THE USE OF SEMANTIC ORGANIZATION
BY CHILDREN WITH AUTISM

by

JANINE PRIVETT
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Department of Audiology and
Speech Science

The University of British Columbia
Vancouver, Canada

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ABSTRACT

The purpose of this study was to investigate whether a semantic network exists for children with autism. Ten children participated in the study: five with autism or Aspergers syndrome and five controls. The subjects ranged in age from 9;8 to 14;11 and had normal non-verbal IQs as measured by the Test of Non-Verbal Intelligence-2. Children in the two groups were matched exactly for auditory-verbal memory span as measured by the recall of 10 unrelated words after a 30 second filled delay and they were required to have a receptive vocabulary level of at least 7 years as measured by the Peabody Picture Vocabulary Test-Revised. All subjects participated in an experimental memory task with two conditions: 1) a free-recall task with lists of eight related words to be remembered after a 30 second filled delay, and 2) a cued-recall task with similar lists and delays. There were two trials in each condition. A semantic network would be evident if the subjects grouped categorically related words upon recalling the list of words, or if subjects’ recall was aided by either clustering or being given category names as cues. Findings revealed similar results for both subjects with autism and control subjects with or without category cues. Results further indicate that individuals in both groups clearly used clustering strategies, and that both groups benefited from clustering and from category cues. These findings demonstrate the existence of a semantic network for children with autism.
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Chapter One

INTRODUCTION

The present study investigates whether children with autism have a semantic network, and also looks at whether these children are able to use such an organization of semantics with or without adult mediation. The question of whether or not this organizational network exists in children with autism stems from research by O'Connor and Hermelin (1967) as well as by Tager-Flusberg (1991) investigating the ability of these children relative to other children, to recall lists of unrelated words and lists of semantically related words. They found that while both groups did equally well in the free recall of a list of unrelated words, autistic children were less proficient than control subjects in their free recall of semantically related words. Semantic relatedness normally boosts total recall and leads to members of single categories being recalled in adjacent clusters. The autistic children in O'Connor and Hermelin's study showed less clustering of semantically related words. Tager-Flusberg showed that given a list of words representing one single category (animals) the autistic children recalled significantly fewer correct items on the list than the control subjects. However, Tager-Flusberg also demonstrated that the children with autism could recall these same list items when given the category name as a semantic cue.

Two conflicting conclusions were drawn from these studies. O'Connor and Hermelin concluded that children with autism have an inability to organize words based on conceptual properties due to a deficit in their ability to encode stimuli meaningfully. In contrast, Tager-Flusberg concluded that success on the cued recall task indicated that children with autism merely fail to effectively use linguistic information to facilitate the recall of stored information. The first hypothesis (O'Connor and Hermelin) suggests that meanings are not being encoded in a network while the second hypothesis (Tager-Flusberg) suggests that meanings are being stored in an organized network in semantic
memory (demonstrated by the fact that cues help to retrieve words) but are not spontaneously being recalled using this networked information.

Tager-Flusberg's study seems to demonstrate that a semantic network exists for children with autism. However, in her methodology, she presented a list of words from only one category for the free recall task, and needed to provide category cues before children with autism could demonstrate use of a network. Her clustering task therefore did not examine whether subjects could group words from different categories. The conclusion therefore cannot be made that subjects who do not cluster (i.e. more than one category of words) are aided by cued recall.

Hermelin and O'Connor concluded that subjects with autism do not have a semantic system; however, they neglected to investigate further to truly distinguish between the lack of a system and the lack of use of a system.

The purpose of this study is to investigate whether children with autism show evidence of a semantic network in a free-recall task involving more than one category. If a semantic network is not demonstrated in a free-recall task, the study will investigate, whether a semantic network exists through the use of free recall. It will investigate how the system can be accessed in these subjects who cannot cluster in recall with more than one category. This extends the work of Tager-Flusberg (1991).

**Brief definition of the semantic network**

As background for the methodology used, these next sections discuss semantic networks, their development, and memory issues relating to their use.

A semantic network is, in theory, an organized mental structure incorporating a set of words/concepts associated in semantic memory. Such organization serves to provide the full meaning of a concept by linking properties of concepts and indicating relationships among and between concepts (Norman, 1982). These links create meaning
in at least three different ways. First, they associate features of concepts, such as beak, wings and feathers as part of the concept 'bird'. Secondly, they structure what we in a specific culture consider to be a prototype of a concept. For example, the links might structure robins to be more prototypical birds than flamingoes. Finally, the links serve to associate words in hierarchical categories by relating superordinates and subordinates. Such organization allows us to understand and use language accurately and efficiently.

We see evidence of the structure of semantic networks in aphasic patients and brain-injured patients. Often, those patients with naming difficulties are still capable of producing the superordinate of a target item. They may be at a loss for the word “robin” but retrieve the word “bird”. Yet other aphasic patients have naming difficulties for only a subset of concepts, demonstrating that the particular subset must be somehow clustered in a network if it is the only affected category. For example, a number of brain-injured patients show a greater loss of comprehension for inanimate objects as opposed to animate objects and food (Caplan, 1992, p. 99). A patient described by Hart, Berndt, and Caramazza (1985, as cited in Baddeley, 1990, p. 351) only had difficulty naming fruit and vegetables.

Despite such clinical evidence, semantic networks are, thus far, hypotheses and not fact. Hence, there are various theories about the composition of a concept and the composition of the semantic network itself, as is discussed below.

Organization and structure of semantic networks

Theories differ in the way they conceptualize which items are linked in the network and how they are linked. There have been two main theories of the links between concepts within a semantic network: the classical theory and the prototype theory. In the classical theory, concepts are composed of clusters of necessary features. A concept is defined by all of its necessary features and these features are present in every
instance of the concept. The classical structure of concepts can be illustrated with the example of the concept 'square'. The features of a square are 1) four sides, 2) a closed figure, 3) all sides of equal length and 4) all corners the same angle. All squares have these features and the set taken together defines the concept (Baddeley, 1990). In natural categories however, the boundaries of concepts are not as evident. The concept ‘bird’, for example may be defined by the features 'has a beak', 'flies' and 'lays eggs'. In this case, an ostrich would not be considered a type of bird because the feature 'flies' does not apply to ostrich. In the prototype theory, however, features exist but not all features necessarily apply to all instances of a concept. In general however, an instance of a concept is considered to be more typical as more of the features apply to it. For example, a robin may be a more prototypical example of a bird because it embodies all three features of ‘bird’. An ostrich on the other hand is less typical, because it only embodies two of the defining features (Baddeley, 1990).

In addition to proposing different defining structures for concepts, theories differ in their view of the nature of the links between them. The two basic types of models that are proposed to represent the network are linear models and connectionist models (also, parallel associative models or spreading activation models). Both models show the network made up of concept nodes with relational links between concepts. In a linear model the links between concepts are different lengths and time taken to retrieve a concept is a function of the length of the link. There are shorter links between more highly related items and longer links between lesser related items. This way, related items or items that are used together more frequently are retrieved faster than items not as closely related or those not used together as frequently. Within this system of nodes and relations, the components are clustered to make the system as efficient as possible (Baddeley, 1990, p.353).

The following is an example of a linear model of a network modelled after an example by Norman (1982). Each concept is a node and nodes link to other nodes and to
features by relational meaning. For example, if we have the node BIRD, the feature 'beak' is linked by 'has-a-part' and 'bird' is linked to the superordinate category of animal by 'type of'.

```
Beak
Wings
feather

Figure 1: Linear model of a network
```

Note that in this network the parts of 'bird' are clustered and are found closer to BIRD than to the more distant, superordinate concept of animal.

In a connectionist model, strength of association is viewed as the result of differently weighted links and activation levels rather than differing distances. Each lexical item has a particular activation level and each link between lexical items is weighted as per the importance of the one lexical item to the other. When a given concept is activated, all lexical items related to that concept are simultaneously activated but to varying degrees depending on the number of features shared with the initial concept and the weights linking the features to the concept (Caplan, 1992).

