least, excluding this important aspect of lexical organization.

The design and implementation of the AGP reading program in this school and others in the district were motivated by institutional pressures to increase reading scores in the district. Interestingly, this vocabulary-based reading program is predominantly used in two elementary schools located in demographically minority populated sections of the city. Reading programs in schools outside of these target areas were less centralized in format and tended to be comprehension-based programs. The population of the school in which the classroom observations took place was predominantly Black. Hispanics were the second largest population, followed by Asians. A school located less than one mile away was used to recruit the subjects in the present study. The population of this school is similar to the previously mentioned with the exception of a relatively larger Anglo population. Whereas the Anglo population of the former was miniscule compared to the other groups, bussing brought in a higher number of students to the latter school. AGP was used in the fourth grade classrooms used in the study.

Semantic Memory, Lexical Organization, and Reading Comprehension

The present study seeks to contribute to the reading literature that documents the relation between vocabulary knowledge, semantic

memory and reading comprehension. Little is known about the relation between semantic memory and reading comprehension (Prawat, 1982; Smith, 1978) or the effects of learning different types of semantically-related lists on lexical organization and retrieval (Vaughn, 1982).

Semantic memory and lexical organization. Models of semantic memory attempt to specify the properties which hold between words and the relations that give them meaning (cf. Smith, 1978). One theory of organization that is exceptually useful for explicating the relation between vocabulary knowledge and learning is George Mandler's two-dimensional theory of organization (G. Mandler, 1979). Although he talks about the theory as a global model of learning and organization of knowledge, he often relates the properties of the model to lexical organization. It is in terms of lexical organization that the theory will be discussed.

Mandler (1979) distinguishes between two intersecting processing dimensions along which word knowledge varies. One dimension is referred to as integration and is defined as the extent to which a word forms a compact interstructural whole. New words are unfamiliar in a variety of ways. We may know how pronounce a word, but not how to spell it. We may not know how to spell, define, or understand its use in a sentence. As we become more familiar with the word, the many relations that capture a unique aspect of its meaning form a structure that is accessible under a variety of conditions.

There are two variables that contribute to integration: repetition and reinforcement. Repetition is the medium through which a

unit increases along the integrative dimension and becomes compact. In this way it is the major "functional variable" in lexical organization:

> Repeated presentations make possible attention to its internal structure and even may restore internal aspects that have been "lost" or misconstrued over time. Concretely, repeating a word, for example, draws attention to its spelling, its phonemic constitution, pronounciation, etc. Repetition of such well-integrated items might increment the original integration or emphasize some specific structural characteristics internal to the unit (p. 298).

Repetition effects depend on producing "certain predictable outcomes internally or in the external world" and reinforcement mediates predictability. Reinforcement motivates us by giving us confidence in our use of what we have learned. To the extent that our prediction about some outcome is verified, our knowledge can be evaluated and, if necessary, updated. High levels of integration result in automatic encoding of a lexical item upon its subsequent presentation.

Elaboration refers to the extent to which a word is interrelated with other words that give it meaning. For example it could refer to the ability to classify words on the basis of the features that they share conceptually. It is the interstructural organization within a complex higher order context that characterizes elaborative dimension organization.

Between-unit organization is primary in elaborative processing. It is the medium through which a word unit is related to a more general structure. Encoding requires the formation of complex relations between units of knowledge with the intention of imposing meaningful structure. These relations typically form some coordinate, superordinate, or subordinate network in which one unit or "node" can be thought of as

connected by paths that lead from one to another. This sort of interconnected path-like structure is common to theories of long term memory. In these theories, elaboration is considered the mechanism by which retrieval from long term storage is facilitated (cf. Collins & Quillian, 1969; Anderson, 1980). The more interconnections a unit has with other structures, the more retrieval paths that can lead to its access.

Repetition of interrelated structures (e.g., "paleontologist" is a type of "job") leads to a similar outcome as repetition of a single unit (e.g., the letters that make up the word "paleontologist"); that is, the compactness and internal unitization of the structure. In this way, integration is the building block for elaboration and repetition is the mediating variable. Mandler states the relationship in the following way:

> As a first step in understanding such second-order integrative processes, it is useful to remember that structural development is a hierarchical process. Once a particular unit has been integrated and functions as a single chunk, then it can become a node in another, higher order unit. A phoneme becomes part of a word, a word part of a phrase, a phrase becomes the unit of a sentence or a paragraph. Similarly, structural rules that order phonemes or those that order words in sentences are transferable and applicable to new words and new sentences (p. 299).

