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Potential age differences in encoding strategies and their effects on memory performance were investigated in two related experiments. Underlying these investigations was Underwood's (1969) hypothesis that the internal memory for an event may be conceptualized as a collection of attributes. Developmental variations in the encoding of verbal materials along the semantic dimensions of similarity and complementarity suggested by Denney (1974a) were examined in Experiment 1. Complementary dimensions were defined as having functional-contiguous relationships; similarity dimensions were defined as having synonymous or superordinate criteria. A false-recognition paradigm was employed to investigate the salience of these dimensions for first graders, sixth graders, college students, and elderly adults over 65. Experiment 2 was designed to examine the relationship between type of encoding and retention. In an incidental learning task, college students were forced to encode along either complementary or similarity dimensions to determine whether subsequent recall varies as a function of encoding type employed.

The results of Experiment 1 indicated that developmental differences in encoding occurred. However, these variations were not in accord with those suggested by Denney (1974a). The results of Experiment 1 indicated that similarity dimensions were used by first graders, that college students and elderly adults employed complementary dimensions, and that sixth graders demonstrated no preference for encoding type. It was suggested that, if children younger than six years were tested, the developmental shift predicted by Denney might be found.

The findings of Experiment 2 demonstrated that the type of encoding dimension employed does affect memory performance. In the forced-orientation task, the complementary encoding groups demonstrated better recall performance than the groups who had similarity forced-oriented instructions.

It was argued by the author that complementary dimensions were superior to similarity ones for memory performance. This argument was based on the findings of better recall performance for the complementary groups at immediate testing, and the superior recognition performance of the college and elderly subjects who demonstrated a preference for complementary dimensions. Several hypotheses were suggested to account for the unpredicted findings of both experiments.

COMPLEMENTARY AND SIMILARITY ENCODING: DEVELOPMENTAL

TRENDS AND THE RELATIONSHIP TO

ADULT RECALL

by

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APPROVAL PAGE

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TABLE OF CONTENTS

	Page
APPROVAL PAGE	ii
ACKNOWLEDGMENTS	iii
LIST OF TABLES	vi
CHAPTER	
I. INTRODUCTION	1
Attributes of Memory: Developmental Implications	2
Similarity and Complementarity - Categorization Criteria	3
Categorization and Memory: Implications for Encoding	5
False Recognition and Memory Encoding	6
Purpose of the Present Research	10
II. METHOD	12
Experiment 1	12
Subjects	12
Design	13
Materials	13
Procedure	14
Experiment 2	15
Subjects	15
Design	15
Materials	15
Procedure	16
III. RESULTS	17
Experiment 1	17
Description of Analyses	17
Recognition Accuracy	17
False Recognitions	17
Experiment 2	21
Description of Analyses	21
Accuracy in the Orienting Task	24
Recall	24
Orienting Accuracy for Recalled Words	26
Intrusions	26

CHAPTER | Page

IV. DISCUSSION 30

Importance of the Normative Data Items 30
Age Differences in Encoding 32
Recall Data 37
Sex Differences in Recognition 41
Differential Forgetting Rates of Semantic Dimensions . . 41
Age Differences in Recognition Performance 41
The Effectiveness of Complementary Encoding 43
Summary 43

BIBLIOGRAPHY 47

APPENDICES

A. Examples of Materials 50
B. Analysis of Variance Summary Tables 55
C. Item Analyses 68

LIST OF TABLES

Table | Page

1. Mean Number of Correct Recognitions of the 16 Normative-Data Items as a Function of Age Level and Retention Interval 19

2. Mean Number of False Recognitions of the 16 Normative-Data Items as a Function of Age Level and Type of Error 22

3. Mean Number of Correctly Recalled Words as a Function of Forced Orientation and Retention Interval 25

4. Mean Number of Each Type of Forced Orientation Response for the Recalled Words as a Function of Forced Orientation and Time 27

5. Mean Number of Each Type of Intrusion Error as a Function of Forced Orientation 29

INTRODUCTION

The concept of encoding has become a central aspect of contemporary approaches to human memory (e.g., Melton & Martin, 1972). Encoding may be defined as the process by which the representation of an event is established in memory. With this concept, memory researchers acknowledge the importance of the organism's cognitive structures in determining how external information is translated into internal information. As Melton (1973) states, "the coding concept has been introduced in order to take into account the interaction of the cognitive structure and processes of the learner with input information in producing what is stored in the memory trace, engram, or 'code' for the event" (p. 508). Due to this interaction of the cognitive structures of the organism with the input information, varying types of encoding may exist. The nature of the stimulus event, the past experience of the individual, and the environmental circumstances in which the event occurs may determine the type and strength of the stored code, which then influences what is later available in memory.

From a developmental perspective, young children's memory deficits may reflect disparities in the durability and accessibility of memories that are the result of developmental differences in what is encoded about a stimulus event. These differences relate to hypothesized coding processes and their relationships to memory performance, rather than to any underlying theory concerning the structures or processes of memory.

The present study is concerned with potential age differences in encoding strategies and their effects on memory performance. The first purpose of this study was to examine developmental variations in the encoding of verbal materials along the semantic dimensions of similarity and complementarity suggested by Denney (1974a). Complementary dimensions are those which have functional-contiguous criteria; similarity dimensions are those which have synonymous or superordinate relationships. The salience of these two dimensions was investigated by examining the false-recognition errors made by subjects at four age levels. In the false-recognition paradigm, the types of dimensions subjects employ at encoding are inferred from the qualitative nature of the type of errors, i.e., false recognitions, made by the subjects at test. A second purpose of the present research was to examine the relationship between type of encoding and retention. In an incidental learning task, college subjects were forced to encode along either complementary or similarity dimensions to determine whether subsequent recall varies as a function of how the material was processed.

Attributes of Memory: Developmental Implications

The internal memory representation of an event may be conceptualized as a collection of attributes (Underwood, 1969). These attributes represent different types of information that are stored about an event during the encoding process. According to Underwood, the attributes function to differentiate one event stored in memory from another and to aid in retrieval. A number of potential encoding dimensions have been suggested by Underwood (1969). For example, one dimension consists of verbal-associative attributes, i.e., during encoding, words may implicitly elicit other words such as a synonym, antonym, or category label. Spatial dimensions may constitute a second attribute, i.e., the physical position of the event at presentation may serve as a differentiating cue for memory. Another possible attribute is the acoustic or the sound of a word when it is pronounced.

A developmental implication of this approach to memory is that there may be differences in the type of attributes that are encoded due to age or age-related experience. According to Underwood (1969), young children are likely to encode along certain dimensions, such as the acoustic and spatial. As children participate in the formal education process, these early attributes lose their dominance and are replaced by verbal-associative attributes. With this developmental shift, children, who once employed acoustic and physical attributes, now encode the more salient and perhaps more efficient semantic attributes. Underwood's suggestion that the attributes of a young child's memory may be different from those of older children and adults implies that there are qualitative age differences in encoding. Such differences in young children's coding may account for their poor memory performance, since they may encode information that is inefficient for retrieval and discrimination of events in memory or that is rapidly lost from memory.

Similarity and Complementarity - Categorization Criteria

Hypothesized developmental variations in the types of semantic attributes that are encoded may be linked to Denney's (1974a) conclusions concerning age trends in categorization style. Denney maintains that the criteria which an individual uses to organize and classify verbal materials undergo developmental changes. According to Denney, children aged six through nine years classify with functional-contiguous strategies, i.e., complementary categorization style, while older children and adults employ similarity criteria, i.e., they categorize according to synonyms and superordinates. This change may reverse itself in old age. Thus, Denney defines two types of categorization criteria for verbal materials. The first or complementary classification is based on contiguous, functional relationships; the items are different in meaning, but share some interrelationship from the subject's past experience or his experience in the experimental situation. For example, the item scissors may be grouped with the word cut, since scissors are used to cut. Similarity, the second categorization style, is characterized by meaning as its main criterion; grouping is according to synonymity and superordination (class membership). For example, the item blossom may be grouped with flower, since the two items are relatively synonymous.

Denney (1974a) further maintains that all individuals are capable of categorization according to either complementary or similarity criteria but that environmental factors determine which criteria are chosen. According to Denney, young children and older adults are most concerned with events occurring in their immediate environment where relationships of physical and temporal proximity are salient. She contends that complementary groupings are more natural, e.g., cars are often seen in garages and baseballs with bats. Thus, the young child and elderly adults prefer functional or complementary categorizations that involve relationships among items occurring in time and space rather than similarity categorizations that often involve relationships among items separated in time and space. Denney suggests that for young children the change from complementarity to similarity occurs at age six as the child begins a formal education in which similarity and other abstract relationships are emphasized. After retirement when the external pressures of education and work are removed, a return to complementary types of classification may occur for the elderly.

Categorization and Memory: Implications for Encoding

If developmental changes in categorization criteria reflect a pervasive change in the individual's mode of processing information, related differences in the encoding of verbal materials should occur. The results of free-recall clustering studies are consistent with this notion. Clustering refers to the subject's tendency to recall items that share an experimenter-defined common characteristic in adjacent output positions, even when the items were presented in random order. For example, if the items dog, apple, chair, cat, lamp, banana were presented, a recall protocol of dog, cat (animals), chair, lamp (furniture), banana, apple (fruit), would demonstrate the use of a clustering strategy by the subject. The occurrence of clustering can be interpreted as evidence that the clustered items were encoded along the same dimension.