Quillian's model is an example of a connectionist, spreading activation model. In his model, concepts are located as nodes in a network and properties of the concept are related to the concepts by links running between them. Nodes are linked to many other nodes so that properties and concepts are linked to other properties and concepts. Links are ranked as to how important a property is to a concept. For example, the fact that a typewriter is a kind of machine is important to the meaning of typewriter; however, the fact that a typewriter is an instance of a machine is not as essential to the meaning of 'machine'. The meaning of any concept is the whole network as linked to the concept node (Collins and Loftus, 1975).
Although recent work with connectionist models has provided valuable insight into cognition and cognitive development, much of the literature relevant to this study pre-dates connectionist modeling. For this reason, further discussion here will use constructs drawn from linear models.

The role of the semantic network

A semantic network allows us to perform a number of functions/tasks. It allows us to: 1) acquire vocabulary systematically, 2) comprehend meanings and connotations of words, 3) make inferences, 4) maintain topic/make appropriate topic shifts, and 5) use certain memory strategies. The following sections provide a brief introduction to each of these functions.

Acquiring new vocabulary

When we learn a new word, we learn some of its features. Other features that make up the meaning of the word may pre-exist in the network, as associated with other, related items. The system is organized so that the new features are encoded into the network and organized amongst the existing features.

Carey (1982) talks about her research into the process of vocabulary acquisition (specifically colours) and how new vocabulary words become linked to information existing in the system. She suggests two phases of "mapping" information about words into memory. During the first few encounters with a word a small portion of information learned about the word is 'fast mapped' into semantic memory. The rest of the information is gradually mapped into memory and the map becomes more complete as the learner is exposed to a word and gathers information about it. Carey (1982) cites her study with Bartlett (1978) as having demonstrated that mappings are affected by the
properties of a child's existing lexicon (i.e. existing categories). Consider the example of a new animal name being incorporated into semantic memory. The mapping of this term would be different for a child whose existing lexicon consisted of the category *animals* than for a child whose lexicon did not already contain the category *animals*. Carey also notes that mappings are affected by the name previously used for the information. Take for example, the word “fuchsia” as it refers to the colour ‘fuchsia’. The links formed when mapping fuchsia into the lexicon will be different for a child who previously used the word “pink” for this colour than for the child who previously used “the colour of my favourite dress”. Fuchsia will be linked much more closely to 'pink' in the first child's lexicon than the second child's lexicon. The second child's lexicon will link 'fuchsia' more closely with the category 'clothing'. For a child still in the first stages of mapping this new term, the response to the word 'fuchsia' would either be "the one that is pink?" or, "the one that is like my dress?". A semantic network therefore, organizes the incoming new vocabulary, relating the new terms to existing terms.

**Representing meanings/connotations of words**

A semantic network allows us to understand meanings accurately and efficiently. The understood meaning of the word is comprised of all associated features in the system. For example if someone talks about a carrot, the meaning of carrot is generally linked to food and vegetables. If this person speaks of a carrot in the context of a snowman, one uses its general meaning along with its link to ‘snowman’ and ‘nose’ to understand its connotation in this context.
Inferencing

A semantic network also allows us to make inferences in order to express and understand meanings. Because the net links concepts to one another, we can make statements that are not explicit and they will be understood. For example, if I tell you that "The rabbit ate a carrot from Mrs. Smith's garden", you would infer that Mrs. Smith has a vegetable garden (and may or may not have a flower garden). Your semantic network linked up 'carrot' as a type of vegetable and therefore linked up 'garden' with 'vegetable' and not 'flower'. Without these connections, the carrot and the garden would not be logically related, and the inference that Mrs. Smith has a vegetable garden would have to be explicitly stated.

Topic maintenance and appropriate topic shifts

The ability to maintain topic and shift topic appropriately is dependent on the association of words in the semantic network. Due to the organization of semantics, conversation partners understand the shift in topic and can shift it back to the original topic or make further shifts that maintain coherent discourse. For example, if someone is talking about golfing and then shifts the conversation to tennis, the conversation is coherent because the speaker is still talking about sports. This conversation shift would not seem coherent to a listener who did not make an association between golf and tennis. A semantic network can provide this association.

Memory

A network allows us to use memory efficiently by providing the basis for a memory strategy. Clustering and cued recall are two memory strategies that have been demonstrated in experimental tasks and that we use in everyday life.
Clustering was first demonstrated by Bousfield (1953). He presented subjects with a list of 60 words from four different categories, and asked them to recall as many as they could remember. Adult subjects tended to recall words in clusters of categories. The act of 'clustering' these words into categories facilitated memory for the list of words. This free-recall procedure has been a popular method for evaluating semantic organization because the subject actively organizes the given words in order to output them in an order that is dictated by relationships between words (Anglin, 1970).

When we recall things in everyday life, we may use clustering as a memory strategy. For example, to give a list of countries traveled in, one might recall them by continent. To recall what to pick up at the grocery store, one might remember items by food groups.

Another memory facilitator is cued recall. Cued recall taps into the semantic network by explicitly eliciting a search of the semantic memory for the target word associated with the stimulus word. After a word is encoded as being associated with a target word, it may be used as a cue for the retrieval of that target word. If 'cat' and 'grass' are paired on a list of items to be recalled, one will be the cue for the other because they are associated on the list. An item could also be cued by a description of its function, its superordinate term or its attributes, e.g., 'flower' could be recalled by 'grow' or 'plant' or 'petals'.

In conversation, cued recall is often used when someone forgets what he or she was going to say. The conversation partner will cue the speaker by reminding him/her of the most recent key words used in the conversation or topics they have covered. The speaker's idea will often be triggered by one of these words.

The development of a semantic network

When contemplating the development of a semantic network, that is, the linking of appropriate lexical items by relationships, we question how the child's system
compares to an adult system. It is possible that: (1) no organization exists and thus, organization must occur; (2) children have an organization similar to adults, where nodes of relational meaning must be added through experience in order to form a system, or (3) a child-specific organization exists which will developmentally assimilate to the adult organization (K. Nelson, 1978). As will be discussed below, there is some evidence that between 6 and 8 years of age, children's semantic organization shifts from a child-specific organization to one resembling that of an adult. However, the development of semantic network before the age of 6 years is not well understood.

The development of a semantic network in preschool children

We derive some knowledge of semantic networks in preschoolers (2-6 years) from studies demonstrating categorical knowledge in children of this age. K. Nelson's (1978) review indicates that children have demonstrated their knowledge of categories in a number of tasks, including discrimination tasks, habituation of attention, and priming. When children were given category names and were asked to choose the pictures that were instances of those categories, they demonstrated the ability to sort pictures into categories appropriately (Saltz, Soller and Sigel, 1972). Halperin (1974) has shown that, although children could not always spontaneously recall category words in a free-recall task, they could recognize the words as belonging to categories (Halperin, 1974). These non-production tasks suggest that preschoolers do have categorical knowledge that could be represented in a semantic network.

Using verbal tasks, K. Nelson (1974) found that preschool children (5-year olds) could name instances of categories. Rossi and Rossi (1965) demonstrated category clustering by 2-4 year-olds by asking them to do a free-recall task. As well, Denney and Zibrowski (1972) showed clustering by first-grade students. Again, these studies suggest a semantic network.
While the above-mentioned studies found evidence for categorical information in preschoolers, there are mixed findings as to whether young children have the same categorical organization as that of adults. There remains the question of whether a child's network is organized similar to that of an adult and must be modified through experience, or whether the organization is child-specific and will developmentally assimilate.

One study supporting the hypothesis that a child's semantic organization is similar to that of an adults is K. Nelson’s (1974). She asked children to name members of categories such as animals and clothes. She found that younger children named fewer category items, but that the responses were organized similar to those of older children. Restricted knowledge of categories may have roots in the fact that children are still gaining knowledge of the world from which they learn concepts and categories.

