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THE STRUCTURE OF ASSOCIATIVE MEMORY IN CREATIVE CHILDREN

Doctoral Dissertation

Presented to The University of Ottawa,

School of Graduate Studies

by

Kelly A. Boyko, M.A.

School of Psychology

University of Ottawa

In fulfillment of requirements for the degree of

Doctor of Philosophy

in Clinical Psychology

January, 1995

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Dedication

Personally, I would like to dedicate this document to my close friends at the University of Ottawa and at the Royal Ottawa Hospital for their support in helping me through the final stages of my Ph.D. programme. I also dedicate this document to my parents for their financial support throughout my university career.

On a more global level, this document is dedicated to abused children everywhere, who have been denied their childhood and the opportunity to be creative.

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The author is indebted to Pierre Mercier for his hard work and invaluable assistance in programming and implementing computer software for the present research. Due to Pierre's veritable computer wizardry, the association-decision task possessed a human and fun element for children. Thanks to him, we can now see what the associative memory networks of creative children look like. Particular mention should also be made of Pierre's substantial contribution in co-developing the research design, in helping with the data analysis, and in facilitating the compilation of this document. The author would like to take this opportunity to convey considerable gratitude to Pierre for his consistent support during the final stages of this research.

Also, the author wishes to express appreciation to Alain Desrochers, Barry Schneider and Gail Crombie for their critical evaluation of this research project. Alain's expertise in the area of cognition was especially influential.

Special thanks goes to Patty Wilson for her conscientious assistance in administering the experimental tasks individually to a subset of students. As well, the author would like to thank Michelle Picard for her diligence in rescoring a sizeable portion of protocols for the Torrance Tests of Creative Thinking, so that a measure of inter-rater reliability could be obtained.

It should be noted that this research would not have been possible without the participation of the Carleton Roman Catholic School Board and the Ottawa Board of Education, and their affiliated schools. From the Carleton Roman Catholic School Board, these schools included: Holy Trinity Catholic High School, Our Lady of Wisdom Elementary School, St. Matthew Catholic High School, and St. Patrick Catholic Elementary School. Schools from the Ottawa Board of Education included: Dunlop Public School, Lady Evelyn Alternative School, and R. Byrns Curry Public School. The author wishes to express her sincere appreciation for the efforts of the principals, vice principals, teachers and students who participated in this research, as well as research staff at the various school boards who helped to facilitate it. In particular, the author would like to say that she was very impressed and inspired by the spontaneity and openness of the students who completed the experimental tasks, as well as by their willingness to share some of their creative thinking processes with her.

ABSTRACT

THE STRUCTURE OF ASSOCIATIVE MEMORY IN CREATIVE CHILDREN

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Theorists operating in the associationist tradition have consistently maintained that creative thinking involves the ability to generate remote associations. It has been inferred that this ability requires a particular kind of associative memory structure, one which is characterized by many between-configuration links and many weak within-configuration links. However, there has been a paucity of studies examining the associative memory structures of creative individuals. Still, considerable effort has been devoted in the developmental literature to delineating various types of organizational structures in children's memories. Consequently, this research explored how associational processes operate in children vis-à-vis their memory structures. As well, an attempt was made to replicate part of a frequently-cited developmental shift from children's use of themes and categories to their use of categories as organizational structures on memory tasks.

A series of three studies, each employing different memory tasks, were conducted to examine differences in the associative memory structures of more creative and less creative children in grades 3 and 7. Stimulus words used for the experimental tasks comprised three configural dimensions: within category, within theme, and between category and theme. The expected developmental shift towards increased category

usage with age was partially replicated on a sorting task; Grade 3 children used more associations than Grade 7 children, and Grade 7 children used more categories than Grade 3 children. Results obtained on two receptive memory tasks (i.e., associability-rating and association-decision) indicated that the associative memory structures of more creative versus less creative children, as well as older versus younger children, appear to be characterized by many strong within-category associative links, fewer and weaker within-theme associative links, and very few and weak between-category-and-theme associative links. Yet, results obtained on one productive memory task (i.e., recall) revealed that both older more creative children and younger children tend to retain the use of weak between-category-and-theme associative links, whereas older less creative children relinquish these over time. These results suggest that the creative individual's continued ability to access weak between-configuration links from memory accounts in part for his/her ability to generate remote associations. As well, it appears that this ability to generate remote associations occurs not during the encoding stage but during retrieval. This coincides with recent developments in the computational modelling of creative thinking processes. Such developments highlight the creative individual's selection of viable associations among ideas, rather than the generation of associations among ideas per se.

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THE STRUCTURE OF ASSOCIATIVE MEMORY IN CREATIVE CHILDREN

Poincaré, a renowned mathematician of the early 1900s, vividly recalled the memory of his own creative process in the following manner.

For fifteen days I strove to prove that there could not be any functions like those I have since called Fuchsian functions. I was then very ignorant; every day I seated myself at my work table, stayed an hour or two, tried a great number of combinations and reached no results. One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come from the hypergeometric series; I had only to write out the results, which took but a few hours (Ghiselin, 1952, p. 36).

Based on his own experiences, Poincaré believed that at the core of creative thinking was the making of new and useful combinations of associative elements, drawn from domains which were far apart (Ghiselin, 1952). Einstein too spoke of the combinatorial/associative play of logically-related concepts as being an essential feature of creative thinking (Ghiselin, 1952). However, Einstein noted that the combinatorial/associative play that creative individuals engage in coincides with certain logical relations that are being sought (Ghiselin, 1952). Poincaré as well emphasized the rational selection of useful combinations, guided by the creative individual's sensitivity to aesthetic quality in a particular domain (Ghiselin, 1952). In addition to Poincaré and Einstein, many other eminent creative individuals, including novelists and poets, have offered similar first-hand accounts of the creative process (e.g., see Barron & Harrington, 1981; Busse & Mansfield, 1980; Ghiselin, 1952; Koestler, 1964; Mumford & Gustafson, 1988; Perkins, 1981; Stein, 1968).

Apart from introspectionist accounts, early theoretical interest in the cognitive processes underlying creative thinking received its impetus from psychoanalytic theory. Drawing upon Freud's (1962/1908, 1987/1920) somewhat vague notions about creativity, Kris (1952) proposed the more specific notion of 'regression in the service of the ego', and attempted to explain how unconscious and preconscious material were made conscious in the creative individual. The notion of 'regression in the service of the ego' implies that, at some point during the creative process, the ego acts to control the functions of the id. According to Kris, this involves a transient movement from secondary-process (i.e., logical, deductive, analytic and reality-oriented) thinking to primary-process (i.e., free-associative, emotional and illogical) thinking. Kris added that the creative process has two phases, one consisting of an initial inspirational phase entailing regression in the service of the ego, and a subsequent stage of elaboration, consisting of a return to secondary-process thinking. This is consistent with what eminent creative individuals have described as the generation of novel combinations of ideas, followed by the working through of these ideas. Kris's notion of 'regression in the service of the ego' highlights the emergent view that creativity is guided by rational and highly selective thought processes, which operate on the generation of combinations of previously unrelated ideas and domains.

Creativity as the Ability to Generate Remote Associations

Investigators operating in the associationist tradition (e.g., Barron, 1955) believe that the ability to think creatively involves being able to access a large number of associations, some of which are statistically infrequent or remote. Offering an

associationist theoretical model, Mednick (1962) described creative thinking as the ability to form mutually remote associative elements into new and useful combinations. Based on observations of individuals' free associations to stimulus words, Mednick (1962) argued that the organization of an individual's associative elements, in terms of the number and strength of associations, influences the probability and speed of achieving a creative solution. According to Mednick, less creative individuals have a high concentration of associative strength in a small number of statistically frequent or conventional associative responses (i.e., a steep associative hierarchy). Therefore, less creative individuals have a low probability of generating a remote response. That is, the less creative individual responds quickly with several conventional responses, and then associative strength for other responses decreases rapidly. In contrast, Mednick states that more creative individuals have an even distribution of associative strength spread out over a large number of associative responses (i.e., a flat associative hierarchy). This kind of associative organization allows more creative individuals greater opportunities to generate a remote response. Specifically, the more creative individual responds relatively slowly and steadily, generating many associative responses. Thus, in the associationist view, an even distribution of associative strength, combined with higher associational fluency, in individuals increases the likelihood that they will generate remote associations.

It has been frequently inferred that individuals who are regarded as creative are better able than other individuals at generating remote associations. Indeed, after administering a word association test to architects, MacKinnon (1962) found moderately

remote associations to be one of the best predictors of creative achievement. Similarly, Gough (1976), who administered a word association test to science and engineering students, found that moderately remote associations were more strongly correlated with creativity than were extremely remote associations or common associations.

Nevertheless, there remains some concern over what constitutes a remote association. Perkins (1988) suggests that an association is remote if it comes from a domain different from that which is related to a particular problem. In order to appreciate what a remote association might be, it is useful to consider a concrete example. Implicit in a metaphor is a remote association, for understanding a metaphor requires that an individual associate a concept from one domain with a concept from another domain, in terms of similarity. Tourangeau and Sternberg (1981) found that metaphors judged as the most creative were those whose terms occupied similar positions within domains that were not very similar to each other. Consequently, generating a remote association may be analogous to linking elements derived from two distinct domains or conceptual organizations. Drawing upon Tourangeau and Sternberg's (1981) study on metaphor, as well as on Simonton's (1988) writing on the structure of associative memory in creative individuals (which will be elaborated upon in the next section), a remote association will be defined here as a combination of elements derived from two separate conceptual organizations within a memory structure. Remote associations may have numerous and weak chains of links, or they may be just one link apart and yet belong to two different conceptual organizations. Based on the associationist literature (e.g.,

Mednick, 1962), it is unclear as to which characterization best describes remote associations.

Furthermore, it should be emphasized that an individual's ability to produce remote associations is only one part of the creative process. As Johnson-Laird (1988) writes, "Much more is at stake in writing a poem, painting a picture or composing a sonata than merely producing a chain of remote associations" (p. 254). At a very basic level, creative thinking may be regarded as a two-stage process involving the generation and selection of ideas, along with some mechanism for preservation (Campbell, 1960; Mednick, 1962; Perkins, 1988).

Campbell (1960) contends that a 'blind-variation-and-selective-retention' process is fundamental to all knowledge processes, including creativity. 'Blind variation' implies that combinations of ideas are produced without prior knowledge of which ones will prove useful. Beginning with an external criterion, the individual selects a creative solution from multiple exploratory combinations of ideas. Once the individual blindly comes upon a combination that fits some selection criterion, the creative process is successfully terminated. According to Campbell's model, the creative process is not entirely random but rather consists of the active generation and verification of possible combinations of ideas. A major criticism of Campbell's model is that Campbell leaves much of the creative process to chance (Rowe & Partridge, 1993); that is, he fails to specify how combinations are generated or on what basis selection criteria are applied. As a result, his model cannot differentiate between consistently creative individuals, and those who occasionally come up with a creative idea (Rowe & Partridge, 1993).

In contrast, Johnson-Laird (1987, 1988) emphasizes the importance of evaluative criteria or constraints to guide the creative thinking process. He proposes three possible models for creative thinking: neo-Darwinian, neo-Lamarckian, and multi-stage. In a neo-Darwinian model, elements which exist in memory are combined/modified arbitrarily, and constraints are used to filter out combinations that are not viable. A neo-Lamarckian model would hold that elements existing in memory are combined/modified according to constraints, and an arbitrary choice is made amongst viable combinations. In a multi-stage model, elements existing in memory are combined/modified according to some constraints, then nonviable combinations are filtered out according to further constraints, and finally an arbitrary choice is made amongst viable combinations. According to Johnson-Laird (1987, 1988), the creative process, whether it involves chord sequences in jazz or works of art such as novels and paintings, likely depends on a multi-stage model, in which the creative process occurs over many stages of revision. As Johnson-Laird (1987, 1988) himself asserts, generating combinations of ideas at random is grossly inefficient in that millions of combinations have to be generated before a creative product emerges. Considering Johnson-Laird's proposed multi-stage model, it would seem that the most efficient creative process would allow for the generation of a few viable ideational combinations, which would then be progressively revised according to a series of constraints.

Still, the ability to generate unique combinations of ideas, or remote associations, is important in that it constitutes the first stage of creative thinking and, as such, offers a starting point for empirical study of the creative process. Generating remote

associations is a cognitive process which involves combining elements from two distinct conceptual organizations once discrete elements have been accessed from memory. Thus an individual's ability to generate remote associations can be related to his/her associative memory structure. If one accepts the associationist view of creativity as the ability to generate remote associations, it is possible that more creative individuals, relative to less creative individuals, possess associative memory structures which allow them greater access to more remote associations.

Simonton's Model of Typical Associative Memory Structures for Less Creative and More Creative Individuals

Building upon the notions of his predecessors (e.g., Campbell, 1960), Simonton (1988), a social psychologist, offers a chance-configuration theory of creativity. According to Simonton, the creative process involves the generation of chance combinations or associations amongst free-floating 'mental elements' which exist in memory. 'Mental elements' are fundamental cognitive units and may include ideas, concepts, schemata or categories. In Simonton's opinion, chance associations amongst mental elements can vary appreciably in terms of stability, and it is the more stable associations which have a higher probability of being retained for subsequent selective processes. Simonton refers to stable associations as 'configurations', whereby mental elements cluster together by chance. According to Simonton's theory, it is a particular organization of chance configurations which constitutes the structure of associative memory in the creative individual.

Accepting associationist assumptions regarding creativity, Simonton (1988) contends that individuals differ considerably in their ability to generate remote associations. For Simonton, this ability is linked to a certain kind of cognitive processing style which presupposes a particular type of associative memory structure.

Consequently, Simonton (1988) proposes a model of creativity which differentiates individuals according to two dimensions: 1) the number of mental elements in memory; and 2) the distribution of association strengths amongst mental elements. In this model, individuals are presumed to lie on a continuum with respect to these two dimensions. That is, some individuals will possess few mental elements, whereas others will possess many. Similarly, there will be individuals who possess many strong associations, just as there will be individuals who possess many weak associations.

On the basis of the two previously-defined dimensions, Simonton describes four ideal types of individuals, each with a characteristic associative memory structure. 'Normals' (presumably individuals of normal intelligence) possess fewer mental elements than 'geniuses' (presumably individuals of above average intelligence). This implies that there are fewer mental elements available for remote associations in normals than in geniuses. Nevertheless, being a genius does not guarantee that mental elements will necessarily be combined to form remote associations. Rather, this ability depends on the distribution of association strengths. The 'analytical genius' has many mental elements linked by a small set of strong associations. In contrast, the 'intuitive genius' has a comparable number of mental elements linked by many weak associations. To the extent that an 'analytical genius' represents a less creative individual with above

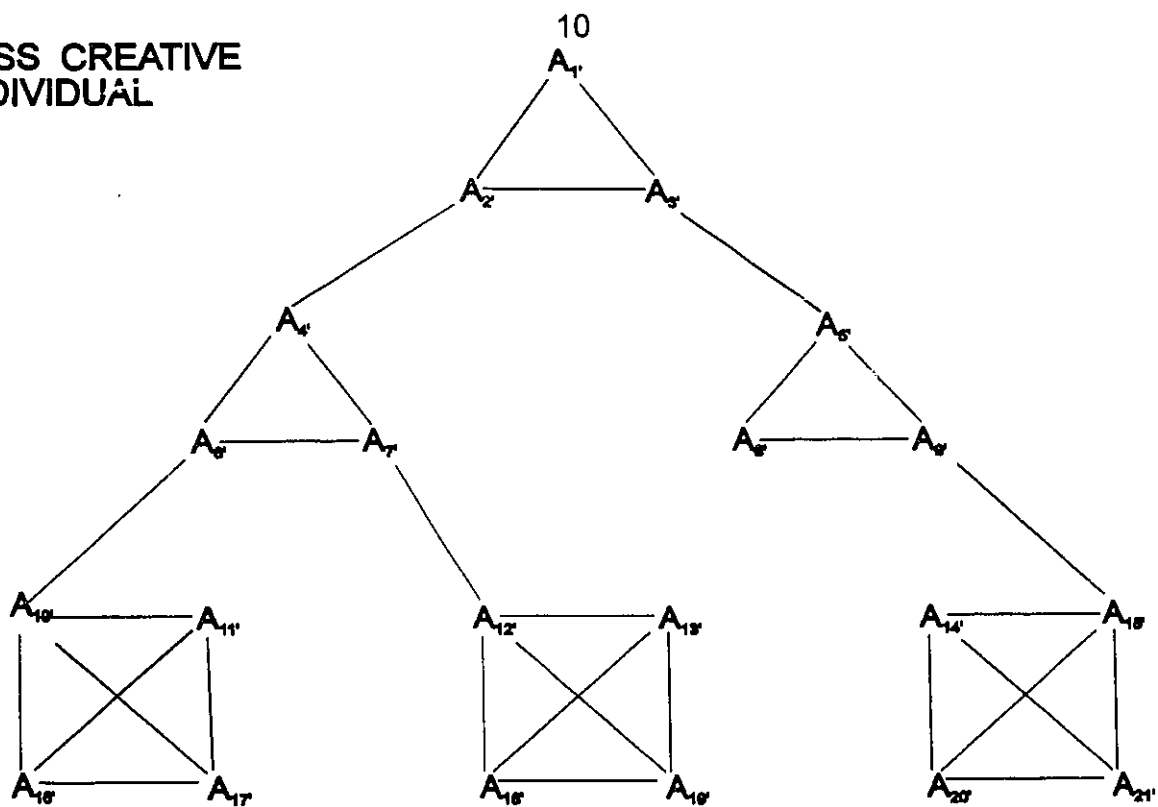
average intelligence and an 'intuitive genius' represents a more creative individual also with above average intelligence, it is possible to conceive of 'analytical' and 'intuitive' geniuses as 'less creative' and 'more creative' individuals, respectively. Thus in Simonton's (1988) model, the memory structures of less creative and more creative individuals can be differentiated on the basis of the number and strength of associations among elements (see Figure 1).

According to Simonton's model, the associative memory structure of the less creative individual consists of mental elements arranged in distinct configurations which have a hierarchical order (see Figure 1). Here, configurations are very clear, in that elements within a configuration have strong associative links. As well, configurations are very distinct, since elements within a configuration have few associative links with elements in other configurations.

Alternatively, configurations are less clear and distinct in the associative memory structure of the more creative individual (see Figure 1). This is because elements within a configuration have weak associative links, and there are many associative links between elements in separate configurations.

For Simonton, it is the more creative individual's associative memory structure, characterized by many weak associative links and many associative links amongst configurations, which allows him/her to retrieve information in a unique way. Since the more creative individual has more associative links amongst elements than the less creative individual, the more creative individual has many more potential options when moving from one element to the next. This becomes apparent when one traces all

LESS CREATIVE
INDIVIDUAL



**MORE CREATIVE
INDIVIDUAL**

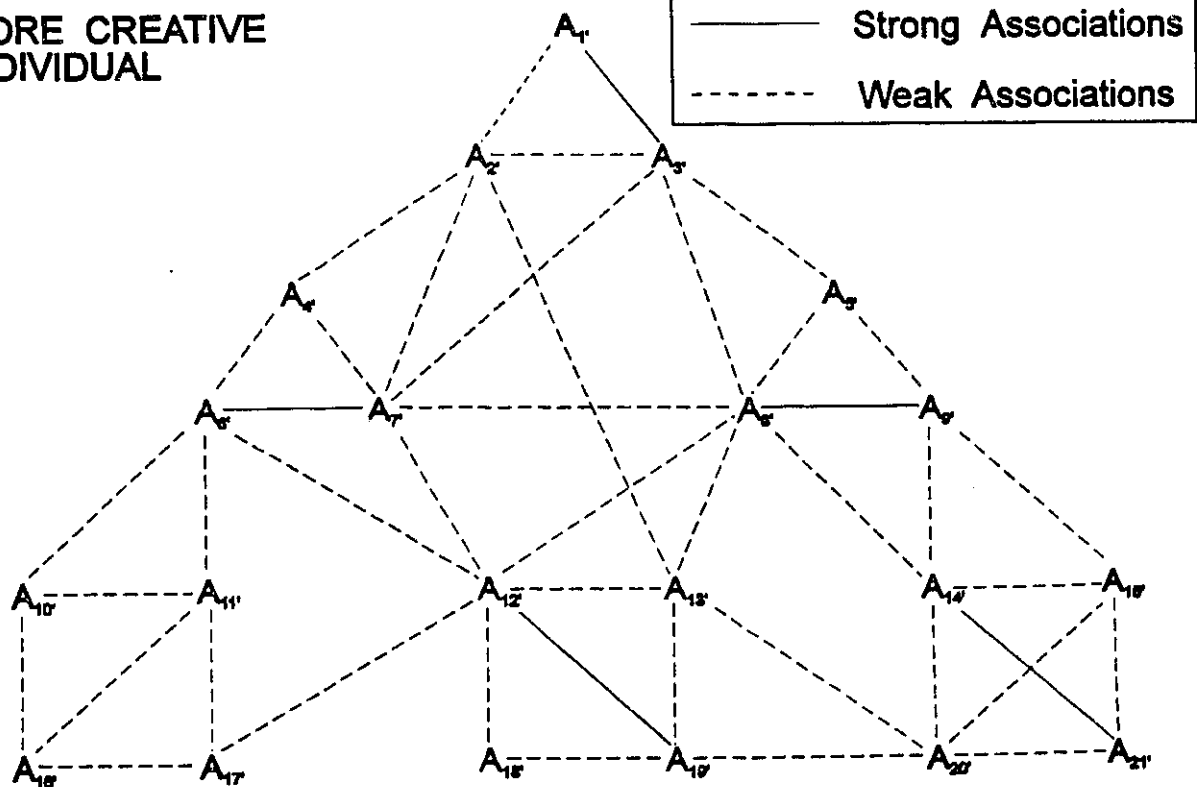


Figure 1. Simonton's (1988) model of the typical associative memory structures for creative individuals (p. 401).

possible paths between any two randomly selected elements in the associative memory structures depicted in Figure 1. For instance, consider paths between the two elements, A_1 and A_{13} . The less creative individual is very limited in the way A_{13} can be evoked by A_1 , because there are relatively few paths and these are characterized by strong associations. In contrast, the more creative individual has many possible paths between A_1 and A_{13} to choose from; these paths are characterized by weak associations and therefore can be accessed with a roughly equal probability. Such a memory structure increases the potential for generating remote associations.

According to Simonton (1988), creativity, as measured by the ability to generate remote associations, requires a vast number of weak interconnections among the contents of memory. If there are many weak associative links in the more creative individual's associative memory structure, as Simonton suggests, then the more creative individual has a large pool of potential associations to draw upon. Also, if there are many associative links between configurations in the more creative individual's associative memory structure, one idea could easily be activated by another. Still, having an associative memory structure similar to that of the less creative individual may be regarded as an intellectual asset. After all, clear and distinct configurations can be organized hierarchically and thus promote the efficient organization of information in memory. However, ironically, such well-organized configurations do not readily lend themselves to the generation of remote associations, due to the lack of weak interconnections amongst ideas.

Although there has yet to be a direct empirical test of Simonton's (1988) model, evidence from one study supports the notion that more creative individuals do differ from less creative individuals in terms of memory. Corkill and Glover (1987) conducted three experiments to examine differences in the memory processes of creative and less creative individuals. Results from the first experiment indicated no significant differences between creative and less creative undergraduate students in the size of iconic memory, the longevity of working memory, or the speed with which information is manipulated in working memory. In the second experiment, creative and less creative undergraduate students were asked to recall a set of 40 words which could be grouped into four categories of 10 words each. No significant differences were observed between creative and less creative undergraduate students in overall recall or clustering. Yet, creative individuals, as compared to less creative individuals, recalled significantly more words that did not appear in the original stimulus list but that were logically consistent with the stimulus categories. This finding was replicated in the third experiment, in which creative and less creative undergraduate students first read, and later heard, an essay. Again, there were no differences in overall recall between creative and less creative undergraduate students. Still, creative individuals, relative to less creative individuals recalled significantly more ideas that were not in the original essay but that were logically consistent with it. Based on these experiments, Corkill and Glover (1987) surmised that creative and less creative individuals differ in the organization of their long-term memory or in their retrieval processes.

Nevertheless, it is difficult to interpret Corkill and Glover's results with respect to Simonton's (1988) model. One could speculate that because of the fairly weak and even distribution of associative strength within a creative individual's associative memory structure, many associative links of equal strength are activated simultaneously in response to a stimulus word, and the creative individual fails to select among them. Clearly, a more direct test of Simonton's model is necessary, in order to provide empirical support for the notion that more creative individuals differ from less creative individuals, with respect to their associative memory structures.

Developmental Changes in the Basis of Memory Structure

Unfortunately, Simonton's (1988) model fails to specify the nature of configurations in the memory structures of more creative and less creative individuals. However, examining the literature on developmental changes in the basis of children's memory organization, it appears that several types of organizational structures may exist in memory.

As demonstrated by their performance on free recall and classification/sorting tasks, younger children seem to prefer what has been termed complementary/thematic/associative organizations, whereas older children seem to prefer similarity/taxonomic/categorical organizations (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972; McCauley, Weil, & Sperber, 1976; Worden, 1976). In these studies, the terms 'complementary', 'thematic' and 'associative' appear to be synonymous and reflect an organizational structure characterized by functional-contextual relations among items; examples of such relations among words include

hammer--nail, *school--student* and *banana--monkey*. In contrast, the terms 'similarity', 'taxonomic' and 'categorical' all appear to be indicative of logic-based, class-inclusion relations among items; *nurse--doctor*, *shirt--hat* and *lion--tiger* are all examples of these relations among words.

Results from early studies of free classification, conceptual styles, word associations, word definitions, and free recall with children suggest that, between the ages of 6 and 9, the basis of children's classification changes from 'complementary' to 'similarity' criteria (Denney, 1974). Here, 'complementary' criteria refer to relations among items based on past experience, whereas 'similarity' criteria refer to items which are either perceptually or functionally similar. The free classification studies of Inhelder and Piaget in the late 1950's provided preliminary evidence of a developmental shift from complementary- to similarity-based groupings in children from 2½ to 5½ years of age (see Denney, 1974). Using toys as stimuli, Inhelder and Piaget observed that younger children placed together toys that shared some meaningful relationship (e.g., a baby and a crib), whereas older children placed together similar toys (e.g., all furniture or all people). These observations led Inhelder and Piaget to conclude that as children grow older, they shift from grouping items on the basis of complementary relations to grouping items on the basis of similarity relations.

It has been proposed that themes and categories may be differentially prominent as organizational structures for younger and older children. Even though children from 4 to 6 years of age display evidence of hierarchical conceptual information and an understanding of categorical relations, they do not tend to use that information on

memory tasks (see Markman, 1984, 1989; Whitney & Kunen, 1983). Rather, on classification tasks, for example, young children tend to classify thematically (Markman, 1984, 1989). Markman (1989) suggests that young children's preference for organizing objects into eventlike structures such as themes may be due to the fact that children are more attentive to causal, temporal and spatial relations among objects, or to the fact that thematic relations are simpler and can be more readily constructed than categorical relations. However, while young children appear to be captivated by thematic relations on memory tasks, this finding has been only partially replicated with children of various ages.

In a study by Worden (1976), children in grades 2 and 5 were asked to sort, and later recall, pictures and words that could be classified according to either thematic or taxonomic/categorical dimensions. Overall, Worden found no significant relation between age and children's tendencies to form themes or categories in free sorting/recall. Yet, the general trend in sorting was for second-graders to use greater proportions of themes over categories and for fifth-graders to use equal proportions of themes and categories. In recall, fifth-graders showed more evidence of categorical clustering than second-graders, though this difference was not significant. Consequently, studies examining themes and categories as possible preferred organizational structures for children have provided only limited evidence for the view that there are qualitative developmental changes in children's memory structures.

More recently, Bjorklund and colleagues (Bjorklund, 1989; Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1984, 1985; Bjorklund & Muir, 1988) have

proposed a shift in children's use of associative versus categorical relations in memory with age. Preliminary support for this view came from McCauley et al. (1976) who investigated Kindergarten and second-grade children's use of associative and categorical relations, as measured by their reaction times in naming pairs of pictures on a priming task. McCauley et al. found no differences between Kindergarten and second-grade children in their reaction times for naming pictures that varied in degree of associative relatedness; specifically, all children named high associates faster than low associates. However, when pictures differed in degree of categorical relatedness, only second-grade children differentiated between high and low categorically-related pictures, naming pictures high in categorical relatedness faster than pictures low in categorical relatedness. These findings suggest that associative relations are established early in children's memory and that categorical relations are less salient for younger children.

Two studies by Bjorklund and de Marchena (1984) provide more substantial evidence of a developmental shift in the basis of children's memory organization, from associations to categories. In the first study, children in grades 1, 4 and 7 were given a sort/recall task with a list of words that could be organized into associative or categorical pairs. Although Bjorklund and de Marchena found that the use of associative relations was relatively high for all children, there was a significant increase in the use of categorical relations with age. In the second study, Bjorklund and de Marchena heightened the salience of categorical relations over associative relations for children, by increasing only the number of categorical word pairs. The results of Bjorklund and de Marchena's second study replicated those of their first. That is, Grade 1 children

used a high number of associative relations, Grade 4 children used a comparable number of associative and categorical relations, and Grade 7 children used a high number of categorical relations. Taken together, these results suggest that there is a developmental shift in children's memory organization, from associations to categories, and this seems to occur some time between grades 3 and 5, if not earlier. However, the problem with Bjorklund and de Marchena's study is that the researchers used pictures as stimuli with Grade 1 children and words as stimuli for children in grades 4 and 7, thereby rendering any comparison across grades questionable.

A subsequent study by Bjorklund and Jacobs (1985) attempted to further delineate the complex and changing relation between associations and categories in memory with age. In this study, students in grades 3, 5, 7 and 9 were given a list of words from different categories for free recall. Within a given category (e.g., ANIMALS), some word pairs were highly associated (e.g., *dog--cat*), whereas others were low in associability (e.g., *dog--lion*). To simultaneously assess the role of associative relations and categorical organization in memory, students were presented with items either randomly, blocked by categories with low interitem associability (e.g., *dog, lion, cow, tiger, cat*), or blocked by categories with high interitem associability (e.g., *dog, cat, cow, lion, tiger*). In terms of free recall performance, Bjorklund and Jacobs found that while students at all grades made much use of highly-associated categorical items, students in grades 7 and 9 displayed more evidence of categorical organization in memory than students in grades 3 and 5. Also, it was observed that the use of categorical organization in free recall could be enhanced through experimental manipulation. Furthermore, as measured

by interitem response latencies for the random condition, Bjorklund and Jacobs found that students in grades 3 and 5 were unable to distinguish between within-category and between-category word pairs which were weakly associated. In contrast, students in grades 7 and 9 were able to make such a distinction, responding faster with weakly associated within-category word pairs than with weakly associated between-category word pairs. However, these latter results reported by Bjorklund and Jacobs must be regarded as tentative at best, considering the method used to obtain interitem response latencies. Latencies were recorded between consecutively recalled words and were thereby confounded with previous responses made. In addition, there was no direct or precise measure of students' response latencies at the time of recall because latencies were measured by an observer who listened to a tape recording of students' recall. Consequently, the most that one can conclude from Bjorklund and Jacobs' study is that with age, children expand upon their existing associative relations in memory to include categories.

On the basis of findings by McCauley et al. (1976), and Bjorklund and colleagues (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985), there does not appear to be a clear progression from associations to categories in children's memory structures. Rather, children's use of strong associations remains relatively stable, while their use of categories increases with age.

Still, there remains the issue of how themes operate as organizational structures in children's memory with age. At present, researchers tend to equate themes with associations, even though studies which have investigated these organizational

structures separately have achieved different results in terms of developmental trends. It is possible that, as far as organizational structures are concerned, themes are more sophisticated than associations and less sophisticated than categories. Or perhaps, themes are simply alternative organizational structures to categories. Given that children's memory organization is particularly unstable between the ages of 6 and 9 years (see Denney, 1974), it remains to be demonstrated whether children's memory organization for this age range is characterized primarily by associations, themes, categories, or some combination thereof.

With respect to creativity, the issue of themes is equally problematic for Simonton's (1988) model. When Simonton refers to 'configurations', one cannot be certain whether Simonton intended this to mean categories, themes, associations, or something altogether different. Even if Simonton's 'configurations' are interpreted to mean categories, it might not necessarily be the case that both less creative and more creative individuals possess associative memory structures which are comprised primarily of categories. Rather, it could be that the associative memory structures of more creative individuals are comprised primarily of themes, or some other type of organizational structure. Of course, one might be more likely to find evidence of this with 6- to 9-year-old children, who tend to use themes on memory tasks (Worden, 1976) and who are more or less creative. However, it is unclear at this point as to how the associative memory structures of creative children are organized.

Conceptualizations of Creativity and Its Measurement

Before one can examine the associative memory structures of creative children, one must first be able to identify creativity in children. Yet creativity, as manifested in individuals, is a highly complex and diffuse construct (Sternberg, 1988). Among theorists and researchers, there has been considerable disagreement as to what constitutes creative behaviour. Indeed, various definitions of creativity have referred to: the characteristics of the individual who creates; the process of creation; the quality of the product created; and/or the situation which promotes creation (see Brown, 1989).

The fact that there has been no single, widely-accepted definition or theory of creativity has done little to unify and direct efforts at assessment. Thus tests purporting to measure creativity do so in different ways, which reflect largely the preconceptions of test developers (Treffinger, Renzulli, & Feldhusen, 1975). Furthermore, there is a lack of convergent validity among different methods used to assess creativity (see Hocevar, 1981). As a result, it has been generally acknowledged that the validity and reliability of creativity measures are low to moderate (Mönks & van Boxtel, 1985; Owen & Baum, 1985). Thus crucial problems in creativity research relate primarily to issues surrounding measurement and validity of the construct (Arasteh & Arasteh, 1968).