Denney and Ziobrowski (1972) compared the recall and clustering performance of first-grade and college subjects on two stimulus lists. One list consisted of pairs of words sharing similarity relationships (e.g., king, ruler), while the second list consisted of pairs of words sharing complementary relationships (e.g., chair, sit). Under these conditions, first graders showed more clustering of related words on the complementary list, but college students showed more clustering of related words on the similarity list. In a second study (Denney, 1974b), the same materials were used with middle-aged and elderly subjects. Although the middle-aged subjects showed more clustering on the similarity list than on the complementary list, the elderly subjects did not show greater clustering of complementary than similarity pairs. In fact, they showed no evidence of clustering. This latter outcome is inconsistent with the hypothesis of a change in categorization criteria after retirement. However, as Denney recognized, her elderly subjects were residents of nursing homes and, so, may not have constituted a representative sample.

False Recognition and Memory Encoding

Another approach to the identification of encoding dimensions involves an examination of the types of errors that subjects make on a false-recognition memory task. The false recognition technique involves the presentation of target items and distractors, i.e., words which are presented with the target and may or may not have some relationship to it, for recognition by the subject. A false recognition occurs when a subject selects a distractor as a target item. The number and type of false-recognition errors made provides a measure of the prominence of the various attributes which were implicitly and spontaneously aroused at the time the target items were originally presented for study. Since clustering may reflect an optional, strategy-based type of encoding, the false-recognition procedure may be a more sensitive means of assessing the salience of different potential encoding dimensions. Although a number of investigations (e.g., Bach & Underwood, 1970; Felzen &

Anisfeld, 1970; Freund & Johnson, 1972) have demonstrated the usefulness of false-recognition approaches in detecting developmental trends in encoding, only research related to the present topic of semantic encoding is reviewed here.

Young children's word associations are often a different part of speech than the stimulus word but could fit in a sentence with it (e.g., run, fast), while older children's associations are more often the same part of speech as the stimulus word and could substitute for it in a sentence (e.g., run, walk) (Brown & Berko, 1960; Entwistle, 1966a; Ervin, 1961; McNeill, 1966). The relationship between this syntagmatic and paradigmatic transition and memory performance was investigated by Anderson and Beh (1968) in a continuous-recognition procedure. They reported that first graders made more false recognitions of distractors which were syntagmatically related to the target words than to distractors which were paradigmatically related to the target words. Second graders showed the opposite pattern of results. Although Anderson and Beh's findings are consistent with the word-association data, their stimulus materials were not published and their criteria for the selection of paradigmatic and syntagmatic distractors are unclear. Examination of their target items suggests that dimensions other than just form class, i.e., same part of speech, such as similarity, were shared by targets and paradigmatic distractors and that dimensions other than grammatical ones, such as complementarity, were shared by targets and syntagmatic distractors. As Denney (1974a) suggests, it is possible that the syntagmatic-paradigmatic shift may be due to the more general cognitive transition from complementary to similarity criteria.

Furthermore, Anderson and Beh's continuous-recognition procedure in which the subject was required to respond to every word allowed more than one type of recognition error to occur for a target word; and, thus, determination of the dominant type of encoding was obscured.

Cramer (1973) examined the role of associative and quantitative factors in determining memory encoding. Second and sixth graders were presented the same study list. For half of the subjects, the test list was composed of the target words, antonym associates of the targets, and unrelated control words; and, for the other subjects, synonym associates were substituted for the antonym associates. The children studied the list under instructions either to aid recall by thinking of antonyms for each word, or to aid recall by thinking of synonyms for each word, or to aid recall by listening carefully. At both age levels, across test lists and instructional sets, more false recognitions of strong associates than of weak associates were made. A strong associate is one which normatively has a high degree of relationship to the target word, while a weak associate has a normatively low relationship to its target. The antonym-facilitative instructional set increased antonym errors for sixth graders but not for second graders, while the synonym-facilitative instructional set increased synonym errors for the younger children but not for the older children. A developmental implication of Cramer's findings is that the importance of associative strength in determining recognition errors will continue unchanged from early childhood to adulthood but the relative importance of different semantic attributes, such as synonymity and antonymity, may be demonstrated to shift with age when associative strength is constant.

In a second study, Cramer (1974) investigated false-recognitions of object-referent distractors that were functionally related to the target words and dimension-referent distractors that were logical coordinates (foot-hand) and contrasts (long-short) of the targets. Kindergarten children made more dimension-referent than object-referent responses, and no difference in the two types of errors was shown by the second and sixth graders. Although these data seem inconsistent with Denney's (1974a) hypothesized complementarity-similarity shift, the items used by Cramer may not have been appropriate. Although the object-referent items included functional relationships, the nature of the functional relationships may have been too abstract for young children. For example, in one set of items woman, girl, child, woman-girl was the synonymous relationship while woman-child constituted the complementary relationship. Furthermore, the subject's responding may have been affected by intralist associations. Words within the test list may have elicited each other, since relationships other than the ones being studied existed among the words. Upon examination of the materials used by Cramer, several unintended relationships were discovered. For example, interset elications, such as burn-medicine, two functional items; stool-foot, two target items; and butter-cheese, two control items, may have occurred. In an analysis of Felzen and Anisfeld's (1970) findings, Cramer and Schuyler (1974) maintained that two factors, similar to those suggested here, may have confounded the results. They observed that the stimuli employed in the test list did not represent mutually exclusive categories and the possibility of intralist associations existed.

<u>Purpose of the Present Research</u>

In Experiment 1, developmental variations in the encoding of verbal materials along the dimensions of similarity and complementarity were examined. First-grade, sixth-grade, college, and elderly subjects were tested in a discrete, forced-choice recognition task in which the subjects selected each word from four alternatives: the correct word, a similarity distractor, a complementary distractor, and an unrelated control word. According to data presented by Bach and Underwood (1970), different attributes may show different rates of forgetting. The phenomenon of different rates of forgetting refers to the possibility that one type of attribute may be lost from memory more rapidly than another. Immediate and delayed retention groups were included to examine this possibility with respect to the semantic dimensions of complementarity and similarity. Analyses of the number of correct responses and the frequency of the different types of errors were performed. If Denney's (1974a) analysis of age changes in categorization criteria can be considered to represent general and pervasive changes in the individual's mode of information processing, complementary encoding was expected to be dominant at each end of the life span. Similarity encoding was predicted to be the preferred style of older children and young adults.

The first experiment was also designed to eliminate the methodological problems of the previously cited studies. First, continuous-recognition may not be a sufficiently sensitive means of investigating the encoding of verbal attributes. A forced-choice method permits only one error for any set of semantically related words yet still allows for differing types of errors and controls for intralist elications. Unlike the Cramer (1973) procedure in which each subject could only make the differing types of distractor errors for different words, subjects in the forced-choice method employed here could make only one of the three types of distractor errors--complementary, similarity, and control--for every word. Second the degree of associative relatedness among the target items and their complementary and similarity distractors must be considered. The normative frequencies with which the similarity and complementary distractors were given as word associations to their targets were equated as nearly as possible to hold constant the effect of implicit high or low associations (Hall, 1968, 1969). Equating the associative strength of both types of distractors precluded the possibility that the subjects' responses might have been due to association value.

In Experiment 2, the relationship between type of encoding and memory accuracy was investigated. In an incidental learning task, two groups of college students were forced to encode along either complementary or similarity dimensions. Recall of the words was tested immediately or after a delay. If young children's and elderly adults' memory deficits are due to the encoding of complementary attributes that are hypothesized to be relatively ineffective for retrieval and/or lost from memory quickly, forced complementary encoding in college students should hinder memory performance. Therefore, complementary encoding subjects were predicted to have poorer memory performance than similarity encoding subjects.

METHOD

Experiment 1

Subjects. One hundred and sixty subjects, consisting of 40 first graders, 40 sixth graders, 40 college students, and 40 elderly adults were tested. The first and sixth graders were students at two elementary schools in Greensboro, North Carolina. The mean age for the first graders was 6.6 years and for the sixth graders 11.6 years. The college students were enrolled in introductory psychology courses at the University of North Carolina at Greensboro and received course credit for their participation. The mean age of the college students was 19.6 years. The elderly subjects consisted of retired adults aged 65 years or older who lived in the Greensboro area and who were not institutionalized or under any extensive medical care. The mean age of these subjects was 74.5 years. Only elderly adults who completed college were tested. These criteria were used in view of Denney's (1974b) observation concerning differences in memory performance between retired persons who are nursing home residents and retired persons who live in the community, and also, in view of the necessity of making the elderly and college samples as comparable as possible.

At each age level, 20 of the subjects served in the immediate testing condition and 20 in the delayed testing condition. Subjects were assigned to each condition on a random basis. An equal number of males and females were tested in each condition at each age level.

Design. A randomized group design with four between-subjects factors (age, sex, time of testing, and study list) was used.

Materials. Forty items consisting of 30 target words and 10 filler words were presented on the study list. The recognition test consisted of 30 forced-choice sets. Each set contained four words: the target word, a complementary distractor, a similarity distractor, and an unrelated word (e.g., stove, cook, oven, rejoice). The order of the words within each set was random, with the restrictions that the target word did not occupy the same position in more than two consecutive sets and that each target and type of distractor appeared as equally often as possible in each of the four positions. The target word appeared in position one, seven times; in position two, nine times; in position three, eight times; and in position four, six times.