Other studies support the alternate hypothesis that children have a semantic organization different from that of an adult. Saltz, Soller and Sigel (1972) used pictures of categorical items and asked the children to "pick out all the (category names)". They found that younger children did not include as many category items as older children; however, they also chose items that were different from those chosen by older children. For example, many of the younger children put the pictures of stuffed animals in both the category 'animal' and the category 'toy'. Denney and Zibrowski (1972) showed children clustering differently than adults. They demonstrated that adults categorize based on similarity, whereas 6 and 7-year-old children categorize based on complementary relationships. Similarity relationships exist between words with similar semantic features, for example, *spoon* and *fork*. Complementary relationships exist between words that are usually found in the same context, for example, *spoon* and *cereal*. The study used a list from which words with complementary relationships could be clustered, and a list from which words with similarity relationships could be clustered. The children clustered more words on the former list. Denney and Zibrowski propose that the difference in clustering criteria could be due to a preference of criteria or criteria relative to their own
needs (i.e., play or school tasks). Various studies (e.g. Anglin, 1970, p. 13) have ascertained, furthermore, that in a word association task, young children give different responses than adults. Given a target word, young children associate words from a different part of speech. This is defined as a syntagmatic response. An adult will associate words from the same part of speech as the stimulus word. This is defined as a paradigmatic response (Anglin, 1970). For instance, given the stimulus 'cup' (noun), younger children would most frequently respond with 'drink' (verb) whereas adults would respond with 'plate' (noun). The fact that children respond differently to word association tasks seems to reflect a difference between the lexical organization in children and adults. This seems to fit with Denney and Zibrowski's ideas concerning how children group words. Recall that Denney and Zibrowski (1972) remarked on children's use of complementary relationships and adults' use of similarity relationships. Complementary relationships are generally syntagmatic and similarity relationships are generally paradigmatic.

Petrey (1977) concurs that children's lexical organization is different from that of adults. However, based on her analysis of word association data from kindergarten subjects, she suggests a somewhat different interpretation of how the organization differs. She proposes that children's associations are situationally based whereas adults' associations are semantically based. To illustrate, an adult's typical response to examine is test or look whereas a child will respond with a word from their medical lexicon such as doctor, pill or sick. She sees the children's associations as being distinctly from autobiographical memory and not from semantic content.

Petrey's conclusion might lead us to question more generally whether the tasks used by researchers are suitable for determining the structure or existence of a semantic network. For example, clustering in recall may depend on a memory strategy that is not yet used by young children who may nevertheless have networked concepts. Or, as Denney and Zibrowski (1972) believe, children may have different categories from those
of adults, making it difficult for adult researchers to recognize children's use of categorical knowledge. Finally, K. Nelson (1974) alerts us to the fact that perhaps preschool children are not used to doing meaningless tasks such as free-recall tasks. She states that perhaps children at such a young age do not even fully understand the tasks. Thus, there are a number of possible reasons that we might not readily observe categorical organization in preschoolers even if the information available to them is indeed networked in some organized fashion.

The development of a semantic network in school-age children

Between the ages of 6 and 8 and up to 10 years, children's organization of semantic information comes to resemble that of an adult (Anglin, 1970 p. 13). The largest body of evidence stems from the above-mentioned studies concerning the shift in the kinds of responses given in word association tasks. This shift is termed the "syntagmatic-paradigmatic shift". Children shift from giving word associations which are syntagmatic (words belonging to a different part of speech) to those which are paradigmatic (words belonging to the same part of speech).

Although the above-mentioned studies showed differences between children and adult semantic organization, other studies of children over 6 years have demonstrated a semantic network equal to that of an adult in terms of hierarchical organization of features and categorical information. For example, K.E. Nelson and Kosslyn (1975) investigated organization of features of concepts in semantic memory by using a decision task. Subjects were timed as they retrieved semantic information to make a decision about the validity of a sentence. For example, the subjects were asked to judge whether sentences such as, "A lion has a mane" or "A lion has skin", were true or false. This particular task does not depend on whether the subject can explicitly use information in the system for a conceptual task; rather, it depends on an unconscious search for
information from within the network. It is this search in memory that is essentially timed. Properties stored close to the concept node should take less time to be activated than properties stored farther from the concept node. This task therefore probes the hierarchy of features that compose a concept and where in the hierarchy general information is stored. It is important to note that the results of this task would depend on the child's knowledge of and experience with various features. K.E. Nelson and Kosslyn demonstrated that 8-, 11- and 13-year-olds had the same pattern of retrieval as adults.

Yet another study investigating organization of categorical information is Steinberg and Anderson (1973) whose method involved cued recall. Children were shown pictures and then asked to recall the names of the pictures when given a categorically associated word as a cue. The hierarchy of the categorical system was investigated by using word cues that varied hierarchically in terms of associated categories. Cues included close super-ordinates, remote super-ordinates, close cohyponyms and remote cohyponyms. (Cohyponyms are words which name members of a common class.) This study did not compare children's performance to adult performance on the same task but results demonstrated an adult-like hierarchical organization in children as young as 6 years.

Memory revisited

Some studies of clustering and word association have suggested that children and adults may have different types of semantic networks. However, many of the experimental paradigms used to explore development of semantic networks are relying on a memory process. It may be that these studies have more to do with memory than semantic networks themselves.

It has been demonstrated that preschoolers have categorical knowledge that is not evident in free-recall tasks or word association tasks. One possible explanation for this
finding (K. Nelson, 1978) is that clustering in recall depends on a memory strategy not yet used by such young children. In general, it has been found that clustering increases with age over the elementary school years (Ornstein and Corsale, 1979). This notion of improvement makes it possible that clustering is actually a memory strategy that develops throughout childhood. As further evidence, Hasselhorn (1995) explains that it is not until the age of 8-10 years that there is a marked gain in the use of conscious memory strategies. It is from 8-10 years of age that children deliberately activate knowledge for use in learning. Moely, Olson, Halwes and Flavell (1969) investigated the possibility that because of a lack of memory strategy, categorical knowledge was not demonstrated through free-recall tasks with younger children. The experimenters taught the memory strategy to kindergarten children and children in grades 1, 3 and 5. Having been taught the memory strategy, children at each grade level showed similar levels of clustering. This exemplifies that clustering in free-recall may involve a conscious memory strategy whereby the subject must elicit the search in semantic memory and use the information stored. This conscious memory strategy is possible if semantic information is organized categorically within semantic memory.

In the following section I will explore a similar possible explanation for the failure of some autistic children to cluster.

Clustering in free recall by children with autism

As we have seen from the previous sections of this paper, clustering words in a free recall task may involve a number of factors. Children must have developed concepts and features and have them stored in a semantic network. In addition, children may need to be conscious of a memory strategy enabling clustering and decide to use that memory strategy in the free recall. If children with autism do not cluster words in a free recall task, it is possible that they are impaired in one or more of these factors.
Overall, research has shown that one of the main characteristics of autism is a deficit in language. Researchers, (Fay and Schuler, 1980; Menyuk, 1978) have speculated that the aspect of language representation most specifically impaired in people with autism is semantics. This being the case, it seems likely that children with autism could be impaired in the areas specific to semantic memory. The research done on the areas of concept development, memory and use of skills in children with autism will now be reviewed in order to investigate factors which may contribute to the failure of some autistic children to cluster in free recall.

We must first ask whether children with autism have conceptual knowledge. Research investigating conceptual knowledge in children with autism, however, is limited. Tager-Flusberg did two studies showing that in fact children with autism did have an organized semantic system. Tager-Flusberg (1985a) attempted to test autistic subjects' ability to categorize and determine their knowledge about relationships among concepts at the superordinate level. Indeed, she found that high-functioning children with autism did understand super-ordinate relationships among words and also among pictures. Given a target picture or word, the subjects were able to choose another picture/word that "was like" the target. This task demonstrated the ability to categorize abstract, super-ordinate level concepts using pictures and words. This demonstrates categorical knowledge, and implies a semantic organization.