A major problem in validating creativity as a construct is the potential degree of overlap between creativity and intelligence. There is some evidence to suggest that measures of creativity yield low to moderate positive correlations with measures of intelligence, for individuals in various types of occupations (see Mumford & Gustafson, 1988). Still, Wallach and Kogan (1965) have found that while a certain degree of

intelligence appears to be a minimal prerequisite for creativity, the more intelligent individual is not necessarily the more creative one. In addition, an increasing number of researchers (e.g., Kershner & Ledger, 1985; Rossman & Horn, 1972; Sternberg, 1988) are finding that creativity and intelligence represent relatively orthogonal dimensions.

Implicit in the conceptualization and measurement of creativity is a personality dimension which renders the construct distinct from intelligence. A number of authors (e.g., Barron, 1955; Barron & Harrington, 1981; MacKinnon, 1962; Nicholls, 1972) have suggested that personality factors underlie most of the individual differences found for creative individuals. On the basis of an extensive literature review, Dellas and Gaier (1970, 1975) concluded that a particular constellation of personality characteristics emerges consistently for creative individuals. These characteristics include: an achievement orientation, a need for order, curiosity, a lack of inhibition, constructively critical, well-informed, independent, autonomous, versatile, socially sensitive, intuitive and empathic; also, the creative individual is said to possess radical opinions, wide-ranging interests, self-sufficiency and initiative, and sees him/herself as creative (see Stein, 1968). In addition, Sternberg (1988) has presented a model highlighting certain personality attributes that are particularly conducive to creative performance; these personality attributes include a tolerance for ambiguity, a determination to overcome obstacles, a willingness to grow, intrinsic motivation, moderate risk-taking, a desire for recognition, and a willingness to work for recognition. Similarly, Amabile (1983) has offered an interactive model of creativity which features intrinsic motivation as one of its main components.

If creativity is indeed a personality trait/attribute, one would expect to see some continuity in creativity from childhood to adulthood. There is some support for this view in the literature. Even at a preschool level, wide individual differences have been observed for such factors as nonconformity, freedom of expression, playfulness, and curiosity (Arasteh & Arasteh, 1968). Similar to creative adults, creative children have been described as being highly sensitive to their environment and, at the same time, independent and nonconforming in thought and behaviour (Arasteh & Arasteh, 1968). Furthermore, children's and adolescent's scores on measures of creativity demonstrate long-range predictive validity a number of years later, with correlations ranging from .44 to .51 (Cropley, 1972; Harrington, Block, & Block, 1983; Magnusson & Backteman, 1978). The creative achievements of adolescents tend to be preceded by early creative accomplishments in childhood (Schaefer, 1980), and foreshadow later creative accomplishments in late adolescence (Schaefer, 1972a) and in early adulthood (Schaefer, 1972b).

Since observed creative output in everyday living tends to be fairly stable across time (Schaefer, 1980), it is becoming increasingly important to regard creative performance as the criterion by which we designate individuals as creative (Amabile, 1983; Renzulli, 1978). Some researchers (e.g., Amabile, 1983; Bailin, 1984) have even gone so far as to argue that the ultimate criterion of creativity is the degree of novelty and appropriateness or value in a product or endeavour, as this provides an observable manifestation of the construct.

Although products and performance may be useful means of identifying individuals as creative, these criteria still only reveal what creative individuals do. In order to understand how creative individuals produce or perform as they do, it is important to examine the cognitive processes underlying creative individuals' products or performances. As discussed previously, creative individuals engage in a cognitive process which involves idea generation. Consequently, one way of identifying creative individuals may be in terms of idea generation.

Historically, studies of individual differences in idea generation have focused on divergent thinking (Mumford & Gustafson, 1988). On the basis of his (1956) Structure of Intellect model and over a decade of factor analytic research, Guilford identified a group of intellectual abilities as representative of divergent thinking. Divergent thinking refers to an individual's ability to generate multiple solutions to a given problem. Measures of divergent thinking typically present individuals with open-ended problems and require them to generate as many solutions as possible; an example would be a test of Alternate Uses, in which individuals are required to think of a variety of alternate uses for common objects. Such measures can be distinguished from tests of convergent thinking (e.g., standard intelligence tests), in that they require many different responses, instead of a single correct answer. In general, divergent thinking measures have been found to yield moderate positive correlations with creative achievement (see Mumford & Gustafson, 1988) and to be reasonably reliable, with both validity and reliability coefficients around .45 (Harrington et al., 1983; Magnusson & Backteman, 1978). Thus

some form of divergent thinking may be a key cognitive component underlying creativity (Mumford & Gustafson, 1988).

A number of investigators (e.g., Torrance, 1990b; Wallach & Kogan, 1965) have developed measures of creativity which may be regarded as adaptations of Guilford's notion of divergent thinking. Yet these measures are narrower in focus, more unified and more independent of intelligence. One such measure is the Torrance Tests of Creative Thinking (TTCT; Torrance, 1990a, 1990b).

The TTCT is the best known and most widely used measure of creativity (Davis, 1989). Originally, the TTCT was developed during the 1950s and 1960s from Torrance's Minnesota Tests of Creative Thinking, which were based on Guilford's (1956) Structure of Intellect model (Davis, 1989; Torrance, 1990b). Designed to measure various kinds of creative thinking, activities on the TTCT are open-ended and encourage individuals to be as spontaneous as possible. For example, the most recent version of the TTCT Verbal Test, Form B (Torrance, 1990a, 1990b) consists of the following six activities: Asking, Guessing Causes, Guessing Consequences, Product Improvement, Unusual Uses of Tin Cans, and Just Suppose.¹ From individuals' written responses for Verbal activities, separate raw scores can be derived for ideational Fluency (total number of ideas produced), Flexibility (ability to produce different types of ideas) and Originality (ability to produce unusual, yet appropriate, ideas). These scores are then summed for the entire test. Total raw scores for Fluency, Flexibility and Originality are converted into

¹Unusual Questions, an activity formerly included in earlier versions of the TTCT, has been removed from the most recent version because it has been found to contribute little to the predictive validity of the test (Torrance, 1990a, 1990b).

standard scores ($M = 100$, $SD = 20$) and percentile ranks, using graded norms. The Battery Average or score for the Total test is obtained by taking the mean standard score for Fluency, Flexibility and Originality combined, and then locating the associated percentile rank, using graded norms.

Various reviews of the TTCT in Buros (1972, 1978) and Mitchell (1985) have concluded that the TTCT has adequate psychometric properties as a research instrument, for identifying creative individuals in Kindergarten through graduate school. The normative sample for both the Verbal and Figural Tests (both Forms A and B) consisted of over 125,000 individuals, including 120,510 from the United States and 5,212 from Canada (Torrance, 1990c). Reported test-retest reliabilities for the TTCT range from .50 to .93 over one- to two-week periods, and inter-rater reliabilities are high, ranging from .85 to .99 (Mitchell, 1985, p. 1296). Inter-subtest correlations for the TTCT are in the .30 to .50 range, whereas intercorrelations among the Verbal Fluency, Flexibility and Originality scores are much higher, ranging from .74 to .80 (Mitchell, 1985, p. 1296). For Verbal Form B in particular, Torrance (1990b) provides data indicating that intercorrelations among standard scores for the Total test, Fluency, Flexibility and Originality range from .70 to .98, across various grades.² As for concurrent validity, there is evidence that TTCT scores are positively correlated with observed creative leadership activities, evaluations of student dramatic talent, and teacher ratings of student creative thinking and activities (see Mitchell, 1985). More recent studies have

²This is not surprising, given that scores obtained for Flexibility and Originality are dependent to some extent on Fluency scores.

shown the TTCT to be significantly correlated with creativity in imaginative stories, involvement in creative activities and hobbies, preferences for creative and unconventional careers, and teacher nominations of the student who thinks of the most unusual ideas (see Davis, 1989). Correlations between verbal scores on the TTCT, and intelligence and academic achievement scores, respectively, have been reported as low to moderate (see Davis, 1989), allaying claims that the TTCT is simply another test of intelligence or academic achievement. A major criticism of the TTCT as a measure of creativity has been that the tests lack a unified, comprehensive theoretical base (see Buros, 1972, 1978; Mitchell, 1985; Treffinger et al., 1975), which is a problem for the study of creativity at large. Still, at present, the TTCT is the most extensively researched instrument among those currently available for assessing creativity in children (Davis, 1989).

Of the various indices of creative performance on the TTCT (i.e., Fluency, Flexibility, Originality, Total score), ideational Fluency appears to be the most independent from intelligence (see Wallach, 1970 for a review). In general, ideational fluency may be defined as the ability to generate numerous ideas which are relevant to a given task. Evidence that measures of ideational fluency can be reliably distinguished from intelligence makes them particularly valuable in the study of creativity, for they provide a way of differentiating intelligent individuals who perform creatively from those who do not.

Still, creativity is increasingly being acknowledged as multidimensional in nature (Mumford & Gustafson, 1988; Treffinger et al., 1975), and measures of creativity are now

reflecting this. Consequently, researchers (e.g., Amabile, 1983; Dellas & Gaier, 1970, 1975; Renzulli, 1978) have recommended that the assessment of creativity reflect not only ideational fluency but also domain-relevant skills, personality attributes, cognitive style, and task motivation. To accomplish this, a number of researchers (e.g., Martinson, 1980; Renzulli, 1978; Renzulli & Smith, 1980; Torrance, 1981) have stressed the need to supplement traditional approaches, which test individuals' ideational capabilities, with ratings of individuals' personality and performance.

One measure which may be used as a systematic means of obtaining teacher ratings of students' observed level of creativity is the Creativity subscale of the Scale for Rating Behavioral Characteristics of Superior Students (SRBCSS; Renzulli & Hartman, 1971) (see Appendix A). On the Creativity subscale of the SRBCSS, there are 10 items, which were selected on the basis of frequently-cited characteristics of creative individuals in the literature; these characteristics include: curiosity, ideational fluency, a lack of inhibition, a sense of risk-taking, intellectual playfulness, a sense of humour, emotional sensitivity, aesthetic sensitivity, nonconforming and constructively critical (see Renzulli & Hartman, 1971; Appendix A). Teachers are required to read each item separately and consider the degree to which they have observed the presence or absence of a given characteristic in a particular student. They are then asked to place an X on a 4-point scale, according to how often they have observed that characteristic in the student, with 1 being ALMOST NEVER, 2 being SELDOM, 3 being OFTEN, and 4 being ALMOST ALWAYS. The total number of Xs for each of the 4 points are added and then multiplied by their respective weights (i.e., 1, 2, 3, or 4), in order to obtain weighted totals. These

weighted totals are summed to yield a score for Creativity. Due to the way the 4-point scale has been constructed, scores on Creativity can range from a minimum of 10 (if all 10 items are rated as 1) to a maximum of 40 (if all 10 items are rated as 4).

The Creativity subscale of the SRBCSS appears to have reasonable psychometric properties. Stability and interjudge reliability correlations for the Creativity subscale have been reported as $r = .79$, $p < .01$, and $r = .91$, $p < .01$, respectively (Renzulli, Hartman, & Callahan, 1980, p. 9). As for discriminant validity, the Creativity subscale has been shown to discriminate between groups of children identified as 'gifted' and 'average', $F(1, 78) = 31.43$, $p < .01$ (Renzulli et al., 1980, p. 9). Also, in terms of concurrent validity, scores on the Creativity subscale have been found to correlate significantly with Verbal Test scores on the TTCT for ideational Fluency, $r = .37$, $p < .05$, Flexibility, $r = .44$, $p < .05$, and Originality, $r = .48$, $p < .01$, but not with any of the Nonverbal/Figural Test scores (Renzulli et al., 1980, p. 10). Still, the long-term predictive validity of the Creativity subscale of the SRBCSS is questionable, when compared with other measures of creativity (i.e., Guilford-type tests and the TTCT) (Houtz, Lewis, Shaning, & Denmark, 1983). Since research on the Creativity subscale of the SRBCSS is still forthcoming, this measure of creativity should probably be reserved for the purposes of research and preliminary screening. Nevertheless, the SRBCSS does allow teachers to identify creative behaviours in their students.

Despite difficulties in the conceptualization and measurement of creativity, it appears that one can identify more creative and less creative children on the basis of their performance on ideational fluency measures and teacher ratings. Furthermore,

given that creativity is generally regarded as a stable and normally distributed individual difference variable (Guilford, 1950; Hocevar, 1981; Nicholls, 1972), it should be possible to study creativity not only in creative geniuses but in normal children as well.

Summary of the Present Research

Two separate, yet related, issues will be considered in this research. One issue pertains to differences in the associative memory structures of more creative and less creative individuals, in relation to Simonton's (1988) model. A second issue involves possible age-related differences in the basis of children's associative memory structures, with respect to themes and categories. Each of these issues will be discussed in turn.

Implicit in Simonton's model are several hypotheses regarding the number and strength of associative links in the memory structures of more creative and less creative individuals. Specifically, Simonton proposes that there are more between-configuration links and more weak within-configuration links in the associative memory structures of more creative individuals, than in those of less creative individuals. However, Simonton is vague in specifying the nature of configurations within associative memory per se, and whether these configurations are different for more creative and less creative individuals.

Based on the literature examining memory organization in children (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972; McCauley et al., 1976; Worden, 1976), it appears that at least two organizational structures are possible in memory; these have been referred to by various terms, including themes and categories. On memory tasks, the tendency of younger children

to rely on themes and the tendency of older children to rely on categories has been interpreted as evidence of diverse memory structures among children.

In order to explore alternate memory structures in creative individuals, as well as age-related differences in the basis of memory organization, a series of three studies were conducted to examine the structure of associative memory in more creative and less creative children at grades 3 and 7. Each study consisted of a memory task which required children to either: rate the associability of word pairs; recall and sort a set of words; or make a quick decision as to the associability of word pairs. Stimulus words used in the memory tasks consisted of words which comprised two organizational structures, categories and themes. This allowed for the analysis of several different levels of memory organization: two configural dimensions (within category, within theme), and one transecting configural dimensions (between category and theme).

Prior to the administration of the memory tasks, children in each of grades 3 and 7 were divided into two groups, More Creative and Less Creative, on the basis of their assessed level of creativity. Simonton's (1988) model was recast into associationist terms because there was a considerable parallel between Simonton's writing and the associationist view, and because the model had to be made testable. Assuming that Simonton's model is accurate, there should be more between-configuration links in the associative memory structures of more creative children, than in those of less creative children. Thus one could hypothesize that more creative children would recall more between-category-and-theme word pairs than less creative children. Furthermore, there should also be more weak within-configuration links in the associative memory structures

of more creative children, than in those of less creative children. If this is true, then one could hypothesize that more creative children would regard within-category and within-theme word pairs as being more weakly associated than less creative children. In terms of behavioural responses, this would translate into more creative children giving lower ratings, and making slower decisions, of associability for within-category and within-theme word pairs than less creative children.

To capture part of the previously observed developmental shift from the use of associative/thematic and categorical relations to the use of categorical relations in memory, children in grades 3 and 7 were employed in this research. The justification for this was primarily empirical, rather than theoretical, and rests specifically on findings reported by McCauley et al. (1976), and Bjorklund and colleagues (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985). Consistent with studies reporting evidence of developmental trends in children's organizational preferences, one could hypothesize that Grade 3 children would be more likely to use a combination of themes and categories, whereas Grade 7 children would be more likely to use categories, on a sorting task.

Preliminary Screening for Creativity

Subjects

A total of 18 classes (10 Grade 3 classes and 8 Grade 7 classes) from six schools located in the Ottawa-Carleton region participated in this research. The number of child participants was evenly distributed across the six schools. All phases of the research

were conducted with children at their respective schools, during regular school hours, between January and June, 1992, inclusive.

In conforming with ethical guidelines, all children were informed as to the nature of the research being conducted and were given the option of choosing not to participate at any point in the research. They were basically told that the researcher was interested in how they remember things. In addition, children were reassured that they were not expected to have good memories to be able to perform the tasks, but they were encouraged to try their best. At the outset, children were informed that after the initial phase of the research (i.e., screening), only some children would be selected to complete other tasks. Any questions that either children, teachers or parents had were answered. To ensure anonymity, the identity of each child was indicated by a code. The results of all individual children remain confidential, and only experimental group means will be reported publicly.

Initially, 203 children in grades 3 and 7, who had obtained parental consent, were screened for creativity. Children with reading/writing impairments or exceptionalities (e.g., learning disabilities) participated in the screening process alongside their classmates. However, 13 children with a known or suspected reading/writing impairment or exceptionality were selected out from the original subject pool; also, their data were omitted from all statistical analyses. This amounted to nine children who were identified by teachers as having a reading/writing impairment or exceptionality.³ In addition, four

³Four of these children (three males and one female) were in Grade 3, and five of these children (four males and one female) were in Grade 7.

children were identified by the researcher as having a possible reading/writing impairment or exceptionality.⁴ Once the 13 children with known or suspected reading/writing impairments or exceptionalities were excluded from the original sample, a total of 190 children remained in the subject pool.

Of the 190 children remaining in the sample, 111 (49 males and 62 females) were in Grade 3, and 79 (47 males and 32 females) were in Grade 7. The average age of children in Grade 3 was 8 years 10 months, while the average age of children in Grade 7 was 12 years 11 months. English was the first language for 97% of the children; 1% had French as a first language, and the remaining 2% had a language other than English or French as their first language.

A separate group of 22 Grade 3 children participated in a pilot study designed to assess the feasibility of instructions and procedures, as well as the relative salience of stimuli; the instructions, procedures and stimuli were to be employed in the initial (screening) and subsequent (experimental) phases of the research. Children in the pilot sample were from a school which was not among those participating in the actual research, though this school too was located in the Ottawa-Carleton region. In the pilot sample, there were 5 males and 17 females, all with an average age of 8 years 6 months. The first language for all of these children was English.

⁴Three of these children (two males and one female) were in Grade 3, and one (female) was in Grade 7. Of these children: one male in Grade 3 had considerable difficulty understanding what was expected of him and in writing his responses; another male in Grade 3 indicated that he was being assessed for a possible visual impairment, reading disorder or learning disability; one female in Grade 3 was extremely slow in responding to all verbal stimuli and showed signs of a possible communication impairment; and one female in Grade 7 admitted having some difficulty in understanding the English language, as she had recently immigrated from China.

Materials

Ideational fluency, as measured by the TTCT (Torrance, 1990a, 1990b), was one criterion used to assess creativity in children. Although the TTCT provides scores for the Total test, Fluency, Flexibility and Originality, it was the Fluency scores which were of primary interest to the present research. As discussed previously, theorists and researchers generally agree that the creative process involves the generation of numerous ideas or ideational fluency (see Mumford & Gustafson, 1988). Therefore, ideational Fluency scores on the TTCT were used to identify children who produce many ideas and who might consequently have a high probability of generating remote associations. Also, correlational studies have shown that ideational fluency measures appear to be the creativity indices most independent of intelligence (see Hocevar, 1980 and Wallach, 1970 for reviews).

The Verbal Test, Form B of the TTCT was administered to children in group format. Children were provided with pencils and booklets for their responses.

The TTCT was first administered to the Grade 3 pilot sample, to determine whether the instructions, as read verbatim from the manual (Torrance, 1990a), could be easily understood and followed by Grade 3 children. Also, since the TTCT manual (Torrance, 1990a) recommends administering the Verbal Form individually to children in Grade 3 and to small groups of children in Grade 4, it was uncertain as to which of these formats would be optimal for Grade 3 children.

Upon administering the TTCT to the Grade 3 pilot sample as specified in the manual (Torrance, 1990a, 1990b), it was observed that many Grade 3 children had

difficulty understanding and following the TTCT instructions as read verbatim (see Appendix B). Consequently, the TTCT instructions were modified somewhat to include short, simple sentences, while preserving the same basic ideas contained in the original instructions (see Appendix C). As well, with the Grade 3 pilot sample, it was found that a small group format, with groups containing a maximum of 6-8 children, seemed to be optimal in maintaining the attention and concentration of Grade 3 children, and in motivating them to complete each of the TTCT Verbal activities.

Due to the questionable validity and reliability of creativity as a construct (Mönks & van Boxtel, 1985; Owen & Baum, 1985), identifying children as creative by the TTCT alone may not be considered sufficient. It has been argued (Amabile, 1983; Dellas & Gaier, 1970, 1975; Martinson, 1980; Renzulli, 1978; Renzulli & Smith, 1980; Torrance, 1981) that a multi-informational approach is necessary to confirm that one is in fact identifying creative children. Consequently, in this research, the identification of More Creative and Less Creative children by means of the TTCT was supplemented with teacher ratings of children's observed creative behaviours, using the SRBCSS.

The Creativity subscale of the SRBCSS was given to teachers to fill out on each child who completed the TTCT. To complete this subscale, teachers were provided with rating sheets, and the researcher reviewed the instructions on the front page with them. Several teachers who found some of the items ambiguous were instructed to form a general impression of the item and then apply it to a given student.

Procedure

The Verbal Test, Form B of the TTCT was administered to groups of children in grades 3 and 7. With Grade 3 children, the TTCT was administered in small groups, typically in a small quiet room or enclosed area; there were between 2 and 8 children in a group, depending on how accessible various children were on a particular day. However, with Grade 7 children, the TTCT was administered in large groups, generally on a class-by-class basis, in a large quiet room, consistent with recommendations in the manual (Torrance, 1990a, 1990b); there were between 8 and 28 students in a group at one time, again depending on how accessible students were on a given day.

It took about 60 minutes for each group of children to complete the TTCT. In general, the researcher read the modified standard instructions for each Verbal activity to a group of children and began timing once children's questions had been answered. The time allotted for each activity conformed to that outlined in the TTCT manual (see Torrance, 1990a, 1990b; Appendix C).

Concurrent with the administration of the TTCT, teachers completed ratings of creativity for children in their class. On average, it took teachers approximately five minutes per child to fill out the Creativity subscale of the SRBCSS. In return for completing the rating sheets for their class, each teacher was paid \$30, which was to be put towards the purchase of new classroom materials.

Summary Statistics for the Screening Sample

After the administration of the TTCT, each child's scores on the Total test, Fluency, Flexibility and Originality were calculated. For all 190 children in the screening

sample, mean TTCT standard scores were found to be near the 50th percentile for the Total test ($M = 99$, $SD = 16.38$), Fluency ($M = 97$, $SD = 18$), Flexibility ($M = 98$, $SD = 16.39$), and Originality ($M = 103$, $SD = 16.05$). In addition, all of these TTCT scores were found to be highly and significantly intercorrelated ($\alpha/6 = .01$) (see Table 1). Since these results are similar to those reported for the TTCT normative sample (see Torrance, 1990c), the use of modified instructions with the screening sample did not seem to have an appreciable effect on TTCT scores.

Each child's score on the Creativity subscale of the SRBCSS was also calculated. Based on all 190 children in the screening sample, the mean score obtained for teacher-rated creativity was 24 ($SD = 5.13$). Interestingly, this mean is similar to that reported by Renzulli et al. (1980) for 'gifted' students in grades 5 and 6 ($N = 40$), $M = 25$, $SD = 7.64$, but not for 'average' students in grades 5 and 6 ($N = 40$), $M = 17$, $SD = 4.70$ (p. 9).

For all 190 children in the screening sample, scores obtained on the Creativity subscale of the SRBCSS were correlated with standard scores obtained on the TTCT ($\alpha/4 = .01$). Although smaller than those reported by Renzulli et al. (1980), these correlations were significant for TTCT standard scores for the Total test, $r(188) = .24$, $p < .01$, Fluency, $r(188) = .21$, $p < .01$, Flexibility, $r(188) = .24$, $p < .001$, and Originality, $r(188) = .24$, $p < .01$.

Table 1

Intercorrelations Among TTCT Standard Scores (Screening Sample)

Standard Scores ^a	Fluency	Flexibility	Originality
Total	.99***	.96***	.97***
Fluency		.92***	.95***
Flexibility			.89***

a: $N = 190$.

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

Overview of the Methodology for the Experimental TasksSubjects

Initially, an attempt was made to identify children as creative on the basis of both Fluency scores obtained on the TTCT and teacher ratings of creativity obtained on the SRBCSS. However, there were very few children who obtained either very high or very low scores on both measures simultaneously, and it was not possible to obtain a sufficient sample size for statistical analyses to be performed. Consequently, a decision was made to identify children as creative by using the TTCT, a measure of creativity with known psychometric properties, instead of the SRBCSS, a measure of creativity whose psychometric properties are largely unassessed.

As part of the process of selecting children for the More Creative and Less Creative groups, criteria were applied to children's Fluency scores on the TTCT.⁵ At first, the criterion for inclusion in each of the More Creative and Less Creative groups was that children had to have TTCT Fluency scores greater than the 75th percentile and less than the 25th percentile, respectively; the aim of using such a criterion was to form extreme groups with respect to creativity. However, after 65 Grade 3 children were screened using the TTCT, only 8 could be classified as More Creative, whereas 21 could be classified as Less Creative, using the previous criteria. Conversely, when 57 Grade 7 children were screened using the TTCT, 21 could be classified as More Creative, whereas only 4 could be classified as Less Creative, using the same previous criteria. This distribution was unexpected, in view of that obtained by Corkill and Glover (1987) and the normative data reported for the TTCT (see Torrance, 1990c). Since the Verbal Form of the TTCT is essentially a written test, it is possible that ideational fluency is confounded with written ability, at least to some extent. This might account for the low number of Grade 3 children and the high number of Grade 7 children who could be classified as More Creative, as well as the reverse; that is, Grade 3 children are not yet proficient at written skills, whereas Grade 7 children are.

Eventually the criterion adopted was that children's TTCT Fluency scores had to be greater than the 65th percentile and less than the 35th percentile, in order to be selected for the More Creative and Less Creative groups, respectively. This criterion

⁵In Corkill and Glover's (1987) sample of 72 undergraduate students, approximately 24% could be classified as creative on the basis of their TTCT scores alone. As a result, it was expected that, out of 190 children in the present research, there would be at least 46 children, 23 at each of grades 3 and 7, who could be identified as creative.

was chosen because it potentially allowed for at least 15-20 children to be selected for the smallest groups at each grade (i.e., More Creative Grade 3's and Less Creative Grade 7's), with further sampling. Also, with this criterion leaving the middle 30% of the normative distribution of TTCT scores intact (see Torrance, 1990c), there was still a high probability of obtaining fairly extreme groups in terms of creativity.

An attempt was made to include all children identified as More Creative and Less Creative in the experimental sample. Unfortunately, with the relatively late decision to extend the criteria for inclusion in the More Creative and Less Creative groups, one female in Grade 3 identified as More Creative and one male in Grade 7 identified as Less Creative could not be included in the experimental sample. Owing to the large numbers of children who were identified in Grade 3 as Less Creative and in Grade 7 as More Creative, additional children for these groups were sampled randomly from each class after the first 20.

A total of 85 children were included in the experimental sample and went on to complete the experimental tasks. However, in order to be retained as part of the experimental sample, children had to have completed all experimental tasks associated with the three studies conducted; this permitted comparison of the results across the three studies for the same children. With this stipulation, two Grade 3 children (one male and one female) were later excluded from the experimental sample because they each had incomplete data for one experimental task.⁶ Due to extraneous or subject

⁶The male in Grade 3 had missing data for 12.5% of the associability-rating task, and the female in Grade 3 moved before the associability-rating task could be administered.

factors providing less than optimal experimental conditions, three additional children, two (one male and one female) in Grade 3 and one (male) in Grade 7, were subsequently excluded from the experimental sample.⁷ Consequently, a total of 80 children were retained in the experimental sample.

Of the 80 children in the experimental sample, 42 children (24 males and 18 females) were in Grade 3, and 38 children (24 males and 14 females) were in Grade 7. The average age of children in Grade 3 was 8 years 10 months, whereas the average age of children in Grade 7 was 13 years 0 months. There were at least two children from each of the 18 classes originally sampled. In terms of first language, 99% of these children had English as a first language, and 1% had a language other than English or French as their first language.

To summarize, from the original sample pool of 190 children who were screened for creativity using TTCT Fluency scores, 80 children comprised the experimental sample. The experimental sample consisted of groups of More Creative and Less Creative children at each of grades 3 and 7. For Grade 3, there was a total of 15 children (8 males and 7 females) in the More Creative group and 27 children (16 males and 11 females) in the Less Creative group. At Grade 7, there was a total of 28 children (14 males and 14 females) in the More Creative group and 10 children (all males) in the

⁷Specifically, these children were excluded for the following reasons: it was observed that one Grade 3 male was inattentive and extremely fatigued on the second half of the association-decision task; one Grade 3 female was found to be inattentive throughout the association-decision task; and the performance of one Grade 7 male on the recall task was impeded by being in an extremely noisy room.

Less Creative group.⁸ Neither teachers nor children were informed as to which experimental group children belonged to.

Inter-rater reliability was computed for TTCT scores, based on 25% of the screening sample. This amounted to 48 TTCT Verbal Test booklets (24 from Grade 3 and 24 from Grade 7) being randomly selected from those obtained for the screening sample. These were then scored by a second rater who had no previous involvement with the present research.⁹ In order to obtain a measure of inter-rater reliability for TTCT scores, the intraclass correlation coefficient (Bartko, 1966) was used, rather than the Pearson correlation coefficient which has been commonly used to calculate inter-rater reliability for TTCT scores (see Torrance, 1990b). The intraclass correlation coefficient provides a more stringent measure of inter-rater reliability than the Pearson correlation coefficient (Bartko, 1966; Berk, 1978), which can yield a spuriously high estimate of inter-rater reliability (Bartko, 1976). Obtained intraclass correlation coefficients were .94 for the Total test, .96 for Fluency, .91 for Flexibility, and .91 for Originality. Given that a very high degree of inter-rater reliability was obtained for all TTCT scores using the more stringent intraclass correlation coefficient, there was considerable confidence in the reliability of the More Creative and Less Creative groups, formed on the basis of TTCT Fluency scores.

⁸The fact that there were no females in the Grade 7 Less Creative group implied that any significant effects found for the Grade 7 Less Creative Group would be confounded with gender.

⁹The second rater was first trained on a separate subset of 10 TTCT Verbal Test booklets selected randomly from the screening sample, and a very high degree of inter-rater reliability was quickly established.

Stimulus Materials

Since both verbal intelligence and educational level can influence children's obtained scores for creativity (Stein, 1968), it was necessary to administer several control measures in addition to the experimental tasks. In order to control for potentially significant correlations between creativity and intelligence among children, as frequently reported in the literature (see Wallach, 1970 for a review), it was necessary to obtain a measure of children's general intellectual abilities. To accomplish this, the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974) was employed.¹⁰ The WISC-R has excellent norms, reliability and validity (see Sattler, 1982, 1992; Wechsler, 1974).

In order to be time-efficient and still provide an estimate of children's overall intellectual functioning, a Short-Form combination of subtests on the WISC-R was used, as described in Sattler (1982, 1992). The Vocabulary and Block Design Short Form was eventually chosen¹¹ because the two subtests are quick to administer, have high reliability, correlate well with the Full Scale of subtests over a wide age range, and provide good measures of global intelligence (Sattler, 1992); in addition, both the Vocabulary and Block Design subtests tap into the verbal and performance skills of children, respectively. Sattler (1982, 1992) recommends that Short-Form scores be

¹⁰During the initial stages of this research, the Wechsler Intelligence Scale for Children-III (WISC-III) was only beginning to be distributed on a nationwide basis, and supplemental psychometric data necessary for interpreting WISC-III scores was still in the process of being published. As a result, the WISC-III was not used in this research.

¹¹Initially, a WISC-R Short Form consisting of four subtests (i.e., Similarities, Picture Completion, Vocabulary, Block Design) was chosen, but piloting indicated that this Short Form took too long to administer, in view of the other tasks children had to complete at one time.

transformed into a Full Scale IQ estimate, or Deviation Quotient ($M = 100$, $SD = 15$). The procedure for computing a Deviation Quotient is outlined in Sattler (1982, 1992). According to Sattler (1982, 1992), Deviation Quotients provide fairly reliable estimates of Full Scale IQs. Nevertheless, he suggests that WISC-R Short Forms are adequate for research but not for clinical or psychoeducational purposes.

To ensure that children were functioning at their current grade level academically, the Wide Range Achievement Test-Revised (WRAT-R; Jastak & Wilkinson, 1984), Levels 1 and 2, was used to assess children's level of academic skills. The advantage of using the WRAT-R, over other measures of academic achievement, is that: it is quick and easy to administer; it provides standard scores ($M = 100$, $SD = 15$); and it provides general information about reading, spelling and arithmetic skills. According to the authors (Jastak & Wilkinson, 1984), the standardization sample, test-retest reliability and validity (content, construct and concurrent) of the WRAT-R are all adequate (see Jastak & Wilkinson, 1984). However, the WRAT-R manual (Jastak & Wilkinson, 1984) provides no information about the SES distribution for the standardization sample, and no reliability coefficients or indices of internal consistency for the entire sample (Sattler, 1992). Consequently, Sattler (1992) recommends that the WRAT-R be used only for screening and not for diagnostic/placement decisions.

Procedure and Design

The order, format and time required for the administration of the screening measures and experimental tasks is outlined in Appendix D. Since the procedure for administering the screening measures has already been described in the previous

section, only the general procedure related to the experimental phase of the research will be discussed here.

