USE OF THESES

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p. 17, para. 3 line 13 should read-

Trials to criterion was non-cumulative; as already described it took into account all trials to reach a criterion of perfect performance on two successive trials.

THE SELECTIVE REMINDING TECHNIQUE: DEVELOPMENTAL IMPLICATIONS FOR CHILDREN'S MEMORY ASSESSMENT

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Submitted in partial fulfilment of the requirements of the degree of Masters of Clinical Psychology, Department of Psychology, Australian National University, 1988.
Declaration

I declare that this thesis reports my original work, that no part of it has been previously accepted or presented for the award of any degree or diploma by any university, and to the best of my knowledge no material previously published or written by another person is included, except where due acknowledgement is given.

[Signature]

Vincenza A. Mart
This thesis describes original research carried out by the author in the Department of Psychology of the Australian National University during 1987.

Virginia Hart
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ABSTRACT

A commonly-used procedure for the clinical assessment of memory functioning is Buschke's (1973) Selective Reminding Technique (SRT). Although clinicians have employed the SRT with patients of all ages, they have largely ignored a particular problem in interpreting child data. This difficulty stems from the fact that qualitative changes in knowledge occur during the course of children's cognitive development and that such changes affect memory performance. Thus, a given pattern of apparent deficits may reflect a certain "normal" stage of development, rather than clinical impairment.

This study examined the effects of developmental change in the knowledge base on selected SRT variables. Subjects from four age groups, representing different stages of development with respect to predominant modes of organizing information, were required to learn three lists, which varied in degree of congruence with these modes. List-type was found to have a significant effect at each age level, but the type of effect varied across age. This result has implications for the establishment of qualitative, as well as the usual quantitative child norms, as a prerequisite to the further clinical employment of the SRT with children.
Within the field of clinical psychology, there exists an array of theoretical and empirical approaches to the assessment of memory. As with memory research in general, clinical paradigms have been utilized to assess memory functioning by employing recognition, and free list, serial and paired-associate recall tasks. In 1973, Buschke described a new method for use as a clinical and research tool in the assessment of memory. Termed the 'Selective Reminding Technique', the method has demonstrated its utility as an empirical and diagnostic tool.

SELECTIVE REMINDING TECHNIQUE

Selective reminding is a method of administration and scoring that can be applied to a free list learning task. The procedure is as follows. The subject is read a list of words at a fixed rate and is then required to recall as many of the words as possible in any order (free recall). Following this, the subject is 'selectively reminded' only of those words not recalled on the immediately preceding trial. This is termed the 'reminding trial'. In the subsequent test trial, the subject attempts to recall all words on the list, both those recalled on the previous test trial and those presented on the reminding trial. This procedure of alternating test and reminding trials is continued until either a criterion number of trials is reached or the subject recalls all words on two consecutive trials.

The selective reminding technique (SRT) allows for the simultaneous evaluation of the relative effects of acquisition, storage and retrieval in free recall learning (Buschke, 1974). Buschke argues that traditional list learning tasks do not adequately permit the separation of storage and retrieval. The SRT, however, does allow for this componential separation. From the subject's recall performance, scores for several memory components can be calculated. These scores partition recall into short-term storage, long-term storage, short-term retrieval and long-term retrieval components.
With regard to the long-term components, an item can be considered to have entered and been retained in long term storage when it has been recalled on two consecutive trials, without reminding prior to the second recall trial. Buschke (1973) argues that recall of an item without presentation on the previous trial indicates that retrieval from long term storage has occurred (see also Craik, 1968; Tulving & Colotla, 1974). Once an item is retained in long term storage two outcomes are possible. The subject might forget, or fail to recall an item on one or more subsequent trial(s), in which case it is classed as a retrieval error. That is, the item has been deposited in long-term storage but not retrieved from there. Alternatively, the item may be both retained in and retrieved from long-term storage, as is the case when the item is recalled on all trials subsequent to its entry: in this case long-term retrieval has occurred. Given that some items satisfy the operational definition for entry into long-term storage, an estimate of 'consistent long-term retrieval' can be calculated from the subject's overall recall scores.

With regard to the short-term components of memory, the SRT provides an analysis of recall in terms of short-term storage and short-term retrieval. To illustrate these processes, consider the case in which on any given trial an item is forgotten (failure to recall). The subject is then reminded of that item on the reminding trial. If the item is recalled on the immediately following trial, but forgotten on the subsequent trial, the first recall is evidence of retrieval from short-term storage. Thus, retrieval from short-term storage is termed short-term retrieval. Hence, the technique allows the separation of storage and retrieval components associated with the long-term and short-term processes of memory.
CLINICAL APPLICATIONS OF THE SELECTIVE REMINDING TECHNIQUE

Buschke (1973) originally used the SRT in a single subject design. He demonstrated that a patient suffering from chronic alcoholism was impaired in the initial storage of items in memory as well as in subsequent retrieval operations. Since its inception, the SRT has been used to investigate memory disorders in a variety of clinical populations. The structure of the procedure has been modified with regard to predicted decrements in memory functioning for the population under consideration. For example, manipulations have included decreasing the list length from twenty to six words to eliminate floor effects with severely impaired groups, the addition of a cued recall trial, and the inclusion of a thirty minute delayed recall trial (Peter & Levin, 1977).

With its various procedural modifications, the SRT has been employed to elucidate patterns of memory dysfunction found in patients with Korsakoff's syndrome (Buschke & Fuld, 1974); to investigate dementia of the Alzheimer's type (Fuld, 1982); and to probe the consequences of brain injury (Levin, Benton & Grossman, 1982). Amnesia has been studied using the standard procedure with an additional cued recall trial (the first two letters of each word) to establish the effects of partial information on the recall performance of amnesiacs (Warrington & Weiskrantz, 1970).

The effects of pharmacological treatments have also been evaluated with the SRT. In a series of studies, Peters & Levin (1977, 1979) compared the performance of patients with Alzheimer's disease under baseline, placebo and treatment conditions in order to assess the effects of cholinergic agents on memory performance. Christadoulou (1981) examined the effects of lithium carbonate, a treatment commonly used for affective disorders, on recall performance with particular interest in the attentional and concentrational processes necessary for the initial phase of list learning. The SRT allows
isolation of attentional contributions to memory in its short-term storage and retrieval measures. In another study on the effects of lithium on memory, Shaw, Stokes, Mann & Manevitz (1987), utilized the SRT to provide evidence for long-term retrieval deficits in the population studied. In addition to its utility as a general procedure for the assessment of memory functioning, the SRT enables a more precise componential analysis of memory disorders. This allows for the localization of deficits in terms of storage and retrieval processes.