Tager-Flusberg (1991) also demonstrated semantic organization in children with autism. Her task involved having the subjects recall a list of words from a single category when given the category name as a cue. The cue facilitated recall of the words, thereby substantiating the organized nature of their categorical knowledge. The present study will further investigate whether children with autism have semantic organization. It seems from the limited research that, like preschoolers, children with autism may have categorical knowledge that is not tapped by a free-recall task.
The second question is whether children with autism have the memory strategy that is perhaps required for clustering in a free recall task. In fact, research has shown that a prominent characteristic of autism is a deficit in some aspects of memory (Boucher and Warrington 1976; Boucher and Lewis 1989). Although studies have shown good immediate and rote memory (Hermelin and O'Connor, 1967), normal associative and cued memory (Boucher and Warrington, 1976) and good memory for the echoic or recency component of immediate recall (Boucher, 1981), the above-mentioned studies have also shown deficits in long-term memory, recognition tasks, memory for recent events and auditory verbal memory for words when recalled following a filled delay.

Boucher and Lewis (1989) demonstrated how this deficit in memory affects children with autism's ability to do certain tasks. They also showed that upon removing the memory element from a task, subjects with autism were more capable of performing the underlying language task. For example, subjects were given tasks in which they were required to ask questions, carry out instructions and answer questions about past activities. They were impeded on each of these tasks when memory was involved; however, using picture cues to facilitate memory, the subjects succeeded in each of the tasks. This research does not give a direct indication of the availability of memory strategies, although it did show that memory could be facilitated using a visual strategy. The demonstration of poor memory could be an indicator that no memory strategies are available to ameliorate memory function. This is a possible reason for the lack of clustering in a free recall task.

It is also possible that a memory strategy is available and is not being used by the child with autism. One characteristic of verbal children with autism is that they may not willingly use their language skills for communication. Research have also demonstrated the non-use of other cognitive skills acquired by autistic individuals. For example, Ungerer and Sigman (1981 as cited in Tager-Flusberg, 1985b) cite the non-use of sensorimotor abilities, and Ramondo and Milech (1984) cite the non-use of syntactic
knowledge to facilitate recall. Based on these findings it is plausible that children with autism do not use memory or memory strategies available to them in a free recall task, hence the limited amount of clustering evident in their recall.

Thus, previous research appears to indicate that children with autism do have categorical knowledge, but that it may not be evident in a free recall task. It seems likely that a deficit in memory, a lack of memory strategies or the non-use of available memory strategies are factors that can inhibit clustering of related words in a free recall task.

Hypotheses

The present study will examine, by use of a free and cued recall task, evidence of the existence and the use of a semantic network in children with autism. It is hypothesized that children with autism will demonstrate a semantic network. It is further hypothesized that the information in the network will not facilitate the free recall of related words; however, the use of cues is hypothesized to help access the network.
Chapter Two

METHOD

Subjects

Ten subjects participated in the study: five subjects with autism or Asperger's syndrome and five control subjects. Record of an official diagnosis of autism or Asperger's syndrome was documented in school files. The subjects with autism and Asperger's syndrome The subjects with autism ranged in age from 10;5 to 14;11 with an average age of 13;2. The control subjects ranged in age from 9;8 to 12;5 with an average age of 11;6. The subjects were exactly matched for auditory verbal memory span (maximum difference of +/- 0.5 words) and it was possible to match four of the pairs on Peabody Picture Vocabulary Test-Revised (PPVT-R, 1981) raw scores within 20 points. The average memory span for the subjects with autism was 4.1 words and for the control subjects, 4.3 words. Note that memory matching led to a control group that was on average two years younger than the experimental group. The average Peabody Picture Vocabulary Test - Revised (1981) score for the autistic subjects was 129.6 and for the controls, 114.4. Each subject had an average non-verbal cognitive score as determined by the Test of Non-Verbal Intelligence (TONI-2) (Brown, Sherbenou & Johnsen, 1990) (See Table 1 for subject characteristics). The subjects were recruited through local schools.
Table 1: Subject characteristics

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age</th>
<th>TONI Quotient</th>
<th>PPVT raw score</th>
<th>PPVT percentile score</th>
<th>CELF – R standard scores</th>
<th>Memory score for unrelated words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autistic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>12;2</td>
<td>90</td>
<td>121</td>
<td>50</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>S2</td>
<td>13;8</td>
<td>103</td>
<td>154</td>
<td>96</td>
<td>11</td>
<td>3.5</td>
</tr>
<tr>
<td>S3</td>
<td>14;10</td>
<td>104</td>
<td>140</td>
<td>63</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>S4</td>
<td>10;5</td>
<td>103</td>
<td>124</td>
<td>87</td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td>S5</td>
<td>14;11</td>
<td>114</td>
<td>109</td>
<td>5</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>Mean</td>
<td>13;2</td>
<td>102.8</td>
<td>129.6</td>
<td>60.2</td>
<td>7</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S6</td>
<td>9;8</td>
<td>91</td>
<td>104</td>
<td>50</td>
<td>14</td>
<td>2.5</td>
</tr>
<tr>
<td>S7</td>
<td>11;11</td>
<td>84</td>
<td>115</td>
<td>37</td>
<td>11</td>
<td>6.5</td>
</tr>
<tr>
<td>S8</td>
<td>12;5</td>
<td>103</td>
<td>128</td>
<td>66</td>
<td>9</td>
<td>5.5</td>
</tr>
<tr>
<td>S9</td>
<td>12;0</td>
<td>95</td>
<td>112</td>
<td>28</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>S10</td>
<td>12;2</td>
<td>103</td>
<td>113</td>
<td>30</td>
<td>10</td>
<td>3.5</td>
</tr>
<tr>
<td>Mean</td>
<td>11.6</td>
<td>95.2</td>
<td>114.4</td>
<td>42.2</td>
<td>10.6</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Prior to inclusion in the study, the children were screened for cognitive ability and vocabulary level. Subjects were selected to participate on the basis of:

(1) Cognitive Ability: Subjects chosen for the study had an IQ score of between 80 and 120 on the Test of Non-Verbal Intelligence (1990). Students with autism who scored in this average range were chosen so as to ensure that the characteristics of their functioning were specific to autism, and not just the result of a low I.Q. The TONI-2 is a non-verbal test requiring perceptual judgements. See Appendix A for a description of this test.

(2) Vocabulary Level: Children with a vocabulary score equivalent of at least age 7 (raw score 82) on the Peabody Picture Vocabulary test (PPVT-R) (1981) were considered to have the vocabulary level required for the experimental task due to the fact that the experimental tasks involved lists of words with relatively high frequency in the speech of children up to 7 years of age. (See Appendix A for a description of the PPVT-R.)

Five children were tested that were not ultimately included in the study. Three of these children did not meet the above described criterion, one child showed characteristics of autism but was not diagnosed with autism and one other child was selectively mute.

Materials

Standardized tests

Subjects were given three standardized tests in order to assess cognitive ability, assess vocabulary level and obtain a standard language score, two as mentioned above (TONI-2, PPVT-R), and also the Clinical Evaluation of Language Function (CELF-R) subtest Listening to Paragraphs (1980). This is a test which involves listening to two
paragraphs and responding to four questions for each. The responses require an understanding of the information given as well as memory for details and the ability to make inferences. (See Appendix A for a further description of these tests.)

**Experimental tasks**

**Overview and rationale**

Subjects in this study were asked to do a set of memory tasks. They each listened to lists of words and later recalled as many as possible. This recall was done after a 30-second delay interval during which they worked on a separate task. The first two lists were each comprised of ten unrelated words. The remaining four lists were each comprised of eight words derived from two different categories. The subjects recalled the final two of these lists given category cues.

The 30-second delay interval was imposed in order to eliminate the use of specific memory rehearsal strategies prior to recall. Postman and Phillips (1965) showed that in immediate recall, the last few items in a list are the ones which will most likely be recalled. This is known as the recency effect. Postman and Phillips (1965) showed that when subjects were asked to recall a list of words after a 30-second delay, the recency effect was eliminated. If an unfilled 30-second delay is imposed, the subject has 30 seconds in which to rehearse the word list. Rehearsal is a conscious memory strategy that can increase the likelihood that words will be recalled in the same order as they were presented (Mandler, 1968). Postman and Phillips therefore used a filled 30 second delay which prevented the rehearsal of words. In the present study we did not want the subjects to repeat the lists of words verbatim. Therefore, a 30-second filled delay was imposed in these free recall tasks to eliminate both the rehearsal and recency effects in the recall of the related words.
The second experimental task in this study involved recall of words when the subjects were given the category name of items as cues. This method was used by Tulving and Pearlstone (1966). They presented subjects with a list of words from different semantic categories. Half of the subjects recalled the items without the use of cues, while the other subjects were cued by the experimenter giving category names. They found that subjects given category names recalled more items than those given no cues. Doing such a recall with category cues will demonstrate whether a subject could associate group members with a category cue, therefore demonstrating a semantic network.