Sixteen of the target items and their complementary and similarity distractors were chosen from the word association norms of Palermo and Jenkins (1964, 1966) and Entwistle (1966b). The complementary and similarity distractors were selected so as to be approximately equal in associative strength to their target word. The mean associative strength of the complementary distractors was 15% for first graders, 13% for fourth graders, and 17% for college students. For the similarity distractors, the mean associative strength was 16% for first graders, 13% for fourth graders, and 16% for college students. The remaining 14 target words and their complementary and similarity distractors were constructed by the author, and did not have normative data available for them. The 14, author-constructed items were used, however, to avoid possible ceiling effects, i.e., recognition performance without any errors. Thus, it should be noted that the 16 normative-data items were critical ones, since any differences in the types of recognition errors which subjects made on them could not be attributed to uncontrolled differences in associative strength.

The 10 filler items used in the study list and the 30 control words used in the recognition test list were judged by the author to be unrelated to the target words and to the complementary and similarity distractors. The previously cited word association norms were used, where possible, in determining whether a word was unrelated to the target words and the distractors. An attempt was made to randomize all possible relationships among the items except the complementary and similarity relationships that were examined. Two random orders of the study list and two random orders of the recognition test were prepared and recorded on tape. On both study lists, the same four filler words were used as the buffer items--two at the beginning and two at the end of each list.

Procedure. Each subject was tested individually. After they were seated across a table from the experimenter, the subjects were told that they were going to hear a list of words, to which they should listen carefully. They were instructed to repeat each word after they heard it on tape and that their memory for the words would be tested later. These instructions were given twice, first on the tape and then by the experimenter. The items were presented on the tape at the rate of five seconds per word.

After the study list was presented, a one-minute filler task, consisting of circling all the number "7's" on a page of random numbers, was given to the first-grade subjects; and a one-minute filler task, involving completion of number sequences, was given to the sixth-grade, college, and elderly subjects. The recognition test was then given to the immediate-test group. The subjects were told that they would hear 30 sets of words once and that each set would consist of four words. They were instructed that their task was to choose, from each set, the word which they had heard on the study tape. To insure that the subjects understood the testing procedure, an oral example was given by the experimenter. This example was followed by a practice trial on the tape. Both of the practice items involved materials that were unrelated to those on the test-list tape. The experimenter recorded the oral choices of the subjects. An interval of three seconds between each word was left on the test tape. The procedure for the delayed-test group was identical, except that the test list was presented after a 24-hour retention interval.

The testing was done by the author.

Experiment 2

Subjects. Sixty-four college students served as subjects, 16 in each of the four conditions. The subjects were students enrolled in introductory psychology courses at the University of North Carolina at Greensboro and received course credit for their participation. Assignment to each condition was done on a random basis.

Design. A randomized group design with two between-subjects factors (forced orientation and time of testing) was employed.

Materials. The stimulus words were the 30 target items used in Experiment 1. Two random orders of the words were taped.

Answer booklets consisting of 30 pages were prepared for the subjects' recording to their complementary or similarity responses. Only one response was permitted on each page.

Procedure. The subjects were tested in small groups of four students. In both conditions, they were told that they would hear a list of words but were not forewarned about the memory test. The words were presented on a tape at a five-second rate. Subjects in the complementary group were instructed to write in their answer booklet a word which had a functional relationship to each of the words presented on the tape, such as pencil-write. The similarity group was told to write down a word which had a synonymous or superordinate relation to each presented word, such as pencil-pen. After the list was presented, a one-minute filler task, involving completion of number sequences, was given. The immediate-recall subjects then received two minutes to write down all the words that they could remember. The procedure for the delayed-recall group was identical, except that recall was tested after a 24-hour retention interval.

The testing was conducted by an undergraduate student.

RESULTS

Experiment 1

Description of analyses. A four-way analysis of variance with the between-subjects factors of age (4), sex (2), retention interval (2), and study list (2), was performed on the total number of correct recognitions. A similar analysis was performed on the number of correct recognitions of the 16 items that had been constructed on the basis of normative data. The second analysis was performed because of the lack of control over the total list that resulted from the inclusion of the 14, author-constructed items for which normative data was not available.

A five-way analysis of variance, with the between-subjects factors of age (4), sex (2), retention interval (2), and study list (2) and the within-subject factor of type of error (3), was performed on the total number of falsely recognized words. For the reasons cited above, a second identical analysis was performed on the false recognitions that were made on the 16 normative-data items.

Analysis of variance summary tables are presented in the Appendix to this paper.

Scheffe post hoc (Winer, 1971) analyses were performed on all significant outcomes.

Recognition accuracy. The analysis of the total number of correctly recognized words indicated significant main effects of age, F (3, 12) = 20.6903, $p < .001$, $MS_e = 9.397$, and retention interval, F (1, 4) = 19.029, $p < .05$, $MS_e = 50.728$. The post hoc analyses showed that the first graders made fewer correct responses than the sixth graders (C.V. = 2.28961, $p < .01$) and the college and elderly subjects (C.V. = 3.9018, $p < .001$). The remaining age groups did not differ in their recognition accuracy. More items were correctly recognized in the immediate condition than after the 24-hour delay.

The analysis of the number of correctly recognized words for the 16 normative-data items showed that there was a significant main effect of age, F (3, 12) = 16.7689, $p < .001$, MS_e = 2.2361. Post hoc analyses indicated that the first graders made fewer correct responses than the elderly and sixth grade subjects (C.V. = 2.13, $p < .001$). No significant differences occurred among the other age groups. A significant main effect of time also occurred, F (1, 4) = 14.4254, $p < .05$, MS_e = 21.35301, and indicated that recognition performance at immediate testing was superior to that at delayed testing. The interaction of age X retention interval was significant, F (3, 12) = 5.2698, $p < .05$, MS_e = 2.9239; the cell means for this interaction are presented in Table 1. Post hoc analyses indicated that, at immediate testing, the first graders made significantly fewer correct responses than the sixth graders (C.V. = 1.74, $p < .05$), while at delayed testing, both the first graders and the sixth graders made fewer correct responses than the college subjects (C.V. = 1.74, $p < .05$). For the first graders, sixth graders, and the elderly subjects, fewer words were recognized at delayed testing than at immediate testing (C.V. = 1.74, $p < .05$). This difference did not occur for the college students, since they maintained their performance across time on these items.

TABLE 1

Mean Number of Correct Recognitions of the 16 Normative-Data Items as a Function of Age Level and Retention Interval

Age Level	Retention Interval	
	Immediate	Delay
First Grade	11.10 (.69)	8.15 (.51)
Sixth Grade	13.60 (.85)	9.50 (.59)
College Students	12.40 (.78)	11.30 (.71)
Elderly	12.60 (.79)	9.65 (.60)

Note. Proportions of the total number (16) of possible correct recognitions are given in the parentheses.

False recognitions. The analysis of the total number of false recognitions indicated significant main effects of age, F (3, 128) = 3.8453, $p < .05$, MS_e = 15.80596, retention interval, F (1, 128) = 26.2185, $p < .001$, MS_e = 15.80596, and type of error, F (2, 256) = 3.2558, $p < .05$, MS_e = 6.6056. *Post hoc* analyses showed that the first graders made significantly more errors than each of the other age groups (C.V. = .797, $p < .05$), while the elderly made more errors than the college students (C.V. = 7.97, $p < .05$). A greater number of errors were made after the 24-hour delay than at immediate testing, and significantly more errors were made to similarity distractors than to the control, unrelated distractors. A triple interaction between sex, retention interval, and study list occurred, F (1, 128) = 4.0828, $p < .05$, MS_e = 15.80596. However, the *post hoc* analyses showed that this interaction could be attributed to the effect of time, rather than to sex or study list.

In the analysis of the number of errors made on the 16 normative-data items, significant main effects of time, F (1, 128) = 23.7814, $p < .001$, MS_e = 6.0134, and type of error, F (2, 256) = 3.7007, $p < .05$, MS_e = 2.5710, were obtained. More errors were made at delayed testing than at immediate testing, while more false recognitions were made to complementary and similarity distractors than to unrelated items. There was no difference between the number of complementary and similarity false recognitions.

The important finding for the present research is that a significant interaction of age X type of error was obtained in the analysis of the normative-data items, F (6, 256) = 2.1319, $p < .05$, MS_e = 2.5710.

The cell means for this interaction are presented in Table 2. Due to the fact that the interaction of age and type of error was significant, the previously described main effect of type of error must be considered in light of the interaction. Post hoc tests showed several significant differences. The first graders made more similarity errors than complementary or unrelated errors (C.V. = .4813, $p < .05$), but there was no difference in the number of complementary and unrelated errors. (The frequency of each type of false recognition was expressed as a proportion of the total number of errors which were made. For the first graders, the proportions for each type of error were: complementary errors = .31, similarity = .40, unrelated = .29.) The college students made more complementary false recognitions than similarity and unrelated errors (C.V. = .4818, $p < .05$). There was no difference between the number of similarity and unrelated errors (complementary responses = .43, similarity = .30, unrelated = .27). The elderly subjects also made more complementary false recognitions (C.V. = .4813, $p < .05$), but showed no difference in their responding to similarity and unrelated words (complementary errors = .40, similarity = .32, unrelated = .28). The error types were evenly distributed for the sixth graders (complementary responses = .34, similarity = .31, unrelated = .35).

Experiment 2

Description of analyses. A three-way analysis of variance, with the between-subjects factors of forced orientation (2), retention interval (2), and study list (2), was performed on the number of correct words recalled. A similar analysis was performed on the number of correct responses that the subjects wrote in the answer booklets.