A unit changes in definition as a single node is elaborated into a higher order structure. The definition could be at the level of a simple description of the characteristics of an item or as elaborate as a rule that defines how various items are common to a particular set. The interconnections associated with items, their definitions, and rule-governed properties are determined by repeated exposures.

It is the intersection of word knowledge along these two dimensions that characterizes a "rich" and "quick" theory of access to lexical organization. Each dimension can vary with respect to its degree of organization for a word. Word knowledge that is highly integrated and elaborated creates the optimal condition for retrieval.

Classification and concept learning. Western psychologists view taxonomic organization as more natural and superior to others ways that people classify their experience. In fact, taxonomic thinking does not dominate human thought; other classificatory systems are as important (J. Mandler, 1979). One other way we organize information is according to thematic structure. Taxonomic and thematic organization share some structural principles, while each differs in important ways. Taxonomic organization governs understanding of the relations that hold among members of a class. This knowledge includes our abstractions of class inclusion or the various ways objects make up a class. The ability to abstract relations enables both inductive and deductive reasoning, while variability in classification enables flexibility in its use as a problem solving strategy (J. Mandler, 1979). There are no principles that govern direct relations among coordinate members of a category apart from the features each share with the concept that subordinates them as a class. For example, the word 'fruit' is a higher order concept for objects that share its features, such as apple, orange, banana, pear, and peach.

Unlike taxonomic items, the relationships among coordinate items in thematic groupings presuppose a "unity of time" or place for a collection of things and emphasize the links between them (J. Mandler,

1979). Our everyday experience is filled with events that are structured routines and our knowledge of these events is organized by this structure. For example, when we dine in a restaurant we expect a particular sequence of events to occur in a particular order. In a fancy restaurant we expect to be seated by a hostess, given a menu, have our order taken, served our meal, given the check, etc. When events deviate from the typical pattern, we notice the unusual and try to make sense of what has taken place (Bower, Black, & Turner, 1979).

There are serious difficulties in attempting to predict whether the interconnections among parts of thematic structures will result in more complete recall than taxonomic structures (J. Mandler, 1979). Stories or routine events are accurately reproduced in their gist or in "synonymous expressions", while verbatim recall of taxonomic items is considered important. Of those studies that have contrasted the two semantic structures, the results clearly suggest that thematically related items are recalled more completely than taxonomic ones (e.g., Rabinowitz & Mandler, 1983).

One source of difference between the two types of structure is the greater complexity of thematic items. J. Mandler uses the findings of two studies to demonstrate that increasing taxonomic structure produces effects similar to thematic structure. In each study intricate taxonomic structure was produced by identifying each item in the list with multiple retrieval cues. One study increased taxonomic complexity by introducing a list of 112 words that were separated into four equal sized and unrelated hierarchies (Bower, Clark, Lesgold & Wizenz, 1969). Each hierarchy was further divided into four categories. Recall was

excellent for items presented in this format. Broadbent, Cooper, and Broadbent (1978) embedded items in a matrix structure, with two lists and two independent dimensions crossing each other. Similar results to those of Bower et al. were found, even though the lists were shorter. The multilevel hierarchy provided a series of nested retrieval cues, while the matrix structure provided two or more independent retrieval cues.

The suggestion that taxonomic structures represent an optimal form of organization has been particularly salient in the developmental literature (Rabinowitz & Mandler, 1983). Developmental studies examining the use of alternate forms of organization are becoming more frequent. One such study was performed by Worden (1976). She was interested in the extent to which second and fifth graders could benefit in their recall when they could use their subjective or "self-generated" structures to sort lists. In order to control for developmental differences in organizational preference, Worden employed a set of stimulus items that could be simultaneously and equally classifiable as either a thematic or taxonomic category scheme. In one group, the thematic structure was made salient and taxonomic structure was salient in a second group. The third, and last group of subjects, was presented the lists in such a way that they were left to sort the list in any way they preferred. In addition to the superior overall recall performance of fifth over second graders, the self-generated condition recalled significantly more items than did the thematic or taxonomic groups. The grade level difference was not significant for amount of clustering in recall, but the self-generated group clustered significantly more than

the other two groups.