Word lists for the auditory memory tasks

Unrelated word list

Two lists of ten unrelated words were composed for use in the baseline auditory memory task. A pool of possible items was created by first listing four common members of ten different categories (money, drinks, furniture, utensils, professions, body parts, nature, shapes, clothing and sports). Everyday categories were chosen to ensure that the subjects would be familiar with the words in the list. Four of these categories have been used in studies investigating the development of the semantic system in pre-school age children and words from the other six categories are used in standardized tests for children under 6 years of age. These forty items were then checked for frequency of occurrence in the spoken language of pre-school-aged children as measured by Hall, Nagy, and Linn (1984). Words whose frequency was too high or too low as compared to the other words were rejected as possible list words. This left two words per category to make two lists.
Where possible, word pairs with the same syllable length were assigned to the two lists. When this was not possible, the one- and two-syllable words were alternated between the two lists so that each list contained approximately equivalent numbers of one and two syllable words. As a further criterion, none of the words within a list could rhyme.

When the words for each list were chosen, the words were numbered from one to ten. Using a random number table, the items on each list were randomly ordered with the exception that no two words starting with the same sound could be adjacent. These lists comprised form A. The randomization procedure was repeated in order to create two more lists for form B which contained the same words in a different order.

**Related word list**

Four lists of eight words (four each from two different categories), were composed for use in the experimental tasks 1 and 2, as follows. Eight words per list were chosen based on expectations of memory span for subjects in this age range, in an attempt to allow for gains without overwhelming the subjects.

Four different categories were identified and subdivided to yield eight groups of four words each: farm animals, domestic animals, insects that fly, insects that crawl, vehicles with four wheels, other vehicles, school supplies used for cut and paste and school supplies used to draw/write. Again, these categories were chosen to ensure that subjects would be familiar with words in the lists. Two of these four categories were chosen from curriculum and daily use in grade 1, one category was chosen from past studies of development of the semantic system in pre-school-aged children, and one category was chosen from a standardized test for pre-school-aged children. All words were one or two syllables. Due to category constraints, it was not possible to control the
words within or across category for absolute frequency. However, all of the words in the lists have been reported to occur in the speech of pre-school- and kindergarten-aged children (Hall, Nagy, & Linn, 1984; Wepman & Haas, 1969). None of the four words in each list rhymed.

These eight lists of four semantically related words were paired to create four lists of eight words; 1) insects that fly and vehicles on wheels, 2) insects that crawl and other vehicles, 3) domestic animals and school supplies used for cut and paste, and 4) farm animals and school supplies used to write/draw.

These combinations of categories (insects/vehicles and animals/school supplies) were randomly determined with the exception that the categories 'insect' and 'animal' could not be paired due to the fact that insects may be viewed as 'animals'.

The random number table procedure as described above was used to produce two randomized orders of the items in each of the four lists with the constraints that a) no more than two words from the same category could be adjacent, b) no two words starting with the same sound could be adjacent, c) no two words that rhymed could be adjacent and d) no two adjacent words could have a possible syntactic relationship. The assignment of lists to conditions, and their ordering, was counterbalanced across children. Each child did a recall task with each of the four lists. Word lists for all tasks are included in appendix B.

Visual search task

Between listening to the lists of words and recalling the words, the subjects were given a sheet of randomly spaced, randomly ordered symbols and were asked to find all instances of a target symbol. The sheet consisted of a white piece of paper with nine double spaced lines of keyboard symbols (!,@,#,$,%,,&,*,(,) in 18 point font with 0 to
Procedures

Auditory memory tasks

1. Memory task for unrelated words

The first memory task was done in order to match subjects for auditory memory span. Subjects were told:

"I am going to read you a list of words. When I am done I am going to give you this paper (visual search task) and you will circle all of these signs (experimenter circles the symbol at the top of the page). After a little while I will take the paper away from you, even if you have not finished. Then, you tell me all of the words that I said, in any order. Okay?"

The experimenter proceeded to read the first list of 10 unrelated words in a monotone voice with one second between each word. When the list was completed, the experimenter lay the visual search task face-up in front of the subject, with a pen on top. While the subject circled the indicated symbols, the experimenter timed 30 seconds on her stopwatch. At the end of 30 seconds, she said, "OK" and turned the paper face-down. Then she instructed:

"Now tell me all the words you remember".

As the subject recalled words, the experimenter wrote them on a piece of paper in the order they were recalled, acknowledging each word with a nod. The subject's recall of
words ended when he/she said "That's all", or if the subject paused for 10 seconds, the experimenter asked, "Any more?" and the subject said "No".

The experimenter told the subject "that was great" and explained that "now we will do the same thing with different words. Ready?". The second list of words was tested by the same procedure as the first list of words.

2. Memory task for semantically related words: no cue

The second experimental task was designed to measure clustering of related material in the recall of a list of related words. The procedure for this task was identical to the above described experimental task with the exception that the experimenter read a randomized list of eight words drawn from two categories. As in the above task, this procedure was repeated for each of the two lists.

3. Memory task for semantically related words: cued

The third experimental task followed the same procedure as the previous two tasks up to the point where the subjects were asked to recall the words. After the subject had circled symbols for 30 seconds, the experimenter said "OK", turned the paper face-down and then instructed the subject:

"Tell me all the (name of one category) you remember".

The subject's recall of words ended when the subject said "that's all" or when the subject paused for 5 seconds. The experimenter then said:

"OK, tell me all the (name of the other category) you can remember".

Once the recall was completed, the experimenter told the subject:

"Now we will do that one more time with new words".
The procedure was then repeated. The order of the categories to be recalled was counterbalanced across subjects.

Sessions

Each subject was tested over two sessions. Both sessions were held in a quiet room in the subject's school. The first session was approximately 40 minutes in duration. The subjects were first given the test of auditory memory, followed by the TONI-2 and the PPVT-R.

The second session was approximately 20 minutes in duration. It took place from two days to one week following the first session. In this session, the subjects were given the experimental memory task for semantically related words-no cue, followed by the experimental memory task for semantically related words-cued. Lastly, the Listening to Paragraphs subtest of the CELF-R was administered.

Scoring

Memory task for unrelated words

The score for the memory task for unrelated words was the number of words recalled, in any order, averaged over the two lists.

Memory task for related words

Scoring the memory task for related words involved scoring the amount of clustering of words from the same category while taking into account the number of
words recalled in total. Clustering is the number of times within a recalled set of words that a word from one category follows another word from the same category.

The ARC score (Roenker, Thompson and Brown, 1971) was chosen to measure the amount of clustering in the recall of related words. The ARC score "represents the proportion of actual category repetitions above chance to the total possible category repetitions above chance" (Roenker, Thompson and Brown, 1971). Therefore a score of 0 represents no clustering above chance and a score of 1 represents perfect clustering given the words recalled. ARC is determined by the following formula:

\[ \text{ARC} = R - \frac{E(R)}{\text{maxR}-E(R)} \]

where

- \( R \) is the total number of observed category repetitions, which is defined by the number of times an item follows another item from the same category.
- \( \text{maxR} \) is the maximum possible number of category repetitions, as defined by \( N-k \), where \( N \) is the total number of items recalled, and \( k \) is the number of categories represented in the recall protocol.
- \( E(R) \) is the expected (chance) number of category repetitions defined by \( \frac{\sum n_i^2}{N}-1 \), where \( n_i \) is the number of items recalled from category \( i \), and \( N \) as before.