The SRT is a well established procedure for the clinical assessment of memory, with particular utility as a fine-grained and sensitive instrument for assessing adult memory functioning. However, the use of the procedure for the clinical assessment of memory functioning in children must be approached with some degree of caution. In the course of 'normal' development, children exhibit a range of memory "problems" relating to the initial encoding of information (e.g., Druker & Hagen, 1968), as well as to its subsequent storage (Bjorklund, 1985) and retrieval (Brainerd, Howe, Kingma, & Brainerd, 1984). The existence of these development-related "deficiencies" poses difficulties for the clinical evaluation of children's memory using the SRT because it renders the meaning of any deficits found potentially ambiguous. On the one hand, such deficits may well imply the presence of a clinical memory problem but, on the other, they may merely be consistent with 'problems' typifying a particular developmental stage.

Recently, Bjorklund (1985) has traced development-related memory problems to inferior knowledge of particular content areas. As will be seen in the next section, there are age differences in the facility with which children handle various kinds of semantic relationship: the conceptual apparatus, or knowledge base, which assimilates incoming information, develops with age (Brown, 1975; Naus & Ornstein, 1983). Such developmental changes have implications for memory testing. The knowledge base places restrictions on the type of stimulus
information which can be encoded and, hence, subsequently stored and retrieved. If the material presented is consonant with the existing knowledge base, in the sense of being amenable to the processes of assimilation and organization, then memory performance is optimized. However, if the current knowledge base is inadequate for grasping the structure of the to-be-remembered material, that is, the experimenter-designated structure, memory for that material is weakened.

It is for this reason that care should be taken in clinical settings when assessing children's memory functioning. Since the knowledge base undergoes considerable modification with development, material employed in memory tasks should be selected so as to avoid the "Type 1" error of accepting a pattern of deficits as an index of clinical impairment where it might be more appropriately characterized as an epiphenomenon of a relatively immature, though developmentally "normal", level of conceptual knowledge.

In acknowledgement of the fact that recall increases with age, some research on the SRT has been conducted with children. Buschke (1974) compared five- and eight-year-old children on a memory task. In this study, he employed lists of words taken from the same taxonomic category, for example, animals or furniture. As expected, five-year-olds' total recall score was inferior to that of eight-year-olds. However, a novel finding that emerged from the componential analysis of total recall scores, provided by the SRT, was that younger children's lower recall score was attributable to their poorer retrieval abilities relative to those of older children, as well as to inferior storage.


While each of these child studies has provided age-normative data for the
type of list employed in the memory task, neither has directly addressed the problem of interpreting child data which results from developmental changes in the knowledge base. In neither study did considerations of development in this respect serve as a guide to the selection and development of stimulus lists. Thus, there still exists a potential problem of misclassification of child testees as clinically impaired. Since clinical assessment occurs in a single subject situation, the difficulty of establishing an accurate interpretation of the results is exacerbated by the lack of a clear cut developmental picture of memory functioning. This problem points to the need for the SRT to be employed with a normal child population to elucidate patterns of memory functioning at various developmental stages. This would provide a necessary developmental contrast to patterns of clinical impairment that might be observed in individual subjects. The research described later in this thesis was designed to explore memory performance, assessed by the SRT, as a function of the level of conceptual knowledge available to the child. Since the selection of material for learning and recall in this study was guided by theory and research on conceptual knowledge and its development, a review of literature in this area is appropriate.

DEVELOPMENT OF THE KNOWLEDGE BASE

There is general agreement that knowledge is organized in terms of concepts (e.g., Brown, 1975). In theory, there exists a variety of criteria on which objects can be grouped as the basis for conceptual networks. For example, grouping might be based on likeness in physical characteristics, with objects possessing similar properties being grouped together. Alternatively, objects could be clustered in terms of functional similarity. A third criterion is thematic connection. On this criterion, real world events are "organized in terms of temporal and causal relations between component acts" (Nelson, 1983, p. 55). Yet another possible organization of knowledge about the world is in terms of taxonomic categories.
Empirically and theoretically, the conceptual structures that have received most attention are those based on taxonomic categories. These categories can be described as tree structures, objects being grouped at a single level of the structure and levels arranged hierarchically, with each level moving up the hierarchy, representing a more inclusive grouping (for example, deck chair->chair->furniture). While concepts based on standard taxonomies are important constituents of the adult's knowledge base, the efficient utilization of these concepts develops over an extended period in childhood. How, then, do children organize their knowledge of the world prior to the establishment of these taxonomies?

There is anecdotal evidence to suggest that at the earlier stages of language acquisition young children's conceptual knowledge is based, to some extent, on similarity in physical characteristics. Thus, for example, toddlers are happy to accord any passing male the title of "daddy", or refer to any smallish, four-legged animal as "doggy".

More solid evidence shows that contemporaneous with, or just subsequent to, the use of similarities in physical properties to structure information about the world, children begin to focus on thematic relationships (Nelson, 1974). These thematic relationships, or 'scripts' as Nelson has called them, appear to become dominant over concepts based on physical characteristics and are a notable feature of children's conceptual organization for an extended period of cognitive development (Denney, 1974). Thematically based concepts are schematic representations of objects and events rather than organizations based on physical similarities. In such schemas objects are grouped on the basis of their co-occurrence in time or the causal connection between items. As an illustration of a thematically based concept, we may take the hypothetical case of a child who, when confronted with the term "breakfast", mentally groups together: cereal, plate, refrigerator, milk, sugar, spoon, and T.V. cartoons.
Thematically based concepts differ not only from concepts based on physical similarities but also from taxonomically based concepts with their hierarchical structure. It appears that these thematic organizations function as developmental precursors to the standard hierarchical relations available to adults. Evidence points to a developmental shift from principal reliance on thematic concepts in young children to principal reliance on taxonomic concepts in older children and adults. However, this is not to assert that adults are unable to employ thematic organization when it may be the most efficient and task-appropriate strategy. Similarly, it does not imply that children given explicit instructions and optimally structured tasks are totally unable to engage in taxonomic organization. Rather, the idea of principal reliance on one style of conceptual organization over another describes the tendency to spontaneously employ that mode of organization in the task at hand.

MEMORY IMPLICATIONS FOR THE DEVELOPMENT OF THE KNOWLEDGE BASE

What is already known is a major determinant of the type of new information that is encoded and remembered. A study by Chi(1978) neatly illustrates this point. Configurations of chess pieces were presented both to ten-year-olds experienced in the game of chess and to neophyte adults. The results showed that the experienced ten-year-olds had superior recall to the adults, enabling Chi to conclude that the knowledge base (in this instance an extensive and detailed knowledge of chess) was of considerable importance in determining levels of memory performance. In order to establish that these results were due to pre-existing knowledge rather than another variable such as intelligence, Chi gave both groups comparable memory tasks using arrays of digits. As predicted, the results were the reverse of those achieved for chess positions, with adults' performance superior to that of children.