As interesting outcome of this study is that thematic structure fell in the middle of the taxonomic and self-generated groups' performances. Recall of salient thematic groupings was not significantly better or worse than the others. However, in a measure of the mean frequency of each type of sorting category for the self-generated group, second graders produced significantly more categories than fifth graders and, overall, subjects produced a significantly greater number of thematic categories than taxonomic or idiosyncratic. Worden concluded that organizational preference was not found between the two grade levels and that when the organizational structure of the stimuli is congruent with thematic classification preferences of children, the advantage of using a self-generated structure is minimized.

There have also be ocassional studies semantic memory that directly explored the results of embedding words in taxonomic and thematic list structures. Two such experiments were conducted by the author (Vaughn, 1982). In a prior study by Bower and Clark (1969), story narration was shown to benefit recall when subjects were instructed to serially interweave a list of unrelated words into a story. The group serial recall score for list items was seven times greater than control subjects who were instructed to learn the lists in any way they thought helpful for recall. The goal of the follow-up studies was to determine the degree to which story narration would facilitate serial learning of semantically-related word lists. The author reasoned that different semantic relations would either facilitate or hinder the use of story narration in list learning.

Each experiment employed two types of instruction (narrative and control) and two list structures (blocked and random) in a between subjects design. Subjects studied taxonomically-related lists in the first experiment. The hypothesis was that requiring subjects to serially interweave a story out of a 10-word blocked list containing two equal sized categories (e.g., apple, orange, banana, pear, and peach, tennis, football, hockey, baseball, and basketball) would interfere with list learning as opposed to the facilitative effects of random presentation. This prediction was formed on the basis of literature suggesting that taxonomic classes are represented orthogonally in memory; for example, 'fruit' is a category independent from 'sports'. Presumably, blocking the lists would make the two taxonomic groupings in each list more salient which, in turn, would interfere with the construction of stories. Thus, blocking the lists should result in a decreased recall compared to lists in which the items in the categories are presented randomly. In addition, it was expected that the story groups would be better than the control groups, who were instructed to impose their own memory strategy to learn the lists for recall.

Subjects were given the first word in each list as a recall cue. Both story narration groups, in contrast to the control, recalled more items from the lists, thus replicating the Bower & Clark finding. As anticipated, both narrative groups (blocked and random) had significantly superior list recall than the control groups, suggesting that the narration was such a powerful organizational factor that it enabled subjects to form links between the orthogonal categories in the blocked lists. Although the mean recall score for the narrative random

presentation group was higher than the narrative blocked group, the difference was no significant. The control group that received the blocked lists recalled items from only one of the two categories. Recall of only one category is indicative of the effect we expected in the narrative blocked condition.

The design in the second experiment was the basically the same as the first with the exception of the semantic relation items formed in each list and there was only one category per list. Four groups (narrative blocked, narrative random, control blocked, control random) were also used in this study. Thematic-association items formed the relations in each list in the second study. The natural sequential ordering of thematic associations was considered beneficial for organizing the lists into serial order. The blocked list featured word items common to a single routine or everyday experience (e.g., recipe, oven, temperature, ingredients, mixer, bowl, pan, timer, potholder, counter; which make up the thematic category of "baking things") in the order in which they routinely occur. In this way the lists did not feature blocked lists of the same form as in the taxonomic list study. Instead, blocking meant that subjects were presented 10-word lists in which the first to the tenth word in each list corresponded to the typical sequential order of the embedded script. Random condition lists presented the same items in a scrambled order. The logic was that understanding how we organize information about routine activities is useful for studying how we organize lexical items that represent thematic or script knowledge.

Recall scores for both story narration groups (random and blocked) and those in the control blocked list condition did not differ significantly. The scores showed that sequential or blocked list presentation of the script-related words was the overriding factor in learning the lists. Although recall and clustering were high for all four conditions, subjects presented blocked lists (across narrative and control) showed significantly greater performance on both measures. The conclusion from these studies was that taxonomic and thematic structures result in differential effects of recall.