TABLE 2

Mean Number of False Recognitions of the 16 Normative-Data Items as a Function of Age Level and Type of Error

Age Level	Type of False Recognition		
	Complementary	Similarity	Control
First Grade	1.97	2.57	1.72
Sixth Grade	1.50	1.40	1.55
College Students	1.80	1.25	1.10
Elderly	2.55	1.67	1.50

According to the forced orientation group, the subjects were instructed to write on each page of the answer booklet a word which had a synonymous-superordinate or functional-contiguous relationship to the target words. A response was scored as correct, therefore, when the subjects recorded a word which had the proper relationship to the target word. The scoring of the orienting responses was performed separately by the author and by the undergraduate experimenter. When discrepancies in the scoring of responses occurred, joint discussion of the items resolved the disagreement.

A four-way analysis of variance, with the between-subjects factors of forced orientation (2), retention interval (2), study list (2), and the within-subject factor of type of intrusion error (3), was performed on the number of intrusions in the subjects' recall protocols. An intrusion is a recalled word that did not appear on the study list. The type of intrusion--complementary, similarity, or unrelated--was determined by the author and by the undergraduate experimenter. The complementary and similarity intrusions were, in most cases, the responses that had been written in the answer booklet. If an intrusion did not appear as a subject's response in the answer booklet, a possible complementary or similarity relationship to one of the target words was checked. An unrelated intrusion was one which had no apparent complementary or similarity relationship to any target word.

A four-way analysis of variance with the between-subjects factors of forced orientation (2), retention interval (2), study list (2), and the within-subject factor of type of orienting response (4), was performed on the responses written in the answer booklets for the correctly recalled target words. Four types of responses were analyzed: the three types described for the intrusion analysis (i.e., complementarity, similarity, and unrelated), and omissions (i.e., no response). The type of response was determined by the author and by the undergraduate experimenter, using the method described for determining the type of intrusion.

Analysis of variance summary tables are presented in the Appendix to this paper.

Scheffe post hoc (Winer, 1971) analyses were performed on all significant outcomes.

Accuracy in the orienting task. The analysis performed on the number of words written in the answer booklets in accord to the specific instructions indicated that the similarity and complementary groups made an equivalent number of correct orienting responses, $F\ (1, 7) = 1.0980$, $p > .05$, $MS_e = 3.6426$.

Recall. More words were correctly recalled by both groups at immediate testing than at delayed testing, $F\ (1, 7) = 17.3301$, $p < .005$, $MS_e = 10.71205$. A significant interaction between type of forced orientation and retention interval occurred, $F\ (1, 7) = 6.8454$, $p < .05$, $MS_e = 3.837$. The means for this interaction are presented in Table 3. The post hoc tests indicated that, at immediate testing, the complementary group recalled more items than did the similarity group (C.V. = 1.36, $p < .05$), while, at delayed testing, there was no difference in the recall of the two groups. Both complementary and similarity groups recalled more items immediately than after the 24-hour delay.

TABLE 3

Mean Number of Correctly Recalled Words as a Function of Forced Orientation and Retention Interval

Forced Orientation Group	Immediate	Delay
Similarity Group	7.25 (.24)	5.12 (.17)
Complementary Group	8.68 (.29)	4.00 (.13)

Note. Proportions of the total number (30) of words are given in the parentheses.

Orienting accuracy for recalled words. In the analysis of the responses written in the answer booklets for the correctly recalled target words, significant main effects of type of response, F (3, 168) = 84.5177, $p < .001$, MS_e = 159.9740 and time, F (1, 56) = 27.301, $p < .001$, MS_e = 140.2334 occurred. Significant interactions of forced orientation X type of response, F (3, 168) = 84.5147, $p < .001$, MS_e = 159.9740 and time X type of response, F (3, 168) = 7.3474, $p < .001$, MS_e = 159.9740 also occurred. However, these effects must be interpreted in light of the significant triple interaction of forced orientation X time X type of response, F (3, 168) = 6.7546, MS_e = 159.9740. The means for this interaction are presented in Table 4. In explaining this effect, the variable of time must be considered as reflecting the differences in the number of recalled words due to the two retention intervals. Of importance here are the differences in responses due to forced orientation. The complementary groups gave more complementary associates than did the similarity groups, while the similarity groups made more similarity associates than the complementary groups (C.V. = 16.6242, MS_e = 159.740, $p < .01$). Furthermore, the similarity groups made more appropriate similarity responses than complementary, unrelated, or omission responses; and the complementary groups made more correct, complementary responses than similarity, unrelated, or omission responses (C.V. = 16.6242, MS_e = 159.740, $p < .01$). This result indicates that, for the recalled words, the groups responded according to instructions.

Intrusions. A significant interaction between type of forced orientation and type of intrusion occurred, F (2, 112) = 4.7574, $p <$

TABLE 4

Mean Number of Each Type of Forced Orientation Response for the Recalled Words as a Function of Forced Orientation and Time

Time	Complementary	Similarity	Unrelated	Omission
Similarity Group				
Immediate	16.25	54.38	.00	1.87
Delay	9.38	36.87	2.50	2.50
Complementary Group				
Immediate	58.75	6.25	6.25	3.12
Delay	27.50	4.38	1.25	.62

Note: column heads are under the spanning header "Type of Response".

.001, $MS_e = .4412$. The means for this interaction are presented in Table 5. The complementary groups made more complementary intrusions than the similarity groups (C.V. = .5072, $p < .001$). The complementary groups also made more complementary intrusions than similarity intrusions. The similarity groups showed no difference in the type of their intrusions.

TABLE 5

Mean Number of Each Type of Intrusion Error as a Function of Forced Orientation

Forced Orientation Group	Complementary	Similarity	Unrelated
Similarity Group	.25	.47	.22
Complementary Group	.85	.34	.38

DISCUSSION

Importance of the Normative Data Items

In the construction of the 16 normative items, only complementary and similarity distractors that were of approximately equal associative strength to their targets for all age groups were selected. For example, the two distractors used in the study for the word hammer were saw and pound, which are of approximately equal, but low, associative relatedness to hammer. If, however, the word nail, which has a high degree of associative relatedness to hammer, had been used as one of the distractors, a greater number of complementary errors might have been obtained. However, this effect could have been due to the unequal associative strength values. If distractors could have been selected with both high and equal associative strength values, a greater number of complementary and similarity errors might have occurred. However, it was impossible to construct such items from the existing norms, and thus, low associative strength values were necessary in order to equate the associative strength of the complementary and similarity distractors.

Since associative strength data were not available for the 14, author-constructed items, the results for the total list may have been due to the effect of associative strength, i.e., the total data may not reflect only semantic differences. The analysis of the 16, normative-data items, whose distractors were of equal associative strength to the targets, therefore, demonstrates more accurately the effect of the semantic variables of complementarity and similarity. For this reason, the present discussion will focus on the data from the normative items. The rationale for discussing only the normative items is demonstrated further by the differences in the results of the data analyses for the total list and for the 16 items. The most important of these differences was the lack of a significant age X type of error interaction in the total list, which did occur in the 16-item list. If the normative-data items and the author-constructed items were equally reflecting the effect of the semantic variables of complementarity and similarity, these differences in results should not have occurred.

As stated earlier, the relatively small number of false recognitions that were made to the distractors in the study may be a result of the low associative values of the controlled items. If distractors of high associative strength could have been used, larger effects, i.e., more errors to the distractors, might have been obtained. The greater the degree of associative relatedness of a distractor to the target, the more probable it is that a false recognition will be made to that distractor. For example, Cramer and Schuyler (1974) examined the interaction between associative strength and the semantic variables of synonymity and antonymity in the false recognitions of third and sixth grade children. In that study more responses were made to synonyms and antonyms with high association values than to those with low association values. In another study, Cramer (1973) manipulated the subjects' instructional set at input and found that facilitative instructions increased false recognitions of second and sixth graders only on test items in which the distractors were highly related to the target but not on test items in which the distractors were of low associative relationship to the target. These studies support the conclusion that false recognitions of distractors depends on the distractor's degree of associative relatedness to the target.

Age Differences in Encoding

According to Denney (1974a), the criteria individuals use to organize and classify verbal materials undergo developmental changes. She maintains that, due to age and age-related experiences, a developmental shift occurs from the complementary categorization style of young children to the use of similarity criteria by older children and adults. Furthermore, Denney maintained that this change reverses in old age. Denney suggests that all individuals are capable of categorization according to either complementary or similarity criteria but that environmental factors determine the criteria which are used. Young children and elderly adults presumably make functional categorizations because these groupings involve relationships that are more natural, i.e., they involve items related in time and space. Categorization according to abstract-similarity dimensions is employed, according to Denney, by older children and adults due to the external pressures of formal education and work.

According to Denney (1974a), the effect of the trend in categorization style from complementary to similarity dimensions--as demonstrated by Denney (1974b) and Denney and Ziobrowski (1972) in free-recall studies--is a general one. Therefore, in the false-recognition paradigm of Experiment 1, a developmental shift from complementary to similarity encoding with a reversal trend in old age should have occurred. The younger children and the elderly should have made more complementary than similarity false recognitions, while the sixth graders and college students should have made more similarity than complementary errors.