Chi's study demonstrates the general effect of the knowledge base on
memory performance but does not explore the specific effects of normal developmental changes in knowledge on memory. The importance of development in knowledge for the study of children's memory is highlighted by Ornstein & Naus:

"Given that the contents and structure of information available in the knowledge system change markedly with age, it is of particular importance to examine developmentally the linkage between knowledge and memory performance. It is reasonable to assume that age related differences in language understanding and specific bodies of knowledge are central to corresponding changes in the remembering of information."

(1985, p. 119)

Piaget & Inhelder (1973) provide convincing evidence for the memory effects of developmental change in their extensive study of children at differing developmental stages. Using non-verbal stimulus arrays, they demonstrated that developmental improvement in recall was attributable to progress with respect to operational stage. Arrays consonant with understanding at a given operational stage were poorly recalled by children below that stage. Without their having viewed the stimulus material again, children's subsequent recall increased as a function of having reached the appropriate operational stage.

With respect to verbal stimuli, such as the lists used in the SRT, evidence suggests that young children's failure to spontaneously categorize lists in taxonomic terms has detrimental effects on recall for lists based on standard taxonomic categories. Bjorklund & Thompson (1983) employed stimulus lists, previously rated for category typicality by children and adults, in a cued recall task. They found that overall recall for five-, eight- and eleven-year-olds was
better for lists derived from children's ratings of category typicality than for lists derived from adult ratings. These results strongly suggest that the structuring of the to-be-remembered verbal material in terms of standard (adult) taxonomic categories has a detrimental effect on young children's recall memory. Obversely, in a study by Denney & Ziobrowski (1972) lists based on thematic relations between items were constructed. The investigators demonstrated that a thematic list structure resulted in increased levels of organization and recall in younger children. Together, these studies indicate that the degree of congruence between the child's knowledge structures and the structure of the list presented in a memory task has a significant influence on recall (see, also, Lange & Jackson, 1974; Mandler, 1983; Worden, 1976).

**REVIEW**

In summary, the SRT has been used in the assessment of memory functioning in a variety of settings. With clinical populations it has provided a method for the elucidation of patterns of memory decrements as well as a componential analysis of deficits in terms of the storage and retrieval components of the memory process. In a similar fashion, its use with normal populations of adults and children has provided both a global picture of memory performance and a partitioning of that performance into its component processes. However, in previous use of the SRT with children, the role of conceptual development in memory has been ignored. The omission of this consideration has allowed for the potential confounding of development-related 'deficits' with actual memory impairment. To facilitate accurate interpretation of children's memory performance it is necessary to consider developmental changes in the knowledge base and their consequences for memory performance.

Development in the knowledge base occurs along two dimensions. First, quantitative changes result in increased content knowledge. Second, qualitative
changes, such as the developmental progression from thematic to taxonomic concepts, allow the child to organize the world in a completely different way. The consequence of the latter changes is that efficiency of memory is contingent upon congruence between the child's knowledge base and the structure of the to-be-remembered material. If the material's structure is consonant with his or her underlying conceptual apparatus, recall will be optimized. If however, the material is not congruent with the child's existing knowledge base, memory will be affected detrimentally. More specifically, it is postulated that the structure of the knowledge base will not only influence global memory performance, but also the component processes of storage and retrieval, which are assessed by the SRT.

THE PRESENT STUDY

The study described below examined possible differential effects of type of list on SRT measures, across four age groups. The ultimate aim of the study was to assess "normal" memory performance with different list structures, so as to permit a distinction to be made between genuine clinical impairment in children and deficits due either to an 'immature' knowledge base or to a developmentally-governed failure to spontaneously activate a particular mode of memory organization.

Four age groups, drawn from normal populations, were selected for testing with the SRT: eight-, ten-, and twelve-year-old children and adults. Eight-year-olds were chosen as an age group relying primarily on thematic relationships for organizing information in the knowledge base. Ten-year-olds were selected as an age group progressing from thematic relationships to taxonomic relationships. The selection of twelve-year-olds was based on the assumption, supported by the literature (Rosch, Mervis, Gray, Johnson & Boyes-Braen, 1976), that at this stage taxonomic relationships have become relatively stable constituents of the knowledge base. Finally, the adult group epitomized primary reliance on taxonomic relations.
Subjects in each group were presented with three list types. One list comprised words that were semantically unstructured, that is, words which were unrelated to other words in the list in terms of any standard criterion for grouping. This list served as a baseline, to provide data on different age groups' performance where the possibility of assimilating material within any established organizational schema was minimized. Each of the words in the second list could be related to some other list words in terms of thematic associations. For example, four items in the list were oval, ball, child, soccer, which could be organized as constituents of a "game" episode. The thematic list was designed to be consonant with the preferred mode of organization in eight- and ten-year-olds and, to a lesser extent, to tap organizational tendencies still present in twelve-year-olds. The third list comprised words, each of which could be related to others by virtue of common membership of a particular taxonomic category. This list was designed to be congruent with adults' primary mode of structuring information in memory and with newly developed tendencies in twelve-year-olds.

Dependent measures for each list were for overall recall, long-term storage (LTS), consistent long-term retrieval (CLTR) and trials to criterion, that is, the number of trials taken to reach a criterion performance of correct recall of the whole list on two consecutive trials.

Studies on the effect of list type on memory performance are not new (e.g. Bjorklund & Zeman, 1982; Moely, 1977). What is novel about the present study is that it examined list-type effects on long-term storage and consistent long-term retrieval as well as global recall, as assessed by the SRT. These long-term components were selected for investigation over short-term measures because Buschke (1973) has indicated that, due to technical factors inherent in the SRT procedure, the former are more useful for diagnostic purposes. The three measures above, which relate to the accuracy of total recall and its long-term components, provided one type of index of differential facility, across age, in
dealing with ways of organizing material for memory tasks. The 'trials to criterion' measure provided an alternative index. It is reasonable to assume that any given age group will take fewer trials to the criterion of perfect recall on two consecutive trials with material which is highly congruent with that group's preferred mode of memory organization than with material less congruent in this respect.