Once the More Creative and Less Creative groups were established at each grade, children in these groups then went on to complete the experimental tasks, as well as several control measures. Each of the experimental tasks comprised one of three studies. In order to prevent the priming of stimulus words and their associations, and to maintain children's interest and concentration for the various tasks, the studies were conducted in the following order: Study #2, Study #3, and Study #1, even though theoretically and logically, the numerical ordering makes more sense.

There were two experimental sessions, with an interval of at least one week between them, in order to minimize the possibility of carry-over effects. During the first experimental session, a recall/sorting task (Study #2), the WISC-R Short Form, the WRAT-R, and an association-decision task (Study #3) were administered to each child. This session was conducted on an individual basis by one of two female experimenters, one being the researcher and the other being a fellow graduate student.¹²

The first experimental session lasted about 75-85 minutes. Initially, a child was asked to recall twice a set of words, which he/she was later required to sort, along with a different set of words (Study #2); this took approximately 20-30 minutes to complete. Next came one half of the association-decision task (Study #3) at a time,¹³ with control

¹²Both experimenters were in the advanced stages of completing a Ph.D. program in Clinical Psychology, and both had training and experience in child psychological assessment.

¹³Preliminary piloting revealed that the association-decision task in its entirety was too taxing for Grade 3 children to complete.

measures being administered in between.¹⁴ The first half of the association-decision task, consisting of a short practise and 60 trials, was presented on a computer and took approximately 9 minutes to complete; the child was asked whether pairs of words went together and had to quickly press a button indicating either YES or NO. Then the WISC-R Short Form and the WRAT-R were administered to the child, in accordance with standardized instructions and procedures; the administration of these measures each took approximately 20 minutes. To end the first experimental session, the second half of the association-decision task, consisting of a second 60 trials, was administered to the child and took approximately 6 minutes to complete. Immediately afterwards, the experimenter made an assessment of the child's on-task behaviour during the first experimental session by placing a mark on a scale ranging from 0 to 10; anchors on the scale were 0 (indicating Very Off-Task Behaviour), 5 (indicating Moderately On-Task Behaviour) and 10 (indicating Very On-Task Behaviour).

During the subsequent and final experimental session, an associability-rating task (Study #1) was carried out in group format by the researcher. The group format used for the associability-rating task was basically the same as that used for group administration of the TTCT.¹⁵ For the associability-rating task, children were asked to rate pairs of words on a scale of 1 to 10, on the basis of how well they thought the pairs of words went together. This took children approximately 15 minutes to complete.

¹⁴This order of administration had the effect of creating a varied set of tasks for children to complete, while at the same time capitalizing on their attention and concentration for the association-decision task.

¹⁵Due to the varied availability of students at the end of the school year, the associability-rating task was administered, in some cases, to individual or pairs of children in each grade.

In terms of the overall statistical design, data obtained for each of the experimental tasks comprised one of three studies. The data were generally analyzed according to a Grade (2) x Creativity (2) x Type of Word Pair (3) ANOVA, using SPSS^x (Version 3.1) and SPSS (Version 4.1). Between-subjects variables included Grade (3, 7) and Creativity (More Creative, Less Creative). Type of Word Pair (within category, within theme, between category and theme) was the within-subjects variable and related to the fact that various pairs of words belonged to a pre-established type of organization, as determined by the researcher. Alpha was set at .05 for each hypothesis tested in all statistical analyses. The Tukey HSD procedure was used to test post hoc significant effects found with the ANOVAs computed.

For each experimental group, the sample size was consistent across all three studies. The ratio of the largest to the smallest group was 3:1, thereby meeting the recommendation of Tabachnick and Fidell (1989) that the ratio be no larger than 4:1.

For each of the main ANOVAs computed in each study, the ratio of the largest to the smallest obtained variances rarely exceeded a ratio of 20:1, the criterion suggested in Tabachnick and Fidell (1989) for meeting the assumption of homogeneity of variances. In four cases, there were violations of the assumption of homogeneity of variances. Data transformations were attempted on the few variables that were heterogeneous, but nothing could be done to correct the situation. Consequently, heterogeneous variables are noted in relation to specific analyses, the results of which are reported tentatively.

Descriptive Information on the Experimental Sample

Mean TTCT standard scores obtained with the experimental sample for the Total test ($M = 103$, $SD = 20.75$), Fluency ($M = 101$, $SD = 22.51$), Flexibility ($M = 101$, $SD = 20.57$), and Originality ($M = 105$, $SD = 20.33$) were slightly higher than those obtained for the entire screening sample; though these scores were still at or near the 50th percentile. In addition, the mean teacher rating for creativity on the SRBCSS obtained with the experimental sample was 25 ($SD = 5.08$), which was virtually identical to that obtained with the screening sample.

For the experimental sample, there were no significant correlations found between TTCT scores and teacher ratings of creativity on the SRBCSS ($\alpha/4 = .01$). This further substantiated the difficulty of forming the More Creative and Less Creative groups on the basis of both the TTCT and the SRBCSS. Still, considering that all TTCT standard scores were highly and significantly intercorrelated for the experimental sample (see Table 2), the establishment of different levels of creativity on the basis of the TTCT alone can be accepted with reasonable confidence.

Scores for the two control measures, the WISC-R and the WRAT-R, were calculated for each child in the experimental sample. For the WISC-R, Deviation Quotients, as well as standard scores for the Composite, Verbal and Performance scales, were obtained. In terms of the WRAT-R, separate standard scores were obtained for the Reading, Spelling and Arithmetic subtests.

All intelligence scores obtained on the WISC-R were found to be significantly intercorrelated ($\alpha/6 = .01$) (see Table 3). As well, all academic achievement scores

Table 2

Intercorrelations Among TTCT Standard Scores (Experimental Sample)

Standard Scores ^a	Fluency	Flexibility	Originality
Total	.99 ^{***}	.97 ^{***}	.98 ^{***}
Fluency		.93 ^{***}	.97 ^{***}
Flexibility			.92 ^{***}

a: $N = 80$.

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

obtained on the WRAT-R were found to be significantly intercorrelated ($\alpha/3 = .02$) (see Table 3). When intelligence scores were correlated with academic achievement scores ($\alpha/12 = .004$), WISC-R Verbal scores were found to be significantly correlated with scores on each of the WRAT-R subtests (see Table 3), thereby suggesting that there may be a verbal component underlying each of the WRAT-R subtests. However, it is unclear as to why overall scores on the WISC-R were found to be significantly correlated with scores on only the Arithmetic subtest of the WRAT-R (see Table 3). This could simply be a spurious result, given the large number of correlations computed.

As stated previously, the TTCT was selected as a creativity measure, on the basis of its relative independence from intelligence, particularly with respect to Fluency.

Table 3

Intercorrelations Among WISC-R and WRAT-R Scores (Experimental Sample)

Standard Scores ^a	WISC-R Composite	WISC-R Verbal	WISC-R Performance	WRAT-R Reading	WRAT-R Spelling	WRAT-R Arithmetic
WISC-R DQ	1.00***	.77***	.83***	.27**	.30**	.40***
WISC-R Composite		.77***	.84***	.26*	.29**	.39***
WISC-R Verbal			.29**	.45***	.41***	.44***
WISC-R Performance				.01	.08	.21*
WRAT-R Reading					.72***	.37***
WRAT-R Spelling						.31**

Note. DQ = Deviation Quotient.

a: $N = 80$.

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

Indeed, there were no significant correlations found between any of the scores obtained on the WISC-R, a measure of intelligence, and those obtained on the TTCT, a measure

of creativity ($\alpha/16 = .003$).¹⁶ Similarly, scores obtained on the WRAT-R did not correlate significantly with any of the scores obtained on the TTCT ($\alpha/12 = .004$). Since there were no significant correlations between TTCT and WISC-R or WRAT-R scores respectively, there was no need to partial out intelligence from results obtained with the More Creative and Less Creative groups, as in an ANCOVA design.

Means were computed for the More Creative and Less Creative groups at each of grades 3 and 7, with respect to the following variables: age; TTCT standard scores for Fluency; Composite WISC-R standard scores; separate WRAT-R standard scores for each of the Reading, Spelling and Arithmetic subtests (as recommended by Jastak & Wilkinson, 1984); and on-task behaviour during the first experimental session. A series of Grade (2) x Creativity (2) ANOVAs were conducted with the aforementioned variables, in order to perform a preliminary test on between-group differences.

As one might expect, the mean ages for children in grades 3 and 7 were significantly different, $F(1, 76) = 1995.08$, $MS_e = 21.28$, $p < .001$ (see Table 4 for the means). Grade 7 children ($M = 156$, $SD = 5.20$) were found to be older than Grade 3 children ($M = 106$, $SD = 3.92$). However, mean ages for children in the two creativity groups at each grade were found to be comparable (see Table 4).

Mean TTCT standard scores for Fluency differed significantly for Grade, $F(1, 76) = 7.14$, $MS_e = 62.43$, $p < .01$, and Creativity, $F(1, 76) = 422.45$, $MS_e = 62.43$, $p <$

¹⁶The TTCT has been criticized for being simply another measure of verbal fluency (see Wallach, 1971). However, there were no significant correlations found between Verbal scale scores on the WISC-R and Fluency scores on the TTCT, for any of the four creativity groups comprising the experimental sample. Thus there was some evidence to support the notion that children identified as creative in the experimental sample were actually creative, as opposed to verbally fluent.

Table 4

Means and Standard Deviations for Age (months)

Group	<i>N</i>	Age	
		Mean	Standard Deviation
Grade 3			
More Creative	15	106	3.58
Less Creative	27	105	4.12
Grade 7			
More Creative	28	156	4.79
Less Creative	10	156	6.47

.001 (see Table 5 for the means). Grade 7 children ($M = 112$, $SD = 18.90$) had higher TTCT Fluency scores than Grade 3 children ($M = 92$, $SD = 21.40$). More Creative children ($M = 121$, $SD = 8.20$) received higher scores on TTCT Fluency than Less Creative children ($M = 79$, $SD = 8.14$), thus confirming the existence of extreme groups with respect to creativity.

The ANOVA conducted on mean Composite WISC-R standard scores indicated a significant main effect for Grade, $F(1, 76) = 6.37$, $MS_e = 21.44$, $p < .05$ (see Table 6 for the means). Grade 3 children ($M = 26$, $SD = 5.05$) had higher intelligence scores, as obtained on the WISC-R, than Grade 7 children ($M = 24$, $SD = 4.00$). While it is

Table 5

Means and Standard Deviations for TTCT Fluency Standard Scores

Group	N	TTCT Fluency Standard Scores	
		Mean	Standard Deviation
Grade 3			
More Creative	15	118	6.19
Less Creative	27	77	7.83
Grade 7			
More Creative	28	122	8.98
Less Creative	10	84	6.98

possible that the higher level of intelligence observed in Grade 3 children could account for more efficient information processing on short-term memory tasks (i.e., a greater amount of information recalled and shorter overall reaction times) than Grade 7 children, no firm conclusions have yet been drawn regarding the relation between an increased level of intelligence and efficiency in information processing (Sattler, 1992). In addition, corresponding Deviation Quotients were 119 ($SD = 14.75$) for Grade 3 children and 111 ($SD = 11.39$) for Grade 7 children, suggesting that both Grade 3 and Grade 7 children were in the High Average range, in terms of intelligence (see Sattler, 1982, 1992). Thus the difference in intelligence scores for Grade 3 and Grade 7 children

Table 6

Means and Standard Deviations for WISC-R Composite Standard Scores

Group	<i>N</i>	WISC-R Composite Standard Scores	
		Mean	Standard Deviation
Grade 3			
More Creative	15	27	5.80
Less Creative	27	26	4.68
Grade 7			
More Creative	28	24	3.80
Less Creative	10	23	4.72

was not regarded as great enough to explain significant structural differences in the organization of long-term memory. In fact, in Simonton's (1988) model, the model to be tested in this research, it is assumed that it is creativity which forms the basis for structural differences in associative memory and not intelligence. Furthermore, the between-grade difference in intelligence level did not confound any within-grade analysis of creativity.

Separate ANOVAs conducted on WRAT-R standard scores for the Reading, Spelling and Arithmetic subtests revealed no significant main or interaction effects (see Tables 7-9). This suggests that all four groups (i.e., Grade 3 More Creative, Grade 3

Table 7

Means and Standard Deviations for WRAT-R Reading Standard Scores

Group	N	WRAT-R Reading Standard Scores	
		Mean	Standard Deviation
Grade 3			
More Creative	15	108	11.00
Less Creative	27	108	14.37
Grade 7			
More Creative	28	106	11.40
Less Creative	10	102	15.31

Table 8

Means and Standard Deviations for WRAT-R Spelling Standard Scores

Group	<i>N</i>	WRAT-R Spelling Standard Scores	
		Mean	Standard Deviation
Grade 3			
More Creative	15	100	9.98
Less Creative	27	101	13.05
Grade 7			
More Creative	28	99	13.08
Less Creative	10	94	16.11

Table 9

Means and Standard Deviations for WRAT-R Arithmetic Standard Scores

Group	N	WRAT-R Arithmetic Standard Scores	
		Mean	Standard Deviation
Grade 3			
More Creative	15	113	13.41
Less Creative	27	110	12.89
Grade 7			
More Creative	28	94	11.64
Less Creative	10	98	11.29

Less Creative, Grade 7 More Creative, Grade 7 Less Creative) were comparable and functioning at a grade-appropriate level academically.

Mean ratings of children's on-task behaviour during the first experimental session were found to be comparable for each of the experimental groups (see Table 10 for the means¹⁷). The fact that these mean ratings were all at 9.5 or above (see Table 10) indicates that experimenters observed children's behaviour as being very much on-task

¹⁷For ratings of on-task behaviour, the ratio of the largest to the smallest obtained variance was 433:1. Subsequent attempts to transform the data set failed to resolve this problem. Thus results obtained for the analysis of on-task behaviour should be considered tentative.

Table 10

Means and Standard Deviations for Ratings of On-Task Behaviour for Experimental Session I

Group	N	Ratings of On-Task Behaviour	
		Mean	Standard Deviation
Grade 3			
More Creative	15	9.99	.05
Less Creative	27	9.53	1.04
Grade 7			
More Creative	28	9.62	.93
Less Creative	10	9.88	.35

during individual administration of the recall/sorting task, the control measures and the association-decision task.

In general then, the More Creative and Less Creative groups at each grade differed significantly in terms of creativity. However, they did not differ significantly in terms of intelligence, academic achievement or on-task behaviour.

Study #1: Associability Ratings for Word Pairs

Rationale and Hypotheses

To address the issue of the distribution of associative strength in the memory of more and less creative children, associability ratings were used as indices of memory structure. This is consistent with network theories of semantic memory¹⁸ (e.g., Collins & Loftus, 1975; Quillian, 1968), which view concepts stored in memory as a network of nodes interconnected by associative links.

Elaborating on the earlier work of Quillian (1968), Collins and Loftus (1975) proposed that a memory search is carried out by a spreading of activation from two or more concepts represented by nodes in a semantic network, until a point of intersection is reached. Properties of concepts are represented in the network as labelled links, and links have weights to indicate the degree of relatedness among nodes or concepts. When a node representing a concept is activated, activation spreads out along the paths¹⁹ of the network and is assumed to weaken over time and distance. Activation from various nodes summates, and when summation reaches a certain threshold, a concept is accessed from memory.

Collins and Loftus' (1975) theory not only attempts to explain how activation spreads throughout a network but also how a network is organized. Loftus makes a distinction between a conceptual network and a lexical network in semantic memory (see

¹⁸Semantic memory, or an individual's memory for general concepts, is frequently distinguished from episodic memory, which refers to an individual's memory for personally-relevant experiences occurring through time.

¹⁹A path consists of an interconnecting chain of links between two nodes.

Collins & Loftus, 1975). Most relevant to the present study is the organization of a conceptual network. According to Loftus, the conceptual or semantic network is organized on the basis of semantic similarity; in other words, concepts which are related have a number of shared properties and so will have a number of links among corresponding nodes in the network.

Consistent with this notion of a semantic network, children in the present study were asked to rate the degree of associability between pairs of words. Words which were rated as highly associated were assumed to have short paths, whereas words which were rated as weakly associated were assumed to have long paths. Indeed, there is some evidence that estimates of conceptual proximity correspond to actual conceptual distances in memory (see Cooke, 1992; Cooke, Durso, & Schvaneveldt, 1986). The associability ratings obtained from children in the present study served a dual purpose: 1) to assess the organization of children's memory; and 2) to provide a normative measure of the associative strength among words stored in long-term memory for the subsequent two studies.

The present study employed a methodology similar to that used by Bjorklund and Jacobs (1984), who examined the strength of associative relations in the memory structures of children and adolescents. Bjorklund and Jacobs selected five words from each of five taxonomic categories (e.g., ANIMALS, CLOTHING, OCCUPATIONS, SEASONINGS, and WEAPONS), such that two words within each category were considered to be high associates (e.g., in the category SEASONINGS, the words *salt--pepper*). A list of 50 intracategory word pairs plus 20 intercategory pairs was then

devised, and ratings of associative strength were obtained from children in grades 3, 4, 6 and 8, and from undergraduate students. Bjorklund and Jacobs found that, among the intracategory word pairs, ratings for high-associate pairs were generally higher than for low-associate pairs. In contrast, ratings for intercategory word pairs were found to be low for all students. Bjorklund and Jacobs concluded that the strength of associative relations in memory changes minimally as children and adolescents become older.

Still, Bjorklund and Jacobs' (1984) main assumption is that the underlying basis for associative memory is categorical, and this is reflected in their choice of stimuli which was restricted to essentially categorically-related words. However, it is possible that the underlying basis for associative memory is not necessarily categorical for all individuals. The literature on free recall has shown that individuals will use almost any explicit or implicit organizational scheme in a list of words as a basis for grouping (see Friendly, 1979). Furthermore, in the literature on memory organization in children (Bjorklund, 1989; Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Bjorklund & Muir, 1988; Denney, 1974; Denney & Ziobrowski, 1972; Markman, 1984, 1989; McCauley et al., 1976; Whitney & Kunen, 1983; Worden, 1976), there is considerable consensus that children's underlying organizational structures in memory are different from those of adults. Yet since not all studies have uncovered evidence of a developmental shift in the basis of children's memory organization (e.g., Worden, 1976), there remains the methodological issue of how to access children's changing organizational structures in memory.

Worden (1976) has shown that it is possible to choose a set of words such that they conform to two organizational structures, categories and themes. She constructed a set of 25 words which could simultaneously be organized into either five taxonomic categories or five researcher-defined themes; for example, the word *barn* was both a member of the BUILDINGS category and the FARM theme (Worden, 1976, p. 522). These stimulus words were then arranged so that there was no bias towards either categories or themes. Worden instructed children in grades 2 and 5 to generate their own type of sorting organization for the stimulus words. She found that there was no significant evidence of a developmental shift from themes to categories between grades. Yet overall, she found that all children generated significantly more themes than categories, and significantly more categories than other types of organizations. These results suggest that children of different ages can and do perceive alternate organizations in a group of stimuli, provided that the stimuli chosen offer them the opportunity to do so.

Improving on Bjorklund and Jacob's (1984) study, the present study utilized words that could be organized into categories, themes, or neither categories nor themes. Organizing the stimulus words according to these dimensions allowed for Simonton's (1988) model to be tested and also for alternate organizational structures to emerge. Due to Simonton's (1988) lack of specificity as to the nature of 'configurations', it is difficult to determine what the basis of memory organization really is for either more creative or less creative children. However, the developmental literature has consistently maintained that there is a shift in the basis of organization in children's memory from

complementary/thematic/associative/schematic relations to similarity/taxonomic/categorical relations (see Bjorklund, 1989; Bjorklund & Muir, 1988; Denney, 1974; Markman, 1984, 1989). Consequently, in this research, it was assumed that configurations would reflect categories, themes, or some other type of organization in children's associative memory structures.

In the present study, More Creative and Less Creative in grades 3 and 7 were presented with word pairs to rate. Each of these word pairs could be classified as belonging to a particular configuration (within category, within theme) or as transecting configurations (between category and theme). Applying Simonton's (1988) model to the word pairs used in the present study, it was hypothesized that More Creative children would rate between-category-and-theme word pairs as higher in associability than Less Creative children. This is because More Creative children, relative to Less Creative children, presumably have more between-configuration links in their associative memory structures; therefore, between-configuration links will be more strongly associated in the memory structures of More Creative children than in those of Less Creative children. Also, it was hypothesized that More Creative children would rate within-category and within-theme word pairs as lower in associability than Less Creative children, since within-configuration links are assumed to be more weakly associated in the memory structures of More Creative children than in those of Less Creative children. It is important to note that both within-category and within-theme word pairs should be more weakly associated for More Creative than for Less Creative children. If a word belongs to a dominant type of configuration (e.g., categorical or thematic), then a link between

a word in that configuration and a word in another configuration (e.g., categorical or thematic) automatically constitutes a between-configuration link. Hence, this satisfies the criterion in Simonton's model that both within- and between-configuration links are weaker for more creative than for less creative individuals.

In the developmental literature (i.e., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Worden, 1976), there is reported to be a trend amongst Grade 3 children to use associations/themes and categories, and amongst Grade 7 children to use categories, on memory tasks. Thus, a further hypothesis in the present study was that Grade 3 children would rate thematic word pairs as comparable in associability with categorical word pairs, whereas Grade 7 children would rate categorical word pairs as higher in associability than thematic word pairs.

Various techniques can be applied to reduce proximity estimates obtained from associability ratings to spatial or nonspatial models which can be represented visually. Spatial models, like those produced by multidimensional scaling (MDS), have a mathematical basis in geometry, whereas nonspatial models, like the networks produced by the Pathfinder network scaling algorithm, generally derive from graph theory (Schvaneveldt, Durso, & Dearholt, 1985, 1989). With spatial models, it is assumed that proximity estimates are based on distance for continuous attributes or dimensions in geometric space; therefore, entities are represented as points in space, and relations among entities, as distances between points in space (Cooke, 1992; Schvaneveldt et al., 1985, 1989). In contrast, nonspatial models are based on the assumption that proximity estimates reflect the presence or absence of shared discrete attributes; thus entities are

represented as nodes, and relations among entities, as links connecting nodes (Cooke, 1992; Schvaneveldt et al., 1985, 1989). Whereas spatial models provide a global view of concepts in dimensional space, nonspatial models focus on local relations among concepts (Cooke et al., 1986; Dearholt & Schvaneveldt, 1990; Schvaneveldt et al., 1985, 1989).

The Pathfinder network scaling algorithm is a relatively new nonspatial technique that can map out memory structures in the form of a graph (Cooke, 1992) and thus provide information about memory organization that is not directly available in associability ratings (Cooke et al., 1986). It offers an empirical, as opposed to an intuitive (Chi & Koeske, 1983; Collins & Loftus, 1975; Collins & Quillian, 1969; Friendly, 1979), basis for the generation of network structures. Basically, the algorithm can generate a number of networks when given similarity or distance data obtained for pairs of entities (see Cooke et al., 1986; Dearholt & Schvaneveldt, 1990; Schvaneveldt et al., 1985, 1989). Pathfinder converts these data into proximity estimates, which are measures of the relatedness of pairs of entities. Low proximity estimates indicate similarity, relatedness, or reduced distance, whereas high proximity estimates indicate dissimilarity, lack of relatedness, or increased distance. Based on proximity estimates, Pathfinder assigns a particular weight to each link. Low proximity estimates receive low link weights, and high proximity estimates receive high link weights. Using these weights, Pathfinder then connects certain entities, represented as nodes, by links. This procedure is determined, in part, by the researcher specifying the r and q parameters. The r -parameter is the Minkowski r -metric which computes distance in the network. Also,

there is the q -parameter which constrains the number of links used to generate the network. By varying the r and q parameters, a variety of Pathfinder networks can be computer-generated for a particular set of proximity estimates.

In the present study, the Pathfinder network scaling algorithm was used to generate a graphic representation of the associative memory structures of More Creative and Less Creative children at each of grades 3 and 7, on the basis of obtained associability ratings for word pairs. This was the first attempt to generate Pathfinder networks for creative children (see Durso & Coggins, 1990; Schvaneveldt et al., 1985, 1989).

Visually, it was hypothesized that representations of the associative memory networks of More Creative and Less Creative children would resemble those depicted in Simonton's (1988) model (see Figure 1). That is, the associative memory network of a More Creative child should be characterized by many between-configuration (i.e., between-category-and-theme) links, and many weak within-configuration (i.e., within-category or within-theme) links. In contrast, the associative memory network of a Less Creative child should be characterized by few between-configuration (i.e., between-category-and-theme) links and many strong within-configuration (i.e., within-category or within-theme) links. As well, from a developmental perspective, it was hypothesized that dominant configurations in the memory networks of Grade 3 children would be both thematic and categorical, whereas those of Grade 7 children would be mostly categorical.

Subjects

As previously described, groups of More Creative and Less Creative children were established at each of grades 3 and 7, on the basis of TTCT Verbal Fluency scores. This ultimately led to a sample of 80 children. At Grade 3, there were 15 children in the More Creative group and 27 children in the Less Creative group. Conversely, at Grade 7, there were 28 children in the More Creative group and 10 children in the Less Creative group. The average age of children in Grade 3 was about 9 years, whereas the average age of children in Grade 7 was 13 years. Males and females were approximately evenly distributed across all groups, with the exception of the Grade 7 Less Creative group which was comprised of all males. More Creative and Less Creative children at each grade were comparable in terms of age, intelligence and academic achievement.

Children completed the present study as the last in a series of three. For all children, this study was conducted at least one week following the other two studies (i.e., Studies #2 and #3), in order to minimize possible carry-over effects associated with previous exposure to the stimulus words.

Stimulus Materials

The two organizational structures of categories and themes, adopted from Worden (1976), guided the selection of stimulus words. A category is defined here as an organized structure which is based on class membership. In a category, relations among words are based on similarity; for example, the words *apple*, *banana*, and *pear* possess similar features in that they are all FRUIT. A theme is defined here as a

spatially and/or temporally organized structure, and includes words which are related on the basis of contiguities that have been experienced in space and/or time. Specifically, thematic relations among words can be interactive (e.g., one takes a *bus* to *school*), contextual (e.g., one goes to *school* in the *fall*) or descriptive (e.g., a *hotel* room has a *bed*). Two sets of stimulus words containing both categories and themes were devised for the experimental tasks.

In a set of stimulus words which will subsequently be referred to as Set A, words and respective categories considered for inclusion were among those previously generated by children in grades 3 and 6²⁰ (see Posnansky, 1978). An attempt was made to include words that had moderate to high values on measures of category frequency (Posnansky, 1978) and word frequency (Carroll, Davies, & Richman, 1971).

Themes and corresponding words for stimulus Set A were devised by the researcher, as there were no normative data available to guide the selection of themes per se. Referring to the themes and corresponding words generated by Worden (1976), as well as the associative word pairs generated by Bjorklund and de Marchena (1984), the researcher identified words, from among those already chosen for categories, which were related in terms of a typical scene or event. These words were then related in a part-whole fashion to a particular theme, similar to Worden (1976), for example, who considered the words *horse*, *barn*, *rope*, *cowgirl*, and *jeans* to represent the FARM theme (p. 522). The themes and corresponding words chosen were subsequently piloted, in order to verify that these were relatively salient for children.

²⁰These children were similar in age to those examined in the present study.

For stimulus Set A, four words were selected from each of four categories, with the constraint that a word taken from each of the four categories also comprised one of four themes (see Table 11). Words ultimately selected for each category in Set A were

Table 11

Arrangement of Words into Two Organizational Structures (Set A)

Categories				Themes
WEATHER	DWELLINGS	FURNITURE	VEHICLES	
<i>fall</i>	<i>school</i>	<i>desk</i>	<i>bus</i>	SCHOOL CITY VACATION COUNTRY
<i>wind</i>	<i>apartment</i>	<i>television</i>	<i>subway</i>	
<i>sun</i>	<i>hotel</i>	<i>bed</i>	<i>airplane</i>	
<i>spring</i>	<i>cabin</i>	<i>stove</i>	<i>tractor</i>	

the following: WEATHER--*fall, wind,*²¹ *sun, spring*; DWELLINGS--*school, apartment, hotel, cabin*; FURNITURE--*desk, television, bed, stove*; and VEHICLES--*bus, subway, airplane, tractor*. Also, the same set of words could be rearranged into the following themes: SCHOOL--*fall, school, desk, bus*; CITY--*wind, apartment, television, subway*; VACATION--*sun, hotel, bed, airplane*; and COUNTRY--*spring, cabin, stove, tractor*. Pilot

²¹Originally, the word *smog* had been included in the category WEATHER and the theme CITY in Set A. But given that a considerable number of Grade 3 children in the pilot sample (i.e., 7 out of 13 children surveyed) did not know what the word *smog* referred to, the word *wind* was substituted for the word *smog*.

testing indicated that Grade 3 children could identify both categorical and thematic relations among words in stimulus Set A. Words in stimulus Set A were used in all three studies.

Preliminary analyses were conducted on properties of the words comprising stimulus Set A. As suggested by Murphy and Puff (1982), word frequency and category representativeness are important considerations when selecting words for memory tasks.

Using the word frequency norms of Carroll et al. (1971), mean word frequencies were calculated for all categories and all themes in Set A (see Tables 12 & 13), and submitted to a Category (4) x Theme (4) ANOVA, using SYSTAT. Only the main effects of Category and Theme were tested, as these were of primary interest. Also, the Category x Theme interaction could not be tested, since there was only one observation per cell (Winer, 1991). Despite the low statistical power in the tests of main effects conducted (i.e., $df = 3$), mean word frequencies were found to be comparable across categories and across themes for stimulus Set A. This suggested that words in all categories and in all themes in stimulus Set A had an equal likelihood of being accessed from memory.

In addition, the category norms of Posnansky (1978) were consulted to ensure that words in stimulus Set A could be readily discriminated from other categories and were representative of their respective categories. Posnansky's proportional data indicated that the stimulus categories and corresponding words were highly discriminable (see Table 14). Since category typicality effects have been reported in the literature for children on memory tasks (see Murphy & Puff, 1982), it was important to examine

Table 12

Set A Word Frequencies^a for Categories

Word	Total Frequencies ^b
WEATHER	(1234.75)
<i>fall</i>	824
<i>wind</i>	1336
<i>sun</i>	1977
<i>spring</i>	802
DWELLINGS	(823.00)
<i>school</i>	2599
<i>apartment</i>	183
<i>hotel</i>	106
<i>cabin</i>	404
FURNITURE	(439.75)
<i>desk</i>	324
<i>television</i>	411
<i>bed</i>	841
<i>stove</i>	183
VEHICLES	(181.75)
<i>bus</i>	345
<i>subway</i>	37
<i>airplane</i>	298
<i>tractor</i>	47

Note. Mean word frequencies for categories are in parentheses.

^aWord frequencies were taken from Carroll et al. (1971) and include the total number of times a word occurred out of a corpus of 5,088,721 tokens. ^bTotal word frequencies were computed from samples of text for students in grades 3 to 9, as well as students in other grades.

Table 13

Set A Word Frequencies^a for Themes

Word	Total Frequencies ^b
SCHOOL	(1023.00)
<i>fall</i>	824
<i>school</i>	2599
<i>desk</i>	324
<i>bus</i>	345
CITY	(491.75)
<i>wind</i>	1366
<i>apartment</i>	183
<i>television</i>	411
<i>subway</i>	37
VACATION	(805.50)
<i>sun</i>	1977
<i>hotel</i>	106
<i>bed</i>	841
<i>airplane</i>	298
COUNTRY	(359.00)
<i>spring</i>	802
<i>cabin</i>	404
<i>stove</i>	183
<i>tractor</i>	47

Note. Mean word frequencies for themes are in parentheses.

^aWord frequencies were taken from Carroll et al. (1971) and include the total number of times a word occurred out of a corpus of 5,088,721 tokens. ^bTotal word frequencies were computed from samples of text for students in grades 3 to 9, as well as students in other grades.

Table 14

Set A Category Proportions*

Word	Proportional Value		Largest Proportions for Other Categories		Category
	Gr. 3	Gr. 6	Gr. 3	Gr. 6	
WEATHER	(.144)	(.168)			
<i>fall</i>	.125	.029	-	-	
<i>wind</i>	.172	.260	-	-	
<i>sun</i>	.172	.346	-	-	
<i>spring</i>	.109	.038	-	-	
DWELLINGS	(.316)	(.312)			
<i>school</i>	.203	.029	-	-	
<i>apartment</i>	.328	.144	-	-	
<i>hotel</i>	.672	.942	-	-	
<i>cabin</i>	.063	.135	-	-	
FURNITURE	(.309)	(.365)			
<i>desk</i>	.438	.510	-	-	
<i>television</i>	.125	.135	-	-	
<i>bed</i>	.578	.798	.047	.019	DWELLINGS
<i>stove</i>	.094	.019	-	-	
VEHICLES	(.266)	(.139)			
<i>bus</i>	.547	.337	-	-	
<i>subway</i>	.047	.058	-	-	
<i>airplane</i>	.328	.115	-	.019	DWELLINGS
<i>tractor</i>	.141	.048	-	-	

Note. Gr. = Grade. Mean proportions for categories are in parentheses.

*Proportional data from Posnansky (1978) were used to compile this table. These data represent proportions of children in grades 3 ($N = 64$) and 6 ($N = 104$) who generated specific instances of each category.

category proportions for words in stimulus Set A. To determine how representative words were for various categories and for children similar in age to the present sample, the proportions of children in Posnansky's sample who generated words which comprised stimulus Set A were analyzed according to a Grade (2) x Category (4) ANOVA. Given that the results of this ANOVA indicated no significant main or interaction effects for category proportions for Set A words, words in stimulus Set A were deemed similar in terms of category representativeness across grades and categories.