However, the significant interaction of age and type of false recognition indicated opposite trends to those argued by the author and Denney (1974a). First, the younger children made more similarity errors than complementary errors, while the older children showed no difference in the type of false recognition that they made. Second, both the college students and the elderly subjects made more complementary errors than similarity errors. Thus, it would seem that there was a shift in the type of semantic dimension which the subject encoded but not in accord with predictions. Instead, the data suggest that a change from similarity encoding at the first grade level to complementary encoding at the adult level occurs. The data further suggest that this shift includes a period at the sixth grade level in which encoding preferences are not demonstrated. It should be noted that the findings that the elderly made more complementary errors than similarity errors is consistent with the prediction made by the author, but not for the reasons hypothesized. It was suggested by Denney that the elderly subjects would demonstrate a preference for functional dimensions due to retirement from the external pressures of a career. However, the use of functional attributes was also demonstrated by the college students. Therefore, it seems that the use of complementary encoding by the elderly could not have occurred for the reasons initially suggested.

Although the children's false-recognition data were inconsistent with the author's predictions, they are similar to the results of a study reported by Cramer (1974), which was described in the Introduction.

Cramer investigated the false recognitions of object-referent distractors that were functionally related to the target words and dimension-referent distractors that were logical coordinates and contrasts of the target words and thus bore a similarity relationship to the targets. Cramer reported that the kindergarten children made more dimension-referent than object-referent responses and that no difference was shown by the sixth graders in their error preference. Although the materials used by Cramer may not have been appropriate, as discussed in the Introduction, the trends in encoding demonstrated in her study may be more representative of children's encoding preferences than those argued by Denney (1974a).

Several hypotheses may be suggested to explain the encoding trends that were obtained in Experiment 1 of the present research. However, at the outset, it should be emphasized that the present recognition findings seem to constitute a real phenomenon. This conclusion is supported by the similarity between the results of Experiment 1 and those reported by Cramer (1974) and by the data from the recall study involving forced orientation of college students. The recall data from the incidental learning task of Experiment 2 are consistent with the false-recognition data of Experiment 1, since, in both studies, complementary dimensions appear to have been more effective for memory than similarity ones.

One possible explanation for the obtained trends in preferred encoding dimensions may be found in the studies reported by Denney (1972, 1974b). According to Denney, all individuals are capable of employing either type of categorization style, but the one adopted is determined by environmental factors. These environmental factors could include experimental ones. In Denney's procedure, a list consisting of similarity pairs and a second list consisting of pairs of complementary associates was presented to the subjects. Since each list contained only one type of association, a priming effect may have influenced the subjects' use of one dimension over another. Priming refers to the fact that the encoding of items may be affected by the context in which the items occur or the way in which earlier items were encoded. In the Denney studies, such priming may have occurred at study. Specifically, identification of the particular relationships between the pairs on the lists may have been primed. When presented with pairs of relationships such as complementary and similarity associates, college students may have recognized the similarity-synonymous relationships between the items more readily than the functional relationships and then used the recognized dimensions for the encoding of the subsequent items. For the younger children, relationships between functional items may have been recognized more readily; the young children were, therefore, primed to employ complementary dimensions for subsequent encoding. Thus, Denney's results indicating the encoding of functional dimensions by young children and similarity attributes by adults may reflect experimental priming rather than reflect the types of spontaneous encoding that subjects make.

In Experiment 1 of the present research, priming may have occurred during the recognition test, i.e., subjects may have identified the relationships within the forced-choice items at testing. However, this priming at the time of testing could not have influenced the dimensions with which the target words were initially encoded or stored. Therefore, the possible occurrence of priming at recognition could not have affected the subjects' initial spontaneous encoding, as it was suggested that priming at input could have.

Cramer (1974) suggested an interpretation for the reliance of her first graders on similarity dimensions and the findings of no preference for sixth graders. She maintained that the dimensions which underlie word-association responses may differ from those used for encoding in a word-memory experiment. However, her interpretation may only refer to the complementary-similarity dimension, since other semantic variables, such as synonymity and antonymity, have been demonstrated to be related differentially to recognition errors in accord with predictions based on developmental word association data (Cramer, 1973). It must be noted that Cramer's interpretation is not an explanation of the obtained developmental differences in encoding, since she did not specify under what conditions word-association data are and are not predictive of encoding type in a memory task.

Another reason why the younger children relied on similarity dimensions rather than on complementary attributes may be the emphasis which is placed on classification skills in contemporary early education (Weber, 1973). In contemporary pre-school education, stress is placed on the development of skills involving abstract relations, such as classifying, grouping, and counting. Due to this emphasis on synonymous-superordinate relationships, first grade children may have employed this strategy in their encoding. If children younger than age six could be tested before undergoing this training, the use of complementary dimensions might be discovered.

It is also possible that, in a single test of memory as in Experiment 1, the dimensions used by any age group may differ from those generally relied on in mnemonic tasks. If a continuous series of testing situations were arranged so that the subjects would become more aware of the memory demands being placed on them, perhaps the strategies used by any age level would change across tests. It may be suggested that in a series of tests involving memory performance, young children would gradually begin to demonstrate the use of complementary dimensions, while college students and older children would gradually begin to employ similarity attributes. However, since the purpose of the present research was to investigate developmental differences in spontaneous encoding, the testing situation used in Experiment 1 seems to have been appropriate.

Recall Data

It had been expected that forced complementary encoding would hinder the college students performance in Experiment 2. If the memory performance of young children and elderly adults is typically inferior to that of older children and college students, and if they rely on complementary dimensions as Denney argues, forced complementary encoding should have decreased the college students' recall performance. Likewise, similarity dimensions should have been the more salient and effective encoding attribute for college students. Contrary to these expectations, the students who were in the complementary groups had better recall performance at immediate testing than those in the similarity groups. However, this effect was not a lasting one, since recall did not differ at delayed testing.

One possible explanation for the superior recall performance of the complementary groups at immediate testing may be found in a hypothesis maintained by Paivio (1970). According to Paivio, an individual may transform verbal stimuli into pictorial images at encoding. The individual, therefore, has a dual code consisting of a verbal representation and a pictorial representation. Paivio maintains that concrete stimuli are more easily transformed into pictorial images than are abstract ones. Concrete stimuli also allow for more elaborate imagery. Elaborate imagery, according to Paivio, leads to better memory performance, since the more elaborate the imaged codes, the more stored dimensions one has to facilitate memory for the event. It can be hypothesized that functional types of encoding allow for transformations into more elaborate imagery than similarity dimensions do, because functional stimuli involve more concrete relationships. In Experiment 2 of the present study, forced orientation of complementary dimensions may have resulted in a more elaborate type of imaginal encoding than forced similarity encoding, therefore, permitting better recall performance at immediate testing by the complementary groups.

Rohwer's (1970) research involving the encoding of verb-action sequences offers a second possible explanation for the difference in the performance of the two groups at immediate testing. Rohwer argues that the construction at encoding of verb-action sequences to the presented items may lead to increased memory performance. For example, when the word mountain was presented, a verb-action sequence of climb-mountain may have been constructed by the subjects. Complementary-functional stimuli, it could be hypothesized, allow for more possibilities for the construction of verb-action sequences than similarity-abstract stimuli do. Functional relationships between items imply action, whereas, similarity relationships consist of abstract relationships. Forced complementary encoding may have provided more of an opportunity to construct verb-action sequences than did forced similarity encoding. If Rohwer's hypothesis is correct, the forced complementary groups, therefore, may have demonstrated better recall due to the increased opportunity to construct verb-action sequences. However, Rohwer does not offer any explanation as to why the construction of verb-action sequences aids recall, only that it does aid memory for an event.

Neither of these two hypotheses, however, provides an explanation as to why the superior performance of the complementary groups did not continue at delayed testing. Postman and Burns (1973) demonstrated that, although the imagery value of words correlated with the element of concretedness affects associative learning, imagery is not useful at delayed testing. In their study, 16 paired nouns with varying degrees of imagery and concretedness were presented for study. The retention test given one week later indicated that stimulus concretedness did not have a favorable effect on retention as it had had at immediate testing. Postman and Burns offered two reasons for why imagery of concrete stimuli was not effective at delayed testing. First, the image may have become blurred or faded and, therefore, was not available to aid in retrieval. Second, even if the image did remain intact, the transformation from the image to the appropriate verbal response may have been distorted. Thus, the transformation was likely to conserve some, but not all, of the original information and, therefore, errors occurred.

Like Postman and Burn's (1973) explanation, Paivio's (1970) argument as to why young children have poorer memory performance may be extended to explain why the delayed recall of the two college groups was similar. Paivio maintained that younger children have greater difficulty than adults in making symbolic transformations from the stored mediating image, i.e., the encoded dual dimensions of pictorial and verbal representations, to the required responses. In a study by Dilley and Paivio (1968), nursery-school, kindergarten, and first-grade children were given visual and auditory presentation of pairs of words and line drawings. The order of presentation was manipulated so that every possible visual-auditory combination--picture-picture, picture-word, word-picture, word-word--was included. Dilley and Paivio reported that the picture-word (visual-auditory) representation group demonstrated the best performance, while the performance of the remaining groups were similar. They concluded that visual, pictorial imagery may facilitate learning when pictures appear as stimuli, but hinder learning when they are in response positions.

Perhaps, this difficulty of transformation occurs for adults at delayed recall. If this is the case, then neither the semantic variables of complementarity nor similarity would be more effective in aiding recall. Instead, as demonstrated by the complementary and similarity groups in Experiment 2, the encoding of one type of attribute would not be more effective for memory at delayed testing than the encoding of another type of dimension.