This study, then, provided conditions for specifying with a more fine-grained paradigm than has previously been employed, "normal" effects of developmental changes in the knowledge base on children's memory performance. The specification of such "normal" effects is a starting point in countering the previously discussed potential for ambiguity in interpreting apparent deficits found when using the SRT in the clinical assessment of children's memory.
METHOD

Subjects

As described above, four age groups were selected to reflect differential degrees of reliance on thematic or, alternatively, taxonomic relationships for organizing information in memory. As also noted previously, these age groups consisted of three child samples (eight-, ten-, and twelve-year-olds) and an adult sample. There were twenty-four subjects in each group, with equal numbers of males and females in each. The child samples were selected from standard classes at the Miles Franklin Primary School, Evatt. Mean ages and age ranges for the three child groups were: 8 years, 2 months (range 7.5 to 8.7 years); 10 years, 4 months (range 9.6 to 10.8 years); and 12 years, 1 month (range 11.5 to 12.3 years). Adult subjects were volunteers from the 1987 First Year Psychology Course at the Australian National University, who received course credit for their participation. They ranged in age from 18 years, 2 months to 31 years, 9 months, with a mean age of 24 years, 6 months.

Materials and Presentation Order

The stimulus lists were composed of sixteen words each. The items for all lists were selected on the basis of three general criteria:

a) all words were concrete nouns and high in imagery value. Toglia & Battig (1978) norms were used to select words, rated on imagery value on a scale from 1-7, with all words chosen for inclusion having an imagery rating greater than 5.49.

b) all words were equated for frequency of usage across age groups and lists.
Mt. Gravatt Language Research (1977) reports for appropriate age groups were used to select words for each list that had an index range within the third most frequent grouping of a ten-group frequency range.

c) all words were mono-, bi- or trisyllabic.

In addition to these general criteria, there were criteria specific to each list, viz:

LIST A-unrelated items. These were selected from the Toglia & Battig (1978) norms to ensure that no words were thematically or taxonomically related.

LIST B-thematically related items. Four groups of four items each were generated for this list. Items were included if they formed a common theme as described by Lange (1973) and were highly associatively related, based on association norms where possible (Paivio, Yuille & Madigan, 1968).

LIST C-taxonomically related items. Four categories with four items per category constituted this list. Categories contained items familiar to all age groups, the categories being fruit, furniture, animals and clothing. An attempt was made to minimize the association (frequency of co-occurrence) between items from a category without jeopardizing the items'
typicality status. Using mean typicality ratings for a range of age groups (Bjorklund, Thompson & Ornstein, 1983), items that were not strongly related but had acceptable typicality ratings for their respective categories were selected (this ensured that items did not represent atypical category exemplars for any age-group).

The items in each list were randomly ordered, with the constraint that items from the same thematic set or from the same category were not adjacent. The three lists are attached as an Appendix.

The presentation of the lists was counterbalanced using six orders determined by a Latin square procedure. This resulted in four subjects, two male and two female, receiving each list order.

Design

Each subject received all three lists, thus the study employed a four (age groups) x three(list-type) design.

Procedure

Each subject was tested individually in a quiet room. To begin, the subject was given an explanation of the nature of the memory task, followed by a short practice example to demonstrate the selective reminding procedure. Then the subject was read one of the sixteen-word lists at a rate of one word per four seconds. The subject attempted to recall as many words as possible in any order. The subject was given as much time as s/he wished to recall the words. Following this, the subject was told that s/he had forgotten some of the words on the list and that these would now be read so that s/he could attempt to remember these words along with the previously recalled words. After the subject was 'selectively reminded' another recall trial was given. The procedure of recall followed by a reminding trial was repeated until the subject was able to recall all
the words on the list for two consecutive trials. For each recall trial, the
experimenter recorded the words recalled by the subject and the order of recall
as well as the words the subject failed to recall. In between the presentation of
each list, the subject was distracted by being given a game or colouring-in book to
play with to avoid interference effects between lists.

RESULTS

Scoring

Buschke's (1973) original scoring procedure was used, as far as possible, in
deriving values for the dependent measures. However, two variations were
made to this procedure. First, it was necessary to achieve comparability in
memory scores. These are cumulative scores and therefore, on average, the
more trials to criterion the higher the scores, even though number of trials taken
to criterion is negatively related to memory efficiency. To overcome this
inconsistency, the three sets of accuracy scores described above were derived
from the lowest number of trials to criterion taken by any of the ninety six
subjects. This number was six.

Overall recall for any stimulus list was the number of items recalled on a
trial, cumulated over the first six trials. To derive the long term storage score for
each list it was assumed (as per Buschke) that where a word was recalled on two
consecutive trials (without reminding on the second occasion) it entered LTS on
the first of these trials. This score was also cumulative across the first six trials.
The consistent long-term retrieval measure (CLTR), also cumulative, was derived
from items in the first six trials which, having qualified for entry into LTS, were
subsequently recalled. Although this represents a measure commonly used in
the SRT, it confounds efficiency in retrieval with efficiency in storage because it
does not control for differences in initial storage level. Therefore, a second
variation was made to Buschke's scoring procedure. This was a measure of long
term retrieval which controlled for differences in initial storage and was derived
by subtracting CLTR scores from LTS scores. Trials to criterion was non-
Overall Recall

The means and standard deviations for correct total recall scores by age and list-type are presented in Table 1. A four (age groups) x three (list-type) split-plot Analysis of Variance with repeated measures on list-type was conducted on the data presented in Table 1. The results of the analysis are presented in Table 2.

The analysis shows a significant main effect of age, $F(3,32)=40.95; \ p<.001$ and list type, $F(2,183)=129.91; \ p<.001$. However, these main effects were qualified by a significant age by list type interaction, $F(6,183)=3.43; \ p<.01$.

The interaction was examined by analyses of simple effects of list type at each age level. These analyses showed a significant list-type effect for all ages, $F(2,183)=20.87; \ p<.001$; $F(2,183)=35.25; \ p<.001$; $F(2,183)=38.02; \ p<.001$ and $F(2,183)=28.29; \ p<.001$, for eight-, ten-, twelve-year-olds and adults, respectively.

However, Tukey tests comparing mean recall scores for the three lists within each age group showed that, although list-type had an effect at each age, the effect differed across ages. With alpha set at 0.05, the critical value for all age groups was $dT=3.96$.

The Tukey comparisons showed that, for eight-year-olds, performance on both the thematic and taxonomic lists was significantly better than performance on the unrelated list. Unexpectedly, the value for the difference between recall on the thematic list and recall on the taxonomic list, in favour of the former, failed to reach the conventional level of significance, although, at 3.79, it did closely approach this level.