Different studies involving clustering within free recall have used different formulas with which to measure the amount of clustering. Hermelin and O'Connor (1967) used a repetition count which did not take into account chance level clustering. Bousfield and Bousfield (1966) and Roenker, Thompson and Brown (1971) used scoring methods which did account for chance level clustering. The Roenker, Thompson and Brown scoring method (ARC) has previously been discussed in this chapter. The other two methods that were not chosen to score the data in the present study will now be
examined in order to compare them to Roenker, Thompson and Brown's ARC score and justify the use of ARC scoring in the present study.

Hermelin and O'Connor's repetition count scored clusters of words by giving a score of 2 when two words from the same category were recalled sequentially, a score of 3 when three words from the same category were recalled sequentially and a score of 4 when four words from the same category were recalled sequentially. Their results stated that each group had recalled approximately an equal number of words and that control subjects had clustered significantly more than the autistic subjects; however, the scores were not then compared to any chance level. It is therefore possible that the actual clustering that took place above chance level was not significantly different between groups. Hermelin and O'Connor's repetition count was rejected as the primary method of scoring for the present study on the basis that they did not take into account the chance of clustering.

In contrast to the repetition count, the scoring system devised by Bousfield and Bousfield (1966) does take into account the chance of clustering given the words recalled. Like the ARC score, the BB measures compare the actual amount of clustering (the number of times within a recalled set of words that a word from one category follows another word from the same category) with the expected chance clustering score given the words recalled. For example, if the subject recalled two words from one category and three words from another category, the score for chance is referring to the chance that the two words from one category would be recalled sequentially and the three words from the other category would be recalled sequentially.

The difference between the BB scores and the ARC scores is that while BB scores are simply the difference between the obtained cluster score and the expected (chance) cluster score, the ARC score is a ratio of the difference between the obtained cluster score
and the expected (chance) cluster score and the difference between the maximum possible cluster score (given the words recalled) and the expected (chance) cluster score. BB is a score of how much clustering is done above chance. ARC is a ratio of how much clustering is done above chance to how much one could possibly cluster above chance.

The benefit of a ratio score is demonstrated in the following example. If a subject recalls two words from one category and one word from another category, he/she has clustered .33 over chance. However, it is impossible to score more than .33 over chance given this pattern of recall because the subject has clustered as much as possible. With BB scoring, this recalled list would be given a clustering score of .33; however, with ARC scoring, it would be given a clustering score of 1 to represent perfect clustering.

The ARC score is therefore more detailed in its information. Not only does it tell how much valid clustering was done but also what could have been done. For this reason, the ARC scoring method was chosen for this experiment.
Chapter Three

RESULTS

This study was designed to examine evidence of the existence and the use of a semantic network in children with autism. This was done using a free recall task and a cued recall task. The free recall task was designed so that related words could be recalled in clusters. Clustering would be a sign that a network exists and is being used to facilitate memory. The cued recall task was designed to tap into the existence of a semantic network even if a subject did not cluster in the free recall task. If the subject's recall is facilitated by a cue (a category name), then we can assume the existence of a semantic network. The results of the study will therefore answer two questions: 1) do children with autism cluster words in a free recall task significantly less than typical children?; and 2) do category cues facilitate clustering for children with autism in the recall of related words? Because each subject participated in two trials for each of condition 1 (free recall without cues) and condition 2 (recall given category cues), the results were calculated based on the average score of the two trials for each condition. As described in the previous chapter, clustering was measured by the ARC scores which represent the proportion of the actual category repetitions above chance to the total possible category repetitions above chance.

The first analysis addressed the question of whether children with autism cluster words in a free recall task significantly less than typical children. The relevant data were the free recall performances, without cues, obtained in condition 1 (see Table 2). Mean ARC scores for clustering of words for subjects with autism were compared to the mean ARC scores for clustering of words for typical subjects. These values were: subjects with autism, 0.4808 words and typical subjects, 0.209 words. A Mann-Whitney U Test was performed to test the statistical significance of the difference between these means. No
significant difference was found (U=7, p>0.15 (1-tail)). Subjects with autism did not cluster related words in a free recall task significantly less than typical subjects.

Table 2: ACR scores for condition 1 and condition 2 for all subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mean ARC score</th>
<th>Mean memory scores</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Condition 1</td>
<td>Condition 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free-recall</td>
<td>Cued-recall</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>unrelated words</td>
<td>related words</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(maximum=10)</td>
<td>(maximum=8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autistic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>1.0</td>
<td>1.0</td>
<td>6.0</td>
<td>7.0</td>
</tr>
<tr>
<td>S2</td>
<td>0.549</td>
<td>1.0</td>
<td>3.5</td>
<td>7.5</td>
</tr>
<tr>
<td>S3</td>
<td>0.285</td>
<td>1.0</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>S4</td>
<td>1.0</td>
<td>1.0</td>
<td>2.5</td>
<td>4</td>
</tr>
<tr>
<td>S5</td>
<td>-0.43</td>
<td>1.0</td>
<td>3.5</td>
<td>5</td>
</tr>
<tr>
<td>Mean</td>
<td>0.4808</td>
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<td>5.8</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S6</td>
<td>-0.465</td>
<td>1.0</td>
<td>2.5</td>
<td>5.5</td>
</tr>
<tr>
<td>S7</td>
<td>0.285</td>
<td>1.0</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>S8</td>
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<td>5</td>
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<tr>
<td>S9</td>
<td>0.750</td>
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<td>3.5</td>
<td>5.5</td>
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<tr>
<td>S10</td>
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<td>0.209</td>
<td>1.0</td>
<td>4.3</td>
<td>5.1</td>
</tr>
</tbody>
</table>
The second analysis addressed the question of whether category cues facilitate clustering for children with autism in the recall of related words. Mean ARC scores for clustering of words for subjects with autism given category cues were again compared to the mean scores for clustering of words for typical subjects given category cues. These values were: subjects with autism 1.0 words and typical subjects, 1.0 words. These scores do not signify that subjects recalled all of the words in the list. The scores signify that the subjects recalled the words from the correct category without intrusions of words from other categories. These scores clearly fail to indicate any difference in performance between the two groups and suggest that both groups of subjects benefited from category cues. These results therefore suggest that subjects with autism do have access to a semantic network.

The results from condition 1 could be interpreted as indicating that the subjects with autism and the typical subjects clustered equally in the free recall task. However, there is still a possibility that neither group was actually using clustering in recall. It is possible that the words were recalled in random fashion and that the apparent clustering of category words was due to chance. The ARC scores did indicate clustering above chance but they did not reveal if the clustering above chance was statistically significant. Two sorts of further analyses were conducted to help to determine if clustering was used. The first considered the actual chance values. A statistical test of the difference between clustering scores and chance clustering scores would suggest whether clustering was being used or not. The second approach looked at memory performance. The ARC score clustering analysis does not compare the absolute values for the total number of words remembered. Because clustering is a memory facilitator for recall, clustering should aid in the memory of words and yield higher total scores. If groups are clustering it would be expected that memory span would be greater for the related words in condition 1 than for
unrelated words. It would also be expected that memory span would be greater in condition 1 for subjects with high clustering than for subjects in condition 1 who had low clustering.

With these considerations in mind, analyses were conducted to answer three additional questions: (1) Was there a significant difference between observed clustering scores and the clustering scores expected by chance alone, (2) Was there a significant difference in memory span for related words in the free recall task (condition 1) as compared to unrelated words for either group? (3) Was there a significant difference between increase in memory span for low clusterers and high clusterers?

(1) To answer the question of whether or not there was a difference between the observed clustering scores and chance clustering scores, the score given for the amount clustered on each of the two lists of related words (L1 and L2 in condition 1) was compared to the clustering scores expected on the basis of chance alone. Across all subjects the mean clustering score for L1 was 2.8 and for L2 was 2.0. The mean score for chance clustering for L1 was 2.0 and for L2 was 1.9. No significant difference between observed and expected values was found for either list (L1 U=35.5, p>0.27; L2 U=47, p>0.82). This suggests that no clustering was taking place.