Sex Differences in Recognition

The data of the recognition study indicated that there were no differences in performance at immediate and delayed testing due to sex differences. These results support the findings of May and Hutt (1974). In a study involving auditory or visual presentation of words to nine-year olds, May and Hutt reported that girls performed better on recall tasks than boys when presented auditory stimuli, but there were no sex differences in recognition performance when presented auditory or visual stimuli.

Differential Forgetting Rates of Semantic Dimensions

In order to examine the possibility that different attributes may show different rates of forgetting, as suggested by Bach and Underwood (1970), immediate and delayed retention groups were included in the present study. Differential rates of forgetting were not obtained, however, for the semantic variables of complementarity and similarity. This conclusion is supported by the lack of an interaction between the variables of retention interval and type of error.

Age Differences in Recognition Performance

In the present study, age differences in recognition performance were obtained. The recognition performance of the first graders was inferior to that of the other age groups. This difference has been reported in several studies, while in others the recognition performance of young children has been found to be equally good as older children's. For example, Felzen and Anisfeld (1970) found that the overall number of false recognitions made by third and sixth graders was similar, while, in a study by Bach and Underwood (1970), second-grade subjects showed better recognition performance than sixth graders. However, Hall (1968, 1969) and Hall and Ware (1968) found that younger children made more recognition errors than older children.

A possible reason for the children's inferior performance in the present study may have been their reliance on similarity dimensions. The younger children's reliance on similarity dimensions may have hindered their performance due to the abstract relationships of synonymous-superordinate attributes. In accord with Paivio's hypothesis, the abstract nature of synonymous-superordinate relationships may not have allowed for verbal and pictorial representation which was effective enough to aid memory performance. This argument is consistent with the recall findings of Experiment 2 which indicated that, at immediate testing, similarity dimensions were less effective for college students than were complementary attributes. A second reason for the poor recognition performance demonstrated by the first graders may be found in the task itself. Attentional factors in particular may have influenced the performance of the younger children, i.e., the type and length of the test might have negatively affected the children's performance due to their inability to maintain attention throughout the session.

Consistent with the literature on the elderly's recognition performance are the present results that the elderly did not differ in recognition performance from the college students and sixth graders at immediate testing. Schonfield and Robertson (1966) and Harwood and Naylor (1969) demonstrated that the recognition performance of elderly subjects is similar to that of other adult age groups at immediate testing. The recall performance of the elderly was demonstrated, however, to be inferior to that of other adult groups. According to Schonfield and Robertson, recognition is a different, easier process than recall since the former presumably involves only the matching of a presented stimulus to a stored code. Recall, however, is considered to involve the retrieval of information from storage and, thus, is a difficult one for the elderly.

Contrary to Harwood and Naylor's (1969) results of poor recognition at delayed testing, the elderly subjects in the present study showed good but decreased delayed recognition. However, this difference may be due to the difference between the retention intervals employed. Harwood and Naylor's interval consisted of four weeks, while that of Experiment 1 was 24 hours. More important, however, is the finding that the elderly's recognition performance did not differ from the college students at delayed testing. The encoding of complementary dimensions may be the reason for the recognition performance of the elderly. As stated, the use of complementary dimensions proved to be more efficient for recall at immediate testing for college students and may be more effective for memory than similarity attributes.

The Effectiveness of Complementary Encoding

From the recognition and recall findings, the encoding of complementary dimensions appears to be more effective for memory performance than the encoding of similarity dimensions. Several results support this observation. Although the recognition performance of the sixth graders, college students, and the elderly subjects was similar at immediate testing, recognition differences occurred at delayed testing. The sixth graders, who showed no preference in encoding type, demonstrated the best recognition performance at immediate testing. However, their recognition performance decreased considerably at delayed testing and was significantly inferior to that of the college students and the elderly. A decrease in recognition performance at delayed testing was also demonstrated by the elderly, who showed a preference for complementary encoding. Their delayed performance, however, did not differ significantly from the college students. The decrease in performance shown by the elderly may have been due to factors other than ones involving the types of dimensions encoded. According to Harwood and Naylor (1969), recognition performance of the elderly decreases after a delay due to decay of the stored trace to which the stimulus must be matched. They argue that this decay of the trace occurs regardless of the nature of the trace. Thus, complementary dimensions may have been more effective at delayed testing for the elderly if they were not susceptible to rapid loss of all types of traces.

Another reason for the conclusion that complementary encoding may be more effective may be found in the results of the recall data. In the incidental learning task, the college students who were assigned to the complementary groups demonstrated better recall performance at immediate testing than the similarity groups. It must be noted, however, that this difference did not occur at delayed testing.

Most important for the argument that complementary dimensions are superior for memory performance is the fact that the college students who preferred complementary encoding maintained their performance across time and did not show a decrease in performance.

In light of these results, the use of complementary dimensions in the present study appears to have been the most effective means of encoding material for recognition at immediate and delayed testing and for recall at immediate testing.

<u>Summary</u>

The present studies were concerned with potential age differences in encoding strategies and their effect on memory performance. Underlying these investigations was Underwood's (1969) hypothesis that the internal memory for an event may be conceptualized as a collection of attributes. According to Underwood, attributes represent different types of information that are stored about an event during encoding. It was suggested that differences in the type of dimensions that are encoded may exist due to age or age-related experience, i.e., young children's attributes of memory may be different from those of older children and adults. The present experiments examined the possibility that such differences in attribute encoding may account for children's poor memory performance and that one type of encoding dimension may be more effective for retrieval and discrimination of events in memory than another. To study these questions, developmental differences in the encoding of verbal materials along the semantic dimensions of complementarity and similarity were examined as was the relationship between type of encoding and memory accuracy in adults.

The results of Experiment 1 indicated that developmental variations in encoding occur, and the findings of both studies demonstrated that the type of encoding dimension employed by a subject affects memory performance. Along the semantic dimensions of complementarity and similarity, however, the obtained differences were not in accord with those suggested by Denney (1974a). The results of the present research indicated that similarity dimensions were used by first graders, that college students and elderly subjects employed complementary dimensions, and that sixth graders demonstrated no preference for encoding type. It is possible that, if children younger than six years were tested, the shift hypothesized by Denney would be detected. In Experiment 2, the finding that complementary dimensions were more effective than similarity ones for adult recall was also inconsistent with the author's predictions. To examine further this phenomenon, a forced-orientation paradigm in which subjects would be given their forced-orientation responses as cues for recall could be conducted, to determine if complementary dimensions would still be more effective than similarity ones.

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APPENDIX A

Examples of Materials

EXPERIMENT I

Study List I	Study List II
jewel	jewel
feather	feather
answer	clean
baby *	piano
sour *	gift
hammer *	boat
piano	guns *
dream *	minister
study	string
cup	march
needle *	hammer *
clock	stove *
mix *	sour *
doors *	dream *
whistle *	whistle *
zoo	tobacco *
save	needle *
shirt	clock
sun	throw
string	weigh
broom	shut
weigh	answer
cars *	study
boat	mountain *
mountain *	cup
numbers *	zoo
tobacco *	baby *
thief *	dress
minister	save
march	draw
dress	mix *
gift	run *
run *	thief *
stove *	sun
guns *	cars *
draw	doors *
throw	numbers *
clean	broom
pain	pain
napkin	napkin

Note. * indicates normative-data items.

Recognition List

EXPERIMENT I

Random Order I

throw *
west
cry
close
scale
learn
chief
save *
hill
glass
cook
windows
clock *
count
air
enjoy
whistle *
arrive
thief *
guitar
mix
smoke
shine
give
wish
season
run *
plant
saw
lemons

pitch
picture
baby *
tight
poor
school
mop
bank
serve
cup *
rejoice
dance
blood
storm
boat *
suit
tune
needle *
robber
piano *
cake
tobacco *
moon
gift *
trouble
guns *
fast
cars *
pound
promise

ball
draw *
follow
listen
weigh *
kiss
broom *
collect
mountain *
drink
oven
doors *
time
numbers *
ship
dress *
wild
pin
steal
play
stir
cigarettes
waste
present
bed
shoot
taffy
ride
stomach
sour *

shout
paint
child
shut *
measure
study *
sweep
move
high
city
stove *
open
watch
letters
sail
wear
sing
sew
yard
hang
station
dog
sun *
lost
dream *
rifle
walk
trucks
hammer *
bitter

Note. * indicates target items.

Recognition List

EXPERIMENT I

Random Order II

air	boat *	ship	sail
enjoy	suit	dress *	wear
smoke	tobacco *	cigarettes	dog
scale	poor	weigh *	measure
whistle *	tune	wild	sing
wish	trouble	bed	dream *
plant	cars *	ride	trucks
learn	school	kiss	study *
hill	serve	mountain *	high
thief *	robber	steal	yard
glass	cup *	drink	city
clock *	blood	time	watch
give	gift *	present	lost
run *	fast	taffy	walk
cry	baby *	follow	child
cook	rejoice	oven	stove *
arrive	needle *	pin	sew
lemons	promise	sour *	bitter
close	tight	listen	shut *
west	picture	draw *	paint
throw *	pitch	ball	shout
chief	mop	broom *	sweep
shine	moon	waste	sun *
save *	bank	collect	move
guitar	piano *	play	hang
windows	dance	doors *	open
season	guns *	shoot	rifle
count	storm	numbers *	letters
mix *	cake	stir	station
saw	pound	stomach	hammer *

<u>Note</u>. * indicates target items.