Two other studies that were designed to explore the differential recall effects of embedding items into either taxonomic or thematic structure were performed by Rabinowitz and Mandler (1983). They assumed that the systematic coordinate level interconnections between thematic items would enable subjects to more completely recall the items in each list than retrieval from taxonomic lists. In one experiment, instead of using nouns, as in the Vaughn experiments, they emphasized the event structure of lists by using short phrases, each containing a verb and a noun (e.g, buy opera glasses, put on evening clothes, go to theater, watch ballet, drink champagne were items that made up the thematic category going to ballet) and eat pineapple, eat peanuts, eat birthday cake, drink hot chocolate, drink champagne made up the taxonomic category food. The lists of phrases were presented blocked according taxonomic or thematic groupings or in random order.

Subjects in the schematic condition recalled more items than those in the taxonomic and random presentation groups. The taxonomic presentation led to better recall than the random presentation

condition. Overall, subjects clustered significantly more into thematic than taxonomic groupings. Clustering scores were significantly better for the thematic blocked list than the taxonomic or the random lists. In fact, the thematic blocked recall was nearly perfect. The groups did not differ in the number of categories recalled. These outcomes are consistent with the prediction that the coordinate level interconnections among items in a thematic grouping promotes structure and organization, as evidenced by near perfect recall of thematic lists in which the temporal ordering of the event is made salient (blocked).

In order to control for the possibility that the results of the above study was due to subjects' preference for using thematic structure in recall, a second experiment was performed. More emphasis was placed on the taxonomic structure of categories in this experiment. The thematic items in this experiment formed a "looser" structure. This was accomplished by forming associations that were not clear cut event sequences (e.g., live on farm, wear overalls, milk cow, grow corn, drive tractor for the thematic category living on farm). Again, schematic lists produced greater recall effects than taxonomic and random lists which did not differ. The groups also were equal in the number of categories recalled. Also consistent with the earlier finding was that blocked lists did not differ in recall clustering effects, but both were superior to random list presentation. Unlike the earlier finding, there were no differences between thematic and taxonomic in overall recall, the major difference being that the thematic list recall was not exclusively thematic, that is small amounts of taxonomic clustering were found.

A procedure is used in the present study to provide a basis for subsequent comparisons of thematic and taxonomic lists. The studies of semantic organization and structure mentioned above focus on the the learning and retrieval of lists that embody familiar words. Lists of verb-nouns or nouns that present the thematic, taxonomic or a mix of both properties in ways that make those properties salient influences what subjects learn and their output. Little is known about how these structural properties and their differential effects on learning can aid elementary level reading and vocabulary instruction. Presumably, teaching unfamiliar words in thematic grouping could allow subjects to use what they know about the thematic structure of these lists to facilitate learning and use of their knowledge in various tests of word knowledge. On the otherhand, presenting unfamiliar words in taxonomic groupings may be more useful. In thematic groupings (e.g., order beverage, pay receipt, get entree, see menu, see hostess as belonging a dining out thematic category or grouping) subjects may not discover the sequential properties of the lists which is known to aid learning. They may know a lot about going to a restaurant, for example, but not know what an "entree" is. But knowledge of class inclusion has the potentially beneficial properties of category label to aid learning. That is, if the subject knows the properties of "job" it is is possible that this information, although more prototypical than specific, could be applied as a definition for potentially unfamiliar words, such as "paleontologist" or "physician". A related issue is the potential benefits of taking advantage of both thematic and taxonomic properties in teaching vocabulary. As shown in the study by Broadbent et al, two

independent dimensions of word relatedness can facilitate its structure and retrieval. It may be that relating a word on both taxonomic and thematic dimensions could also facilitate learning and retrieval.

The experiment examines the effects of taxonomic word lists, where items could be classified on the basis of a single category label and thematic lists that can be classified on the basis of semantic properties that instantiate a common script. A third list featured equal numbers of both taxonomic and thematic items. These three semantic list type comparisons were used to examine the effects of semantic organization on recall, word knowledge, and sentence level comprehension.