For ten-year-olds performance on both the thematic and taxonomic lists was superior to performance on the unrelated list. In addition, however, performance on the thematic list significantly exceeded performance on the taxonomic, the mean difference between the two being 5.41.
Table 1: OVERALL RECALL scores as a function of age and list-type

<table>
<thead>
<tr>
<th>LIST-TYPE</th>
<th>unrelated</th>
<th>thematic</th>
<th>taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>50.62(9.20)</td>
<td>61.71(8.01)</td>
<td>57.92(5.92)</td>
</tr>
<tr>
<td>10</td>
<td>51.34(6.71)</td>
<td>65.83(6.02)</td>
<td>60.42(6.94)</td>
</tr>
<tr>
<td>12</td>
<td>57.92(6.21)</td>
<td>70.37(4.69)</td>
<td>71.67(8.06)</td>
</tr>
<tr>
<td>ADULTS</td>
<td>61.37(4.12)</td>
<td>70.54(5.31)</td>
<td>74.54(3.57)</td>
</tr>
</tbody>
</table>

Table 2: Summary of results of ANOVA for effects of age and list-type on OVERALL RECALL scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>d f</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age groups(A)</td>
<td>7498.73</td>
<td>3</td>
<td>2499.58</td>
<td>40.95***</td>
</tr>
<tr>
<td>Suj.w. groups</td>
<td>5615.30</td>
<td>92</td>
<td>61.04</td>
<td></td>
</tr>
<tr>
<td><strong>Within subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List-type(L)</td>
<td>8637.91</td>
<td>2</td>
<td>4318.96</td>
<td>129.91***</td>
</tr>
<tr>
<td>A x L</td>
<td>696.69</td>
<td>6</td>
<td>116.12</td>
<td>3.43**</td>
</tr>
<tr>
<td>L x Suj.w.groups</td>
<td>6084.23</td>
<td>183</td>
<td>33.25</td>
<td></td>
</tr>
</tbody>
</table>

*significant at 0.05, ** 0.01 , *** 0.001
For twelve-year-olds, the now familiar result for thematic and taxonomic list performances' superiority over unrelated list performance was found. The difference between the two former lists was not significant ($dT_{thematic-taxonomic}=-1.30$), though, contrary to the pattern for the two younger groups, this difference was slightly in favour of the taxonomic list.

Finally, adults also evidenced superior recall on the thematic and taxonomic lists relative to the unrelated list. Like the twelve-year-olds, adults showed better recall on the taxonomic than on the thematic list, but here the difference between the two was significant. The results for overall recall are graphed in Figure 1 (p. 21).

**Long Term Storage (LTS)**

Storage scores, derived as described above, are shown in Table 3 (p. 22) for age groups as a function of list type. An ANOVA equivalent to that performed on overall recall data was carried out on the data in Table 3. The results are presented in Table 4 (p. 22). It revealed a significant main effect of age, $F(3,95)=32.839; p<.001$, a significant main effect for list type, $F(2,183)=106.249; p<.001$ and a significant interaction, $F(6,183)=3.927; p<.01$.

The interaction was examined by an analyses of simple effects of list-type at each age. This revealed a significant list type effect for all ages, $F(2,183)=22.05, p<0.001$, $F(2,183)=28.92, p<0.001$, $F(2,183)=32.49, p<0.001$ and $F(2,183)=34.56, p<.001$, for eight-, ten-, twelve-year-olds and adults, respectively.

Tukey tests were used to compare mean total storage scores for the three list-types within each age group, with $a=0.05$, $dT=4.823$. These comparisons produced results directly comparable with the overall recall results. The comparisons are presented in Table 5 (p. 25), in which significant differences are
Figure 1: OVERALL RECALL scores as a function of age and list-type
Table 3: Total number of items STORED(LTS) as a function of age and list-type

<table>
<thead>
<tr>
<th>LIST-TYPE</th>
<th>unrelated</th>
<th>thematic</th>
<th>taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 43.79(10.77)</td>
<td>55.29(9.48)</td>
<td>51.54(7.61)</td>
</tr>
<tr>
<td></td>
<td>10 43.54(7.98)</td>
<td>60.34(6.90)</td>
<td>53.16(8.29)</td>
</tr>
<tr>
<td></td>
<td>12 52.08(8.46)</td>
<td>66.25(4.92)</td>
<td>66.21(8.42)</td>
</tr>
<tr>
<td>ADULTS</td>
<td>55.21(6.02)</td>
<td>64.79(7.78)</td>
<td>70.46(5.59)</td>
</tr>
</tbody>
</table>

Table 4: Summary of results of ANOVA for effects of age and list-type on LONG TERM STORAGE scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td>19127.08</td>
<td>95</td>
<td>201.34</td>
<td></td>
</tr>
<tr>
<td>Age(A)</td>
<td>9890.74</td>
<td>3</td>
<td>3296.91</td>
<td>32.839***</td>
</tr>
<tr>
<td>Subj.w. groups</td>
<td>9236.34</td>
<td>92</td>
<td>100.40</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td>20656.06</td>
<td>191</td>
<td>108.15</td>
<td></td>
</tr>
<tr>
<td>List-type(L)</td>
<td>10474.34</td>
<td>2</td>
<td>5237.17</td>
<td>106.249***</td>
</tr>
<tr>
<td>A x L</td>
<td>1161.40</td>
<td>6</td>
<td>193.57</td>
<td>3.927**</td>
</tr>
<tr>
<td>L x Subj.w. groups</td>
<td>9020.33</td>
<td>183</td>
<td>49.29</td>
<td></td>
</tr>
</tbody>
</table>

** significant at 0.01 , *** 0.001
Table 6: Number of items RETRIEVED\((CLTR)\) as a function of age and list-type

<table>
<thead>
<tr>
<th>LIST-TYPE</th>
<th>unrelated</th>
<th>thematic</th>
<th>taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>35.37(13.64)</td>
<td>50.58(13.31)</td>
<td>47.13(9.15)</td>
</tr>
<tr>
<td>10</td>
<td>35.87(10.86)</td>
<td>58.54(8.43)</td>
<td>48.58(12.67)</td>
</tr>
<tr>
<td>12</td>
<td>45.58(8.49)</td>
<td>65.87(5.08)</td>
<td>65.34(9.49)</td>
</tr>
<tr>
<td>ADULTS</td>
<td>51.42(4.72)</td>
<td>64.71(7.97)</td>
<td>70.46(5.59)</td>
</tr>
</tbody>
</table>

Table 7: Summary of results of ANOVA for effects of age and list-type on CONSISTENT LONG TERM RETRIEVAL scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age(A)</td>
<td>16952.55</td>
<td>3</td>
<td>5650.85</td>
<td>38.951***</td>
</tr>
<tr>
<td>Subj.w. groups</td>
<td>13346.89</td>
<td>92</td>
<td>145.07</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List-type(L)</td>
<td>19411.67</td>
<td>2</td>
<td>9705.83</td>
<td>140.541***</td>
</tr>
<tr>
<td>A x L</td>
<td>1734.38</td>
<td>6</td>
<td>289.06</td>
<td>4.186**</td>
</tr>
<tr>
<td>L x Subj.w. groups</td>
<td>12638.16</td>
<td>183</td>
<td>69.06</td>
<td></td>
</tr>
</tbody>
</table>

** significant at 0.01 , *** 0.001
indicated by asterisks. The data on which these comparisons were based are graphed in Figure 2.