EXPERIMENT II

Study List I

baby
sour
hammer
piano
dream
study
cup
needle
clock
mix
doors
whistle
save
shut
sun
broom
weigh
cars
boat
mountain
numbers
tobacco
thief
dress
gift
run
stove
guns
draw
throw

Study List II

piano
gift
boat
guns
hammer
stove
sour
dream
whistle
tobacco
needle
clock
throw
weigh
shut
study
mountain
cup
baby
dress
save
draw
mix
run
thief
sun
cars
doors
numbers
broom

APPENDIX B

Analysis of Variance Summary Tables

Analysis of Variance Summary Table of the Total Number of Correct Recognitions

Source of Variance	Error Term	F	SS	dF	MS
Age Level (A)	AS	20.6903***	583.2686	3	194.4229
Sex (B)	BS	1.4811	31.50624	1	31.50624
Retention Interval (C)	CS	19.0291*	965.3062	1	965.3062
Study List (d)			135.0873	1	2.256249
Subjects (S)			135.0873	4	33.77182
A X B	ABS	.4497	29.86876	3	9.956253
A X C	ACS	1.6381	81.46846	3	27.15633
B X C	BCS	.0461	1.056152	1	1.056152
A X d	AdS	2.3248	132.5189	3	44.17296
B X d	BdS	.2045	11.55625	1	11.55625
C X d	CdS	.3601	6.006202	1	6.006202
A X S			112.7618	12	9.396820
B X S			85.0876	4	21.27190
C X S			202.9117	4	50.72794
d X S			98.83754	4	24.70940
A X B X C	ABCS	.1630	10.11879	3	3.372930
A X B X d	ABdS	1.0581	34.41859	3	11.47286
A X C X d	ACdS	.4039	36.76860	3	12.2562
B X C X d	BCdS	3.0743	97.65637	1	97.63657
A X B X S			265.6584	12	22.13820
A X C X S			198.9296	12	16.57745

Analysis of Variance Summary Table of the Total Number of Correct Recognitions (continued)

Source of Variance	Error Term	F	SS	dF	MS
B X C X S			91.66125	4	22.41531
A X d X S			228.0064	12	19.00053
B X d X S			226.0345	4	56.50862
C X d X S			66.70917	4	16.67729
A X B X C X d	ABCdS	3.7399	88.11322	3	29.37106
A X B X C X S			248.2687	12	20.68906
A X C X d X S			364.1282	12	30.34401
A X B X d X S			130.1179	12	10.84315
B X C X d X S			127.0605	4	31.76514
A X B X C X d X S			94.24072	12	7.853394

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

Analysis of Variance Summary Table of the False Recognitions Made to the Total List

Source of Variance	Error Term	F	SS	dF	MS
Age Level (A)	S(ABCd)	3.8452*	182.3333	3	60.7777
Sex (B)	S(ABCd)	.0527	.83333	1	.83333
Retention Interval (C)	S(ABCd)	26.2185**	414.4082	1	414.4082
Study List (d)	S(ABCd)	.1524	2.408333	1	2.40833
Type of Error (e)	Se(ABCd)	3.2558*	43.0124	2	21.50623
A X B	S(ABCd)	.9926	47.06665	3	15.68888
A X C	S(ABCd)	1.1787	55.89160	3	18.6305
B X C	S(ABCd)	.5741	9.074951	1	9.07495
A X d	S(ABCd)	2.0883	99.02493	3	33.00830
B X d	S(ABCd)	.0132	.208330	1	.208330
C X d	S(ABCd)	.5257	.8333664	1	.8333664
A X e	Se(ABCd)	.8356	29.15361	6	4.858934
B X e	Se(ABCd)	1.2417	16.40419	2	8.20209
C X e	Se(ABCd)	1.0960	14.47899	2	7.239494
d X e	Se(ABCd)	.4942	6.529190	2	3.264594
A X B X C	S(ABCd)	.7077	33.55811	3	11.18640
A X B X d	S(ABCd)	1.0943	51.89166	3	17.29721
A X C X d	S(ABCd)	1.2204	57.86665	3	19.28888
B X C X d	S(ABCd)	4.0828*	64.53310	1	64.53310
A X B X e	Se(ABCd)	1.0091	39.99524	6	6.665873
A X C X e	Se(ABCd)	1.1788	46.71944	6	7.786572

Analysis of Variance Summary Table of the False Recognitions Made to the Total List (continued)

Source of Variance	Error Term	F	SS	dF	MS
B X C X e	Se(ABCd)	2.0049	26.48692	2	13.24346
A X d X e	Se(ABCd)	1.1414	45.23662	6	7.53943
B X d X e	Se(ABCd)	2.8388	39.50403	2	18.75201
C X d X e	Se(ABCd)	1.0089	13.32895	2	6.664474
A X B X C X d	S(ABCd)	1.2098	57.36630	3	19.12210
A X B X C X e	Se(ABCd)	.8609	34.47646	6	5.744076
A X B X d X e	Se(ABCd)	1.7484	69.29405	6	11.54901
A X C X d X e	Se(ABCd)	.8394	33.26697	6	5.544495
B X C X d X e	Se(ABCd)	.3371	4.453751	2	2.226875
S(ABCd)			2023.163	128	15.80596
A X B X C X d X e	Se(ABCd)	1.3736	54.43877	6	9.073128
Se(ABCd)			1691.029	256	6.605582

*p < .05
**p < .001

Analysis of Variance Summary Table of the Total Number of Correct Recognitions
Made to the 16 Normative-Data Items

Source of Variance	Error Term	F	SS	dF	MS
Age Level (A)	AS	16.7698**	117.0250	3	39.00833
Sex (B)	BS	1.8633	14.400	1	14.400
Retention Interval (C)	CS	14.4254*	308.0249	1	308.0249
Study List (d)	dS	1.3321	13.225	1	13.225
A X B	ABS	1.3660	30.14949	3	10.0500
A X C	ACS	5.2698*	46.22485	3	15.40828
B X C	BCS	.0734	.8999023	1	.8999023
A X d	AdS	2.4029	60.72499	3	20.24165
B X d	BdS	.1718	3.599982	1	3.599982
C X d	CdS	.1521	.6250982	1	.6250982
A X S			27.91321	12	2.32610
B X S			30.91245	4	7.728111
C X S			85.41205	4	21.35301
d X S			39.71248	4	9.928120
A X B X C	ABCS	1.0320	19.65005	3	6.550018
A X B X d	ABdS	.3969	7.250024	3	2.416675
A X C X d	ACdS	.6910	17.92490	3	5.974965
B X C X d	BCdS	1.8694	16.89975	1	16.89975
ABS			88.28679	12	7.357232
ACS			35.08630	12	2.923859
BCS			49.03751	4	12.25938

Analysis of Variance Summary Table of the Total Number of Correct Recognitions
Made to the 16 Normative-Data Items (continued)

Source of Variance	Error Term	F	SS	dF	MS
AdS			101.0860	12	8.423836
BdS			83.83736	4	20.95934
CdS			16.43765	4	4.109413
A X B X C X d	ABCdS	1.8420	17.55003	3	5.850011
ABCS			76.15981	12	6.346650
ABdS			73.05952	12	6.088293
ACdS			103.7606	12	8.646718
BCdS			36.16125	4	9.040314
ABCdS			38.11148	12	3.175957

*p < .05
**p < .001

Analysis of Variance Summary Table of the False Recognitions
Made to the 16 Normative-Data Items

Source of Variance	Error Term	F	SS	dF	MS
Age Level (A)	S(ABCd)	2.2810	41.14999	3	13.71666
Sex (B)	S(ABCd)	.0222	.1333	1	.1333
Retention Interval (C)	S(ABCd)	23.7814**	143.0083	1	143.0083
Study List (d)	S(ABCd)	.0887	.53333	1	.5333
Type of Error (e)	Se(ABCd)	3.7007*	19.02916	2	9.514580
A X B	S(ABCd)	1.7987	32.44998	3	10.81666
A X C	S(ABCd)	1.4047	25.34167	3	8.447225
B X C	S(ABCd)	.6111	3.674988	1	3.674988
A X d	S(ABCd)	2.5896	46.71666	3	15.5722
B X d	S(ABCd)	.0887	.53333	1	.5333
C X d	S(ABCd)	.3118	1.874991	1	1.874991
A X e	Se(ABCd)	2.1319*	32.88747	6	5.481244
B X e	Se(ABCd)	.7787	4.004150	2	2.002075
C X e	Se(ABCd)	1.0218	5.254059	2	2.627029
d X e	Se(ABCd)	1.4837	7.629150	2	3.814575
A X B X C	S(ABCd)	1.5839	28.57494	3	9.524970
A X B X d	S(ABCd)	.8213	14.81667	3	4.938890
A X C X d	S(ABCd)	1.4361	25.90820	3	8.636067
B X C X d	S(ABCd)	2.3295	14.00833	1	14.00833
A X B X e	Se(ABCd)	1.3556	20.91238	6	3.485397

Analysis of Variance Summary Table of the False Recognitions
Made to the 16 Normative-Data Items (continued)