In the present study thematic, taxonomic, and a mix of the two structures were employed. As in Rabinowitz and Mandler's study, the thematic items were presented in verb-noun groupings. The difference was that the groupings in the present study were constrained to single verb and single noun pairs (e.g., get detergent). Although the thematic structure pairs were selected to conform to a sequentially ordered list, the nature of the learning task in which each list of words was embedded arranged a random presentation. Subjects, as a result did not have the benefit of blocked thematic lists of the type used by Rabinowitz and Mandler. Due to their random presentation, the subject would have to discover the event ordering of list items. In this way, the lists were more thematic than schematic in representation. The mixed list was more complex than the others. The words were arranged to focus on two ways of classifying each word. Half of the items in a list were presented in a taxonomic grouping (e.g., tailor, homemaker, designer, seamstress,

couturier, as members of the category people who make clothes) and the other half were blocked on the basis of a thematic grouping (e.g., pick pattern, lay fabric, cut material, sew garment, set hem, as actions in the category making clothing). Thus, these lists are considered more intricately structured than single hierarchy taxonomic lists and similar in complexity to themes.

Computers in Education

Computers in reading instruction. Children become actively involved in learning situations they find meaningful (Riel, 1983) and mentally challenging (Malone, 1981). The motivational aspects of computers is one reason for augmenting their use in education. Video games first brought attention to the motivational aspects of computers. Nawrocki and Winner (1983) point out several other motivational aspects of video games. They suggest that winning a game while remaining challenged is primary. Individual scoring was considered the most "effective incentive" to creating challenge.

The educational potential of microcomputer-mediated tasks is no better than the design of the software. For educational purposes, winning either by beating another opponent, the computer, or your last score is only one part of the task. Challenge and success must be intimately intertwined with the school-like properties of the task in order to fullfill the instructional goals. The difficulty of past research in showing learning transfer from computer games to school tasks may be a result of the discrepancy between winning and learning as goals in an educationally appealing game (Nawrocki & Winner, 1983). For

this reason, Nawrocki and Winner argue that it is difficult to determine the educational value of software.

Other factors that make educational software motivating are: (1) the capability to allow the students to play against themselves, as well as the computer and others and (2) transformation of the task into higher levels of difficulty as the players develop their expertise. When students are able to play against themselves, they can alleviate the potential stress of having to compete with more capable peers. This is especially important, given the finding that some students learn best under cooperative, rather than competitive conditions (Kagan, 1981). One of the nice features of arcade-like games is transformation of the task environment as the player reaches higher levels of play. Each level is more demanding than the previous ones, although the goals of the game remain basically the same. For example, the player may have to respond under faster conditions or other circumstances that cause the task to be more difficult.

Microworlds are computer-mediated task environments in which meaningful activities and mental challenge can be coordinated in parallel to school-like task constraints. In addition, these environments allow the student to take on a "piece" or character in the imaginary world. The social cognitive research literature indicates that point of view or perspective-taking in the task environment increases learning (cf. Keenan & Baillet, 1980).

The task employed in the present study draws on theories of lexical organization and the motivating features of microcomputer

environments. The use of cognitive theory and "real world" knowledge to design classroom curricula is a neglected enterprise; therefore any approach that focuses on this issue is breaking new ground (Charles Crook, personal communication). The "microworld", RESCUE, is designed to involve subjects in a fantasy world in which they have been commissioned to protect a space station from small spaceships that can approach from any one of three sides (see Figure 1). Half of the approaching spaceships are friendly, and therefore they are allowed to land on the center spaceship. The other spaceships are unfriendly and they must be destroyed with laser beams. The friendliness of the approaching vessel is determined by the relation between two words that appear on the screen. A full description of the RESCUE task is presented in the Method section and the Appendix. For the immediate purposes, the discussion will focus on the arrangement of word relations and subject responses in the task.

In the bottom half of the display in Figure 1 there are six words, three on each side. Just under the center spaceship and above the fuel gauge is a target word (PANSY). The six words in the bottom half 1 refer to category words, one of which is the category label for the target word displayed (e.g., PANSY is a FLOWER). At the start of the task, one of these category words is selected to become the "active" word. Active words are noticeable by the difference in their display (ANIMAL). They are embedded in a display that has a shaded background as shown in the figure. Also shown in the figure is way that the approaching ship is associated with the target word PANSY and the active