Thus analyses of word frequencies and category proportions for stimulus Set A supported the selection of Set A words. Set A words were found to be relatively frequent, as well as highly discriminable and representative of categories, for school-aged children.

For the rating task, the 16 words from stimulus Set A were arranged in pairs, such that every word was paired once with every other word, either within category, within theme, or between category and theme. The order of words within a pair was random instead of being systematically presented twice, once on each side, because that would have meant doubling the total number of word pairs for children to rate (i.e., 240).²² Consequently, each pair of words was only presented once for children to rate.

In total, there were 120 word pairs for children to rate. This included 24 within-category word pairs, 24 within-theme word pairs, and 72 between-category-and-theme word pairs. To control somewhat for order of presentation effects, and to prevent copying among children during the rating task, four different random orders of the word

²²Such a task had been anticipated as too demanding for Grade 3 children to complete.

pairs were used on the rating sheets provided for children. Word pairs were displayed on sheets of 21.25 x 27.5 cm white paper and were accompanied by visual analogue scales (see Table 15 for an example of a visual analogue scale). Typically, five word

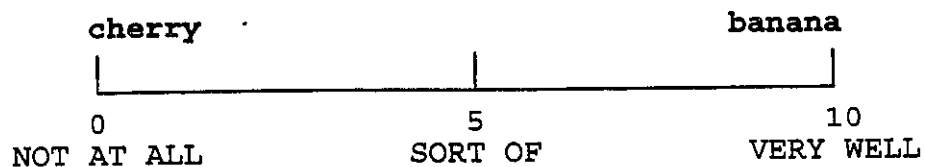
Table 15

Example of a Visual Analogue Scale for Associability Ratings (Actual Practise Item)

INSTRUCTIONS:

How well do these words go together?
Put a mark on the line below each pair of words.
This will show how well you think the words go together.

EXAMPLE:



pairs were displayed on a page. Rating sheets consisted of a packet of 25 pages stapled together, with the first page containing identifying information, instructions and an example, and the subsequent 24 pages containing one set of instructions and 120 word pairs for children to rate on visual analogue scales. Each child was given a packet of rating sheets, along with a pencil.

A standard word pair was used in the example provided on the first page of the rating sheets. The word pair used in the example was different from those used on the actual rating sheets. This particular word pair, *cherry--banana*, was generated in a study by McCauley et al. (1976), and received a moderate associative rating (a mean rating of 5.0 on a 9-point scale) and a high categorical rating (a mean rating of 8.2 on a 9-point scale) by college students (p. 514). The same example was letter-set on a 50 x 75 cm section of foam board for the purposes of group administration of the task.

Procedure

At each grade level, the associability rating task was administered to groups of children by the researcher. The entire task lasted approximately 15 minutes. Children were not informed as to the predetermined configural dimensions of the word pairs they were being asked to rate.

Initially, children were told that the researcher was interested in how well they thought various pairs of words went together (see Appendix E for the actual instructions). They were instructed to rate each pair of words on a scale of 0 to 10, according to how well they thought the two words went together (i.e., the degree of associability they perceived to exist between the two words); 0 indicated that the words did not go together at all (no associative strength), 5 indicated that the words "sort of" went together (moderate associative strength), and 10 indicated that the words went together very well (very strong associative strength). Children were told to indicate their rating of the associability of each word pair by placing a mark on the corresponding visual analogue scale. To ensure that children understood what was expected of them, the researcher

demonstrated with an example how one would rate a word pair considered to be either strongly, moderately or weakly associated. Children were further told that there were no right or wrong answers, and they were instructed to guess if they did not know. The researcher stressed that children make a decision for **all** word pairs.

Once the researcher was assured that children understood the task, they were left to complete the rating sheets on their own, with the researcher present. As children completed the rating task, rating sheets were collected, and children were thanked for their participation.

Results and Discussion

Since one aspect of Simonton's (1988) model deals with strength of associations in memory, mean associability ratings were computed for within-category, within-theme, and between-category-and-theme word pairs, for each child. As a test of Simonton's model which posits differential distributions of associative strength in the memory structures of more creative versus less creative individuals, a Grade (2) x Creativity (2) x Type of Word Pair (3) ANOVA was carried out on children's mean ratings of associability for Set A words. The results of this ANOVA revealed only a significant main effect for Type of Word Pair, $F(2, 152) = 34.06$, $MS_e = 1.50$, $p < .001$ (see Table 16 for the means). Mean ratings of associability for all children were found to be significantly higher for within-category word pairs ($M = 6.00$, $SD = 1.90$) than for within-theme word pairs ($M = 2.50$, $SD = 1.46$), which in turn were significantly higher than those for between-category-and-theme word pairs ($M = 1.66$, $SD = 1.44$). Still, it is important to note that, in view of the original scale, mean ratings for categorical word pairs were

Table 16

Means for Associability Ratings

Group	N	Type of Word Pair		
		Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	15	5.81 (2.37)	2.12 (1.49)	1.48 (1.31)
Less Creative	27	5.28 (1.86)	1.93 (1.12)	1.35 (1.39)
Grade 7				
More Creative	28	6.63 (1.59)	3.14 (1.47)	1.95 (1.56)
Less Creative	10	6.42 (1.53)	2.86 (1.58)	1.96 (1.41)

Note. Standard deviations are in parentheses.

actually moderate, whereas those for thematic and other word pairs were actually weak (see Figure 2). A normative table of the mean associability rating for each within-category, within-theme, and between-category-and-theme word pair can be found in Appendix F.

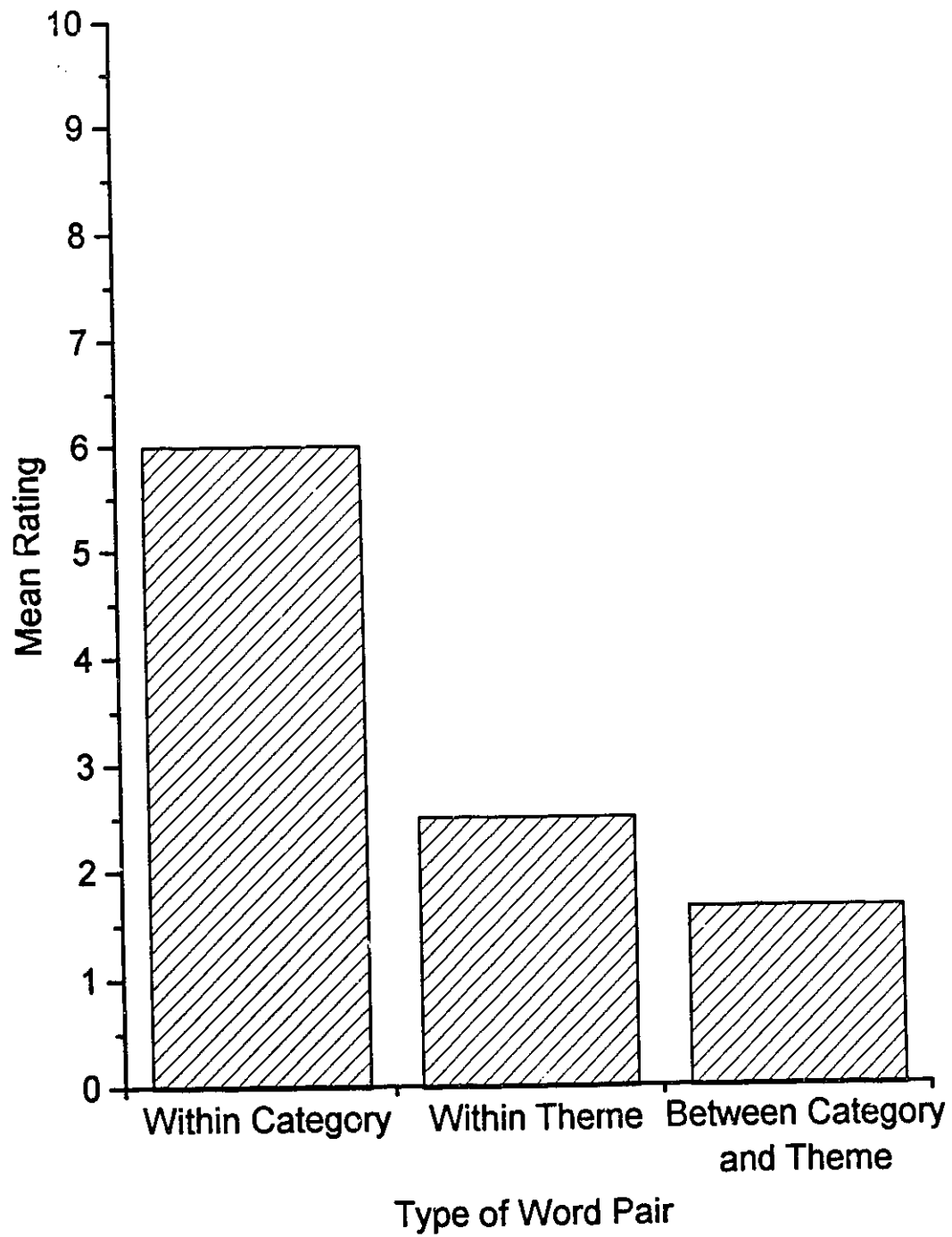


Figure 2. Mean associability ratings for various types of word pairs.

Results obtained for children's mean associability ratings indicate that, contrary to hypotheses, both More Creative and Less Creative children view within-category and within-theme word pairs as being higher in associative strength than between-category-and-theme word pairs (see Figure 2). These results suggest that, in fact, the associative memory structures of More Creative children tend to resemble those of Less Creative children, particularly when one considers that, according to Simonton (1988), less creative individuals should have strong within-configuration links and weak between-configuration links in their associative memory structures. Thus, if one is willing to equate Simonton's 'configurations' with the categories and themes used here, it does not appear that More Creative children have weaker within- and between-configuration links in their associative memory structures than Less Creative children.

Furthermore, in the present study, Grade 7 children, as well as Grade 3 children, rated within-category word pairs as having higher associative strength than within-theme and between-category-and-theme word pairs. That is, children in both grades 3 and 7 rated within-configuration word pairs as higher in associative strength than between-configuration word pairs. Similarly, in an earlier study also examining associability ratings, Bjorklund and Jacobs' (1984) found that children and adolescents across a wide age range rated within-category word pairs as higher in associative strength than between-category word pairs. On the basis of findings obtained in the present study, as well as those reported by Bjorklund and Jacobs (1984), categories seem to be particularly salient for children in grades 3 and above, though these children do perceive themes and other types of organizations in pairs of words presented to them.

Aside from differences in the strength of associations, Simonton's (1988) model also proposes differences among more creative and less creative individuals in the number of strong versus weak associative links in memory. Therefore, it was important to test Simonton's model in terms of frequencies, as well as means. In converting ratings to frequency data, the median value of all children's ratings for Set A words was designated as the arbitrary distinction between strong and weak associative links. In this study, the median of all 9,600 associability ratings (i.e., 80 children x 120 word pairs) was .20. Consequently, all ratings which were greater than .20 were taken to be indicative of strong associative links, and all ratings which were less than or equal to .20 were taken to be indicative of weak associative links; ratings equal to .20 were taken to be indicative of weak associative links because .20 represented a value at the low end of the rating scale, which ranged from 0 to 10.

The mean proportions of strong and weak associative links for Set A words were computed for each child, and submitted to separate Grade (2) x Creativity (2) x Type of Word Pair (3) ANOVAs. As the results for weak associative links are the direct inverse of those found for strong associative links, only the results for strong associative links are reported here. On the basis of the ANOVA for strong associative links, significant effects emerged for Grade, $F(1, 76) = 4.15$, $MS_e = .13$, $p < .05$, and Type of Word Pair, $F(2, 152) = 142.56$, $MS_e = .03$, $p < .001$ (see Table 17 for the means). Thus Grade 7 children ($M = .63$, $SD = .22$) demonstrated a significantly greater proportion of strong associative links than Grade 3 children ($M = .50$, $SD = .20$). Also, there was evidence of a significantly greater proportion of strong associative links for within-category word

Table 17

Mean Proportions of Strong Associative Links

Group	N	Type of Word Pair		
		Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	15	.85 (.21)	.44 (.27)	.39 (.28)
Less Creative	27	.74 (.19)	.37 (.22)	.30 (.27)
Grade 7				
More Creative	28	.90 (.14)	.57 (.27)	.46 (.31)
Less Creative	10	.87 (.13)	.51 (.34)	.43 (.33)

Note. Standard deviations are in parentheses.

pairs ($M = .83$, $SD = .18$) than for within-theme word pairs ($M = .47$, $SD = .27$), and for within-theme word pairs than for between-category-and-theme word pairs ($M = .39$, $SD = .30$). The reverse was true for weak associative links (see Table 18).

The results of the analyses for strong and weak associative links further substantiated those found for children's associability ratings. Contrary to hypotheses

Table 18

Mean Proportions of Weak Associative Links

Group	N	Type of Word Pair		
		Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	15	.16 (.21)	.57 (.27)	.61 (.28)
Less Creative	27	.27 (.19)	.63 (.22)	.70 (.27)
Grade 7				
More Creative	28	.11 (.14)	.44 (.27)	.55 (.31)
Less Creative	10	.13 (.13)	.50 (.34)	.58 (.33)

Note. Standard deviations are in parentheses.

deriving from Simonton's (1988) model, More Creative children did not demonstrate more weak between-category-and-theme associative links than Less Creative children; neither did they demonstrate more weak within-category associative links nor more weak within-theme associative links than Less Creative children. Rather, More Creative children, like Less Creative children, demonstrated many strong within-category associative links, fewer

fewer strong within-theme associative links, and very few strong between-category-and-theme associative links. Conversely, both More Creative and Less Creative children demonstrated many weak between-category-and-theme associative links, fewer weak within-theme associative links, and very few weak within-category associative links. The same was true of children in both grades 3 and 7.

Thus it appears that both more creative and less creative children, as well as children in grades 3 and 7, all have similar associative memory structures which are characterized by many strong within-category associative links, a roughly equal number of strong and weak within-theme associative links, and many weak between-category-and-theme associative links (see Figure 3).

Nevertheless, while associability ratings provide a test of Simonton's model of creativity, they do not depict all of the structural aspects of individuals' memory networks. Associability ratings do not inform us as to which concepts or nodes are linked with one another and how one node might be activated via its association with one or many other nodes. For instance, in the present study, does presentation of the word *bed* activate not only the node *bed* but also the node *apartment* and, if so, is the link between the nodes *bed* and *apartment* direct or indirect? Such structural questions, which relate to how words are accessed from memory, are important in creativity research because they attempt to address the issue of how more creative and less creative individuals might access associations from memory differently.

The associability ratings obtained for individual word pairs in the present study provide a vast amount of information about children's interword associative links.

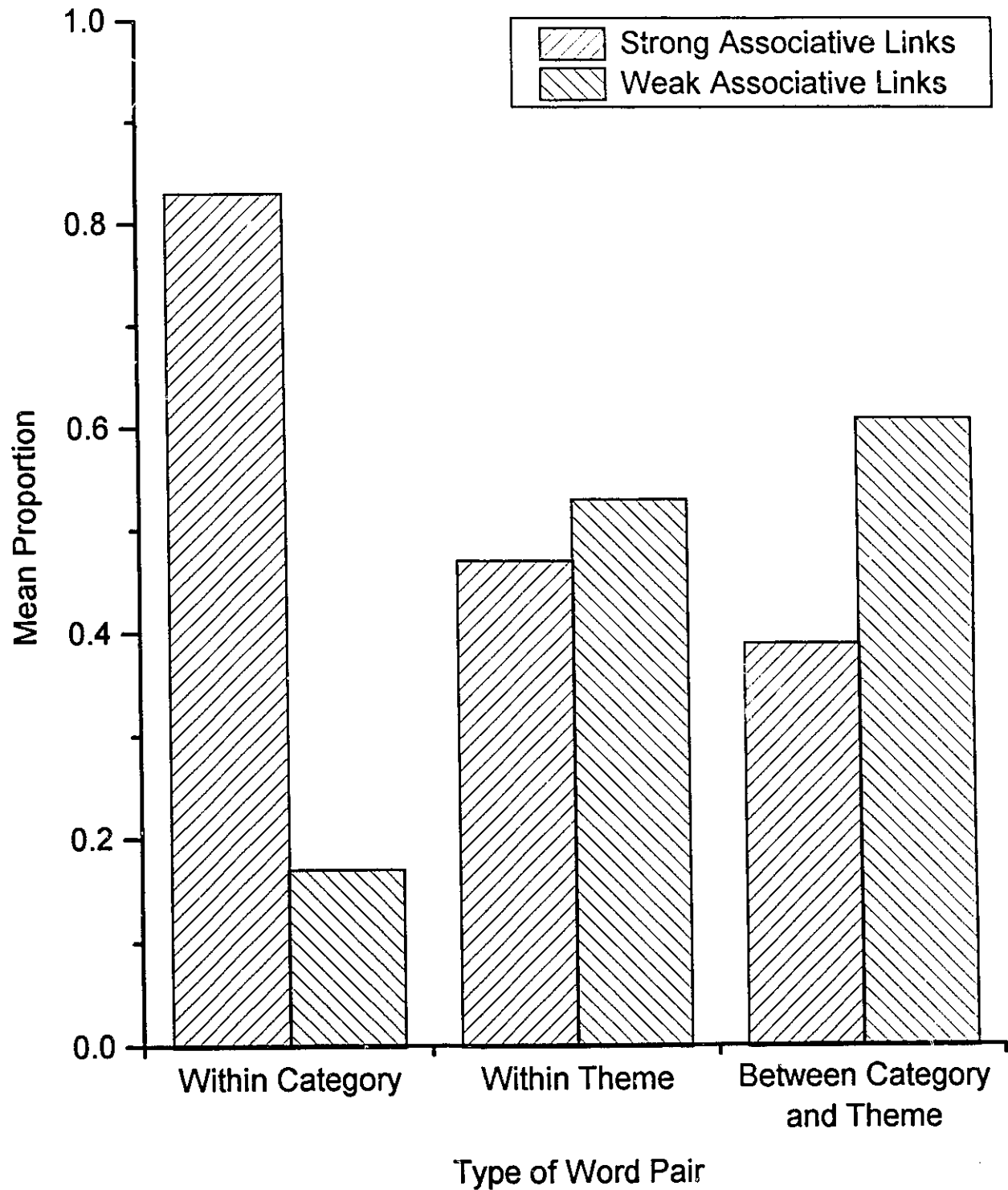


Figure 3. Mean proportions of strong and weak associative links for various types of word pairs.

However, this information is so complex as to be nearly impossible to grasp. Therefore, in order to simplify the linkage information contained in children's associability ratings of 120 word pairs, the data were further analyzed using the Pathfinder network scaling algorithm. Borrowing ideas from MDS, factor analysis and semantic network theory, the Pathfinder network scaling algorithm is a technique used to identify the main associative links in a memory structure (Schvaneveldt et al., 1985, 1989). To achieve this, Pathfinder successively examines which links are activated when a given node is "clamped on" or primed (Schvaneveldt, 1990). Gradually working its way through all nodes, this procedure eventually conveys and yields a set of main links in an associative network, in the form of a graphic representation.

Computer software for the Pathfinder network scaling algorithm comes with a Knowledge Network Organizing Tool for IBM PCs (PCKNOT; Schvaneveldt, Durso, & Dearholt, 1992). Using PCKNOT, children's mean associability ratings were entered as similarity data. The parameter r was set at infinity, as suggested by Schvaneveldt et al. (1992) for the analysis of ordinal data. Parameter q was set to 2, in order to produce networks with a maximum number of links. While minimum-link networks are supposedly easier to interpret and occupy less computer memory (Schvaneveldt, 1990), they offer only a limited view of children's associative memory structures. Thus theoretically, it made more sense to have representations of comprehensive networks, with maximum numbers of links, as opposed to subsets of these.

On the basis of proximity estimates for 120 word pairs and the parameters specified, PCKNOT produced graphic representations of Pathfinder solutions. This

resulted in maps of the associative memory networks for each of the four experimental groups: Grade 3 More Creative, Grade 3 Less Creative, Grade 7 More Creative, and Grade 7 Less Creative. As illustrated in Figures 4 to 7, inclusive, words correspond to nodes in the generated networks; links in the networks are undirected, since proximities were symmetrical for each pair of words. The presence of links in the networks was determined by patterns of proximities. Lengths of the links were determined by weights assigned to proximity estimates. A table of links and respective weights for each of the generated networks can be found in Appendix G. Of note, a low link weight corresponds to a strong association which, in turn, is graphed as a short distance. A high link weight corresponds to a weak association which, in turn, is graphed as a long distance. Although the graphic layout for PCKNOT does not translate the link weights with complete accuracy, the resultant Pathfinder solutions must be considered satisfactory, since they attempt to provide the best fit of the associability-rating data.

To statistically assess whether networks differed across grade and creativity levels, measures of similarity between each pair of networks were obtained. Similarity is determined by the mean proportion of all common links in two networks, with values ranging from 0 (very dissimilar) to 1 (identical). The tail probability for each similarity value indicates the extent to which two networks would be expected to share as many links as they do just by chance. Similarities for all Pathfinder networks were moderate to high, with all tail probabilities $< .001$ (see Table 19), indicating that children's memory networks did not differ very much across grade and creativity levels. Yet although these networks appear to be very similar statistically, they do look very different visually (see

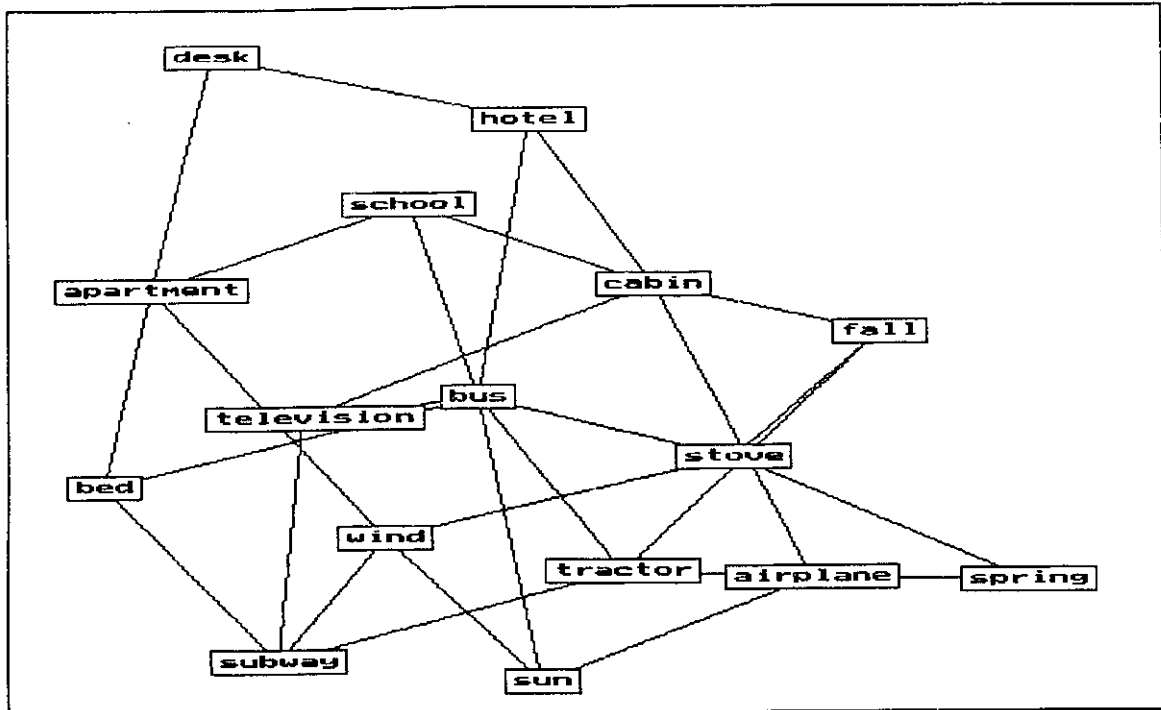


Figure 4. Associative memory network for Grade 3 More Creative children.

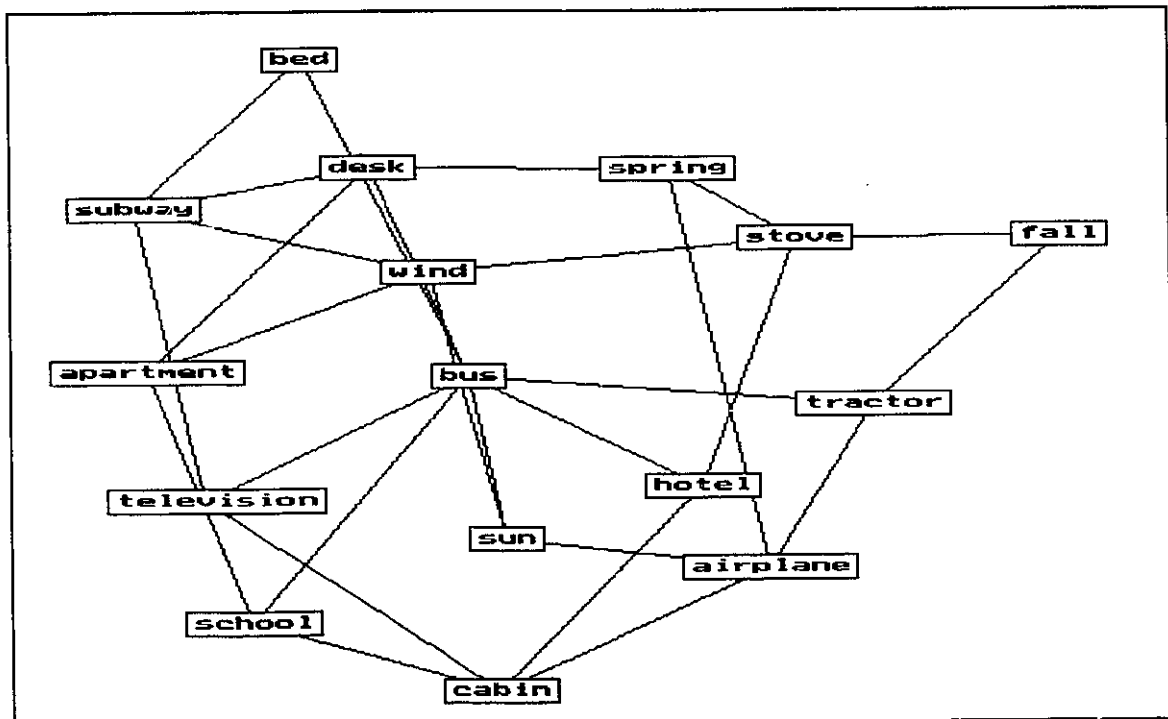


Figure 5. Associative memory network for Grade 3 Less Creative children.

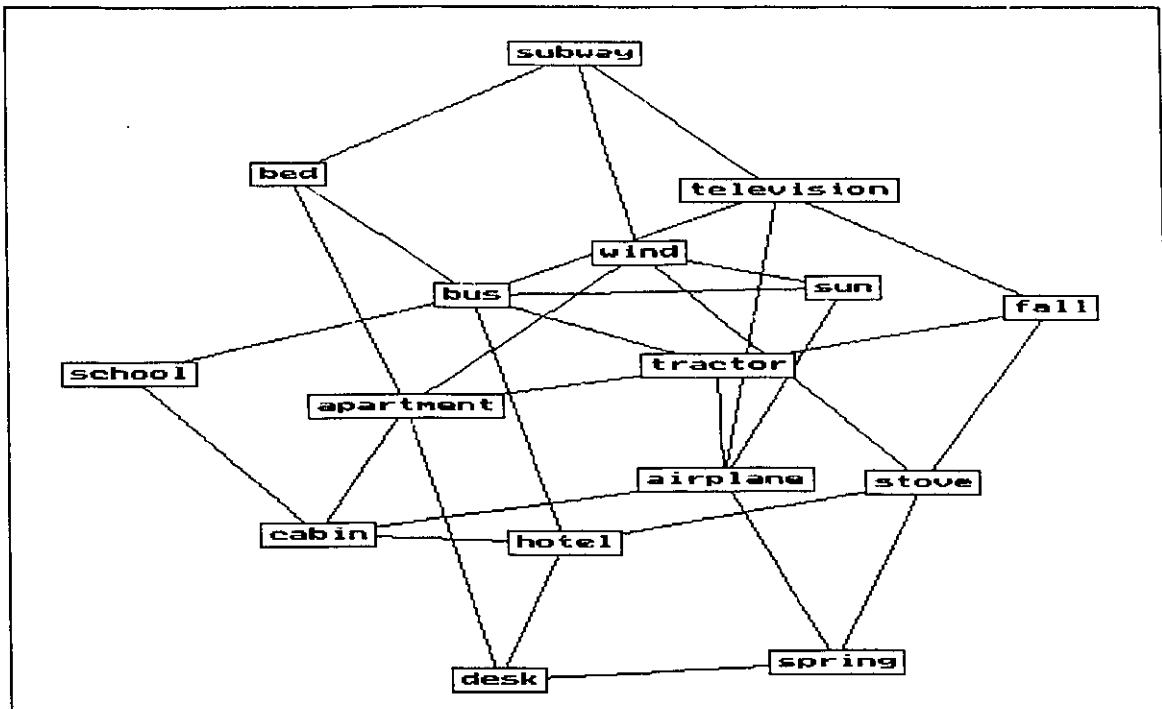


Figure 6. Associative memory network for Grade 7 More Creative children.

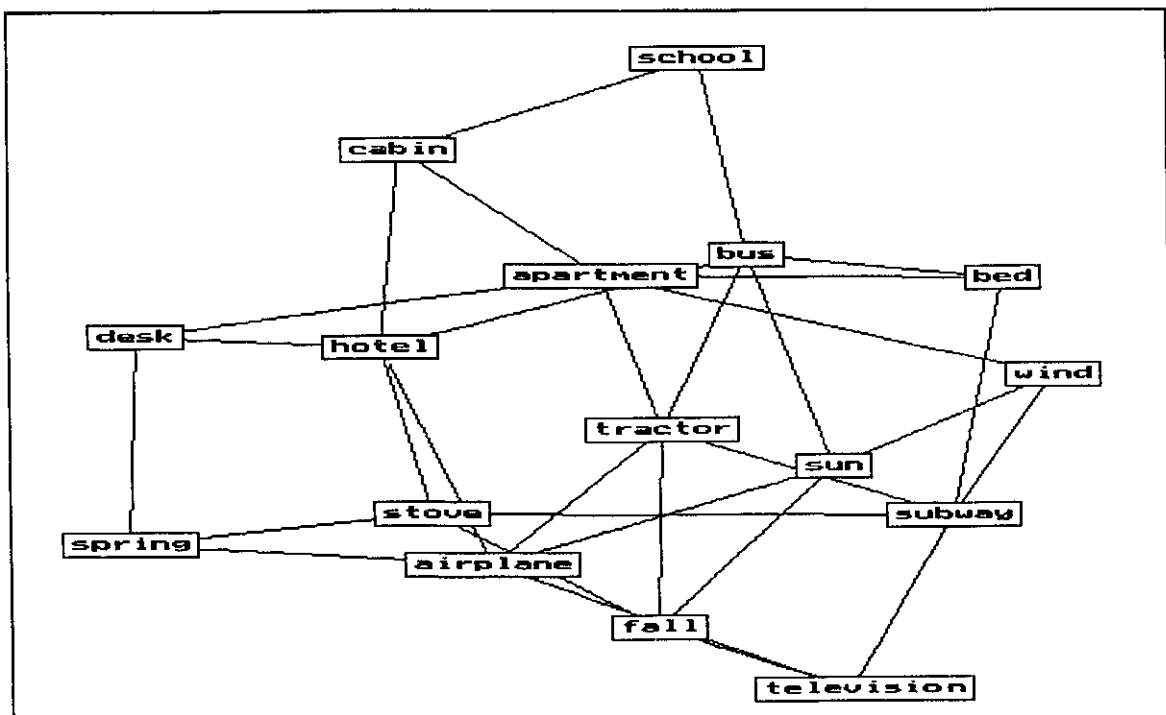


Figure 7. Associative memory network for Grade 7 Less Creative children.

Table 19

Similarities for Pathfinder Networks

Network 1	Number of Links	Network 2	Number of Links	Number of Common Links	Similarity
Grade 3 More Creative	29	Grade 3 Less Creative	28	24	.73***
Grade 3 More Creative	29	Grade 7 More Creative	30	24	.69***
Grade 3 More Creative	29	Grade 7 Less Creative	31	22	.58***
Grade 3 Less Creative	28	Grade 7 More Creative	30	24	.71***
Grade 3 Less Creative	28	Grade 7 Less Creative	31	21	.55***
Grade 7 More Creative	30	Grade 7 Less Creative	31	27	.79***

*Tail Probability < .05. **Tail Probability < .01. ***Tail Probability < .001.

Figures 4-7). This is because the similarity measure only takes into account the number of links and not the strength of the links. So just because the networks generated have a number of links in common does not necessarily imply that the strength of the links will also be the same across networks.