Figure 2: LTS scores as a function of age and list-type
Table 5: Differences between pairs of means for LTS scores

<table>
<thead>
<tr>
<th>age groups</th>
<th>thematic-unrelated</th>
<th>taxonomic-unrelated</th>
<th>thematic-taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>*</td>
<td>*</td>
<td>n.s.</td>
</tr>
<tr>
<td>10</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>12</td>
<td>*</td>
<td>*</td>
<td>n.s.</td>
</tr>
<tr>
<td>ADULTS</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

* indicates significant differences between means at α=0.05,
annotated * indicates 1st named mean > 2nd named mean
- sign before * indicates 1st named mean < 2nd named mean

Consistent Long Term Retrieval (CLTR)

Table 6 (p.23) presents the means and standard deviations for CLTR scores as a function of age and list-type. An ANOVA equivalent to those described above was performed on the data in Table 6. The results of the analysis are shown in Table 7 (p.23). There was a significant main effect for age, $F(3, 92)=38.951; p<0.001$, and for list type, $F(2, 183)=140.54; p<0.001$. There was also a significant age by list type interaction, $F(6, 183)=4.186; p<0.01$.

The interaction was examined by analyses of simple effects of list type at each age. This showed significant list-type effects at each age level, $F(2, 183)=38.951; p<0.001$, $F(2, 183)=34.53; p<0.001$, $F(2, 183)=46.45; p<0.001$ and $F(2, 183)=33.14; p<0.001$, for eight-, ten-, twelve-year-olds and adults, respectively.

Tukey tests were used to compare mean total retrieval scores across list
types for each age group. These comparisons between means directly paralleled those found for overall recall and LTS. The results are presented in Table 8.

Table 8: Differences between pairs of means for CLTR scores

<table>
<thead>
<tr>
<th>age groups</th>
<th>thematic-unrelated</th>
<th>taxonomic-unrelated</th>
<th>thematic-taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>*</td>
<td>*</td>
<td>n.s.</td>
</tr>
<tr>
<td>10</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>12</td>
<td>*</td>
<td>*</td>
<td>n.s.</td>
</tr>
<tr>
<td>ADULTS</td>
<td>*</td>
<td>*</td>
<td>-</td>
</tr>
</tbody>
</table>

* indicates means are significantly different at a = 0.05

critical value = 5.71

unannotated * indicates 1st named mean > 2nd named mean

- sign before * indicates 1st named mean < 2nd named mean

CLTR Controlling For Differences In Initial LTS

The CLTR scores reported above did not control for variations in the level of the initial LTS scores, that is, the higher the latter scores the higher was the probability of achieving superior CLTR scores. However, it is of greater interest for age comparisons of "pure" retrieval efficiency to obtain CLTR measures which control for initial storage. To obtain such a measure, storage-retrieval difference scores were computed for each list-type and age group. These differences, shown in Table 9 (p.28), constituted measures of CLTR with the variation in storage scores accounted for.

An ANOVA was performed on the data in Table 9. The results are
presented in Table 10 (p.28). They reveal a significant main effect for age, $F(3,95)=13.935;p<.001$ and list type, $F(2,183)=33.261;p<.001$. There was no significant interaction.

Tukey tests were conducted to compare mean differences between lists collapsed across age groups ($a=0.05, dT = 3.113$). These revealed that there were no significant differences between mean difference scores for the taxonomic and thematic lists, although both these lists differed significantly from scores on the unrelated list.

**Trials to Criterion**

The means for the number of trials to criterion scores are presented in Table 11 (p.29). An ANOVA was performed on the data, the results of which are presented in Table 12 (p.29). The analysis revealed a significant main effect for age, $F(3,95)=26.03,p<.001$, and for list-type, $F(2,183)=238.742;p<.001$ as well as a significant interaction, $F(5,183)= 10.583;p<.001$.

The interaction was examined by analyses of simple effects of list-type at each age level. This showed a significant list-type effect for all ages, $F(2,183)=5.23,p<.01$, $F(2,183)=4.99;p<.01$, $F(2,183)=6.704;p<.01$, and $F(2,183)=8.529,p<.01$ for eight-, ten-, twelve-year-olds and adults, respectively.

Tukey tests were used to compare means, with $a=0.05,dT=0.53$. These showed that eight-year-olds learned the thematic list in significantly fewer trials than either the taxonomic or unrelated lists, on which they did not differ significantly in number of trials taken to reach criterion.

Ten-year-olds required fewest trials for the thematic list, followed by significantly more trials for the taxonomic. The unrelated list required significantly more trials again.

Twelve-year-olds did not differ significantly in the number of trials to criterion.
Table 9: LTS-CLTR difference scores as a function of age and list-type

<table>
<thead>
<tr>
<th>LIST-TYPE</th>
<th>unrelated</th>
<th>thematic</th>
<th>taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8.42(4.33)</td>
<td>4.71(6.61)</td>
<td>4.29(4.27)</td>
</tr>
<tr>
<td>10</td>
<td>7.50(6.87)</td>
<td>1.79(3.48)</td>
<td>4.58(6.13)</td>
</tr>
<tr>
<td>12</td>
<td>6.37(5.49)</td>
<td>0.37(0.92)</td>
<td>0.87(2.07)</td>
</tr>
<tr>
<td>ADULTS</td>
<td>3.78(3.55)</td>
<td>0.33(0.74)</td>
<td>0.25(0.53)</td>
</tr>
</tbody>
</table>

Table 10: Summary of results of ANOVA for effects of age and list-type on LTS-CLTR difference scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>3094.83</td>
<td>95</td>
<td>32.58</td>
<td></td>
</tr>
<tr>
<td>Age(A)</td>
<td>966.94</td>
<td>3</td>
<td>322.31</td>
<td>13.935***</td>
</tr>
<tr>
<td>Subj. w. groups</td>
<td>2127.89</td>
<td>92</td>
<td>23.13</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>5249.86</td>
<td>191</td>
<td>27.49</td>
<td></td>
</tr>
<tr>
<td>List-type(L)</td>
<td>1370.47</td>
<td>2</td>
<td>685.24</td>
<td>33.261***</td>
</tr>
<tr>
<td>A x L</td>
<td>109.80</td>
<td>5</td>
<td>18.22</td>
<td>0.884</td>
</tr>
<tr>
<td>L x Subj.w. groups</td>
<td>3770.08</td>
<td>183</td>
<td>20.60</td>
<td></td>
</tr>
</tbody>
</table>