Source of Variance	Error Term	F	SS	dF	MS
A X C X e	Se(ABCd)	1.1795	18.19553	6	3.032587
B X C X e	Se(ABCd)	1.5485	7.962372	2	3.981186
A X d X e	Se(ABCd)	.3968	6.120758	6	1.020126
B X d X e	Se(ABCd)	.3314	1.704140	2	.8520699
C X d X e	Se(ABCd)	.1823	.9373713	2	.4686856
A X B X C X d	S(ABCd)	1.0167	18.34148	3	6.113825
A X B X C X e	Se(ABCd)	.6280	9.687393	6	1.614565
A X B X d X e	Se(ABCd)	1.5199	23.44565	6	3.907608
A X C X d X e	Se(ABCd)	.3033	4.679267	6	.7798778
B X C X d X e	Se(ABCd)	.0738	.3793154	2	.1896577
S(ABCd)			769.7200	128	6.013437
A X B X C X d X e	Se(ABCd)	1.0092	15.56868	6	2.594779
Se(ABCd)			658.1868	256	2.571042

*p < .05
**p < .001

Analysis of Variance Summary Table of the Total Number of Correctly Recalled Items

Source of Variance	Error Term	F	SS	dF	MS
Forced Orientation (A)	AS	.0680	.390625	1	.390625
Retention Interval (B)	BS	17.3301**	185.6406	1	185.6406
Study List (C)	CS	.0505	.140625	1	.140625
Subjects (S)			42.60938	7	6.087053
A X B	ABS	6.8454*	26.26563	1	26.26563
A X C	ACS	1.5697	8.265625	1	8.265625
B X C	BCS	.3554	1.890625	1	1.890625
A X S			40.23438	7	5.747767
B X S			74.98438	7	10.71205
C X S			19.48438	7	2.783482
A X B X C	ABCS	2.4775	8.26525	1	8.26525
A X B X S			26.85889	7	3.836984
A X C X S			36.85938	7	5.265625
B X C X S			37.23438	7	5.319196
A X B X C X S			23.35400	7	3.336286

*p < .05
**p < .005

Analysis of Variance Summary Table of the Number of Correct Responses
Recorded in the Answer Booklets

Source of Variance	Error Term	SS	MS	F	dF
Forced Orientation (A)	AS	4.000	4.0000	1.0980	1
Retention Interval (B)	BS	22.5625	22.5625	1.6636	1
Study List (C)	CS	42.2500	42.2500	1.8006	1
Subjects		23.93750	3.419642		7
A X B	ABS	4.000	4.000	.2240	1
A X C	ACS	45.5625	45.5625	2.5838	1
B X C	BCS	12.250	12.250	.4641	1
A X S		25.50	3.642857		7
B X S		94.93750	13.5625		7
C X S		164.250	23.46428		7
A X B X C	ABCS	7.56250	7.56250	.5245	1
A X B X S		124.9993	17.85703		7
A X C X S		123.4375	17.63393		7
B X C X S		184.7500	26.39295		7
A X B X C X S		100.9265	14.41807		7

Analysis of Variance Summary Table of the Intrusions Occurring in the Recall Protocols

Source of Variance	Error Term	F	SS	dF	MS
Forced Orientation (A)	S(ABC)	3.5265	2.083333	1	2.083333
Retention Interval (B)	S(ABC)	1.2695	.7500	1	.7500
Study List (C)	S(ABC)	.0353	.208333	1	.208333
Type of Intrusion (d)	Sd(ABC)	2.2783	2.010416	2	1.005208
A X B	S(ABC)	2.2569	1.33333	1	1.33333
A X C	S(ABC)	.0353	.2083365	1	.2083365
B X C	S(ABC)	.0353	.2083329	1	.2083329
A X d	Sd(ABC)	4.7574*	4.197907	2	2.098953
B X d	Sd(ABC)	.1062	.9374905	2	.4687452
C X d	Sd(ABC)	2.2783	2.010415	2	1.005207
A X B X C	S(ABC)	.0353	.2083305	1	.2083305
A X B X d	Sd(ABC)	.2243	.1979237	2	.9896183
A X C X d	Sd(ABC)	2.9158	2.572923	2	1.286461
B X C X d	Sd(ABC)	1.2867	1.135414	2	.5677071
S(ABC)			33.08301	56	.5907680
A X B X C X d	Sd(ABC)	1.9242	1.697882	2	.8489408
Sd(ABC)			49.41460	112	.4412017

$*p < .05$

Analysis of Variance Summary Table of the Responses Given in the Answer Booklets to the Correctly Recalled Items

Source of Variance	Error Term	F	SS	dF	MS
Forced Orientation (A)	S(ABC)	1.741	244.1406	1	244.1406
Retention Interval (B)	S(ABC)	27.301*	3828.516	1	3828.516
Study List (C)	S(ABC)	.4708	66.0156	1	66.0156
Type of Response (d)	Sd(ABC)	80.1716*	38476.16	3	12825.38
A X B	S(ABC)	2.6769	375.3906	1	375.3906
A X C	S(ABC)	3.0334	425.3906	1	425.3906
A X d	Sd(ABC)	84.5147*	40560.47	3	13520.16
B X d	Sd(ABC)	7.3474*	3526.172	3	1175.391
C X d	Sd(ABC)	.6145	294.9219	3	98.30728
B X C	S(ABC)	.0028	.3906	1	.3906
A X B X C	S(ABC)	.4708	66.01563	1	66.01563
A X B X d	Sd(ABC)	6.7546*	3241.688	3	1080.563
A X C X d	Sd(ABC)	1.5065	723.00	3	241.00
B X C X d	Sd(ABC)	.2824	135.5469	3	45.18228
S(ABC)			7853.07	56	140.2334
A X B X C X d	Sd(ABC)	.9012	432.4844	3	144.1615
Sd(ABC)			26875.63	168	159.9746

$^*p < .001$

APPENDIX C

Item Analyses

Item Analysis for the 16 Normative-Data Items for College Students (40)

Target	#	Complementary	#	Similarity	#	Unrelated	#
dream	26	bed	6	wish	4	trouble	4
whistle	32	tune	1	sing	4	wild	3
sour	30	lemons	2	bitter	3	promise	5
needle	31	sew	7	pin	2	arrive	0
hammer	30	pound	2	saw	4	stomach	4
run	30	fast	5	walk	4	taffy	1
mountain	32	high	2	hill	3	serve	3
baby	36	cry	2	child	1	follow	1
cars	22	ride	5	trucks	4	plant	9
mix	28	cake	7	stir	2	station	3
doors	23	open	7	windows	9	dance	1
numbers	23	count	9	letters	2	storm	6
tobacco	38	smoke	2	cigarettes	0	dog	0
thief	34	steal	2	robber	4	yard	0
guns	29	shoot	5	rifle	2	season	4
stove	31	cook	5	oven	4	rejoice	0

Note. # indicates the number of times the item was selected.

Item Analysis for the 16 Normative-Data
Items for First Graders (40)

Target	#	Complementary	#	Similarity	#	Unrelated	#
dream	27	bed	8	wise	5	trouble	0
whistle	22	tune	4	sing	8	wild	6
sour	27	lemons	4	bitter	8	promise	1
needle	21	sew	6	pin	10	arrive	3
hammer	28	pound	5	saw	4	stomach	3
run	14	fast	6	walk	14	taffy	6
mountain	23	high	9	hill	7	serve	1
baby	26	cry	3	child	8	follow	3
cars	20	ride	3	trucks	10	plant	7
mix	18	cake	4	stir	5	station	13
doors	23	open	9	windows	4	dance	4
numbers	23	count	2	letters	10	storm	5
tobacco	32	smoke	1	cigarettes	1	dog	6
thief	20	steal	6	robber	7	yard	7
guns	28	shoot	5	rifle	5	season	2
stove	28	cook	5	oven	4	rejoice	3

Note. # indicates the number of times the item was selected.

Item Analysis for the 16 Normative-Data
Items for Sixth Graders (40)

Target	#	Complementary	#	Similarity	#	Unrelated	#
dream	28	bed	2	wish	2	trouble	8
whistle	33	tune	4	sing	1	wild	2
sour	26	lemons	3	bitter	4	promise	7
needle	31	sew	5	pin	1	arrive	3
hammer	27	pound	3	saw	8	stomach	2
run	32	fast	2	walk	4	taffy	2
mountain	29	high	2	hill	4	serve	5
baby	34	cry	3	child	2	follow	1
cars	24	ride	6	trucks	4	plant	6
mix	24	cake	9	stir	4	station	3
doors	28	open	1	windows	6	dance	5
numbers	21	count	7	letters	5	storm	7
tobacco	36	smoke	1	cigarettes	2	dog	1
thief	35	steal	3	robber	0	yard	2
guns	31	shoot	2	rifle	2	season	5
stove	23	cook	8	oven	6	rejoice	3

Note. # indicates the number of times the item was selected.

Item Analysis for the 16 Normative-Data
Items for the Elderly Subjects (40)

Target	#	Complementary	#	Similarity	#	Unrelated	#
dream	26	bed	7	wish	3	trouble	4
whistle	34	tune	5	sing	1	wild	0
sour	26	lemons	5	bitter	2	promise	7
needle	28	sew	9	pin	2	arrive	1
hammer	35	pound	0	saw	3	stomach	2
run	23	fast	2	walk	12	taffy	3
mountain	35	high	3	hill	1	serve	2
baby	27	cry	3	child	9	follow	1
cars	29	ride	4	trucks	5	plant	2
mix	23	cake	9	stir	6	station	2
doors	23	open	5	windows	8	dance	4
numbers	22	count	7	letters	2	storm	9
tobacco	34	smoke	4	cigarettes	0	dog	2
thief	24	steal	6	robber	2	yard	8
guns	36	shoot	1	rifle	1	season	2
stove	30	cook	7	oven	1	rejoice	2

Note. # indicates the number of times the item was selected.