Consistent with the similarities previously reported, a careful visual inspection of the Pathfinder networks generated failed to yield any readily discernible patterns or

differences among them. Indeed, it has been criticized that while Pathfinder networks allow researchers to address structural issues regarding memory organization, the information they provide is limited (Cooke, 1990). There is currently no formal methodology for interpreting the semantic content of links in Pathfinder networks. In fact, some (e.g., Cooke, 1990; Johnson-Laird, Hermann, & Chaffin, 1984) have questioned whether all links in a network, or even similar links across networks, are semantically equivalent. Consequently, Cooke (1990) recommends the use of concept elicitation and interpretation strategies to enhance representations obtained with the Pathfinder network scaling algorithm. To date, this has been achieved through the classification of links by having individuals sort linked items into groups according to the type of perceived relation among them, and then submitting the data to cluster analysis (see Cooke, 1990; Schvaneveldt, 1990). However, in the present study, the predetermined classification of links was not hierarchical, and therefore, a cluster analysis would have been unlikely to recover the expected structure.

Consequently, the semantic interpretation of the Pathfinder networks derived from children's associability ratings was assessed by first computing the frequency of links which were within category, within theme, and between category and theme (see Table 20). To enable chi square analyses of these data, frequencies were pooled for within-category and within-theme links, in order to compare within- versus between-configuration links.²³ In addition, frequencies were pooled first across grade level and

²³Frequencies were pooled in this manner because a chi square analysis is limited to a 2 x 2 contingency table and because the comparison of within- versus between-configuration links was of primary interest in view of Simonton's (1988) model.

Table 20

Total Number of Links in Pathfinder Networks

Pathfinder Network	Number of Various Types of Links			
	Total	Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	29	7	6	16
Less Creative	28	6	7	15
Grade 7				
More Creative	30	6	6	18
Less Creative	31	8	7	16

then across level of creativity, as these were the main variables of interest. Collapsing the total number of links across grade level resulted in: 25 within-configuration links and 34 between-configuration links in the networks of More Creative children; and 28 within-configuration links and 31 between-configuration links in the networks of Less Creative children. With the total number of links collapsed across level of creativity, the result was: 26 within-configuration links and 31 between-configuration links in the networks of Grade 3 children; and 27 within-configuration links and 34 between-configuration links in the networks of Grade 7 children.

Separate chi square analyses were conducted on Creativity x Type of Link and Grade x Type of Link; Creativity (More Creative, Less Creative) and Grade (3, 7) were the independent variables, and Type of Link (within, between) was the dependent variable. Not surprisingly, these chi square analyses revealed no significant relationships between Creativity and Type of Link, nor Grade and Type of Link, in the networks generated. This finding coincided with the high number of common links found across the networks generated, as reported previously.

To further test the networks generated as models of children's associative memory structures vis-à-vis Simonton's model, an ANOVA was conducted on the weights of the 19 common links found across the four Pathfinder networks generated (see listing in Appendix H).²⁴ These link weights were submitted to a Type of Link (3) x Grade (2) x Creativity (2) ANOVA, with Type of Link (within category, within theme, between category and theme) as the between-links factor, and Grade (3, 7) and Creativity (More Creative, Less Creative) as the within-links factors. This analysis revealed only a significant main effect for Grade, $F(1, 16) = 96.85$, $MS_e = .39$, $p < .001$ (see Table 21). The Pathfinder networks obtained for Grade 3 children contained higher link weights ($M = 4.35$, $SD = 1.78$) than those obtained for Grade 7 children ($M = 2.87$, $SD = 1.62$). Given that higher link weights in Pathfinder networks indicate increased distance, links in the networks of Grade 3 children may be described as being farther apart or more spread out than links in the networks of Grade 7 children. Thus the associative memory

²⁴Link weights are actually more accurate representations of the original data sets than the generated graphs.

Table 21

Mean Weights for Common Links in Pathfinder Networks

Pathfinder Network	Type of Link		
	Within Category (<i>N</i> = 5)	Within Theme (<i>N</i> = 6)	Between Category and Theme (<i>N</i> = 8)
Grade 3			
More Creative	3.04 (1.06)	5.00 (1.37)	4.07 (1.35)
Less Creative	3.25 (1.28)	5.64 (1.56)	4.69 (1.85)
Grade 7			
More Creative	2.19 (1.53)	3.94 (1.99)	2.55 (1.28)
Less Creative	1.93 (1.40)	3.77 (1.46)	2.73 (1.61)

networks of older children appear to be more tightly interconnected than those of younger children. This would certainly fit with theories of semantic memory which suggest that as associations between concepts become familiar, there is less distance between corresponding nodes in the memory network, and these can therefore be accessed more quickly (Collins & Loftus, 1975; Collins & Quillian, 1969). Since older children presumably have been exposed to more concepts and hence more associations

than younger children, older children possess memory networks whereby nodes tend to have short links between them; younger children, in contrast, possess memory networks in which nodes tend to have long links between them. In view of such associative memory networks, concepts would be accessed with greater efficiency by older children than by younger children.

Based on results obtained from children's associability ratings, more creative and less creative children do not appear to possess different associative memory structures. Rather, the associative memory structures of both more creative and less creative children seem to be characterized by strong within-configuration links and weak between-configuration links. Such an associative memory structure corresponds with Simonton's (1988) description of that for the less creative individual.

In addition, categories seem to represent the predominant type of configuration, over themes and other configurations, in the memory structures of all children, regardless of age. There was no evidence of a shift from themes and categories to categories in children's associative memory structures between grades 3 and 7, as reported in the developmental literature. Yet, children in this study did appear to perceive all three configural dimensions (i.e., within category, within theme, and between category and theme) in the stimulus words, as indicated by the pattern of their mean associability ratings (see Figure 2). So while it would seem that categories are the predominant type of configuration in the associative memory networks of children in grades 3 and above, thematic and other types of configurations do co-exist, but associative links within them are weak.

Computer-generated graphic representations of children's associative memory networks revealed more cohesive networks for Grade 7 children than for Grade 3 children. Thus, the associative memory structures of Grade 7 children seem to be characterized by many strong associative links, whereas those of Grade 3 children seem to be characterized by many weak associative links.

Nevertheless, several questions were left unanswered in this study, namely: How does the structure of associative memory contribute to high ideational fluency and concomitantly the generation of remote associations in creative individuals; and is there a developmental shift from themes and categories to categories in the memory structures of children between grades 3 and 7? Speculating on the former question, it is possible that more creative individuals differ from less creative individuals not in terms of what is already stored in long-term memory but in how they access the contents of long-term memory. This would explain why no differences were found by using an associability-rating task, which is essentially a receptive memory task. The issue of how creative individuals access information from memory could be examined by using a productive memory task, such as a recall task. With respect to the latter question, it may be that the frequently-cited developmental shift in children's memory organization is specific to a particular type of task, that is, sorting. In light of these unresolved issues, the next logical step was to have children recall and sort the same stimulus words from the present study.

Study #2: Use of Associative Links in Recall and Sorting

Rationale and Hypotheses

Recall can provide additional information about memory structure that is not directly available in associability ratings (Cooke et al., 1986). Many different cognitive processes are involved in recall, the chief among them being encoding, storage and retrieval (Lange, 1978; Murphy & Puff, 1982). In simple terms, an individual must form a representation of an item to be recalled and store this representation in memory. Retrieval cues subsequently facilitate activation of the representation of the item in memory, so that the item is recalled (Rudy & Sutherland, 1992). Memory organization or structure is inferred on the basis of recall processes, and recall is assumed to vary as a function of the nature and stability of this memory structure.

It has been frequently reported that levels of recall, as well as the level of categorical organization in recall (i.e., clustering), increase with age (see Bjorklund, 1985; Bjorklund & Muir, 1988; Lange, 1978; Moely, 1977). Such age-related improvements in recall have been related to corresponding changes in memory structure (Bjorklund, 1989).

There is a substantial amount of literature to suggest that children's early concept formation is based on complementary/thematic relations in memory (see Bjorklund, 1985; Lange, 1978). Denney (1974) has proposed that the memory structures of young children are based on complementary relations, which derive from children's past or present experiences. Similarly, others such as Markman (1984, 1989) have argued that children's earliest organizational structures in memory are based on themes, which

reflect children's earliest experiences of objects and their properties (i.e., that objects can be related spatially, functionally and in an event). However, according to Markman (1989), although children five years of age and younger are captivated by thematic relations and find them more salient than categorical relations, young children are biased through their increased experience with language to organize items categorically, for nouns encode categorical relations. In fact, there is ample empirical evidence from a number of studies (i.e., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski; Frankel & Rollins, 1985; McCauley et al., 1976; also see Bjorklund, 1985; Lange, 1978; Markman, 1984, 1989) that an early form of memory structure is characterized by complementary/thematic relations and that a subsequent form of memory structure is characterized by taxonomic/categorical relations.

However, studies examining changes in the bases of children's memory structures have typically relied on a sort/recall procedure. With this procedure, children are given the opportunity to create their own groupings of stimulus items prior to recall via sorting. Investigators have favoured using such a procedure because it allows them to determine whether children use information from sorting in recall, and how children organize information for recall. Furthermore, investigators regard the contents of children's sorting groups as indicative of children's preferred or dominant organizational structures in memory.

Using the standard sort/recall procedure, several studies examining children's sorting and recall performance (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972) have found evidence of a

developmental trend in the criteria children use to group items, with younger children relying primarily on complementary/associative relations and older children relying primarily on similarity/categorical relations. However, other evidence in the recall literature appears to contradict this shift (see Lange, 1978) and not all researchers using the standard sort/recall procedure have found evidence of the shift (e.g., Worden, 1976). Part of the problem here may relate to the fact that researchers employing the sort/recall procedure use: different operational criteria for predetermined organized structures in stimulus materials; stimuli which have varying degrees of salience and which are more or less representative of various organizational structures; and children who vary widely in terms of age.

As well, it is possible that, by administering sorting prior to recall, children may be inadvertently biased to adopt some kind of organizational structure for recall, when they might not otherwise do so naturally. After all, there is no strong theoretical rationale for assuming that the memory processes invoked for sorting are necessarily the same as those invoked for recall. In fact, Worden (1976) found overall correlations between children's sorting and recall performance to be low and negative. Given the demands of each task, it is likely that recall and sorting are tapping into different aspects of children's memory.

Considering the potential for bias in the standard sort/recall procedure, the present study sought to replicate the proposed developmental shift from themes to categories by having More Creative and Less Creative children in grades 3 and 7 first recall a set of words, before sorting them. This recall/sort procedure also permitted examination of

the number and types of associative links in the memory structures of more creative and less creative children, in relation to Simonton's (1988) model.

During the initial phase of the present study, a free recall task was employed. This task was similar to that used by Bjorklund and Jacobs (1985), who assessed the free recall performance of children in grades 3, 5, 7 and 9 with lists of strongly and weakly associated word pairs from various categories. In contrast to Bjorklund and Jacobs' recall task, however, the free recall task employed in the present study made use of within-category, within-theme, and between-category-and-theme configural dimensions.

To the extent that between-category-and-theme associative links represent between-configuration links in Simonton's model, it was hypothesized that More Creative children would use more between-category-and-theme links among words for recall than Less Creative children. This hypothesis was based on the assumption, from Simonton's model, that More Creative children have more between-configuration links to access from their associative memory structures than Less Creative children. It was also hypothesized that More Creative children would use fewer within-category and within-theme links among words for recall than Less Creative children. Assuming that Simonton's model is accurate, More Creative children should have many weak within-configuration links, and Less Creative children should have many strong within-configuration links, in their associative memory structures. Given these differential association strengths for within-configuration links amongst creative children, Less

Creative children should be better able at accessing within-configuration links from memory than More Creative children.

Bjorklund and colleagues (i.e., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985) report evidence of a developmental shift from the use of associative/thematic and categorical relations to the use of categorical relations in memory. Specifically, Bjorklund and de Marchena (1984) found that Grade 1 children used associations, Grade 4 children used associations and categories, and Grade 7 children used categories on a free sorting/recall task. Similarly, Bjorklund and Jacobs (1985) subsequently found that only children in grades 7 and 9 showed clear evidence of categorical clustering in their free recall performance, while children in grades 3 and 5 did not. Extrapolating from these findings to children's recall performance in the present study, it was hypothesized that Grade 3 children would use an equal number of thematic and categorical associative links, whereas Grade 7 children would use more categorical than thematic associative links.

As the second phase of the present study, a sorting task, similar to that of Worden (1976), was employed. In view of the developmental evidence previously cited, it was hypothesized that the sorting performance of Grade 3 children would reflect equivalent use of themes and categories, whereas that of Grade 7 children would reflect greater use of categories than themes. No specific predictions were made regarding the sorting performance of More Creative and Less Creative children, respectively.

Subjects

The same groups of More Creative and Less Creative children in grades 3 and 7 from Study #1 were included in the present study. To ensure that children's previous exposure to the stimulus words would be controlled and that priming of their recall would therefore be minimal, this was actually the first of three studies that children participated in.

Stimulus Materials

Two sets of stimulus words were used in the present study, Sets A and B. In general, a list of words containing Set A words and buffer words was presented twice to children on the recall task. Separate matrices of Set A words and Set B words, respectively, were presented twice to children on the sorting task, with different sets of instructions across the two trials.

On the recall task, Set A words, from Study #1, were used so that results from the present and previous study could be compared. Four different sequences were constructed from the 16 words which could be related both categorically and thematically in Set A (see Table 11). Using an explicitly unblocked presentation order (Murphy & Puff, 1982), words were arranged such that no two words from the same category or theme were contiguous.

Data obtained from initial piloting of the recall task revealed that in addition to controlling for recency effects, it was necessary to control for primacy effects. Consequently, four buffer words were selected randomly from categories which were not included in either Set A or Set B words. These buffer words, selected from Posnansky

(1978), were the following: *hockey* (from the category SPORTS), *shirt* (from the category CLOTHING), *tomato* (from the category VEGETABLES), and *window* (from the category PARTS OF A BUILDING) (see Table 22 for corresponding word frequencies and category proportions). Of these four buffer words, two were selected and inserted

Table 22

Word Frequencies^a and Category Proportions^c for Buffer Words

Word	Total Frequencies ^b	Proportional Value	
		Gr. 3	Gr. 6
SPORTS <i>hockey</i>	13	.188	.308
CLOTHING <i>shirt</i>	222	.797	.856
VEGETABLES <i>tomato</i>	45	.391	.519
PARTS OF A BUILDING <i>window</i>	841	.359	.567

Note. Gr. = Grade.

^aWord frequencies were taken from Carroll et al. (1971) and include the total number of times a word occurred out of a corpus of 5,088,721 tokens. ^bTotal word frequencies were computed from samples of text for students in grades 3 to 9, as well as students in other grades. ^cProportional data was taken from Posnansky (1978) and represents proportions of children in grades 3 ($N = 64$) and 6 ($N = 104$) who generated specific instances of each category.

randomly at the beginning of each sequence of words to control for primacy effects. The remaining two buffer words were inserted randomly at the end of each sequence of words to control for recency effects. In total then, a particular sequence of 20 words was presented twice to each child during the recall task.

On the sorting task, a second, new set of words, Set B, was used as a stimulus, in addition to the words in Set A. For stimulus Set B, words and respective categories considered for inclusion were among those previously generated by children in grades 3 and 6 (see Posnansky, 1978), but were different from those included in stimulus Set A. Set B themes and corresponding words were devised by the researcher, using a procedure similar to that described in Study #1 for establishing Set A themes and corresponding words. The themes and corresponding words for Set B were subsequently piloted, to ensure that they were relatively salient for children.

For stimulus Set B, four words were selected from each of four categories, with the constraint that a word taken from each of the four categories also comprised one of four themes (see Table 23). In stimulus Set B, words in each category were the following: COLOURS--*purple, red, green, white*; BODY PARTS--*hand, heart, knee, stomach*; FLOWERS--*violet*,²⁵ *rose, dandelion, lily*; and ANIMALS--*rabbit, bear, frog, deer*. Set B words could also be rearranged into the following themes: EASTER--*purple, hand, violet, rabbit*; VALENTINE'S DAY--*red, heart, rose, bear*; PICNIC--*green,*

²⁵Originally, the word *carnation* had been included in the category FLOWERS and in the theme CHRISTMAS. However, a number of Grade 3 children in the pilot sample (i.e., 6 out of 13 children surveyed) either had difficulty reading the word or did not know what the word referred to. As a result, the word *carnation* was replaced by the word *violet* in the FLOWERS category.

Table 23

Arrangement of Words into Two Organizational Structures (Set B)

Categories				Themes
COLOURS	BODY PARTS	FLOWERS	ANIMALS	
<i>purple</i>	<i>hand</i>	<i>violet</i>	<i>rabbit</i>	EASTER
<i>red</i>	<i>heart</i>	<i>rose</i>	<i>bear</i>	VALENTINE'S ²⁶
<i>green</i>	<i>knee</i>	<i>dandelion</i>	<i>frog</i>	PICNIC
<i>white</i>	<i>stomach</i>	<i>lily</i>	<i>deer</i>	CHRISTMAS

knee, dandelion, frog; and CHRISTMAS--*white, stomach, lily, deer*.²⁷ Pilot testing of stimulus Set B verified that Grade 3 children could identify both categorical and thematic relations among words.

As with Set A words, it was necessary to conduct preliminary analyses of word frequencies and category proportions for words in stimulus Set B, to determine whether there were any biases present. Mean word frequencies were calculated for all categories and all themes in stimulus Set B, based on the word frequency norms of

²⁶Valentine's Day.

²⁷In the researcher's opinion, since the word *violet* seemed to be more cohesive with words in the EASTER theme than with words in the CHRISTMAS theme, and since the word *lily* seemed to be more cohesive with words in the CHRISTMAS theme than with words in the EASTER theme, the words *violet* and *lily* were switched in the category-theme matrix of Set B words. While both of these words remained in the FLOWERS category, *violet* became part of the EASTER theme and *lily* became part of the CHRISTMAS theme.

Carroll et al. (1971) (see Tables 24 & 25). These mean word frequencies were then submitted to a Category (4) x Theme (4) ANOVA using SYSTAT; Category (words in the four categories) and Theme (words in the four themes) were the independent variables. Only the main effects of Category and Theme were tested because these were of primary interest, and it was not possible to test the Category x Theme interaction with only one observation per cell (Winer, 1991). Mean word frequencies for Set B were found to be comparable across the four categories and across the four themes, thus suggesting no evident bias for recalling words from particular categories or from particular themes.

Also, Posnansky's (1978) category norms for grades 3 and 6 were used to ensure that Set B words could be discriminated from other categories and were representative of their respective categories. In terms of category discriminability for stimulus Set B, words in the FLOWERS category tended to overlap with those in the COLOURS category and vice versa (see Table 26). A potential problem emerged for the word *violet*, which could be categorized with seemingly equal likelihood as either a FLOWER or a COLOUR (see Table 26). However, the limited categorical discriminability for the word *violet* was not deemed likely to affect data analyses for the sorting task, particularly with respect to the proportions of within-category word pairs used by children in sorting Set B words.

Using proportional data obtained by Posnansky (1978), a Grade (2) x Category (4) ANOVA was conducted to examine the categorical representativeness of words in Set B; Grade (3, 6) and Category (the four categories in Set B) were the between-

Table 24

Set B Word Frequencies^a for Categories

Word	Total Frequencies ^b
COLOURS	(1253.75)
<i>purple</i>	157
<i>red</i>	1557
<i>green</i>	1216
<i>white</i>	2085
BODY PARTS	(906.25)
<i>hand</i>	2316
<i>heart</i>	1032
<i>knee</i>	93
<i>stomach</i>	184
FLOWERS	(146.50)
<i>violet</i>	58
<i>rose</i>	461
<i>dandelion</i>	30
<i>lily</i>	37
ANIMALS	(313.25)
<i>rabbit</i>	209
<i>bear</i>	557
<i>frog</i>	171
<i>deer</i>	316

Note. Mean word frequencies for categories are in parentheses.

^aWord frequencies were taken from Carroll et al. (1971) and include the total number of times a word occurred out of a corpus of 5,088,721 tokens. ^bTotal word frequencies were computed from samples of text for students in grades 3 to 9, as well as students in other grades.

Table 25

Set B Word Frequencies^a for Themes

Word	Total Frequencies ^b
EASTER	(685.00)
<i>purple</i>	157
<i>hand</i>	2316
<i>violet</i>	58
<i>rabbit</i>	209
VALENTINE'S DAY	(901.75)
<i>red</i>	1557
<i>heart</i>	1032
<i>rose</i>	461
<i>bear</i>	557
PICNIC	(377.50)
<i>green</i>	1216
<i>knee</i>	93
<i>dandelion</i>	30
<i>frog</i>	171
CHRISTMAS	(655.50)
<i>white</i>	2085
<i>stomach</i>	184
<i>lily</i>	37
<i>deer</i>	316

Note. Mean word frequencies for themes are in parentheses.

^aWord frequencies were taken from Carroll et al. (1971) and include the total number of times a word occurred out of a corpus of 5,088,721 tokens. ^bTotal word frequencies were computed from samples of text for students in grades 3 to 9, as well as students in other grades.

Table 26

Set B Category Proportions*

Word	Proportional Value		Largest Proportions for Other Categories		Category
	Gr. 3	Gr. 6	Gr. 3	Gr. 6	
COLOURS	(.738)	(.873)			
<i>purple</i>	.734	.846	-	-	FLOWERS
<i>red</i>	.922	.962	.031	-	
<i>green</i>	.750	.904	-	-	
<i>white</i>	.547	.779	-	-	
BODY PARTS	(.250)	(.255)			
<i>hand</i>	.422	.471	-	-	
<i>heart</i>	.203	.106	-	-	
<i>knee</i>	.203	.240	-	-	
<i>stomach</i>	.172	.202	-	-	
FLOWERS	(.258)	(.310)			
<i>violet</i>	.094	.212	.156	.135	COLOURS
<i>rose</i>	.719	.779	-	.019	COLOURS
<i>dandelion</i>	.141	.115	-	-	
<i>lily</i>	.078	.135	-	-	
ANIMALS	(.164)	(.286)			
<i>rabbit</i>	.172	.269	-	-	
<i>bear</i>	.250	.375	-	-	
<i>frog</i>	.047	.048	-	-	
<i>deer</i>	.188	.452	-	-	

Note. Gr. = Grade. Mean proportions for categories are in parentheses.

*Proportional data from Posnansky (1978) were used to compile this table. These data represent proportions of children in grades 3 ($N = 64$) and 6 ($N = 104$) who generated specific instances of each category.

subjects variables. Results of the ANOVA conducted on category proportions for Set B words revealed a significant main effect for Category, $F(3, 24) = 16.38$, $MS_e = .04$, $p < .001$ (see Table 26 for category proportions). The mean for the COLOURS category ($M = .806$, $SD = .134$) was found to be significantly higher than that for the BODY PARTS ($M = .252$, $SD = .127$), FLOWERS ($M = .284$, $SD = .290$) and ANIMALS ($M = .225$, $SD = .143$) categories. These results suggest that words in the COLOURS category were more representative of their respective category than words in other categories and therefore had a higher probability of being recalled by children than words from other categories (e.g., see Bjorklund & Muir, 1988). Thus with Set B words, there existed a categorical bias which could potentially limit children's use of within-theme and between-category-and-theme associative links, as well as their use of thematic and other organizational structures, on the sorting task.

Although Set B words appeared to be relatively recognizable by children, it not only was less discriminable than Set A words, but it also contained a categorical bias. Of note, however, Set B words were to be used only on the sorting task, as a basis for comparison with Set A words. Still, some caution was warranted when interpreting results obtained with Set B words.

In total, 16 Set A words and 16 Set B words were presented twice to children, in free and constrained sorting trials, thereby resulting in a total of four sorting trials (i.e., Trial 1, Free Sorting; Trial 2, Free Sorting; Trial 3, Constrained Sorting; and Trial 4, Constrained Sorting) (see Appendix E). The 16 words from Set A, which could be related both categorically and thematically, served as the primary set of stimuli for the

sorting task (see Table 11). For Set A words, the same order was used on the sorting task as that used on the recall task. A second set of words which could be related both categorically and thematically, Set B, was used to compare the stability of children's sorting performance with Set A words (see Table 23). For Set B words, four different sequences were used on the sorting task. As in an explicitly unblocked presentation order (Murphy & Puff, 1982), words in each stimulus set were arranged such that no contiguous words belonged to the same category or theme. The presentation of stimulus Sets A and B on the sorting task was counterbalanced across children, in order to control for any priming effects due to the prior presentation of Set A words on the recall task.

Stimulus words for Sets A and B, as well as buffer words, were offset printed in black letters on 7.5 x 12.5 cm white cards, for presentation purposes. Lettering was 20mm in size, and a font of Helvetica Light was used to facilitate readability of the words.

Procedure

For both the recall and sorting tasks, stimulus words were presented several times to each child in a quiet room, on an individual basis. This lasted approximately 20-30 minutes. Children were not informed that the stimulus words belonged to predetermined configural dimensions.

During the free recall task, each child was asked to pay careful attention to a series of words which he/she would later be asked to recall (see Appendix E for the actual instructions). In addition, he/she was instructed to try hard to remember the

words. The child was then simultaneously read and shown a series of 20 words, at a rate of one word every 4s.²⁸ Afterwards, the child was asked to verbally recall as many words as he/she could remember, in any order. The experimenter then recorded the child's responses in the order that they occurred. Once the child indicated that he/she could recall no more words, the child was prompted by the experimenter to think of all the words that had been presented. As soon as the child indicated that no more words could be recalled, the first recall trial ended, and a second recall trial began.²⁹ For the second recall trial, the child was informed that the same words would be presented to him/her again. Afterwards, the second recall trial followed the same basic procedure as the first recall trial (see Appendix E).

Once the second recall trial had been completed, the experimenter initiated the sorting task (see Appendix E for the actual instructions). For the first free sorting trial, each child was presented with a set of 16 words printed on cards. Each card was held up for the child to name and then placed on a table, face up, in front of the child.³⁰ Cards were placed by the experimenter in a 4 x 4 matrix, such that no two adjacent words belonged to the same category or theme. The child was then instructed to use all the words and to put the words which he/she thought belonged together in groups.

²⁸Words were presented via both an auditory and visual modality to minimize the possibility that Grade 3 children might take longer to read and encode the words than Grade 7 children.

²⁹A second study-test trial for recall was used to assess the course of organizational structures as a function of learning.

³⁰If the child had difficulty reading the word on the card, the experimenter helped him/her by reading the word and then having the child repeat it; the experimenter made note of which word the child had difficulty reading.

In addition, he/she was told that the groups could be big or small. The experimenter emphasized that the child use his/her own judgment in making groups of words.³¹ Once the child indicated that he/she was satisfied with his/her groups,³² the experimenter recorded the words included in the child's groups, as stated by the child, and asked the child for a name to describe each group of words. After the child had described each of his/her groups, the experimenter initiated a second free sorting trial.

The procedures used for subsequent sorting trials were similar to those used for the first free sorting trial, and differed only in terms of the stimulus set and primary instructions used (see Appendix E). On the second free sorting trial, the child was asked to sort an alternate matrix of words into groups of words that he/she thought went together. For the third trial, sorting was constrained. The child was shown the same matrix of words from the first free sorting trial and asked to sort the words into four groups. Similarly, in the fourth sorting trial, also constrained, the child was presented with the same matrix of words from the second free sorting trial and instructed to sort the words into four groups. Completion of the fourth sorting trial signalled the end of the sorting task. At this point, the experimenter praised the child for his/her efforts.

³¹When children attempted to use the homonym *dear* for the word *deer*, the experimenter suggested that they use another form of the word.

³² Any child who asked if words could go in more than one group was told that the words could only go in one group at a time; in this case, the experimenter asked the child to choose which group he/she preferred for the word in question and then noted the alternate groups that the child thought the word could belong to.

Results and Discussion:

Separate sets of data analyses were conducted for the recall and sorting tasks, respectively. The general design for data analyzed in Study #2 was a Grade (2) x Creativity (2) x Trial (2) ANOVA, with Grade (3,7) and Creativity (More Creative, Less Creative) as the between-subjects variables, and Trial (1,2) as the repeated-measures variable. For the analysis of data obtained on the sorting task, Trial was retained as a repeated-measures variable, even though change across time was confounded with a change in instructional set (i.e., instructing children to constrain their sorting groups to four).³³

Recall

The recall performance of More Creative and Less Creative children at grades 3 and 7 was examined with respect to the number of words recalled and organization in recall. Simonton's (1988) model assumes that more creative and less creative individuals of comparable intelligence possess the same basic concepts in their associative memory structures, and only differ in the number and strength of links among these concepts. Consequently, a preliminary analysis of children's overall level of recall

³³An issue arose as to there being a greater probability of children producing more between-category-and-theme associative links than within-category or within-theme associative links simply because there were more between-category-and-theme associative links. However, there was no statistical analysis for any of the production tasks (i.e., the recall and sorting tasks for Study #2) which compared all configural dimensions at one time. Furthermore, the numbers of various types of associative links were converted into proportions of the total number of associative links produced by children. Therefore, the fact that there were more between-category-and-theme than either within-category or within-theme associative links did not pose a problem in statistical analyses for Study #2.

was required to ensure that More Creative and Less Creative children at each grade did not differ in the number of words recalled.

The ANOVA on the total number of Set A words correctly recalled by children indicated significant main effects of Grade, $F(1, 76) = 24.07$, $MS_e = 5.52$, $p < .001$, and Trial, $F(1, 76) = 117.21$, $MS_e = 2.33$, $p < .001$ (see Table 27 for the means). Consistent

Table 27

Total Number of Words Correctly Recalled

Group	N	Number of Words Recalled	
		Trial 1	Trial 2
Grade 3			
More Creative	15	6.00 (1.73)	8.47 (1.89)
Less Creative	27	5.48 (1.78)	7.74 (2.18)
Grade 7			
More Creative	28	7.18 (1.87)	10.29 (2.11)
Less Creative	10	7.30 (2.26)	10.90 (2.08)

Note. Standard deviations are in parentheses.

with literature indicating increased recall with age (see Bjorklund & Muir, 1988; Ornstein & Corsale, 1979), Grade 7 children ($M = 8.83$, $SD = 1.68$) recalled significantly more words than Grade 3 children ($M = 6.83$, $SD = 1.64$). Also, children in general recalled significantly more words on Trial 2 ($M = 9.16$, $SD = 2.41$) than on Trial 1 ($M = 6.40$, $SD = 2.00$). Still, More Creative and Less Creative children at each grade did not differ significantly in terms of the total amount recalled across trials.

Organization in children's recall was measured in two ways: a clustering score, and proportions of various types of associative links observed in recall. Initially, a clustering score was used as a global measure of organization in children's recall because most studies on individuals' recall (e.g., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Corkill & Glover, 1987; Worden, 1976) tend to use clustering scores to assess organization in recall. Clustering is generally regarded as a summary statistic of categorical organization in individuals' recall output (see Bousfield, 1953).

The Adjusted Ratio of Clustering (ARC) score (Roenker, Thompson, & Brown, 1971) was used to evaluate clustering in children's recall since it appears to be minimally affected by extraneous factors, such as the number of categories in the stimulus list, or the number of words recalled (Murphy, 1979; Roenker et al., 1971). The latter factor is particularly important for developmental research, where the amount recalled often varies across children of different ages, as was demonstrated earlier. Various reviews of the ARC score (Murphy, 1979; Murphy & Puff, 1982; Pellegrino & Hubert, 1982) have concluded that it has adequate properties for measuring organization in recall and is amongst the most preferable of clustering measures. For any given recall protocol, the

ARC score represents the proportion of actual intracategory repetitions above chance to the total possible intracategory repetitions above chance (see Roenker et al., 1971).

To assess the degree of categorical and thematic organization in children's recall, ARC scores were calculated for the two recall trials for Set A words, with respect to categories and, analogously, with respect to themes. Mean category and theme ARC scores were then submitted to separate ANOVAs. The ANOVA on children's ARC scores for categories yielded only a significant main effect for Trial, $F(1, 76) = 8.45$, $MS_e = .20$, $p < .01$ (see Table 28 for the means). Children obtained significantly higher ARC scores for categories on Trial 2 ($M = .11$, $SD = .43$) than on Trial 1 ($M = -.10$, $SD = .57$). The ANOVA on children's ARC scores for themes also yielded a significant main effect for Trial, $F(1, 76) = 7.99$, $MS_e = .22$, $p < .01$ (see Table 29 for the means). As with categories, children obtained significantly higher ARC scores for themes on Trial 2 ($M = .04$, $SD = .38$) than on Trial 1 ($M = -.15$, $SD = .52$). Assuming that negative ARC scores are comparable to some extent with positive ARC scores (Murphy & Puff, 1982; Roenker et al., 1971), these results suggest that there was at least some categorical and thematic clustering in children's recall over time.

To test the hypothesis that More Creative children would use more between-category-and-theme associative links in their recall than Less Creative children, the use of consecutive types of associative links was considered in children's recall strings for trials 1 and 2. Each consecutive associative link was first coded as within category, within theme, or between category and theme. Then the various types of associative links were tallied and divided by the total number of associative links. This resulted in

Table 28

Mean Category ARC Scores for Recall

Group	<i>N</i>	Category ARC Scores	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.02 (.59)	.28 (.38)
Less Creative	27	-.22 (.58)	.05 (.56)
Grade 7			
More Creative	28	-.06 (.56)	.06 (.28)
Less Creative	10	-.07 (.60)	.16 (.39)

Note. Standard deviations are in parentheses.

proportional data, a continuous measure to which ANOVA could then be applied. Properties of the method used to calculate proportions of associative links were such that length of string was taken into account and therefore did not need to be calculated separately. Since the use of various types of associative links was similarly examined in children's sorting, data across both the recall and sorting tasks were comparable. Given that distinct configural dimensions in children's associative memory were being

Table 29

Mean Theme ARC Scores for Recall

Group	N	Theme ARC Scores	
		Trial 1	Trial 2
Grade 3			
More Creative	15	-.07 (.50)	.09 (.48)
Less Creative	27	-.14 (.60)	.06 (.41)
Grade 7			
More Creative	28	-.15 (.48)	-.05 (.32)
Less Creative	10	-.26 (.51)	.21 (.27)

Note. Standard deviations are in parentheses.

tested, separate ANOVAs were used to analyze proportions of within-category, within-theme, and between-category-and-theme associative links in children's recall strings for the two trials.