(2) To answer the question of whether or not there was a difference between memory for unrelated and related words, the total number of items remembered in each of these tasks was compared. The mean memory score for unrelated words for all subjects was 4.2 words. The mean memory score for related words for all subjects was 5.45 words. The difference between these means was statistically significant (U=26, p<0.035 (1-tail). Therefore, memory span was greater for related words. This suggests that categories were used to facilitate recall.
Finally, to answer the question of whether or not the increase in memory span for related words (as shown above) was greater for high clusterers than for low clusterers, the association between degree of clustering and the increase in the number of words remembered from unrelated words to related words was determined using the gamma statistic. This is a nonparametric correlational procedure that is especially useful for data with ties. It essentially estimates the probability that subjects with high cluster scores also have greater increase in memory scores.

Gamma was found to be 0.565 ($p<0.04$, 1-tail), a value which proved to be statistically significant. This indicates that there was a definite link between the amount recalled and clustering scores which suggests that clustering was taking place.

To summarize the three ancillary analyses, although the results do not show clustering above chance for the non-cued recall (condition 1), there was evidence of category-based recall for both the autistic and the typical subjects in the increase of memory from unrelated words to related words and in the increase in items recalled for subjects who were higher clusterers. The two latter ancillary analyses are the most appropriate indicators of the amount of clustering done by subjects. The first ancillary analyses requires almost perfect clustering in order demonstrate significant clustering above chance.

The final set of analyses looked at two additional factors that might be related to the clustering behaviour, word frequency and prior knowledge. To examine the effect of word frequency, the seven trials earning the highest ARC scores and the seven earning the lowest ARC scores were analyzed to see whether the words actually recalled were associated with the frequency of the words in everyday usage (Hall, Nagy, & Linn, 1984). Each word in the presented lists was designated as having either high, medium or low frequency of use, then the distribution of recalled words across these categories was
compared to that of the words presented. Separate analyses were conducted for the high-ARC and low-ARC trials. Chi-square tests indicated no difference between the observed and expected frequency distributions in either case. Whether or not they clustered, subjects did not tend to selectively recall words with high, medium or low everyday usage (high-ARC, x2=1.16, DF = 2, P> .05; low-ARC, x2 = 5.99, DF = 2, P> .05).

To examine the role of prior knowledge, a correlation analysis was done to determine if clustering was correlated with general intellectual ability as measured by the TONI-2, or language ability as measured by the PPVT-R, or CELF-R. Spearman Correlation coefficients were calculated to determine the relationship between the ARC score and each of these standard test scores. The resultant values were: TONI-2 (r=-.23); CELF-R (r=-.29); PPVT-R raw score ( r = .38); and the PPVT-R percentile (r=.4). None of these correlations were significant but the vocabulary knowledge as measured by the PPVT-R percentile showed the strongest relationship to clustering, accounting for 16% of the variance.

In summary, the present study was designed to examine, by use of a free and cued recall task, evidence of the existence and the use of a semantic network in children with autism. It was hypothesized that children with autism would demonstrate a semantic network. The information in a network would not facilitate the free recall of related words but would be evident when given a cued recall task. The present data do support the existence of a semantic network. As hypothesized, the network is evident in the cued recall task where all subjects retrieved categorically related words given the category name. However, contrary to the original hypothesis, the networked information did facilitate free recall of related words. The subjects with autism and the typical subjects did not cluster differently in the free recall task with related words, with some children in each group clustering strongly and others virtually not at all.
Chapter Four
DISCUSSION

The present study examined whether children with autism have a semantic network and whether these children are able to use such an organization of semantics with or without facilitation to recall a list of semantically related words. The subjects were asked to do a free recall task of words from two categories followed by a cued-recall task of words from two different categories. The results indicated that (1) children with autism did not cluster related words in a free recall task significantly less than typical subjects and (2) both groups of subjects benefited from category cues. Although neither group of subjects in the present study clustered at levels that were significantly above chance, category use across groups was suggested by the increase in memory from unrelated words to related words and in the fact that high clusterers had more of an increase in memory than low-clusterers. Contrary to expectations, these results suggested that at least some subjects with autism do have access to a semantic network, and use it in memory tasks.

These results support what Tager-Flusberg concluded in her 1991 study regarding the ability of autistic children to use category cues in order to recall categorical information. However, the results do not support conclusions from both Hermelin and O'Connor (1967) and Tager-Flusberg (1991) that children with autism do not cluster categorically related words in order to aid memory in a free-recall task. Results of this study are likely to differ from those of Hermelin and O'Connor and Tager-Flusberg due to three factors: (1) subjects, (2) methodology and (3) scoring.

Hermelin and O'Connor's subject pool differed from that of the present study. Hermelin and O'Connor's subjects were twelve children with the diagnosis of infantile autism or childhood psychosis (diagnosed by psychiatrists) whereas subjects in the present study had a diagnosis of autism or Asperger's syndrome. Because Hermelin and
O'Connor used subjects who were not all diagnosed with autism, they draw conclusions about abilities/difficulties which are not necessarily due to characteristics of autism in particular. The present study focuses on the autism spectrum alone; therefore, results reflect characteristics of autism. In addition, Hermelin and O'Connor's groups were matched on the Peabody Picture Vocabulary Test and scored in a range lower than the subjects in the present study. Hermelin and O'Connor's subjects had a low end PPVT age equivalent score of 2;6 and subjects in the present study had a low end age equivalent score of 7;0. It does not appear that Hermelin and O'Connor matched their target words to the level of their subjects. The difference in results may therefore be due to the fact that Hermelin and O'Connor's subjects may not have been familiar enough with the vocabulary required for the experimental task. In addition, we know that young children in general do not use clustering as a memory strategy. Subjects with autism who have lower vocabulary levels might therefore not be expected to cluster to the same degree as those subjects with higher vocabulary levels. Therefore, the lower levels of the subjects in Hermelin and O'Connor's study may account for the difference in results.

Tager-Flusberg's subjects were more similar to the subjects who participated in the present study, in that they were all diagnosed with autism. As in the Hermelin and O'Connor study, the subjects were matched for verbal age equivalency based on PPVT scores. The average age equivalent score for her subjects with autism was 5:2, a vocabulary age that is closer to the developmental level of subjects in this study, and one at which some clustering might be expected. Children in the present study were still developmentally more advanced than the subjects in Tager-Flusberg's study, however, and hence more likely to use clustering strategies. Subject differences may therefore explain some of the differences in findings between the present study and Tager-Flusberg's study.

It should be noted that Hermelin and O'Connor included 12 subjects in their experimental group and Tager-Flusberg included 15 subjects in her experimental group.
whereas the present study included only 5 subjects in the experimental group. The result of a small sample size in the present study is that results may not hold true over a larger sample size.

Methodological differences also provide an even better explanation for results that differ from those of Tager-Flusberg. Tager-Flusberg's study involved children recalling a list of words from a single category (animals) and the present study involved recalling a list of words from two categories. Although Tager-Flusberg interprets her method as providing an opportunity to cluster and as a task using influences of a semantic network, it is possible that it did not prompt the same kind of organization strategy as the method used in the present study. It is possible that recalling words from two categories prompts categorical memory strategies in a way that one category does not, by providing a comparison between category words.

Hermelin and O'Connor's study also differed in methodology. They used three lists of eight words each to be recalled. In the first list, the words lent themselves to clustering into two categories. In the second list, only four of the eight words were from one category. In the third list, half of the words were from one category and the other half of the words made up a sentence. Clustering in this list was counted as category clustering or clustering of sentence words. Hermelin and O'Connor claimed that subjects did not demonstrate a different degree of clustering for the different word lists; however, the kind of clustering that Hermelin and O'Connor's subjects were asked to do was not the same clustering as subject in the present study were asked to do.

Another methodological difference of both Hermelin and O'Connor's study and Tager-Flusberg's study is the amount of time between hearing and recalling the target list of words. Both of the other studies had subjects do an immediate recall whereas the present study imposed a filled delay between hearing and recalling the target words. Recall from chapter two that Postman and Phillips (1965) showed that in immediate recall, there is a tendency for subjects to show a recency effect. This is eliminated with a
filled 30-second delay, as was imposed in the present study. Given this fact, it is possible that subjects in the other two studies were more likely to recall words in the order they were given, rather than re-ordering the target words into category clusters.