** significant at 0.01 , *** 0.001
Table 11: Trials to criterion scores as a function of age and list-type

<table>
<thead>
<tr>
<th>LIST-TYPE</th>
<th>unrelated</th>
<th>thematic</th>
<th>taxonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>5.617</td>
<td>3.792</td>
<td>4.833</td>
</tr>
<tr>
<td>10</td>
<td>5.625</td>
<td>3.250</td>
<td>4.500</td>
</tr>
<tr>
<td>12</td>
<td>5.417</td>
<td>2.916</td>
<td>3.168</td>
</tr>
<tr>
<td>ADULTS</td>
<td>5.167</td>
<td>2.708</td>
<td>2.375</td>
</tr>
</tbody>
</table>

Table 12: Summary of results of ANOVA for effects of age and list-type on Trials to Criterion scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age(A)</td>
<td>78.095</td>
<td>3</td>
<td>26.031</td>
<td>26.03***</td>
</tr>
<tr>
<td>Subj.w. group</td>
<td>92.006</td>
<td>92</td>
<td>1.001</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subject</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List-type(L)</td>
<td>274.122</td>
<td>2</td>
<td>137.061</td>
<td>238.742***</td>
</tr>
<tr>
<td>A x L</td>
<td>36.455</td>
<td>6</td>
<td>6.075</td>
<td>10.583***</td>
</tr>
<tr>
<td>Subj.w. groups</td>
<td>105.059</td>
<td>183</td>
<td>0.574</td>
<td></td>
</tr>
</tbody>
</table>

** significant at 0.01, *** 0.001
on either the thematic or taxonomic lists, although both these lists required significantly fewer trials than did the unrelated list.

Finally, adults took significantly longer, in terms of trials, to learn the unrelated list than either the thematic or taxonomic list on which they did not differ significantly.
DISCUSSION

Consistent with the usual findings from developmental studies on memory, the present results showed increases with increasing age in all accuracy of recall measures, and a decrease with increasing age in number of trials to criterion. These trends were evident in the significant main effects for age in all analyses. More pertinently in the present context, however, the results illustrated a differential influence of list-type across age.

With respect to the standard SRT measures, overall recall, LTS and CLTR, all ages showed an advantage for both thematic and taxonomic lists over the unrelated list. However, data patterns for the two former lists differed between age groups. Ten-year-olds demonstrated superiority with the thematic versus the taxonomic list and eight-year-olds showed a trend in the same direction although, in the latter group, the thematic - taxonomic differences on SRT accuracy measures did not reach the conventional level of statistical significance. Twelve-year-olds' performances on the thematic and taxonomic lists were statistically comparable, but a slight bias in favour of the taxonomic list was evident in their overall recall. Finally, on the standard SRT accuracy measures, adults demonstrated a clear and consistent superiority in their performance on the taxonomic list.

With the eight-year-olds' data excluded, the preceding results provide a cogent illustration of the effects of changes in the knowledge base on overall recall and its long-term components, as assessed by the SRT. The question remains, however, of why the youngest subjects failed to demonstrate a facilitatory effect for the thematic material which was similar to, or stronger than, the effect in the ten-year-olds.

A possible reason for this discrepancy in an otherwise clear set of data is the ordering of list items in this study. Items within lists were not blocked by
theme or category to further facilitate the appropriate organization, as has been the case with some previous studies (for example, Rabinowitz, 1984). Rather, items were distributed through their respective lists, such that no two thematically or taxonomically related words were adjacent. Nor did this study adopt the alternative experimental manipulation of issuing instructions to group like items as a means of promoting the intended organization of the stimulus material (cf. Corsale & Ornstein, 1980). Thus, the present memory task tapped the spontaneous deployment of different conceptual strategies for grouping items at the list learning phase.

With regard to the spontaneous use of conceptual organization, it could be argued that while eight-year-olds possess structures compatible with the thematic material, it is in a less articulated form than is present in ten-year-olds and, therefore, insufficiently consolidated to be employed efficiently in the memory task. With development, the child acquires a richer set of associations that link items in the knowledge base (Cecile & Richmann, 1982). The elaboration and internal structuring of these associations seems to increase the ease with which information is activated as well as facilitating the detection of underlying semantic relationships in the stimulus material (Corsale & Ornstein, 1980). (In a parallel manner, twelve-year-olds and adults represent substages in the development of taxonomic organization. It is well established that taxonomic representations, having emerged in the child's conceptual structure, become more articulated and internally organized with age (Bjorklund & Zeman, 1982). This 'consolidation' of the knowledge structures allows for their spontaneous deployment in service of a memory task—hence the greater facilitation for the taxonomic list in adults than in twelve-year-olds.)

Support for the view that the eight-year-old subjects' knowledge base was, indeed, organized predominantly in thematic terms, although this organization was not optimally deployed in their list learning, can be adduced from the trials to
criterion measure. This measure is an alternative to the SRT accuracy measures as an index of memory efficiency. The eight-year-olds took significantly fewer trials with the thematic than with the taxonomic list to reach the criterion performance level.

Taken together, the data on the SRT accuracy measures and on the trials to criterion measure strongly indicate that the type of material presented to child subjects when employing the SRT has a marked effect on memory efficiency and that the nature of the effect varies with age.

Specification of the source of the differential effect of type of material across age can be achieved by an examination of the storage-retrieval difference data. As noted previously, the standard CLTR scores were confounded with the LTS scores in that they failed to control for variations in initial storage level. When storage differences were controlled, by subtracting CLTR scores from LTS scores, the significant age x list-type interaction evident in the other analyses did not emerge. There was a main effect for age, indicating that the discrepancy between storage and retrieval diminished with increasing age levels. There was also a significant effect for list-type, indicating that, for all age groups, the potential for both thematic and taxonomic organization facilitated retrieval relative to the absence of the potential for organization on any usual criterion.

The progressive decrease with age in the LTS - CLTR difference scores, in the absence of an age x list-type interaction, is consistent with Buschke's (1974) claim that younger children have special difficulties relating to retrieval, over and above any problems they might have in encoding and storing information. Buschke's contention was based on results of a study that employed only one type of list. The present study, employing three list-types, illustrates the generality of Buschke's finding of an increase in "pure" retrieval efficiency across age: the diminishment with age in the present storage-retrieval difference
occurred on all lists. However, it is the absence of an age x list-type interaction which is germane to the specification of the source of the effect of particular interest here, namely, the effect of list-type within each age group.