In the ANOVA on proportions of within-category associative links in children's recall strings, there was a significant main effect for Trial, $F(1, 76) = 7.49$, $MS_e = .02$, $p < .01$ (see Table 30 for the means). There was a significantly greater proportion of

Table 30

Mean Proportions of Within-Category Associative Links in Recall

Group	<i>N</i>	Within-Category Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.22 (.20)	.30 (.15)
Less Creative	27	.14 (.16)	.23 (.17)
Grade 7			
More Creative	28	.22 (.19)	.23 (.13)
Less Creative	10	.21 (.16)	.30 (.19)

Note. Standard deviations are in parentheses.

within-category associative links in children's recall at Trial 2 ($M = .25$, $SD = .15$) than at Trial 1 ($M = .19$, $SD = .18$).

Similarly, the ANOVA on proportions of within-theme associative links in children's recall strings indicated a significant main effect for Trial, $F(1, 76) = 10.43$, $MS_e = .02$, $p < .01$ (see Table 31 for the means). Similar to within-category associative links, there

Table 31

Mean Proportions of Within-Theme Associative Links in Recall

Group	N	Within-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.17 (.13)	.21 (.15)
Less Creative	27	.15 (.15)	.25 (.17)
Grade 7			
More Creative	28	.16 (.15)	.19 (.13)
Less Creative	10	.16 (.15)	.31 (.12)

Note. Standard deviations are in parentheses.

was a significantly greater proportion of within-theme associative links in children's recall at Trial 2 ($M = .23$, $SD = .15$) than at Trial 1 ($M = .16$, $SD = .14$).

The ANOVA on proportions of between-category-and-theme associative links in children's recall strings revealed not only a significant main effect for Trial, $F(1, 76) = 20.46$, $MS_e = .03$, $p < .001$, but also significant interaction effects for Grade x Creativity, $F(1, 76) = 4.36$, $MS_e = .04$, $p < .05$, and for Creativity x Trial, $F(1, 76) = 4.04$, $MS_e = .03$,

$p < .05$ (see Table 32 for the means). In terms of the significant main effect for Trial, there was a significantly greater proportion of between-category-and-theme associative links in children's recall at Trial 1 ($M = .65$, $SD = .22$) than at Trial 2 ($M = .53$, $SD = .18$).

Table 32

Mean Proportions of Between-Category-and-Theme Associative Links in Recall

Group	<i>N</i>	Between-Category-and-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.62 (.26)	.50 (.17)
Less Creative	27	.71 (.20)	.53 (.19)
Grade 7			
More Creative	28	.63 (.21)	.59 (.17)
Less Creative	10	.64 (.21)	.40 (.16)

Note. Standard deviations are in parentheses.

To test the significant interaction effects for Grade x Creativity and Creativity x Trial, post hoc tests were conducted on means for the four experimental groups at each

trial; it was not possible to collapse means across Trial or Grade, as the variable Grade was involved in a significant interaction effect with one of the other two variables. The results of the post hoc tests indicated that at Trial 1, none of the groups were significantly different, whereas at Trial 2, the Grade 7 Less Creative group displayed a significantly lower proportion of between-category-and-theme associative links in their recall than the Grade 7 More Creative group. Based on their recall performance at Trial 1, all children demonstrated relatively high proportions of between-category-and-theme associative links in their recall (see Figures 8 & 9), as compared with relatively low proportions of within-category and within-theme associative links (see Tables 30 & 31). By Trial 2, proportions of between-category-and-theme associative links declined (see Figures 8 & 9), as proportions of within-category and within-theme associative links increased, in children's recall (see Tables 30 & 31), likely as children began to adopt an organizational (i.e., more categorical) strategy. Proportions of between-category-and-theme associative links in recall remained comparable for both More Creative and Less Creative children in Grade 3 over time (see Figure 8). However, lower proportions of between-category-and-theme associative links were found in the recall of Less Creative children than in that of More Creative children in Grade 7 over time (see Figure 9). Taken together, these findings suggest that older less creative children have difficulty retaining between-category-and-theme associative links for recall, unlike their more creative counterparts who are able to retain this ability.

Since the between-category-and-theme configural dimension was really an undefined structure, it was necessary to rule out an order of presentation effect that

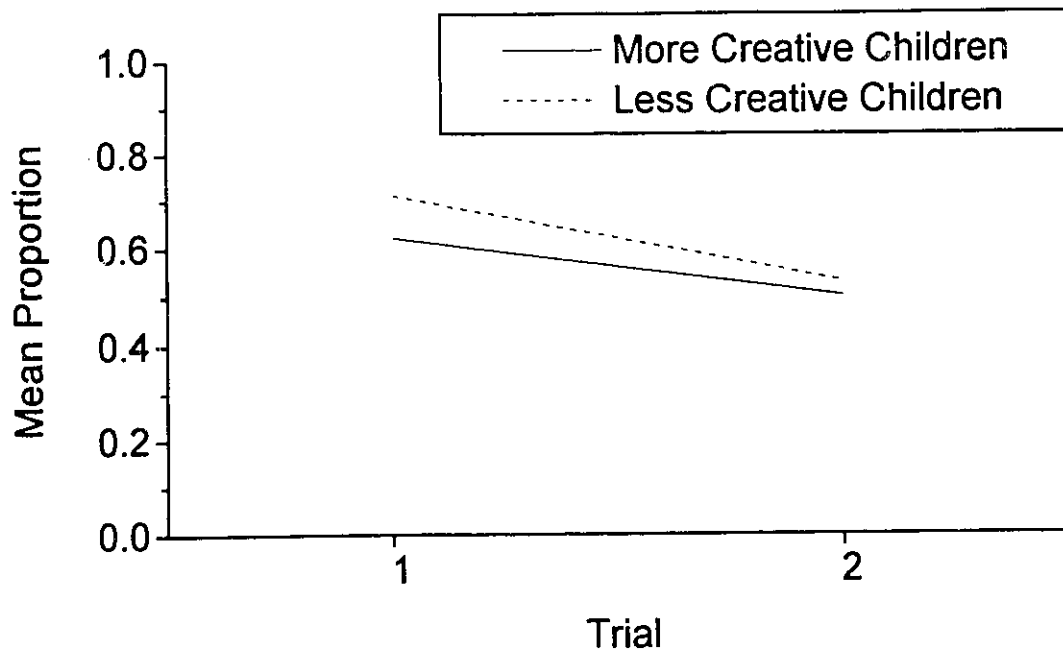


Figure 8. Mean proportions of between-category-and-theme associative links in recall for Grade 3 children across trials.

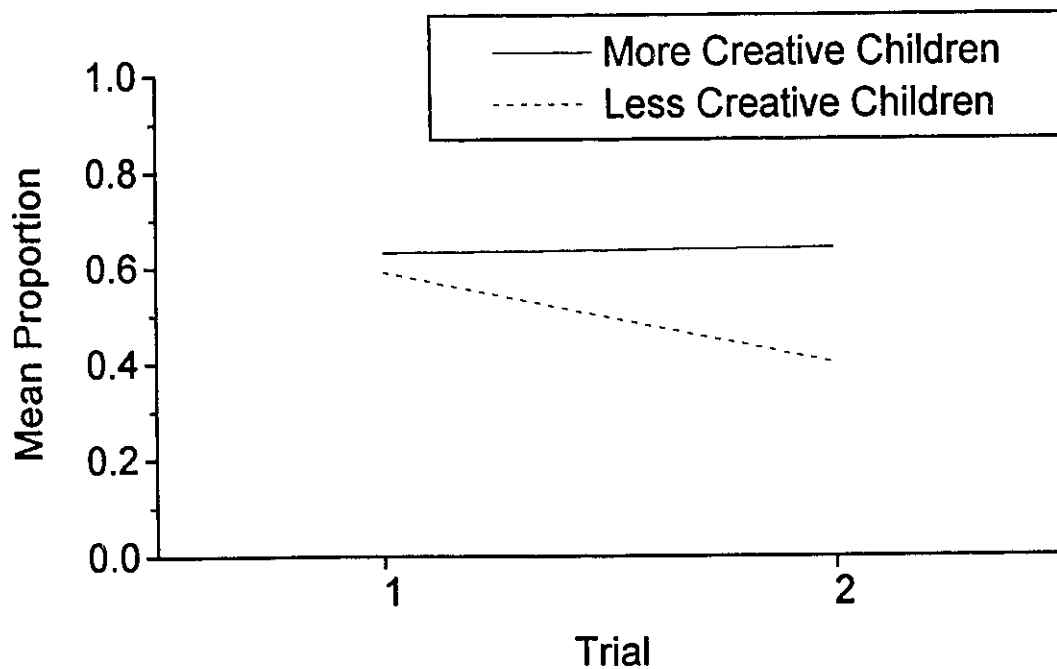


Figure 9. Mean proportions of between-category-and-theme associative links in recall for Grade 7 children across trials.

might account for the relatively high proportions of between-category-and-theme associative links observed in children's recall strings. To this end, several serial position curves were constructed for trials 1 and 2, respectively. At each trial, the number of times the position of a word in the stimulus list matched the position of the word recalled was calculated for each of the 16 words in Set A for all 80 children. As illustrated in Figures 10 and 11, at Trial 1, there was a clear primacy effect which became weaker by Trial 2. However, this primacy effect appeared to be limited to the first word in the stimulus list. In addition, the strongest evidence for the primacy effect at Trial 1 was based on the recall performance of only 26 out of 80 children. Therefore, the primacy effect observed, particularly at Trial 1, could not account for the high proportions of between-category-and-theme links observed in children's recall.

To summarize the results of children's performance on the recall task, older children recalled more than younger children, and children in general recalled more on the second trial than on the first trial, consistent with what has been reported in the literature (see Bjorklund, 1985; Bjorklund & Muir, 1988; Lange, 1978; Moely, 1977). However, contrary to what was hypothesized, there was no evidence of a developmental shift in children's recall in the present study; that is, Grade 3 children did not use equal proportions of within-category and within-theme associative links in recall, nor did Grade 7 children use more within-category than within-theme associative links in recall. Of course, unlike the other studies citing evidence of clear-cut organizational structures in children's recall (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972), the present study did not employ the typical sort/

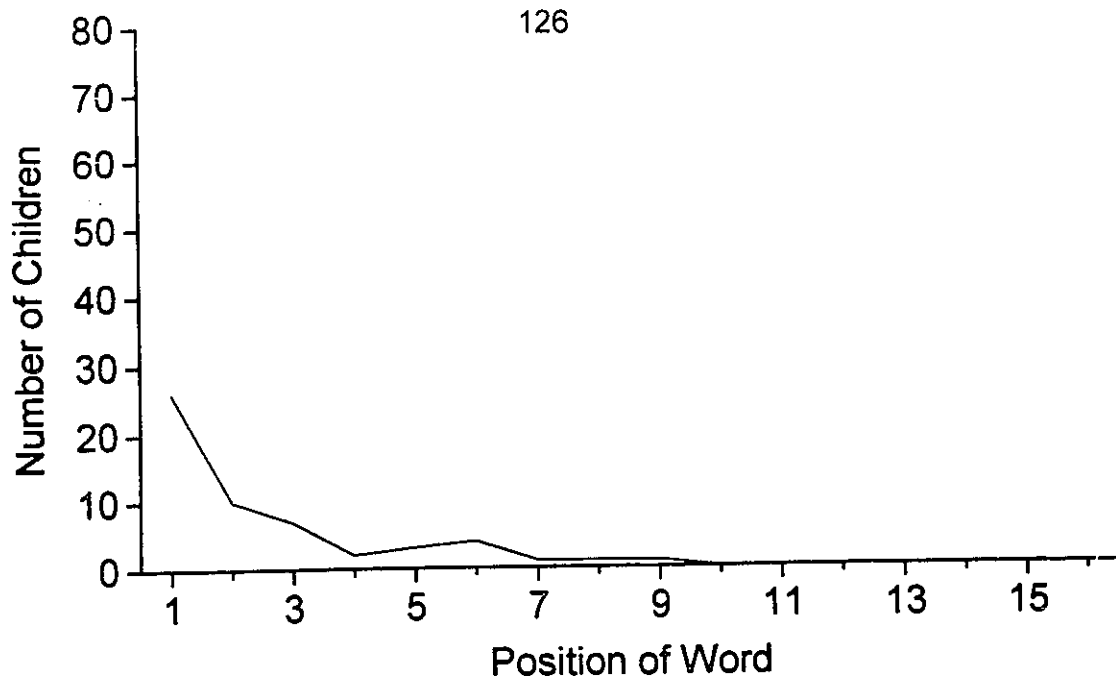


Figure 10. Serial position curve for the recall performance of all 80 children at Trial 1.

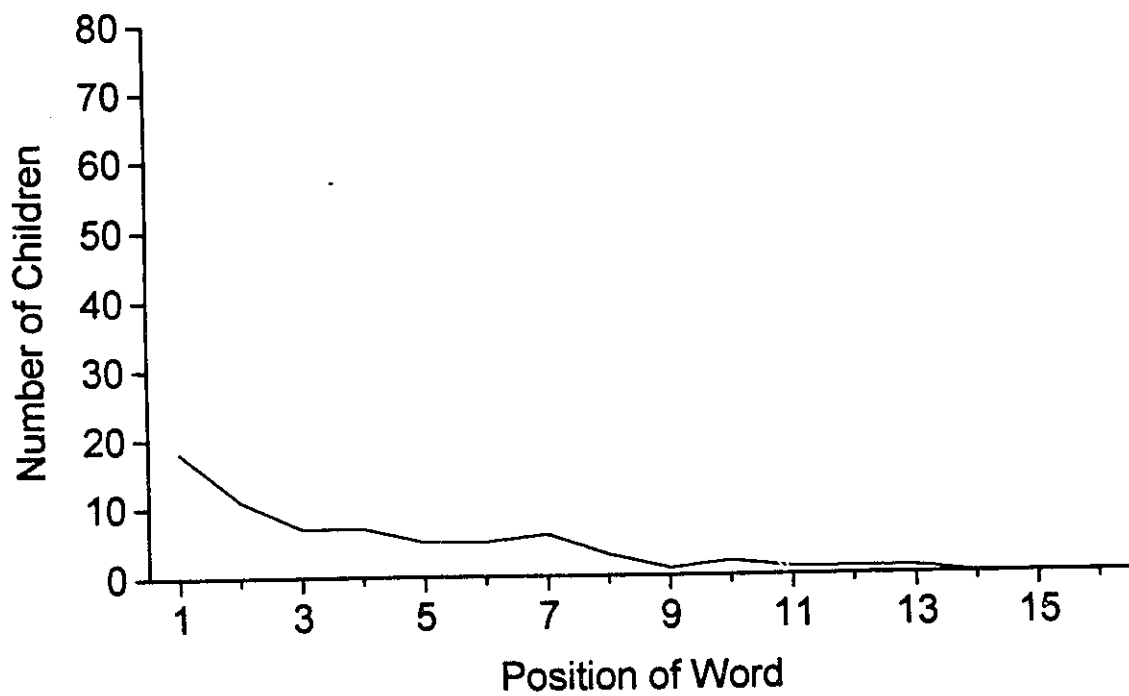


Figure 11. Serial position curve for the recall performance of all 80 children at Trial 2.

recall procedure. In studies that employ this procedure, it may be the sorting task itself which is highly effective in promoting children's use of an organizational structure in recall.

Children in the present study appeared to be using a high proportion of between-category-and-theme associative links to facilitate their recall, and these were not the product of an order of presentation effect. As demonstrated by their recall performance, more creative children tended to be fairly stable in their use of between-category-and-theme links, whereas less creative children tended to drift more towards within-category and within-theme links over time (see Figures 8 & 9). While younger children and older more creative children consistently used a moderate proportion of between-category-and-theme links in memory over time, older less creative children tended to relinquish these in favour of a more strategic and arguably a more conventional approach to recall, that is, by relying primarily on within-category links in memory, similar to the less creative individual in Simonton's (1988) model. Thus results obtained for children on the recall task lent some support for Simonton's (1988) model, in that older more creative children tend to make greater use of between-configuration links and less use of within-configuration links in memory than older less creative children.

Sorting

With respect to children's performance on the sorting task, data obtained for the two sets of stimulus words, Sets A and B, were analyzed separately because the two sets of words were not comparable, nor were they ever used at the same time.

As a control measure, preliminary analyses were conducted on the total number of groups made by children on the sorting task. The total number of groups made by each child on the free sorting trials was calculated separately for both Set A and Set B words, and then submitted to separate Grade (2) x Creativity (2) ANOVAs. No significant effects were found for the number of sorting groups made by children for either Set A or Set B words, thereby indicating that the number of groups made on the free sorting trials were comparable for all children (see Tables 33 & 34). Of note, the

Table 33

Means and Standard Deviations for Number of Groups in Set A Free Sorting

Group	<i>N</i>	Number of Groups	
		Mean	Standard Deviation
Grade 3			
More Creative	15	5.60	1.40
Less Creative	27	5.11	1.01
Grade 7			
More Creative	28	5.25	1.21
Less Creative	10	5.20	1.40

Table 34

Means and Standard Deviations for Number of Groups in Set B Free Sorting

Group	<i>N</i>	Number of Groups	
		Mean	Standard Deviation
Grade 3			
More Creative	15	4.67	1.29
Less Creative	27	4.30	.87
Grade 7			
More Creative	28	4.18	.72
Less Creative	10	4.00	.00

mean number of sorting groups made by children tended to be approximately 5 for Set A words and 4 for Set B words (see Tables 33 & 34). It was not necessary to analyze the total number of groups made by children on the constrained sorting trials for the two sets of words, since these were always experimentally constrained to four via the instructional set.

To assess children's use of organizational structures in sorting, proportions of within-category, within-theme, and between-category-and-theme associative links used by children on the sorting task were examined. For each sorting group made by children

on the two free and the two constrained sorting trials, each associative link was considered sequentially and classified according to the configural dimensions determined a priori (i.e., as within category, within theme, or between category and theme). Frequencies for each type of associative link in each sorting group were calculated and converted to proportions of the total number of word pairs used and the total number of groups made. Proportional data was used here to control for unequal numbers of various types of word pairs and sorting groups across children.

Analysis of the proportions of within-category associative links used by children in sorting Set A words revealed a significant main effect of Grade, $F(1, 76) = 7.32$, $MS_e = .08$, $p < .01$, and a significant interaction effect of Creativity x Trial, $F(1, 76) = 5.05$, $MS_e = .03$, $p < .05$ (see Table 35 for the means). Grade 7 children ($M = .86$, $SD = .17$) used a significantly higher proportion of within-category associative links in their sorting of Set A words than did Grade 3 children ($M = .75$, $SD = .23$).

Four t -tests were conducted to compare each of the four means involved in the significant interaction effect; alpha was divided by four and set to .01 for each t -test conducted, in order to control the Type I error rate. There were no significant differences between More Creative and Less Creative children in the proportions of within-category associative links used in sorting Set A words at trials 1 and 2. For More Creative children, however, there was a marginally significant increase in the proportion of within-category associative links used in sorting Set A words from Trial 1 ($M = .76$, $SD = .26$) to Trial 2 ($M = .86$, $SD = .21$), $t(42) = -2.61$, $p < .06$. In contrast, Less Creative children were fairly stable in terms of the proportion of within-category associative links used in

Table 35

Mean Proportions of Within-Category Associative Links in Set A Sorting

Group	N	Within-Category Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.73 (.28)	.79 (.25)
Less Creative	27	.76 (.26)	.73 (.24)
Grade 7			
More Creative	28	.77 (.26)	.89 (.19)
Less Creative	10	.96 (.08)	.92 (.12)

Note. Standard deviations are in parentheses.

sorting Set A words at Trial 1 ($M = .81$, $SD = .24$) and Trial 2 ($M = .78$, $SD = .23$) (i.e., the difference between the two trials was not significant). However, since any difference obtained across sorting trials is confounded by time and instructional set, it is difficult to ascertain whether the marginally significant difference between trials for More Creative children was due to drift over time or to the manipulation of instructional set. It is possible that More Creative children's greater use of within-category associative links

across sorting trials may reflect their particular sensitivity to constraint (i.e., being asked to make four groups); that is, More Creative children become more categorical in their sorting of Set A words over trial due to their heightened sensitivity to the instructional set (see Martindale, 1977-78).

Yet, this effect was not found for children's sorting of Set B words. Analysis of the proportions of within-category associative links used by children in sorting Set B words indicated only a significant main effect for Grade, $F(1, 76) = 7.41$, $MS_e = .04$, $p < .01$ (see Table 36 for the means³⁴). As with Set A words, Grade 7 children ($M = .93$, $SD = .09$) used significantly more within-category associative links in their sorting of Set B words than did Grade 3 children ($M = .86$, $SD = .17$).

Analysis of the proportions of within-theme associative links in children's sorting of Set A words indicated a significant main effect of Trial, $F(1, 76) = 6.23$, $MS_e = .01$, $p < .05$ (see Table 37 for the means). Although there were no significant interaction effects in this analysis, the Grade x Creative interaction was marginal, $F(1, 76) = 3.90$, $MS_e = .03$, $p < .06$. In terms of the significant main effect of Trial, children used a significantly higher proportion of within-theme associative links in their sorting of Set A words on Trial 1 ($M = .14$, $SD = .17$) than on Trial 2 ($M = .08$, $SD = .12$).

However, analysis of the proportions of within-theme associative links in children's sorting of Set B words indicated a significant main effect of Grade, $F(1, 76) = 4.65$,

³⁴The ratio of the largest to the smallest obtained variance was 22:1 for the analysis of within-category word pairs in Set B sorting. While attempts were made to transform the data set, this ratio remained large. Given that a violation of the assumption of homogeneity of variances exists and cannot be removed, the results for this analysis must be considered tentative.

Table 36

Mean Proportions of Within-Category Associative Links in Set B Sorting

Group	N	Within-Category Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.76 (.28)	.85 (.18)
Less Creative	27	.87 (.17)	.89 (.17)
Grade 7			
More Creative	28	.91 (.15)	.92 (.11)
Less Creative	10	.95 (.06)	.95 (.07)

Note. Standard deviations are in parentheses.

$MS_e = .01$, $p < .05$ (see Table 38 for the means³⁵). Grade 3 children ($M = .05$, $SD = .09$) used a significantly higher proportion of within-theme associative links in their sorting of Set B words than did Grade 7 children ($M = .02$, $SD = .03$).

³⁵For the analysis of within-theme word pairs in Set B sorting, the ratio of the largest to the smallest obtained variance was 64:1. It was impossible to transform the data set, owing to subjects having zero values. Consequently, a violation of the assumption of homogeneity of variances exists for this analysis, and the results must therefore be interpreted tentatively.

Table 37

Mean Proportions of Within-Theme Associative Links in Set A Sorting

Group	<i>N</i>	Within-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.14 (.15)	.05 (.09)
Less Creative	27	.16 (.19)	.12 (.13)
Grade 7			
More Creative	28	.15 (.18)	.06 (.13)
Less Creative	10	.04 (.07)	.05 (.08)

Note. Standard deviations are in parentheses.

Differences obtained for the two sets of words, in terms of proportions of within-theme associative links used in children's sorting, highlight the fact that the two different sets of stimulus words have different properties and hence can create different effects. Specifically, proportions obtained for Set B words suggest that Grade 3 children used more within-theme associative links in sorting than did Grade 7 children, whereas proportions obtained for Set A words suggest that all children used more within-theme

Table 38

Mean Proportions of Within-Theme Associative Links in Set B Sorting

Group	N	Within-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.09 (.13)	.03 (.08)
Less Creative	27	.06 (.16)	.03 (.07)
Grade 7			
More Creative	28	.02 (.05)	.03 (.05)
Less Creative	10	.01 (.03)	.01 (.02)

Note. Standard deviations are in parentheses.

associative links in sorting at Trial 1 than at Trial 2. In view of these mixed results, it was unclear as to the extent of children's usage of within-theme associative links in sorting, with respect to grade.

Analysis of the proportions of between-category-and-theme associative links in children's sorting of Set A words indicated a significant main effect of Grade, $F(1,$

76) = 7.96, $MS_e = .03$, $p < .01$ (see Table 39 for the means³⁶). Grade 3 children ($M = .13$, $SD = .16$) used a significantly higher proportion of between-category-and-theme

Table 39

Mean Proportions of Between-Category-and-Theme Associative Links in Set A Sorting

Group	N	Between-Category-and-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.14 (.20)	.17 (.21)
Less Creative	27	.09 (.12)	.14 (.21)
Grade 7			
More Creative	28	.08 (.15)	.04 (.09)
Less Creative	10	.01 (.02)	.04 (.06)

Note. Standard deviations are in parentheses.

³⁶The ratio of the largest to the smallest obtained variance was 110:1 for the analysis of between-category-and-theme word pairs in Set A sorting. Since subjects had zero values, it was impossible to transform the data set. Thus a violation of the assumption of homogeneity of variances exists for this analysis, and the results should therefore be considered tentative.

associative links in their sorting of Set A words than did Grade 7 children ($M = .05$, $SD = .09$).

Similarly, the ANOVA on the proportions of between-category-and-theme associative links used in children's sorting of Set B words also indicated a significant main effect of Grade, $F(1, 76) = 6.50$, $MS_e = .01$, $p < .05$ (see Table 40 for the means).

Table 40

Mean Proportions of Between-Category-and-Theme Associative Links in Set B Sorting

Group	N	Between-Category-and-Theme Associative Links	
		Trial 1	Trial 2
Grade 3			
More Creative	15	.15 (.17)	.12 (.13)
Less Creative	27	.07 (.06)	.08 (.11)
Grade 7			
More Creative	28	.07 (.12)	.05 (.07)
Less Creative	10	.04 (.05)	.05 (.07)

Note. Standard deviations are in parentheses.

As with Set A words, Grade 3 children ($M = .10$, $SD = .10$) used a significantly higher proportion of between-category-and-theme associative links in their sorting of Set B words than did Grade 7 children ($M = .05$, $SD = .07$).

Based on convergent results obtained from analyses of the proportional data for sorting, Grade 7 children used more within-category associative links in sorting than did Grade 3 children. As well, Grade 3 children used more between-category-and-theme associative links in sorting than did Grade 7 children. However, children's use of within-theme associative links in sorting was less clear, due to differential effects obtained for the two sets of words. Thus, the proposed developmental shift to categories with age was partially confirmed, with Grade 7 children using more categories as organizational structures in sorting than Grade 3 children. While Grade 3 children used more alternate organizational structures in their sorting than Grade 7 children, these proportions were low. In general then, there appeared to be an increase in categorical sorting with grade, and this was preceded by the use of some type (s) of alternate organizational structures.

Each of the four sorting trials was further examined to determine if the distribution of children who tended to use categories, themes or some other type of organization differed with respect to level of grade and creativity. For each set of words and sorting trial, children were classified as either categorical, thematic or other sorters, based on their highest proportion of associative links used in sorting. Multiway frequency analyses were then computed for frequencies of various types of sorters for each set of words at each trial.

All multiway frequency analyses employed a Grade (2) x Creativity (2) x Type of Sorter (3) model. Trials were considered separately because hierarchical loglinear models are not designed to handle correlated variables (Tabachnick & Fidell, 1989).

For Set A words at Trial 1, tests of partial associations indicated a significant one-way effect for Type of Sorter, **partial $\chi^2(2, N = 80) = 103.28, p < .001$** (see Table 41 for

Table 41

Frequencies of Various Types of Sorters for Set A Words at Trial 1

Group	N	Type of Sorter		
		Categorical	Thematic	Other
Grade 3				
More Creative	15	13	1	1
Less Creative	27	23	4	0
Grade 7				
More Creative	28	24	2	2
Less Creative	10	10	0	0

the actual frequencies). Separate follow-up chi square analyses ($\alpha/3 = .02$) revealed a significantly greater number of categorical sorters than thematic, **$\chi^2(1, N = 77) = 51.55$** ,

$p < .001$, or other sorters, $\chi^2(1, N = 73) = 49, p < .001$ (see Table 41). With Set A words, virtually all children could be classified as categorical sorters at the first trial.

At Trial 2, the multiway frequency analysis revealed a significant one-way effect for Type of Sorter, **partial $\chi^2(2, N = 80) = 133.37, p < .001$** , and a significant two-way effect for Grade x Type of Sorter, **partial $\chi^2(2, N = 80) = 6.47, p < .05$** (see Table 42 for

Table 42

Frequencies of Various Types of Sorters for Set A Words at Trial 2

Group	N	Type of Sorter		
		Categorical	Thematic	Other
Grade 3				
More Creative	15	13	0	2
Less Creative	27	25	0	2
Grade 7				
More Creative	28	27	1	0
Less Creative	10	10	0	0

the actual frequencies). As a follow-up to the significant two-way interaction, types of sorters were compared at each grade ($\alpha/6 = .01$). At Grade 3, there was a significantly greater number of categorical sorters than thematic, $\chi^2(1, N = 38) = 38.00$,

$p < .001$, or other sorters, $\chi^2(1, N = 42) = 27.52, p < .001$. At Grade 7, there was also a significantly greater number of categorical sorters than thematic, $\chi^2(1, N = 38) = 34.11, p < .001$, or other sorters, $\chi^2(1, N = 37) = 37.00, p < .001$.

For Set B words at Trial 1, tests of partial associations indicated a significant one-way effect for Type of Sorter, **partial** $\chi^2(2, N = 80) = 124.84, p < .001$ (see Table 43 for

Table 43

Frequencies of Various Types of Sorters for Set B Words at Trial 1

Group	N	Type of Sorter		
		Categorical	Thematic	Other
Grade 3				
More Creative	15	12	1	2
Less Creative	27	25	2	0
Grade 7				
More Creative	28	27	0	1
Less Creative	10	10	0	0

the actual frequencies). Separate chi square analyses ($\alpha/3 = .02$) indicated that there was a significantly greater number of categorical sorters than thematic, $\chi^2(1, N = 77) = 65.47, p < .001$, or other sorters, $\chi^2(1, N = 77) = 65.47, p < .001$ (see Table 43).

At Trial 2, the multiway frequency analysis indicated a significant one-way effect for Type of Sorter, *partial* $\chi^2(2, N = 80) = 165.03, p < .001$ (see Table 44 for the actual

Table 44

Frequencies of Various Types of Sorters for Set B Words at Trial 2

Group	N	Type of Sorter		
		Categorical	Thematic	Other
Grade 3				
More Creative	15	15	0	0
Less Creative	27	26	0	1
Grade 7				
More Creative	28	28	0	0
Less Creative	10	10	0	0

frequencies). Separate chi square analyses ($\alpha/3 = .02$) revealed a significantly greater number of categorical sorters than thematic, $\chi^2(1, N = 79) = 79.00, p < .001$, or other sorters, $\chi^2(1, N = 80) = 76.05, p < .001$ (see Table 44).

On the basis of their highest proportion of associative links used in sorting, almost all children could be classified as categorical sorters for both sets of words. For all of the multiway frequency analyses conducted, there was no effect found for level of

creativity. Still, as Table 41 shows, some Grade 3 children, as well as some Grade 7 More Creative children could be classified as thematic or other sorters with Set A words on the first trial. However, by the second trial, when sorting was constrained to four groups, more children could be classified as categorical sorters, though several children at Grade 3 and one Grade 7 More Creative child remained classified as other and thematic sorters, respectively (see Table 42).

While similar results were obtained for Set B words, higher numbers of categorical sorters emerged for Set B words than for Set A words (compare Tables 42 & 44 with Tables 41 & 43). This may be due to the categorical bias inherent in Set B words, as indicated by earlier analyses of category proportions. Nevertheless, distributions obtained for the various types of sorters across sets of stimulus words and trials seemed to coincide with the proportional data obtained for children's sorting.

In the present study, categories appeared to be the predominant organizational structures used by children for sorting words into groups. Furthermore, children's category usage became more salient with age and likely with instructional set.

Some evidence was obtained in the present study for the often-cited developmental shift to categories in children's sorting performance. As hypothesized, Grade 7 children used more categories for sorting than did Grade 3 children. However, contrary to what was hypothesized, Grade 3 children used more alternate organizational structures for sorting than did Grade 7 children, though the nature of these alternate organizational structures remains unclear.

Directing the number of children's sorting groups via instructional set seemed to have the effect of changing children's entire organizational scheme used in sorting to categories, as opposed to themes or other organizational structures. This is consistent with other studies which have found increased categorical sorting among children when the categorical structures in items have been made more salient, either through increasing the number of items (Bjorklund & de Marchena, 1984) or by presenting items sequentially as in a blocked design (Bjorklund & Jacobs, 1985); the strongest effect, similar to that obtained in the present study, has been obtained with the latter of the two manipulations.

Of course, in the present study, any conclusions made regarding changes in instructional set on the sorting task must be tentative, given the confounding of instructional set with time for the Trial variable. As a result, children's increased use of categories in their sorting performance across trials may be attributed to the subtle experimental manipulation of being constrained to four sorting groups or to the drift towards category usage over time. Interestingly, with respect to level of creativity, more creative children, as compared to less creative children, tended to resist somewhat the overall trend towards increased category usage in sorting, at least initially.