Finally, differences in findings from the three studies may reflect differences in the scoring schemes that were used. This is especially true of the study by Hermelin and O'Connor. These investigators used a repetition count to calculate the amount of clustering. The repetition count scored words by giving a score of 2 when two words from the same category were recalled sequentially, a score of 3 when three words from the same category were recalled sequentially, etc. They did not use ARC scoring as was used in the present study. The repetition count method of scoring could lead to a difference in results between studies because this scoring method, unlike the ARC method, does not tell how much clustering took place above chance level for recalled lists of a given length. If the number of words actually recalled had been used as a basis for estimating chance values, it is possible that the actual clustering that took place in the Hermelin and O'Connor study was not significantly different between groups.

Tager-Flusberg could not easily score the amount of clustering in the recalled list because all of the target words were from one broad category (animals). Instead, she compared the number of words recalled from a list of unrelated words to the number of words recalled from a list of animal names. A similar scoring approach was used in the present study; thus, scoring method alone is not responsible for the differing results.

Even though the sample size was small, the design of the current study allowed more conclusions to be drawn regarding the existence of a semantic network in children with autism than did the designs of the other two studies. The present study investigated the ability of a homogeneous group of subjects in the autism spectrum to recall words from two categories, which allowed for maximum clustering to occur. The method of scoring used in this study determined not only how many words were clustered but also how much was clustered above chance, given the number of words actually recalled.
Finally the recall task was done after a 30-second delay which would have reduced the likelihood of rote memory recall of the lists.

These findings give a more positive view of the organization of the semantic system in high-functioning children with autism. The findings demonstrate that such children are able to develop and use available lexico-cognitive structures in the manner expected for children of equivalent memory span and vocabulary age.

Because a semantic network also provides the associations used to make inferences, maintain topic and represent the meanings of words the present study could be taken to imply that children with autism could demonstrate these skills equally as well as their memory/vocabulary peers, even though these three skills are often mentioned as problems for children with autism (Prior & Ozonoff, 1988). It is not clear whether such claims consider the general language delay in high-functioning children with autism. It is possible that subjects with autism are able to do these tasks involving a semantic network at the level appropriate for their language skills. In support of this view, results in the present study showed a moderate correlation between the subjects' clustering scores and their PPVT raw score. This demonstrates that vocabulary level may have an impact on a subject's ability to cluster. It seems that the ability to listen to words and rearrange their order for output could be aided by depth of vocabulary knowledge in general. It could also be that students learn vocabulary in categories and with related words. This would mean that inherent in learning vocabulary is the exposure to categories and related words.

It is also possible that children with autism have difficulties with topic maintenance, word meaning and inferencing that go beyond what could be explained by their general language delay. If so, it would seem that facilitation in the aspect of the task concerning semantic networks would better able the subjects with autism to do these tasks. Of course these tasks require more than simply an intact semantic network; they are language tasks that require an ability to use context to decipher meaning (both explicit and implicit), an ability to do abstract thinking, divergent thinking, an understanding of
conversational rules, and perhaps even a conscious awareness of what is required of each
 task. Results do not show that all of these skills are intact in the subjects with autism;
 however, the underlying necessary categorical word associations do exist. These
 semantic networks could provide a valuable foundation for work in other areas of verbal
 cognition.

 Limitations of the present study and future research

 The present study has suggested that semantic networks exist and can be used by children
 with autism. This was demonstrated by a controlled experimental task involving
 deliberate recall of a list of categorically related words. The semantic networks should
 have an influence on acquisition of vocabulary, representation of meanings and
 connotations of words, inferencing, topic maintenance and memory. This study has not
 shown how the existence of a semantic network could influence these factors or how
 facilitation of the semantic network could influence these factors for children with
 autism. Further research is needed to examine implications in functional activities of
 everyday life.

 The present study used a group of experimental subjects who were diagnosed with
 autism or Asperger's syndrome, however, all of the subjects were high-functioning.
 Results of this study do not demonstrate the abilities of lower functioning children with
 autism or Asperger's syndrome. Further research is needed to examine semantic
 networks in those lower functioning children.

 Although the results of this study have demonstrated that a network exists and can
 be used by children with autism, the results do not specify whether their semantic
 network has the structure or the size expected for a child of that language level or age.
 Firstly, this study only examined the semantic network as its organization pertained to
 categorizing items that were linked by membership in a superordinate class. The
conclusion cannot be made that every part of a semantic network for children with autism is linked as it is in typical children. Secondly, the tasks traditionally used to investigate semantic networks do not necessarily uncover all aspects of a semantic network. Therefore, results are not conclusive as to the exact nature of a semantic network in these subjects. Recall from chapter one that using word association tasks, children’s semantic networks are seen to shift to a more adult-like network between 6 to 8 and 10 years of age. The results of the present study do not demonstrate whether or not the subjects with autism have made this shift due to the fact that the methodology of the present study did not include a word association task. However, the results of the present study did show that the subjects with autism did not perform differently from the control subjects who were all within the age range for having shifted to an adult-like semantic system. Future research is needed to examine different sorts of word associations within the semantic network of children with autism.
REFERENCES


TONI-2 Test of Non-Verbal Intelligence (1990)
The purpose of this test is to determine a non-verbal cognitive score for a child. The test consists of a series of incomplete patterns, each with six single designs of which one will correctly complete the pattern. Subjects are instructed by example with 6 practice items. The experimenter presents the incomplete pattern, points to the blank box in the pattern and then, one by one, indicates the choices below demonstrating the correct yes/no response for each one. The subject then begins doing the test items until he/she responds incorrectly 3 out of 5 times.

All responses are acknowledged in a positive manner by the examiner. Feedback is not given as to whether or not the responses are correct.

Peabody Picture Vocabulary Test- Revised (1981)
This is a standardized test designed to evaluate single word receptive vocabulary. The subject is presented with a series of plates consisting of four line drawings. One of the four pictures on each plate represents a target word. The experimenter asks the subject to "point to ___." This is repeated for each vocabulary word on the test until the subject incorrectly identifies 6/8 target words. Each response is acknowledged positively but feedback is not given as to which responses are correct.

Clinical Evaluation of Language Fundamentals-Revised (CELF-R) Listening to Paragraphs subtest (1980)
The purpose of this test is to evaluate a subject's ability to interpret information presented in paragraph-long story. The subject is told that he/she will listen to a short story and then the examiner will ask him/her questions about the story. The examiner reads the
paragraph corresponding to the subject's age and asks each of the four questions that follow. This procedure is then repeated for the second paragraph corresponding to the subject's age and the corresponding questions.
APPENDIX B

Word lists for conditions 1 and 2: semantically related words

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>cricket</td>
<td>dog</td>
</tr>
<tr>
<td>truck</td>
<td>tape</td>
</tr>
<tr>
<td>bus</td>
<td>scissors</td>
</tr>
<tr>
<td>moth</td>
<td>rabbit</td>
</tr>
<tr>
<td>car</td>
<td>mouse</td>
</tr>
<tr>
<td>taxi</td>
<td>paper</td>
</tr>
<tr>
<td>wasp</td>
<td>cat</td>
</tr>
<tr>
<td>bee</td>
<td>glue</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>List 3</th>
<th>List 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>chicken</td>
<td>bug</td>
</tr>
<tr>
<td>pen</td>
<td>train</td>
</tr>
<tr>
<td>goat</td>
<td>van</td>
</tr>
<tr>
<td>crayon</td>
<td>worm</td>
</tr>
<tr>
<td>chalk</td>
<td>ant</td>
</tr>
<tr>
<td>pig</td>
<td>subway</td>
</tr>
<tr>
<td>cow</td>
<td>boat</td>
</tr>
<tr>
<td>paint</td>
<td>spider</td>
</tr>
</tbody>
</table>

Each of these lists was prepared in two different orders. Lists 1 and 2, and lists 3 and 4, were counterbalanced across subjects in conditions 1 and 2.
APPENDIX C

Example of visual search task

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