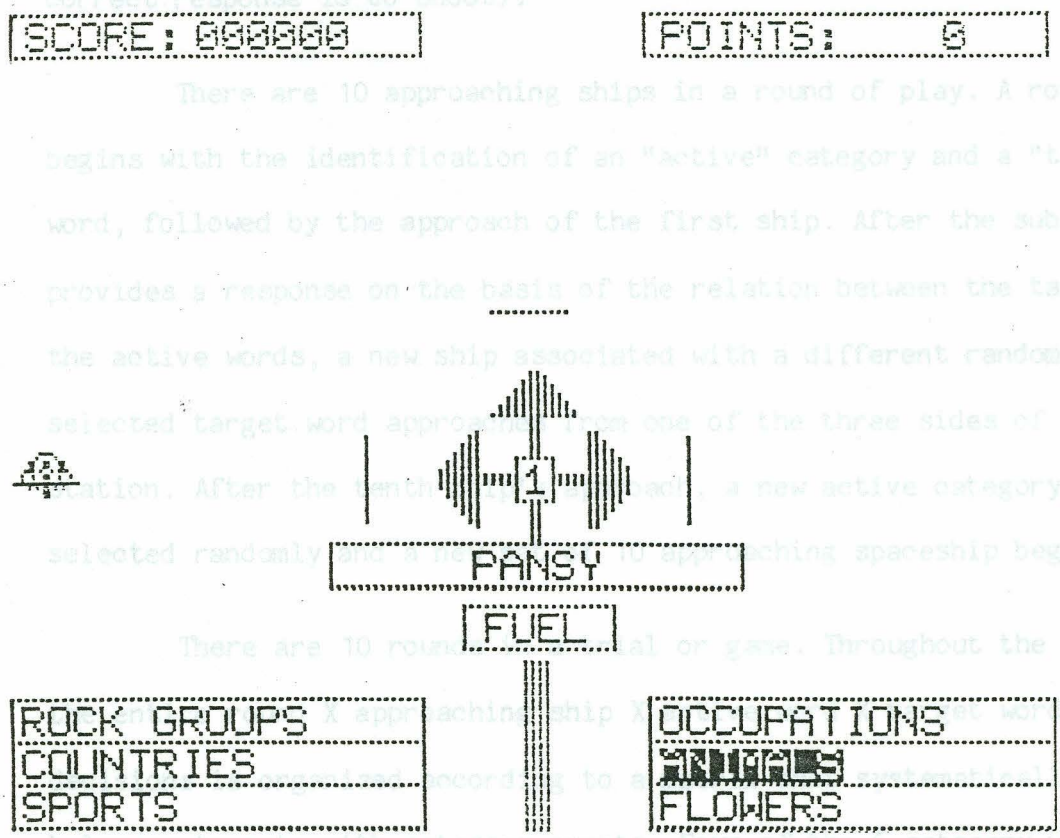

Figure 1. Display of the RESCUE microworld vocabulary task.

category word ANIMAL. Target words that are members of the active word's category are allowed to land in the space station, while all others are to be destroyed with a laser beam (since PANSY is not an ANIMAL, the correct response is to shoot).

There are 10 approaching ships in a round of play. A round begins with the identification of an "active" category and a "target" word, followed by the approach of the first ship. After the subject provides a response on the basis of the relation between the target and the active words, a new ship associated with a different randomly selected target word approaches from one of the three sides of the space station. After the tenth ship's approach, a new active category word is selected randomly and a new set of 10 approaching spaceship begins.

There are 10 rounds in a trial or game. Throughout the trial, the entire round X approaching ship X active word X target word set of decisions is organized according to a matrix that systematically balances targets with category events. Four of the 6 category words become active twice on a randomly selected basis, while the other two categories are active once each, resulting in 10 rounds. In each round 5 of the 10 randomly presented target words are members of the category, while the other five are words from the other five categories, one from each.

Presenting negative examples along with positive instances of a unit of knowledge is considered useful for specifying the conceptual relations among to-be-learned items (Engelmann & Carnine, 1983). In RESCUE subjects are presented unfamiliar words (e.g., paleontologist)

along with familiar categories (e.g, job). The instructional goal is to teach the category to which each unfamiliar word belongs. Presentation of the negative examples enables subjects to use rules of class inclusion to set boundaries on which items belong and which do not belong to a class. The graphics and sound capabilities of microcomputers were used as signals to reinforce subjects for correct responses and indicate when they responded incorrectly.