Study #3: Deciding on the Associability of Word Pairs

Rationale and Hypotheses

The purpose of the third study was to provide an alternate measure of the distribution of associative strength in children's memory structures, in terms of the time taken to access associative links from memory. According to network theories of

semantic memory (e.g., Collins & Loftus, 1975; Quillian, 1968), it is generally assumed that the time taken to compare two items along a dimension is inversely related to the distance between two concepts in memory. Consequently, in research on the organization of semantic memory, the degree of relatedness among concepts has been typically assessed through reaction times (e.g., Collins & Quillian, 1969).

Although it has been argued in the developmental literature (e.g., Bjorklund, 1989; Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972; Markman, 1984, 1989; McCauley et al., 1976; Worden, 1976) that there are changes in the associative basis of semantic memory with age, evidence for age-related changes in speed of retrieval from semantic memory has not been consistent (see Whitney, 1986). Part of the reason for this is that speed of retrieval from semantic memory may not be a simple, unitary phenomenon (Whitney, 1986). In fact, implicit in tasks designed to measure speed of retrieval from semantic memory are several stages of information processing (see Whitney, 1986). Typically, an individual must first perceptually encode some visual stimulus and then access an internal representation for the stimulus. This representation can then be used or manipulated to make a decision which is relevant to the task. To make a decision, the individual selects and initiates a motor response (i.e., pressing a button). Thus an individual's performance on a reaction time task could be influenced by a variety of factors including: the allocation of attention to the stimuli; the encoding of stimuli; strategic processing; and/or physiological responding. However, determining how the aforementioned factors interact with developmental changes in semantic memory has yet to be addressed (Whitney, 1986).

Despite difficulties in determining exactly what reaction times reveal about access from semantic memory, there has been some converging evidence from several studies examining semantic priming effects in children. This evidence suggests that categorical relations become more well-defined and firmly established in semantic memory with increasing age.

McCauley et al. (1976) examined differences in the time taken by children of various ages to name pairs of pictures varying in associative and categorical relatedness. In their study, children in Kindergarten and Grade 2 were shown pairs of pictures, one picture at a time, and were asked to name each picture as rapidly and as accurately as possible. Picture pairs were high and low on dimensions of associative and categorical relatedness, as determined by the ratings of college students. McCauley et al. found that children in Grade 2 were faster at naming pictures than children in Kindergarten. While children of all ages named pictures in high-associative pairs faster than those in low-associative pairs, only Grade 2 children named pictures in high-categorical pairs faster than those in low-categorical pairs. These results suggest that by Kindergarten, strong associative relations are already established in semantic memory, though it is not until Grade 2 when strong categorical relations become evident. On the basis of these results, McCauley et al. (1976) concluded that there is no age-related reorganization of semantic memory, but rather, categorical relations are added to already-existing associative relations.

A study by Guttentag (1984), which employed a picture-naming interference paradigm to assess the organization of semantic memory in children and adults,

provided some support for the results McCauley et al. (1976) obtained with Grade 2 children. In Guttentag's study, Grade 2 children and adults had to name pictures, while trying to ignore distractor words printed inside the pictures. Distractor words were either high or low in associative relatedness with respect to the pictures they accompanied, and picture-word pairs were either within category or between category boundaries. Overall, adults were found to be faster at naming pictures than children. Also, both children and adults displayed slower reaction times when responding to pictures containing within-category, as opposed to between-category, printed words. Yet children, as compared to adults, displayed more interference with within-category, than with between-category, words. These results suggest that categorical relations in semantic memory are not as well-defined for children at the Grade 2 level as they are for adults. Since there was no evidence of any explicit change in associative relative to categorical relations in semantic memory after Grade 2, the most that Guttentag could surmise was that the semantic memory organization of Grade 2 children is based, in part, on categorical relations.

In view of the findings obtained by McCauley et al. (1976) and Guttentag (1984), it is unclear how associative and categorical relations would be organized in the semantic memories of creative children, as well as in children older than 7 years of age. Consequently, in the present study, the responses and reaction times of More Creative and Less Creative children in grades 3 and 7 were compared on an association-decision task. Children were required to decide quickly and accurately as to whether an association existed between various pairs of words presented to them on a computer screen; word pairs could be classified as within category, within theme, and between

category and theme. Reaction times served as measures of associative strength, whereas responses (i.e., YES and NO) served to indicate the existence of associative links, among words presumably stored in children's long-term memory. It was assumed that reaction time decreases as the strength of association between a pair of words increases (Collins & Loftus, 1975; Collins & Quillian, 1969). Still, it must be stressed that reaction times represent the total duration of all events occurring between the presentation of a stimulus and the final motor response (i.e., pressing a key). Thus the time required to access concepts from memory likely accounts for only a small proportion of the entire reaction time recorded. Therefore, using reaction times to estimate the time taken to access concepts from associative memory must be regarded as a rough measure at best.

Nevertheless, for the association-decision task in the present study, it was hypothesized that More Creative children would take longer than Less Creative children to decide on the associability of between-category-and-theme word pairs, since, as Simonton (1988) suggests, more creative individuals tend to have a number of weak between-configuration links while less creative individuals do not. Since weak links should be more difficult to make a decision upon quickly than either strong links or no link at all, it was further hypothesized that, for both YES and NO responses, More Creative children would display slower reaction times than Less Creative children when deciding on the associability of between-category-and-theme word pairs. Also, it was hypothesized that More Creative children would be slower in deciding on the associability of within-category and/or within-theme word pairs than Less Creative children, because

many of the within-configuration links are supposed to be weaker in the associative memory structures of more creative individuals than in those of less creative individuals. No specific hypotheses were made with respect to children's grade level, considering that children were above the Grade 2 level, and changes in semantic memory structure have only been documented for children below the Grade 2 level (e.g., Guttentag, 1984; McCauley et al., 1976).

The present study, when combined with Study #1, represented a significant methodological advance over previous research on associative memory structure. In prior studies examining children's memory organization (e.g., Bjorklund & Jacobs, 1984), as well as word associations (e.g., Gentile & Seibel, 1969), the degree of associability among words has generally been assessed through ratings. According to Cook et al. (1986), there have been no studies to date which have used both ratings and reaction times as measures of associative memory structure.

Subjects

The same More Creative and Less Creative children in grades 3 and 7 who participated in the preceding two studies also completed the present study. This was actually the second study in a series of three.

Hand dominance was considered to be an extraneous factor which could potentially affect children's responses and ensuing reaction times on the association-decision task. In the experimental sample, approximately 93% of the children were right-handed, and 7% were left-handed. To control for response bias due to hand dominance, the buttons designated as YES and NO on the response box used for the association-

decision task were counterbalanced for half of the More Creative and Less Creative children at each grade. The role of counterbalancing was to cancel the handedness effect in the data set. Consequently, handedness was not treated as a source of variance in statistical analyses of data obtained on the association-decision task.

Apparatus and Stimulus Materials

The entire association-decision task was programmed using the Micro Experimental Laboratory (MEL) software package (Schneider, 1989). Stimulus word pairs were presented to each child on a Toshiba T1000 Laptop computer, in a quiet room and in the presence of an experimenter. Characters appeared black on a white LCD screen, which was 10 x 22.5 cm in size and which had a display capacity of 24 lines with 80 characters on each line. A response was entered by a child pressing one of two buttons on either side of a black response box, 15 x 9 x 5.5 cm in size and displaying four red buttons with corresponding lights across the top. The response box was connected to the laptop computer.

Prior to the presentation of the actual stimulus word pairs, each child completed a series of 5 practise trials, each consisting of the presentation of a single word pair. Word pairs selected for the practise trials were taken from McCauley et al. (1976) and comprised the following: *nurse--doctor*, *lion--dog*, *saddle--horse*, *pants--saw*, and *butterfly--hat* (p.514). These word pairs were selected for the practise trials because they had corresponding mean ratings which represented a wide range on dimensions of categorical relatedness and associative relatedness, in McCauley et al.'s sample (see Table 45). A random sequence of these practise word pairs was generated by the

Table 45

Mean Categorical and Associative Ratings for Word Pairs Used on Practise Trials for the Association-Decision Task

Word Pair ^a	Rating ^b	
	Categorical	Associative
<i>nurse--doctor</i>	8.2	8.2
<i>lion--dog</i>	7.2	4.3
<i>saddle--horse</i>	5.1	8.2
<i>pants--saw</i>	3.0	1.0
<i>butterfly--hat</i>	1.0	1.0

^aWord pairs were selected from among those reported by McCauley et al. (1976) to have a range of mean categorical and associative ratings. ^bIn McCauley et al.'s study, college students rated word pairs on a 9-point scale, in terms of the degree to which words belonged to the same category (categorical relatedness) and in terms of associative strength (associative relatedness).

computer for each child, though the order of words within a pair remained constant. Word pairs selected for the practise trials were different from those used on the actual test trials.

The actual stimulus word pairs used were the same 120 word pairs used for the associability-rating task in Study #1; this was done for the purposes of comparing results across the two studies. From 16 words that could be organized both categorically and thematically in stimulus Set A (see Table 11), 120 word pairs were devised for Study #1, such that 24 were within category, 24 were within theme, and 72 were between category and theme (see Appendix F). Thus, on the association-decision task, each child

completed 120 trials, 60 trials at a time, with each trial consisting of the presentation of a single word pair.

For each series of 60 trials, the computer generated a random sequence of 60 word pairs for presentation, though the order of words within a pair remained constant. On each trial, the computer automatically recorded the trial number, the stimulus word pair that had been presented, the child's response, and his/her reaction time in ms.

Procedure

It took approximately 15 minutes for each child to complete the association-decision task. The child typically sat in front of a computer screen, with an experimenter sitting alongside. All instructions, as well as all word pairs, which appeared on the computer screen were read to the child as they were displayed.³⁷

The experimenter began by placing a small 5 x 15 cm card displaying YES and NO on top of the computer keyboard. She explained that the child was going to see pairs of words appear, one at a time, on the computer screen and that his/her task was to decide whether or not the two words belong together by pressing a button on the response box (see Appendix E for the actual instructions). It was emphasized that the child respond quickly yet accurately, and pay attention to the fixation point when it appeared because that would show the child where to focus his/her attention for the word pair. The experimenter demonstrated how the child was to respond YES or NO, depending on whether or not the child thought the two words belonged together. She

³⁷This occurred because many Grade 3 children in the pilot sample displayed difficulty reading the words quickly and accurately from the screen.

then instructed the child to keep his/her hands on either side of the response box. The child was also told to guess if he/she was unsure, since there were no right or wrong answers, and to continue to respond even if he/she had not pressed the button of choice. Once the child indicated that he/she was ready to begin the task, the experimenter started the program. The message 'One moment please' was displayed on the screen as the computer was setting up for various phases of the association-decision task.

On the opening screen, each child saw the cartoon character Garfield who invited him/her to play a game (see Appendix I). As an incentive, the child was required to make a decision for all word pairs to see Garfield score a basket. In order to become familiar with the task, the child was initially presented with a series of 5 practise trials on the computer screen.

Prior to the presentation of a series of trials, the prompt 'Please make a decision for all word pairs. Press any button to begin...' was displayed on the screen. At the beginning of each trial, a fixation point (indicated by a '+' sign) was always displayed in the centre of the screen for a duration of 2000 ms before the word pair to focus children's attention. The rate of presentation for all word pairs was subject-controlled up to 30000 ms. If the child took 30 s or more to respond to a word pair, the computer recorded a reaction time of 30000 ms and automatically proceeded to the next trial.

For all trials, fixation points and word pairs appeared on line 7 of the screen; the reason for this specific location for fixation points was to draw the child's attention to the word pairs first. There were always 9 spaces between each pair of words displayed.

The words 'YES' and 'NO' appeared 6 lines down, and were positioned on either side of the screen, with 18 spaces in between; 'YES' and 'NO' indicated which buttons corresponded to YES and NO on the response box. The order of YES and NO was determined by the computer, which designated the order YES--NO to all children receiving odd subject numbers and the order NO--YES to all children receiving even subject numbers.

As the child responded on each practise trial, the experimenter reinforced the child for his/her responses. If the child hesitated for a long period of time, the experimenter prompted him/her to press a button. After the practise trials were completed, a warning appeared saying 'This is the end of the practise. Let's see what you think of the following words... Press any button to begin.' This remained on the screen, at which point the experimenter praised the child for his/her efforts.

Then the following message appeared on the screen: 'Do these words go together... Please decide quickly. Press any button to continue...' The child then proceeded through the first 60 test trials, on his/her own. Once the child made a decision by pressing a button, the next word pair appeared on the screen. This procedure was the same for all word pairs.

Following the 60th trial, a message appeared on the computer screen indicating that it was time to take a short break. For approximately 40 minutes, the child completed a set of interpolated tasks (i.e., those on a WISC-R Short Form and the WRAT-R).

Afterwards, the child was instructed to return to the computer to complete the final 60 trials. Once the experimenter reiterated a shortened version of the same basic instructions conveyed to the child at the beginning of the task (see Appendix E), the child was left to complete the final 60 trials on his/her own.

After the child completed the 60th trial (or 120th trial in total), the cartoon character Garfield appeared on the closing screen to playfully demonstrate that he had missed the basket, and to reinforce the child for having made a lot of decisions and to thank him/her for his/her help (see Appendix I). The experimenter then praised the child for working hard throughout the session, and thanked the child for his/her help.

Results and Discussion

Mean reaction times were calculated for within-category, within-theme, and between-category-and-theme word pairs, for each of the children in the More Creative and Less Creative groups at grades 3 and 7. Researchers often compute the median rather than the mean for reaction time data because the median is relatively insensitive to extreme fluctuations in reaction times, as sometimes found with small samples. However, given the possibility of differential bias when using median reaction times, Miller (1988) recommends that the mean be used instead of the median when a different number of observations have been obtained, either across trials or across individuals. Since there were different numbers of observations for each of the experimental groups and for each type of stimulus word pair, mean reaction times were computed instead of the median reaction time for each child.

Nevertheless, as a precautionary measure, the overall distribution of children's reaction times was examined for outliers. For the experimental sample, reaction times ranged from a minimum of 1625.70 to a maximum of 3158.74. Values of .60 and .11 were recorded for skewness and kurtosis, respectively, thereby indicating a positively skewed and slightly leptokurtic distribution. This distribution seems to coincide with the fact that children's reaction times overall were quite long. Since an experimenter read the word pairs to children as they appeared on the computer screen, a constant positive value was added to the reaction times obtained, and this may partly explain why the obtained reaction times were so long. Still, none of the recorded reaction times appeared to deviate significantly from normality.

Children's mean reaction times were then submitted to a Grade (2) X Creativity (2) X Type of Word Pair (3) X Response (2) ANOVA; Grade (3, 7) and Creativity (More Creative, Less Creative) were the between-subjects variables, and Type of Word Pair (within category, within theme, between category and theme) and Response (YES, NO) were the within-subjects variables. This ANOVA on children's mean reaction times indicated only a significant main effect for Grade, $F(1, 76) = 8.96$, $MS_e = 1624214.60$, $p < .01$ (see Table 46 for the means). Grade 7 children ($M = 2007$, $SD = 436.07$) displayed significantly faster reaction times than Grade 3 children ($M = 2443$, $SD = 540.60$). One interpretation of this significant finding is that older children are able to access concepts in their associative memories more efficiently than younger children, due to greater speed of information processing. Alternatively, the main effect for Grade could simply indicate that Grade 7 children read more efficiently than Grade 3 children, and

Table 46

Mean Reaction Times* for YES and NO Responses on the Association-Decision Task

Group	N	Type of Word Pair and Response					
		Within Category		Within Theme		Between Category and Theme	
		YES	NO	YES	NO	YES	NO
Grade 3							
More Creative	15	2456 (658.53)	2360 (1074.66)	2360 (522.16)	2206 (633.10)	2357 (863.36)	2245 (746.91)
Less Creative	27	2546 (569.90)	2402 (560.04)	2486 (1103.14)	2337 (511.71)	2645 (881.34)	2305 (420.69)
Grade 7							
More Creative	28	1924 (418.15)	2086 (949.55)	1902 (339.44)	1981 (540.82)	1961 (507.31)	1938 (409.31)
Less Creative	10	2097 (563.23)	2163 (556.75)	2192 (912.98)	1924 (383.50)	2027 (318.44)	1939 (408.41)

Note. Standard deviations are in parentheses.

*Reaction times are in ms.

that this specific component is unequal across the experimental groups. Even if this latter interpretation is true, the within-grade reaction time comparisons remain strong and unconfounded.

On the association-decision task, a YES response was considered to be indicative of an association or link, whereas a NO response was considered to be indicative of no link, in a child's associative memory structure. To determine whether More Creative children had a greater number of links in their associative memory structures relative to Less Creative children, the proportion of YES responses was calculated for within-category, within-theme, and between-category-and-theme word pairs.³⁸ These proportions were submitted to a Grade (2) x Creativity (2) x Type of Word Pair (3) ANOVA. Only YES responses were analyzed, since the results for NO responses were the direct complement of those obtained for YES responses. Nevertheless, the mean proportions of NO responses are reported in Table 48.

The ANOVA on mean proportions of children's YES responses revealed a significant main effect for Type of Word Pair, $F(2, 152) = 20.13$, $MS_e = .02$, $p < .001$, and significant interaction effects for Creativity x Type of Word Pair, $F(2, 152) = 3.60$, $MS_e = .02$, $p < .05$, and Grade x Creativity x Type of Word Pair, $F(2, 152) = 3.12$, $MS_e = .02$, $p < .05$ (see Table 47 for the means). In general, the proportion of YES responses was significantly greater for within-category word pairs ($M = .65$, $SD = .22$), than for either within-theme ($M = .24$, $SD = .15$) or between-category-and-theme word pairs ($M = .14$, $SD = .13$).

³⁸It was decided to include data obtained from all children in this analysis, since from a conceptual standpoint, children who responded with all YES responses or all NO responses were conveying important information about the number of links in their associative memory structures. The number of children who always responded YES or NO were few, amounting to five in total: one in the Grade 3 More Creative group, two in the Grade 3 Less Creative group, and two in the Grade 7 More Creative group.

Table 47

Mean Proportions of YES Responses on the Association-Decision Task

Group	N	Type of Word Pair		
		Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	15	.63 (.22)	.25 (.20)	.15 (.16)
Less Creative	27	.52 (.23)	.20 (.13)	.12 (.13)
Grade 7				
More Creative	28	.75 (.17)	.29 (.15)	.17 (.13)
Less Creative	10	.74 (.11)	.20 (.12)	.13 (.10)

Note. Standard deviations are in parentheses.

To test the significant three-way interaction, post hoc tests were first conducted on proportions of YES responses for each particular type of word pair, comparing all four experimental groups. The Grade 3 Less Creative group had a significantly lower proportion of YES responses for within-category word pairs than did either the Grade 7 More Creative group or the Grade 7 Less Creative group (see Table 47). This

Table 48

Mean Proportions of NO Responses on the Association-Decision Task

Group	<i>N</i>	Type of Word Pair		
		Within Category	Within Theme	Between Category and Theme
Grade 3				
More Creative	15	.38 (.22)	.75 (.20)	.85 (.16)
Less Creative	27	.48 (.23)	.80 (.13)	.88 (.13)
Grade 7				
More Creative	28	.25 (.17)	.71 (.15)	.83 (.13)
Less Creative	10	.25 (.11)	.80 (.12)	.87 (.10)

Note. Standard deviations are in parentheses.

suggested that Grade 3 Less Creative children perceived fewer associative links for within-category word pairs than Grade 7 children, which is consistent with findings reported by McCauley et al. (1976) and Guttentag (1984). Yet it was not clear why Grade 3 More Creative children did not perceive fewer associative links for within-category word pairs as well. In terms of the proportions of YES responses made for

within-theme word pairs, none of the experimental groups were significantly different (see Table 47). Similarly, none of the experimental groups were significantly different in terms of the proportions of YES responses obtained for between-category-and-theme word pairs (see Table 47). Therefore, all children were comparable with respect to the number of associative links perceived for both within-theme and between-category-and-theme word pairs.

Next, post hoc tests were conducted on proportions of YES responses made by each of the experimental groups, comparing within-category, within-theme, and between-category-and-theme word pairs. For the Grade 3 More Creative group, the proportion of YES responses for within-category word pairs was found to be significantly higher than that obtained for either within-theme or between-category-and-theme word pairs (see Table 47). As well, for the Grade 3 Less Creative group, the proportion of YES responses for within-category word pairs was found to be significantly higher than that obtained for either within-theme or between-category-and-theme word pairs (see Table 47). However, the proportion of YES responses made by the Grade 7 More Creative group was found to be significantly higher for within-category than for within-theme word pairs, and significantly higher for within-theme than for between-category-and-theme word pairs (see Table 47). Similar to the results obtained for both the More Creative and Less Creative groups at Grade 3, the Grade 7 Less Creative group made a significantly higher proportion of YES responses for within-category word pairs than for either within-theme or between-category-and-theme word pairs (see Table 47). For all experimental groups, the overall pattern was that children perceived more associative links for within-

category word pairs, than for within-theme or between-category-and-theme word pairs (see Figure 12).

In summary, data obtained on the association-decision task indicated no significant differences between More Creative and Less Creative children in reaction times or responses. As an index of associative strength, mean reaction times obtained for word pairs comprising different configural dimensions were comparable for More Creative and Less Creative children at each grade. Proportions of YES and NO decisions as to the associability of various pairs of words were also comparable for both More Creative and Less Creative children at each grade. These results suggest that, contrary to Simonton's (1988) model, the associative memory structures of more creative and less creative children are similar, in terms of both the number and strength of within- and between-configuration links.

As well, contrary to those who maintain that the content and organization of categorical information develops considerably from 5 to 12 years of age (see Markman, 1984, 1989; Rosch, 1978; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), and the findings of McCauley et al. (1976) and Guttentag (1984) which were described earlier, there was no evidence in the present study of changing categorical relations in memory with age. Of course, the present study examined the reaction times and responses of children in only grades 3 and 7. Since McCauley et al. (1976) found evidence of changing categorical relations between Kindergarten and Grade 2, and since Guttentag (1984) found no evidence of changing categorical relations after Grade 2,

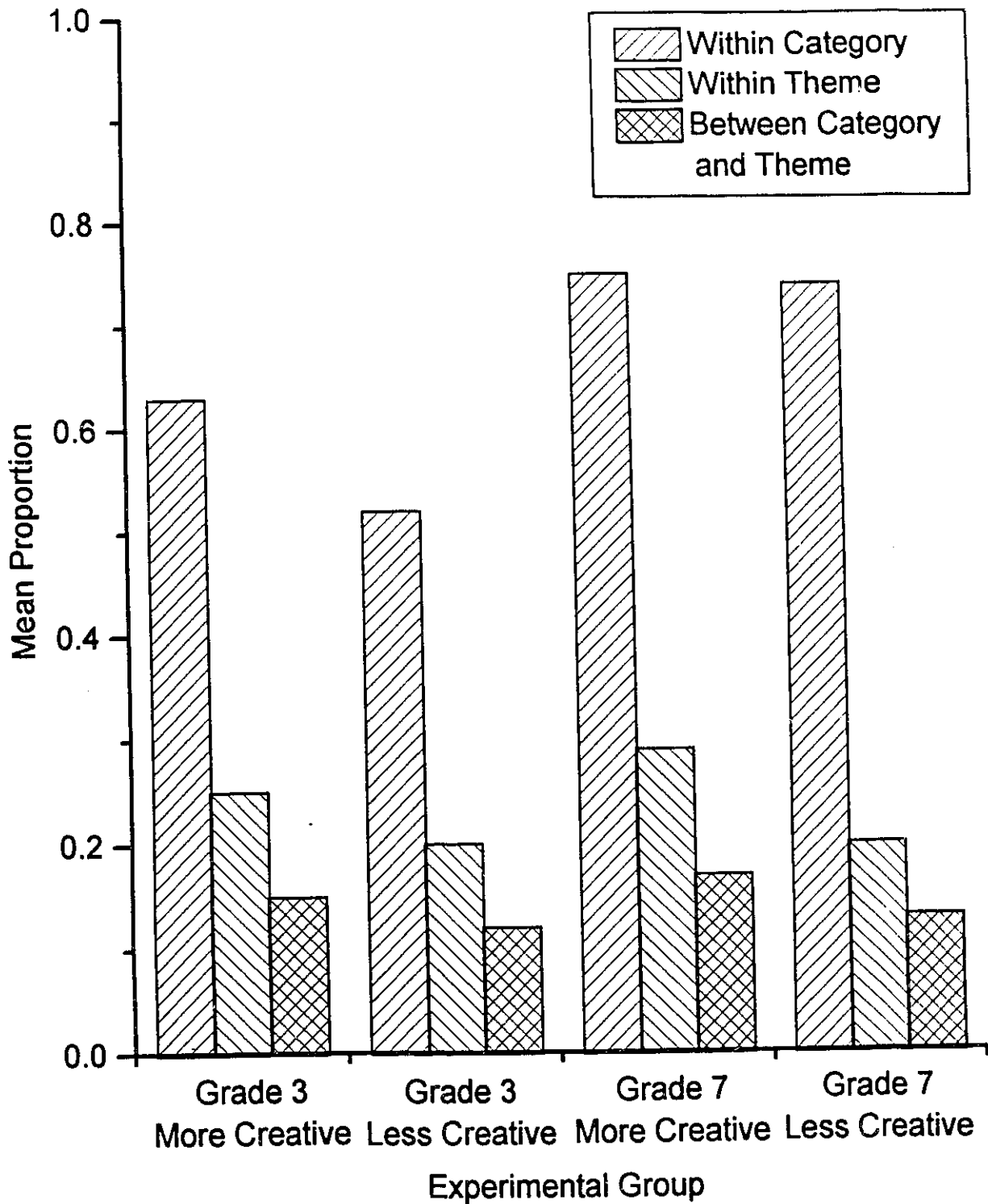


Figure 12. Mean proportions of YES responses for each experimental group for various types of word pairs on the association-decision task.

similar to the present study, it is likely that the most dramatic changes in categorical relations occur with very young children (i.e., 5 or 6 years of age and under).

Still, in the present study, it was found that Grade 7 children were faster than Grade 3 children in deciding whether associations existed for various types of word pairs. This finding is similar to those obtained by McCauley et al. (1976) and Guttentag (1984), which tend to suggest faster speed of semantic retrieval for older than younger individuals. It is possible that older children possess a more efficient associative memory structure which allows them to retrieve information from memory with greater ease than younger children. Older children's greater speed of information processing may be due to having shorter links in their associative memory structures than younger children, as suggested by data obtained in Study #1.

The general trend on the association-decision task employed in the present study was for children to perceive more links for within-category word pairs, than for either within-theme or between-category-and-theme word pairs (see Figure 12). To the extent that YES and NO responses on the association-decision task yield information as to the number of associations or links in children's memory structures, it may be said that categorical word pairs possess more links in children's associative memory structures than either thematic or other word pairs. These results tend to replicate those obtained for the associability-rating task in Study #1, in that children perceive words in categories as being more strongly associated and having more links than words in themes or other types of configurations. Thus convergent evidence was obtained from two studies in the present research to support the notion that categories are the predominant type of

configuration in the associative memory structures of children who are 8 years of age and older.

General Discussion

Deriving from introspectionist accounts by eminent creative individuals (see Ghiselin, 1952), theoretical models following in the associationist tradition (e.g., Mednick, 1962) have proposed that creative thinking involves the ability to generate and select novel and useful combinations of ideas, or remote associations. Simonton (1988) offers a model which posits that a creative individual's ability to engage in such a thinking process relates to the structure of his/her associative memory. However, given that there is a paucity of studies examining the associative memory structures of creative individuals, and that considerable effort has been devoted in the developmental literature to delineating various types of organizational structures in children's memories, this research explored how associational processes operate in children vis-à-vis their memory structures. As well, this research sought to replicate part of a transition often cited in the developmental literature (e.g., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Denney, 1974; Denney & Ziobrowski, 1972; McCauley et al., 1976) from themes to categories as organizational structures in children's memory.

A series of three studies, each employing different memory tasks, were conducted to examine differences in the associative memory structures of More Creative and Less Creative children in grades 3 and 7. Study #1 used children's associability ratings as an index of how words or concepts are organized in children's memories. It was found that all children, regardless of creativity or grade level, rated within-category word pairs

as higher in associative strength than either within-theme or between-category-and-theme word pairs (see Figure 2). Computer-generated associative memory networks derived from the associability-rating data provided further evidence that the associative memory networks of children in each of the experimental groups (i.e., Grade 3 More Creative, Grade 3 Less Creative, Grade 7 More Creative and Grade 7 Less Creative) were remarkably similar, both in terms of the number and strength of associative links (see Tables 19 & 21). In view of the results obtained for children's associability ratings, there appear to be no major differences in the associative memory structures of more creative versus less creative, nor older versus younger, children. Instead, all children's associative memory structures seem to be characterized by many strong within-category associative links, fewer and weaker within-theme associative links, and very few and weak between-category-and-theme associative links.

Study #2 examined children's use of associative links among words, first on a recall task and then on a sorting task. All children used relatively high proportions of between-category-and-theme associative links in recall initially (see Figures 8 & 9), but they used higher proportions of within-category and within-theme associative links in recall over time. Both More Creative and Less Creative children in Grade 3 used comparable proportions of between-category-and-theme associative links in recall, and this was stable across trials (see Figure 8). However, Less Creative children in Grade 7 used lower proportions of between-category-and-theme associative links in recall across trials than More Creative children in Grade 7 (see Figure 9). In contrast, on the sorting task, all children increasingly used a substantial proportion of within-category

associative links across trials. Yet Grade 7 children used a higher proportion of within-category, and a lower proportion of between-category-and-theme, associative links in sorting than did Grade 3 children. Although both the recall and sorting tasks were presumed to be tapping into children's associative memory structures, they yielded different results as to the nature of children's associative memory structures.

In Study #3, an association-decision task was used to assess the degree of associative strength in children's associative memory structures, similar to the associability-rating task used in Study #1. Grade 7 children obtained faster reaction times than Grade 3 children for all pairs of words, suggesting more efficient access to memory as children grow older. Nevertheless, the general trend was for all children to perceive more associative links for within-category word pairs, than for either within-theme or between-category-and-theme word pairs (see Figure 12). These results essentially replicate those obtained for the associability-rating task in Study #1. Specifically, children regard words in categories as being more strongly associated and having more associative links than words in themes or other types of configurations. On the basis of evidence obtained across all three studies, though not all experimental tasks, it would appear that categories constitute the predominant type of configuration in the associative memory structures of children in Grade 3 and above, though themes and other types of configurations do seem to co-exist.

The Associative Memory Structures of Creative Individuals

The three aforementioned studies provide partial support for the hypothesis that more creative children differ from less creative children with respect to their associative

memory structures, yet not in the way Simonton's (1988) model would predict. Data obtained indicate that older more creative children retain the use of between-category-and-theme associative links for recall over trials, as do younger children regardless of creativity level, whereas older less creative children relinquish the use of between-category-and-theme associative links for recall over trials. Consequently, older more creative children may not have a very different associative memory structure from that of other children, but they are better able at consistently accessing between-configuration links than older less creative children. Extrapolating from these results to theoretical models of creativity, it can be argued that creative children's continued ability to access between-configuration links over time is what allows them to generate more remote associations than other children.

Recent evidence obtained in a study by Londner (1991) supports the view that creative children do in fact manifest qualitatively different 'connection-making' processes than less creative children. Observing Grade 6 children as they talked aloud and completed figural tasks on the TTCT, Londner found that children who produced more original drawings adopted what she calls 'a Story-Weaving process', a process which involves combining a wide range of elements and then integrating these in the form of a picture. In contrast, children who produced less original drawings were observed to make connections which were bound to the content and context of their initial idea. This latter finding of Londner's is similar to that obtained in the present research for older less creative children, who eventually abandoned using between-configuration links in favour of using within-configuration links for recall. In view of the present research, one

possible interpretation of Londner's results is that older less creative children remain bound to pre-established associations, unlike older more creative children who remain open to alternate types of associations.

Indeed, such openness to alternate types of associations has long been said to characterize the creative thinking process. In their landmark research on male art students, Getzels and Csikszentmihalyi (1976) observed a relation between the way students went about creating a drawing, and both the judged quality of their creations and their creative accomplishments seven years later. Creative art students, as compared to their less creative colleagues, paid more attention to formulating a problem from an arrangement of given objects and remained open to changing the arrangement of objects as they were drawing them. Getzels and Csikszentmihalyi described this openness to revise decisions made earlier, on the part of the creative individual, as 'problem finding'. Based on Getzels' and Csikszentmihalyi's findings with art students, it appears that the creative individual spends more time exploring possible ideas, instead of quickly narrowing these down by applying a number of constraints. This is consistent with what was found in the present research with older more creative children, that is, a willingness to continue to consider between-configuration associations over time, instead of quickly moving to within-configuration associations like their less creative peers.

The creative individual's ability to remain open to possible associations among ideas and to apply constraints less readily than other individuals seems to bear some relation to his/her associative memory structure. Results obtained on the recall task in

the present research indicated that older more creative children make greater use of between-configuration links and less use of within-configuration links in memory than older less creative children, who tend to rely more on within-configuration links in memory. These results lend some support for Simonton's (1988) model, which suggests that the creative individual's ability to generate remote associations relates to having an associative memory structure which consists almost entirely of weak associations.