As already noted, at each age level there was greater difficulty in retrieving stored items from the unrelated list than from either the thematic or the taxonomic list; and there was no significant difference, at any age level, between the thematic and the taxonomic list in the difficulty of retrieving items which had actually entered LTS. In other words, given that an item was in LTS, the likelihood of its retrieval did not vary between these two list-types. This comparability at all ages suggests that the facilitatory effect of thematic relative to taxonomic material on the recall of ten-year-olds (and, to a lesser extent, of eight-year-olds) and the reverse effect in adults was due, in each case, to a differential probability of storing the two types of item in LTS.

The differential probability of the long-term storage of words, according to their membership of a thematically- or a taxonomically-derived list, might, in turn, be explained in terms of information load in short-term storage (STS). Before words can be entered into LTS, they have to be registered and held in STS, which is limited with respect to its information capacity. It is generally accepted that the maximum number of units of information which can be held simultaneously in STS is seven plus or minus two (Miller, 1956). If individual words in a list cannot be related, each has to be treated in STS as a separate unit; here, the likelihood of holding in STS all items of a list exceeding five to nine words, and subsequently entering all into LTS, is minimal. If, on the other hand, it is possible to group or "chunk" on some criterion of relationship, words forming the chunk constitute only one unit (Zechmeister & Nyberg, 1982), thus reducing the STS information load relative to that imposed by the same number of unrelated words. In the latter case the likelihood of maintaining items for entry into LTS is enhanced.
In the present study, the sixteen items in each of three stimulus lists, if treated as separate units of information, would have substantially exceeded the capacity limitations of STS and, hence, placed severe restrictions on the number of items available for entry into LTS. Such should have been the case with the unrelated list. However, the two remaining lists presented at least the possibility of chunking items to reduce the information load in STS and, therefore, the possibility of preserving more individual items for long-term storage. It is reasonable to assume that the extent to which such a possibility can be realized is dependent on a) the congruence between potential structure in a list and a subject’s principal mode of structuring knowledge of the world, and b) the degree of elaboration and stability in this structural network.

Where an elaborated knowledge structure is based principally either on thematic or on taxonomic relationships, the chunking of list items in terms of the alternative type of relationship should be somewhat diminished. This would explain the ten-year-olds’ better performance with the thematically-oriented list and the reverse result for adults. A lower level of elaboration of a thematic network in eight-year-olds than in ten-year-olds, and of a taxonomic network in twelve-year-olds than in adults, would explain why the younger group in each case, while showing a similar trend to the respective older group, failed to demonstrate the same degree of differentiation as the latter group in their performance on the thematic and taxonomic lists.

This is not to say that primary reliance on one type of relationship for organizing incoming information totally precludes chunking items in terms of another type of relationship. Indeed, in all age groups in this study performance with both the thematic and taxonomic lists was superior to that with the unrelated list. The point to note from the present results is that memory performance is optimized by different types of stimulus material at different ages.
In summary, the present study has demonstrated that the changing knowledge base has an effect on children's overall recall, as gauged by the SRT, which is similar to the effect which has been found in a number of previous developmental studies using alternative (non-clinical) paradigms (e.g. see Bjorklund & Thompson, 1983; Lindberg, 1980; Worden, 1976). Further, the correspondence between the knowledge base and memory was reflected not only in the SRT's overall recall scores, but also in its long-term storage measure (LTS) and its long-term retrieval measure (CLTR). However, in the SRT's scoring procedure, CLTR is confounded with LTS. When retrieval was separated out from storage, in this study, it was possible to establish that the knowledge base has its effect on overall recall solely through its influence on storage (versus retrieval). Specifically, any given mode of organizing knowledge appears to affect differentially the probability with which different types of material are entered into long-term storage. It is suggested that this effect is mediated by variations in the information load in short-term storage which correspond with differing degrees of congruence between the predominant mode of knowledge and the stimulus material.

IMPLICATIONS FOR THE USE OF THE SRT IN ASSESSING MEMORY IMPAIRMENT IN CHILDREN

The employment of the SRT for the clinical assessment of memory typically occurs in a single subject setting. This situation necessitates the establishment of norms against which an individual testee's performance may be evaluated. In the case of adults, it is reasonable to gather normative data on a purely quantitative basis, since the period over which qualitative changes in memory occur terminates at some point in adolescence. In the case of children, however, both quantitative and qualitative considerations should be taken into account. Considerable change occurs in the nature of children's knowledge prior to its reaching a stable (adult) level and some effects of such developmental change on
memory performance have been demonstrated with non-clinical paradigms (Bjorklund & Thompson, 1983; Lindberg, 1980; Worden, 1976).

Previous SRT research with "normal" child samples (e.g. Buschke, 1974; Morgan, 1982) has focussed only on age-related quantitative changes. The present study departed from this approach by examining the effect of developmental changes in the knowledge base on critical SRT measures. The results obtained suggest that, in order to diminish further the possibility of misclassifying a child testee as memory-impaired, the stimulus material used in conjunction with the SRT should be tailored to the testee's stage of general cognitive development. In other words, the stimulus material should be designed to elicit optimal performance.

While only a limited selection of list-types was used in this study, there did emerge an indication that ten-year-olds' memory performance on the SRT may be optimized by thematically-oriented lists and that adults' performance may be optimized by taxonomically-oriented material. The study's results also indicated that, while the use of a thematic list is appropriate for eight-year-olds, memory performance could be further facilitated by the blocking of thematically-related items. Although this age group's principal reliance is on thematic organization, it appears that a lack of consolidation in the relevant conceptual structures, militates against their spontaneous deployment in a memory task. Therefore, some external impetus to do so seems to be desirable. For similar reasons, although twelve-year-olds could be tested appropriately with either thematic material or taxonomic material, further facilitation of performance with the latter might be achieved by either the blocking of taxonomically related items or the issuing of explicit instructions to group them.

The implications drawn above are not meant to be taken as final prescriptions. They are justified on the basis of the comparisons made here
between the performance of a limited number of age groups on only unrelated, thematic and taxonomic lists. However, before optimal lists for different ages can be firmly delineated, it will be necessary to conduct more research of the same type, but with the inclusion of more age groups and extensions to the range of list types. The present study has illustrated the importance of this task as a precondition to future use of the SRT for clinically evaluating children's memory.
REFERENCES


## APPENDIX

### STIMULUS LISTS

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