In Rudy and Sutherland's (1992) terms, the creative individual would appear to possess an open memory system, while the less creative individual would appear to possess a closed memory system. According to Rudy and Sutherland, an open memory system is characterized by elemental associations, or simple connections among elements, whereas a closed memory system is characterized by configural associations, or representations of the joint occurrence of two or more elements. On a recall task, for example, successful performance depends on an individual's ability to prevent interference from irrelevant pre-existing associations to the stimulus words and therefore necessitates the use of a closed memory system. Indeed, Rudy and Sutherland contend that an important aspect of memory functioning is remaining closed to associations that are extraneous to the demands of a given task. Extending the model of associative memory presented by Rudy and Sutherland to results obtained by older more creative children on the recall task in the present research, one can speculate that creative individuals appear to rely more on an open memory system. Unfortunately, Rudy and Sutherland present the performance of brain-damaged individuals who have difficulty selecting viable or correct stimulus responses on memory tasks as evidence of an open

memory system. This is a rather extreme stance in view of the creative individual who makes use of remote associations, though obviously not to the extent of brain-damaged individuals, who oftentimes respond with totally irrelevant associations on memory tasks. Still, the notion that creative individuals have an open memory system with many associations competing for retrieval could account for the creative individual's ability to remain open to potentially novel and useful combinations of ideas.

Still, the creative individual's ability to access associations from memory in a dynamic sense would appear to be relatively distinct from his/her static associative memory structure. After all, convergent evidence of different associative memory structures for more creative and less creative children was not obtained across all three studies in the present research. On receptive memory tasks (i.e., the associability-rating and association-decision tasks) used in this research, all children perceived the various configural dimensions inherent in the stimulus words, according to relative degrees of salience, with categories being the most salient, themes being moderately salient, and other dimensions being least salient. These results suggest that the associative memory structures of more creative children are similar to those of less creative children, particularly when one considers Simonton's (1988) model; that is, more creative children, like less creative children, have many strong within-configuration links and weak between-configuration links in their associative memory structures. However, on one of the productive memory tasks (i.e., the recall task) used in this research, younger children and older more creative children continued to access more between- than within-configuration links from memory over time, whereas older less creative children shifted

from accessing between-configuration links to accessing more links from specific configurations over time. Part of the reason for these seemingly divergent results across different memory tasks is that these tasks are likely tapping into different aspects of memory.

Nowhere was this more evident than in the recall and sorting tasks used in Study #2. On a very simplistic level, a recall task requires the encoding of features of each stimulus word into long-term memory, and later retrieving memory traces of each stimulus word (Brainerd, Howe, Kingma, & Brainerd, 1984; Brainerd, Kingma, & Howe, 1986). The retrieval process can be further broken down into accessing memory, searching through a set of concepts and then decoding a memory trace (Ackerman, 1988; Brainerd et al., 1984). There is some evidence (i.e., Brainerd et al., 1984, 1986) to indicate that children tend to rely more on interword associations than adults on recall tasks, even when categories are implicit in a set of stimulus words. This was found in the present research as well, since all children used more between-category-and-theme, than within-category or within-theme, associative links on the recall task. In view of emerging evidence, there is increasing speculation in the literature (e.g., Ackerman, 1986; Brainerd et al., 1984) that the chief cognitive processes involved in children's recall are invoked during retrieval and not during storage. Thus it is likely that retrieval processes make the most significant contribution to children's recall performance.

In contrast to the typical free recall task, there is some evidence in the literature (e.g., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1984; Worden, 1976) to suggest that the typical sort/recall procedure provides individuals with a strong

categorical organization for retrieval. Indeed, in the present research, the sorting task elicited more categories and categorical associative links from virtually all children, thereby suggesting that sorting may be a more categorical task than recall. Besides memory retrieval, there are several important processes, such as decision making and response selection, involved on sorting tasks (Whitney, 1986). Consequently, it is likely that the sorting task employed in the present research reveals more about task demands, than the way concepts are actually organized in children's associative memories.

In a similar vein, it is possible that the two receptive memory tasks used in the present research reveal more about children's encoding into long-term memory structure, than the productive memory task, which reveals more about children's encoding and especially retrieval processes from short-term memory. Given the varying cognitive demands implicit in the memory tasks used in the present research, it is not surprising that differences were obtained with respect to level of creativity on a production task and not on receptive tasks. Such a pattern of results would seem to indicate that the creative individual's ability to generate remote associations from memory occurs not at the encoding stage but during retrieval. That is, the creative individual possesses the same associative structure in long-term memory as other individuals. Yet it is what the creative individual does with those associations in a productive sense that sets him/her apart. Therefore, the key differentiating factor in the thinking processes of the creative individual versus those of other individuals appears to be in how the creative individual accesses or selects remote associations from memory.

Indeed, more recent theoretical models of creative thinking (e.g., Johnson-Laird, 1987, 1988; Perkins, 1981; Rowe & Partridge, 1993) have focused on the mechanisms underlying the creative individual's ability to select viable combinations of ideas, in contrast to early theoretical models of creative thinking (e.g., Campbell, 1960; Mednick, 1962) which emphasized the creative individual's ability to generate numerous combinations of ideas. It is unlikely that the creative individual generates numerous potential ideas entirely 'blindly', as Campbell (1960) suggests, because this would result in an inordinately large number of worthless ideas being produced, something which is not reported by eminent creative individuals (see Ghiselin, 1952). As Poincaré (see Ghiselin, 1952) and Johnson-Laird (1987, 1988) have suggested, it is only plausible ideas which enter into the thought processes of the creative individual, implying that there is some sort of primary selection process operating. After all, it is the creative individual who is able to select better options and distinguish what constitutes genuine improvements in a particular domain (Perkins, 1981).

Some support for these emerging theoretical notions can be found in the area of artificial intelligence. To date, computer programs deriving from the randomness model have been unable to produce truly creative products and thereby successfully simulate human creative thinking (see Rowe & Partridge, 1993). After critically surveying artificial intelligence programs that have been developed to display some form of creative thinking, Rowe and Partridge (1993) conclude that five characteristics are necessary for both computer-based and theoretical models of creativity. These characteristics include the ability to: develop a maximum number of possible associations, tolerate ambiguity,

make use of multiple representations, access new and useful combinations, and elaborate upon new combinations to determine how viable they are. Such a system, whether it be a computer or an individual, Rowe and Partridge maintain, requires both flexibility and control.

Incorporating the aforementioned characteristics, Rowe and Partridge (1993) describe an emergent memory model for creative thinking, which has been implemented in a program called GENESIS. In the GENESIS program, concepts are not simply recalled but are reconstructed to correspond with particular situations. Memories are reconstructed from the activation of autonomous entities which have weights to determine which of a number of potentially relevant connections become activated. Successful sequences of activation are afforded increased weight, while unsuccessful sequences of activation are gradually reduced in weight. Partial memory representations exist in the system and are used in combination with other partial memory representations. A part of a previous representation may be activated when it conforms to the external constraints of a given situation; then partial representations and autonomous entities may be used to fill in the gaps. In this way, memories are reconstructed in a bottom-up manner, with flexible, high-level representations guiding the process. So far, the GENESIS program shows promise in being able to model creative thinking processes (Rowe & Partridge, 1993).

As suggested by converging results on two receptive memory tasks employed in the present research, creative individuals perceive, and presumably have access to the same types of associative links in their memory structures as other individuals but are

more reluctant to relinquish alternate types of associative links when it comes to production tasks. The question is: Why?

Adopting Kris's (1952) theory of creativity, Martindale and Hasenpus (1978) propose that the answer lies in the creative individual's regression from primary process to secondary process thinking, which coincides with some variation in his/her level of cortical arousal. They hypothesized that the creative process involves an initial inspirational phase carried out at a low level of cortical arousal, followed by a subsequent phase of elaboration entailing a high level of cortical arousal, and that this pattern would be more typical of creative individuals than those who were not creative. To test this hypothesis, an experiment was conducted in which individuals were first asked to think of the plot for a fantasy story (analogous to the inspirational phase) and then to actually write out the story (analogous to the elaboration phase). Martindale and Hasenpus found that highly creative individuals operated at a low level of cortical arousal (or exhibited more alpha waves) during the inspirational phase relative to the elaboration phase, than did less creative individuals. As Martindale (1977-78) suggests, it is possible that primary process thinking, characterized by low cortical arousal, promotes a number of combinations to be considered by the creative individual. In states of low cortical arousal, many associative links may be weakly activated in the memory network of the creative individual, and since none of these links reach a particular threshold, they remain available for consideration. During states of high cortical arousal, which correspond to secondary process thinking, there may be strong activation of a small number of associative links in the memory network of the creative individual, and this

would allow for the selection of viable combinations of ideas or remote associations. The ability of older more creative children to retain more between-configuration links on the productive memory task in the present research could be accounted for by a pattern of activation in their associative memory networks, whereby many between-configuration links are weakly activated and fail to reach a certain threshold so that they continue to be available for consideration. Still, even when one adopts such a theoretical rationale, it remains unclear as to what it is about between-configuration links that makes them so attractive to creative individuals for the purposes of production.

Recently, Martindale (1993, August) has proposed that what differentiates creative from less creative individuals is not the level of cortical arousal per se but how flexible creative individuals are in shifting between different levels of arousal at various stages in the creative process. Interestingly, a computer program can now model regression from secondary process to primary process thinking based on varying levels of arousal, which Martindale suggests is the key mechanism underlying creative thinking (see Rowe & Partridge, 1993).

The notion of varying patterns of activation in the associative networks of creative individuals reflects the recent movement away from semantic network theories of memory (e.g., Collins & Loftus, 1975; Quillian, 1969) towards parallel-distributed processing (PDP) or connectionist models of memory (e.g., see McClelland, Rumelhart, & Hinton, 1986; Rumelhart, Hinton, & McClelland, 1986; Rumelhart & McClelland, 1986; Rumelhart & Norman, 1981). In PDP models, concepts are not represented by individual nodes but are represented by patterns of activation over an entire system of nodes

(Oden, 1987). Rather than static copies of stimuli being stored as memory traces, as suggested by semantic network theories, what is stored are connection strengths between processing units, which allows various patterns of activation to be recreated (McClelland et al., 1986). In essence, memory, from the point of view of connectionist models, is distributed over connections among an enormously large number of processing units. Consistent with current views, memory is now viewed as a set of potential organizations, or as a system capable of generating organized structures (Ehrlich, 1979). Thus current views of memory could potentially explain how it is that a creative individual can still access other types of associations that do not conform to the configurations which are predominant in their associative memory structures.

Developmental Changes in the Organization of Children's Memory

In the present research, categories clearly represented the predominant type of configuration, over themes and other types of configurations, in children's associative memory structures at grades 3 and 7. This is consistent with Rosch's (1978) contention that some kinds of categories are 'basic' because they promote cognitive economy and correlate with what humans perceive in the environment. In fact, Rosch et al. (1976) present experimental evidence which shows that some initial categorizations related to perceptual features of the environment are made as early as infancy. Markman (1989) also argues that categories are one of the main ways in which children try to make sense of the world; categories not only contain important information about the world, but they allow children to expand upon that information through the process of making inferences. Practically speaking then, children rely on categories as organizational

structures, both on memory tasks and in real life, to help them store and retrieve information more efficiently.

Alternatively, the general pattern observed in children's performance on memory tasks in the present research could reflect the relative salience of the stimuli chosen (Worden, 1976). This proposition would seem to have some merit, especially when one considers that in the present study, as well as in Bjorklund and Jacobs' (1984) study, a stimulus set was constructed by selecting words which had a categorical base, while in Worden's (1976) study, the stimulus words selected seemed to reflect a more coherent thematic base. It is possible that children in the present research were simply detecting the more cohesive categorical structure in the stimulus words when they were asked to rate, or make a decision as to, the associability of various pairs of words. However, given the high degree of convergence across a wide array of data obtained in both studies #1 and #3 in the present research, the fact that children consistently perceive categories as having more strong associations than themes or other organizational structures is likely more reflective of their associative memory structures than the structures implicit in the stimulus words.

Despite the widespread salience of categories for children in the present research, there was some evidence of a change in children's preferences for using various types of organizational structures. The often-cited developmental shift towards greater category usage with age was partially confirmed on the sorting task, with Grade 7 children using more categories as organizational structures in sorting than Grade 3 children, and with Grade 3 children using more alternate organizational structures in

sorting than Grade 7 children. To the extent that alternate organizational structures (i.e., between-category-and-theme associative links) reflect associations (e.g., see Bjorklund, 1985; Bjorklund & Muir, 1988), then the results obtained on the sorting task in the present research partially replicate those which indicate that Grade 3 children make use of both associations and categories on sorting tasks (e.g., Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985). Although Grade 3 children tended to use a relatively high proportion of between-category-and-theme associative links for sorting, they were overwhelmingly categorical when classified according to their primary organizational preference. Thus it may be that Grade 3 children in the present research used both associations and categories for sorting, though evidence for this is indirect and such a trend clearly failed to reach significance.

While Grade 3 children in the present research readily acknowledged that themes were less salient than categories and more salient than other types of organizational structures, as did Grade 7 children, Grade 3 children did not tend to use themes as preferred organizational structures for sorting. On the sorting task, there was some indication that Grade 3 children used a greater proportion of within-theme associative links than did Grade 7 children with one set of words, but these results were not obtained with a second set of words. Due to these discrepant results, it is unclear as to what extent Grade 3 children use themes as organizational structures on memory tasks. Yet there is some evidence in the literature (i.e., Ackerman, 1986; Worden, 1976) that themes are preferred organizational structures for younger children. Recently, Ackerman (1986) examined retrieval search by children in grades 2 and 5 for the last

target word in sets of words representative of various categories and themes. He found that Grade 2 children made greater use of thematic than categorical structures, whereas Grade 5 children made greater use of categorical than thematic structures, to facilitate retrieval search through associative memory. These results suggest that categories and themes differ as integrated structures in children's associative memories. This would certainly apply to children in the present research who consistently regarded categories as being relatively more salient than themes. According to Ackerman (1986), thematic associations may be more loosely structured in memory because a given word can be involved with a vast number of themes; however, the same is not true of categorical associations, since words in categories are bounded by a limited set of organizing principles. The implications then of Ackerman's (1986) results are that older children depend more on a stimulus structure for retrieval purposes than younger children, and this seems to relate to how well various structures are organized in their memories. Thus one reason why Grade 3 children in the present research used more associations rather than configurations in sorting is because configurations are not well organized in their associative memories, and consequently they depend less on these structures when sorting words.

In the present research, Grade 3 children not only failed to demonstrate clear evidence of the use of themes but also evidence of the use of categories in their sorting performance. Markman (1989) has outlined difficulties associated with the standard sorting task that may prevent younger children from demonstrating their knowledge of categories. These include: the requirement to form spatial arrangements; the large

number of objects to be sorted; children's relative lack of familiarity with the stimulus categories; and instructional set. Children may view the spatial arrangement of items as being integral to the task, and this may bias them to produce groups on some atypical basis. Faced with a scrambled array of 16 different objects, four from each of four categories, children may scan the array and quickly decide which pairs of words go together. Also, if children are less familiar with the categories used, they may be less likely to sort categorically. Any or all of these factors could have biased Grade 3 children to sort more on an associative basis, as opposed to a categorical basis.

Varying instructional set on the sorting task in the present research had the effect of dramatically changing the basis of children's sorting to categories. Specifically, when children were required to constrain their groups on the sorting task, they inevitably displayed the almost exclusive use of categories in their sorting performance. Surprisingly, just by instructing children in a subtle manner to make four groups, even younger children who were not using a particular structure quickly adopted a categorical structure for sorting. It is possible that instructions endorsing constraint on a sorting task somehow cue children as to there being a predetermined type of structure implicit in a set of stimulus words.

Limitations of the Present Research

One limitation of the present research relates to the measurement of creativity in children by relying solely on the TTCT. Some have questioned whether the TTCT actually measures creativity (see Wallach, 1970). Furthermore, the fact that the TTCT and other measures of creativity, such as teacher ratings, tend to have low

intercorrelations amongst them prevents researchers from being sure that they are in fact measuring creativity. Granted, this is a limitation for the measurement of creativity in general. Still, the TTCT is the best among the currently available measures for assessing creativity in children, and it was on this basis that the TTCT was selected to identify creative children in the present research.

In the present research, creativity was assessed with respect to ideational fluency. Yet as Nicholls (1972) highlights, ideational fluency is not enough to ensure creativity. Other processes, such as those related to intelligence (Nicholls, 1972) and convergent thinking (Barron & Harrington, 1981), need to be considered as well. It is important to acknowledge that creative thinking does not emerge from a void. Rather, the creative individual brings elements already existing in memory into a distinctive relationship with one another (Hallman, 1981), and so possesses an already-existing knowledge base. It has been said that eminent creativity is characterized by intensity of involvement and a high level of mastery in a field (Nicholls, 1972). Thus a creative individual must possess the necessary skills or information, in order to generate novel and useful ideas for a particular domain. Consequently, in view of a distinct population of eminent creative individuals recognized for their creative accomplishments in various domains, the results obtained in the present research for children of varying levels of creativity have limited generalizability.

Furthermore, in this research, creativity was viewed as an underlying cognitive process in individuals, thereby minimizing the dimensionality of the construct. It has now being widely recognized that creativity is an inherently multidimensional phenomenon,

involving a variety of cognitive and personality attributes (Mumford & Gustafson, 1988). According to various writers (e.g., Brown, 1989; Hocevar, 1981; Mumford & Gustafson, 1988), there is no general creative process per se, but instead a set of creative processes which relate differentially to various types of creative endeavours.

In the present research, children's use of within-theme word pairs in sorting was unclear, due to mixed results obtained for two different sets of stimulus words. The problem here involved using two sets of stimulus words to measure the stability of children's memory organizations, something which was definitely an oversight on the part of the researcher. Consistent with commonly-accepted methods used to assess reliability (see Winer, 1991), one way of assessing the reliability of children's associative memory structures would have been to present the same set of stimulus words on a second trial, instead of a second new set of stimulus words. According to Murphy and Puff (1982), if individual differences are of interest empirically, it is not appropriate to vary stimulus materials across subjects, because one wants differences between subjects to be due to subject variables, not variation in the stimulus materials. Indeed, although results were generally convergent for the two sets of words on the sorting task, there were some discrepancies. These discrepancies likely reflect the different properties of the two sets of stimulus words, rather than children's associative memory structures, particularly since Set B words appeared to be a more cohesive set of words with respect to categories than Set A words.

Methodologically, a further difficulty related to the two trials used on the sorting task, in which time was confounded with instructional set. A better design, which would

isolate differences due to time versus instructional set, would be to have children complete two free sorting trials using the same instructional set and then a final sorting trial, in which the instructional set would be changed to direct children to constrain their sorting.

In the present research, the Pathfinder network scaling algorithm proved to be a promising technique in translating a very large set of proximity data into a visual representation. Still, a major problem with this technique, as demonstrated in the present research, is that the computer-generated associative networks are difficult to interpret. Until methods become available to facilitate the interpretation of these networks, researchers will have to resort to analyzing the numbers and weights of links in Pathfinder networks via ANOVA.

Suggestions for Future Research

Brown (1989) suggests that the ability to generate remote associations be studied in individuals who are creative in particular domains. Indeed, given that creativity appears to be domain-specific (Brown, 1989; Hocevar, 1981; Mumford & Gustafson, 1988), an individual who is creative in one domain (e.g., painting) may not necessarily be creative in another domain (e.g., literary composition). Consequently, it would be interesting to replicate the present research with individuals recognized for their creative contributions to various fields (e.g., architects, writers), though of course stimulus materials might have to be modified in order to be appropriate for adults.

In the present research, the researcher took the liberty of equating categories and themes with the configurations which Simonton (1988) describes in his model. However,

categories and themes may not represent what Simonton meant by 'configurations'. Furthermore, the categories and themes used in the present research are by no means the only types of configurations possible. In fact, all children seemed to use between-category-and-theme associative links readily on the recall task in the present research, and these may or may not have some kind of implicit configuration. Thus a future study could address the nature of these between-category-and-theme associative links for children, and determine whether they represent associations or more complex types of configurations. One way of accomplishing this would be to classify all of the between-category-and-theme word pairs which children used on the recall task, in terms of possible bases for association. Reasons children gave for grouping particular words together on the sorting task could be used to guide the construction of such a classification scheme.

On the sorting task, children were asked to provide names and a brief rationale for sorting words into various groups. These data have yet to be analyzed. From a normative perspective, it would be worthwhile to determine whether children's bases for forming sorting groups were similar to those used by the experimenter (i.e., to establish categories and themes for the stimulus sets of words), and are similar for children of different ages (i.e., those in grades 3 and 7). Such an endeavour would offer a significant contribution to the developmental literature, given that there is currently no normative basis available for establishing themes.

In the present research, the Pathfinder network scaling algorithm was applied only to data obtained in Study #1 because children's associability ratings lent themselves

most readily as proximity estimates. It would be useful to apply data obtained from the recall and association-decision tasks (i.e., Studies #2 and #3, respectively), as Cooke et al. (1986) and Cooke (1992) have done, in order to determine whether different memory tasks do in fact lead to the generation of different network structures. Also, it would be interesting to correlate proximity estimates for the three data sets to see if recall contributes something over and above ratings and reaction times with children, as it seems to with adults (Cooke et al., 1986). It is likely that networks generated for data obtained from the recall task would be different for more creative and less creative children at different ages, though it would be difficult to obtain proximity estimates for recall strings, since children generated different words in their recall strings on different trials.

Given the preponderance of between-configuration links used by all children on the recall task, a future study might examine error intrusions in creative children's recall, similar to the way in which Corkill and Glover (1987) examined error intrusions in creative students' recall, so as to replicate their results. In such a study, one could hypothesize that more creative children would make more error intrusions which would be consistent with some type of configuration (i.e., category or theme) in the stimulus set than less creative children.

Implications of the Present Research

This research represents the first empirical attempt to describe the associative memory structures of more creative and less creative individuals, and to document simultaneously age-related differences in associative memory structures. Theoretically,

the impetus for the present research was to contribute to an improved understanding of how associative memory is organized in more creative and less creative individuals, and how age can account for differences in children's associative memory structures. Such information is crucial to further our understanding of creativity per se, and may assist teachers in facilitating children's retention of learned information and in promoting children's creative thinking processes.

On a practical level, knowledge of children's associative memory structures may sensitize teachers to present concepts to children in a manner that will enable them to encode concepts more readily and ultimately retain them over the long term. In the present research, the associative memory structures of all children seemed to be comprised mainly of categories, and to a lesser extent, themes. Thus to capitalize on children's encoding of concepts to-be-learned, it would be worthwhile for teachers to present concepts to children in organized structures such as categories. This would be particularly relevant for children 8 years of age and older, since categories seem to be predominant configurations in their associative memory structures. When children are required to apply concepts that they know in a learning situation, it would be beneficial for teachers to give children older than 8 years of age the option of conveying conceptual information in some organized form, such as categories, given that categories seem to correspond with their preferred organizational structures in memory.

With respect to creativity, it is necessary to enhance our understanding of the creative process, since as a society we evolve with the emergence of creative products. Such products emerge from individuals who engage in a particular kind of thinking

process which can be fostered by certain environmental conditions, as recent personality-related models of creativity (e.g., Amabile, 1983; Sternberg, 1988) suggest. Teachers need to address the issue of how to help develop children's creative thinking abilities, as well as what to develop. As demonstrated in the present research, it is possible for children to master organized bodies of information (i.e., categories) and yet simultaneously remain open to other types of associations among ideas, for this is where true creativity lies. Thus, on the basis of this research, as well as some of the most recent theoretical and empirical models of creativity, it appears that allowing children to be open to possible combinations of ideas and not requiring them to constrain their alternatives too early would facilitate the generation of creative ideas.

The present research is significant in illustrating the current trend in creativity research, which is to view the creative thinking process not as an all-or-none phenomenon, but rather as an extension of individuals' common memory abilities (Perkins, 1981). Still, the creative thinking process remains somewhat elusive, since one can never totally predict when true creative inspiration is about to occur.

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Appendix A

Scale for Rating Behavioral Characteristics of Superior Students

Joseph S. Renzulli/Robert K. Hartman (1971).
Exceptional Children, 38, 243-248.

Name _____ Date _____

School _____ Grade _____ Age _____

Teacher completing this form _____

How long have you known this student? _____

Directions. This scale is designed to obtain teacher estimates of a student's characteristics in the area of creativity. The items are derived from the research literature dealing with characteristics of gifted and creative persons. It should be pointed out that a considerable amount of individual differences can be found within this population; and therefore, the profiles are likely to vary a great deal. Each item in the scale should be considered separately and should reflect the degree to which you have observed the presence or absence of each characteristic. Please read the statements carefully and place an X in the appropriate place according to the following scale of values:

1. If you have observed this characteristic *almost never*.
2. If you have *seldom* observed this characteristic.
3. If you have *often* observed this characteristic.
4. If you have observed this characteristic *almost always*.

Space has been provided following each item for your comments.

(TEACHERS DO NOT FILL OUT THIS SECTION.)

A separate score for the creativity dimension may be obtained as follows:

- Add the total number of X's in each column to obtain the "Column Total."
- Multiply the Column Total by the "Weight" for each column to obtain the "Weighted Column Total."
- Sum the Weighted Column Totals across to obtain the "Score" for the creativity dimension of the scale.
- Enter the Scores below.

Creativity Characteristics _____

Creativity Characteristics

	1	2	3	4
	NEVER	SELDOM	OFTEN	ALWAYS
1. Displays a great deal of curiosity about many things; is constantly asking questions about anything and everything.	☐	☐	☐	☐
2. Generates a large number of ideas or solutions to problems and questions; often offers unusual ("way out"), unique, clever responses.	☐	☐	☐	☐
3. Is uninhibited in expressions of opinion; is sometimes radical and spirited in disagreement; is tenacious.	☐	☐	☐	☐
4. Is a high risk taker; is adventurous and speculative.	☐	☐	☐	☐
5. Displays a good deal of intellectual playfulness; fantasizes; imagines ("I wonder what would happen if..."); manipulates ideas (i.e., changes, elaborates upon them); is often concerned with adapting, improving, and modifying institutions, objects, and systems.	☐	☐	☐	☐
6. Displays a keen sense of humor and sees humor in situations that may not appear to be humorous to others.	☐	☐	☐	☐
7. Is unusually aware of his/her impulses and more open to the irrational in him/herself (freer expression of feminine interest for boys, greater than usual amount of independence for girls); shows emotional sensitivity.	☐	☐	☐	☐
8. Is sensitive to beauty; attends to aesthetic characteristics of things.	☐	☐	☐	☐
9. Is nonconforming; accepts disorder; is not interested in details; is individualistic; does not fear being different.	☐	☐	☐	☐
10. Criticizes constructively; is unwilling to accept authoritarian pronouncements without critical examination.	☐	☐	☐	☐

(TEACHERS DO NOT FILL OUT THIS SECTION.)

Column Total	[]	[]	[]	[]
Weight	[1]	[2]	[3]	[4]
Weighted Column Total	[]	[]	[]	[]
Total	[]			

Appendix B

Standardized Instructions for Administration of the TTCT (Verbal Form B)Specific Instructions for Administering Test Activities

The activities in this booklet will give you a chance to use your imagination in thinking up ideas and putting them into words. There are no "right" or "wrong" answers like there are in most things that we do. We want you to see how many ideas you can think of and we think you will find this fun. Try to think of interesting, unusual, and clever ideas--something that no one else will think of.

You will have six different things to do and you will be timed on each one, so make good use of your time. Work as fast as you can without rushing. If you run out of ideas before time is called, wait until instructions are given before going on to the next activity. Sometimes if you will just sit and think more ideas will come to you and you can add those.

If you have any questions after we start, don't speak out loud. Raise your hand and I shall come to your desk and try to answer your questions.

Activity 1: ASKING

The first three activities will be based on the drawing below. These activities will give you a chance to show how good you are at asking questions to find out things that you don't know and in making guesses about possible causes and consequences of happenings. Look at the picture. What is happening? What can you tell for sure? What do you need to know to understand what is happening, what caused it to happen and what will be the result?

As we go ahead with the first three activities you may look back at this picture. Now, look at the next page, Activity 1: ASKING, and read with me:

On this page, write out all the questions you can think of about the picture on the page opposite this one. Ask all of the questions you would need to ask to know for sure what is happening. Do not ask questions which can be answered just by looking at the drawing. You can continue to look back at the drawing as much as you want to.

(TIME: 5 minutes)

Activity 2: GUESSING CAUSES

In the spaces below, list as many *possible* causes as you can of the action shown in the picture on page 2. You may use things that might have happened just before the things that are happening in the picture, or something that happened a long time ago that made these things happen. Make as many guesses as you can. Don't be afraid to guess.

(TIME: 5 minutes)

Activity 3: GUESSING CONSEQUENCES

In the spaces below, list as many possibilities as you can of what might happen as a result of what is taking place in the picture on page 2. You may use things that might happen right afterwards or things that might happen as a result long afterwards in the future. Make as many guesses as you can. Don't be afraid to guess.

(TIME: 5 minutes)

Activity 4: PRODUCT IMPROVEMENT

In the middle of this page is a sketch of a stuffed toy monkey of the kind you can buy in most novelty stores for about five or six dollars. It is about six inches tall and weighs about six ounces. In the spaces on this page and the next one, list the cleverest, most interesting and unusual ways you can think of for changing this toy monkey so that children will have more fun playing with it. Do not worry about how much the change would cost. Think only about what would make it more fun to play with as a toy.

(TIME: 10 minutes)

Activity 5: UNUSUAL USES OF TIN CANS

Most people throw their tin cans away, but they have thousands of interesting and unusual uses. In the spaces below and on the next page, list as many of these interesting and unusual uses as you can think of. Do not limit yourself to any one size of can. You may use as many cans as you like. Do not limit yourself to the uses you have seen or heard about; think about as many possible new uses as you can.

(TIME: 10 minutes)

Activity 7: JUST SUPPOSE

You will now be given an improbable situation--one that may never happen. You will have to *just suppose* that it has happened. This will give you a chance to use your imagination to think out all of the other things that would happen IF this impossible situation were to come true.

In your imagination, *just suppose* that the situation described were to happen. THEN think of all of the other things that would happen because of it. In other words, what would be the consequences? Make as many guesses as you can.

The improbable situation -- J U S T S U P P O S E a great fog were to fall over the earth and all we could see of people would be their feet. *What would happen? How would this change life on earth?* List your ideas and guesses on the next page.

(TIME: 5 minutes)

Note. Activity 6: UNUSUAL QUESTIONS has been removed from the most recent version of the Verbal Test, Form B of the TTCT, as it has been found to contribute minimally to the predictive validity of the scores (Torrance, 1990a, 1990b).

Appendix C

Modified Standard Instructions for Administration of the TTCT (Verbal Form B)General:

We'll be doing some activities, and I want you to try to have fun with them. I want to see how good you are at thinking up new ideas and solving problems. Try to think of interesting and unusual ideas for the activities--ideas that no one else would think of. Basically, what I want you to do is to use your imagination to think up ideas for the activities, and then I want you to write your ideas down. When you're writing down your ideas, don't worry about spelling or making sentences. I really only want to see how many ideas you can think of. So make as many guesses as you can, and don't be afraid to guess.

Please put your name and the date on the booklet I'm handing out. We're going to do six different activities in this booklet, and you'll have about 5 or 10 minutes to do each one. Try to work quickly, but try to come up with good ideas as well. If you run out of ideas before time is up, then just wait for the next activity. If you have any questions, raise your hand, and I'll come over and try to answer them. This is important: I want to know YOUR ideas, and not those of the person sitting next to you; so try to do your own work, and no talking. Are you ready?

Activity 1: ASKING

Turn to page 2 of the booklet. You'll be using this drawing to do the first three activities. As you do the activities, feel free to look back at this picture whenever you want. Let's see how good you are at asking questions to find out things you don't know about the picture. On page 3 (the next page), write down all the questions you would have to ask to figure out what's happening in the picture. Don't ask questions that can be answered just by looking at the picture. What questions could you ask to help you figure out what's happening in the picture? Write them down. Go ahead.

(TIME: 5 minutes)

Activity 2: GUESSING CAUSES

Turn to page 4 of the booklet. What could have made the things in the picture on page 2 happen? In other words, what **CAUSED** the things in the picture to happen? You can use things that might have happened just before the things happening in the picture. Or you can use something that happened a long time ago. Why are the things in the picture happening? Write down as many ideas as you can think of. Go ahead.

(TIME: 5 minutes)

Activity 3: GUESSING CONSEQUENCES

Look at page 5. Here, I want to know what might happen next because of what's happening in the picture on page 2. You can use things that might happen right afterwards. Or you can use things that might happen in the future. What's probably going to happen next in the picture? Write down as many ideas as you can think of. Go ahead.

(TIME: 5 minutes)

Activity 4: PRODUCT IMPROVEMENT

Turn to page 6. You can see here a picture of a little stuffed toy monkey that you can buy in most stores, and I have the monkey here [display]. On this page and the next one, I want you to write down how you could change this toy monkey so that children will have more fun playing with it. Don't worry about how much this change would cost. Just think about the interesting and unusual things you could do to make this toy more fun to play with. Write down as many ideas as you can think of. Go ahead.

(TIME: 10 minutes)

Activity 5: UNUSUAL USES OF TIN CANS

Turn to page 8. You all know what a tin can is? Well, most people throw their tin cans away. But actually, they have thousands of interesting and unusual uses. What kinds of interesting and unusual things could you do with a tin can? On this page and the next one, write down as many interesting and unusual uses that you can think of for a tin can. The tin can can be big or small, and you can use as many as you like. Try to think about the many new things you could do with a tin can. Write down as many ideas as you can think of. Go ahead.

(TIME: 10 minutes)

Activity 7: JUST SUPPOSE

The last activity is on page 10. I'm going to tell you about a situation that's probably never going to happen. But I want you to JUST SUPPOSE that it happened. Use your imagination to think of all the other things that would happen if this situation actually happened.

There's a picture of this situation on page 10, and the situation is this. JUST SUPPOSE a great fog were to fall over the earth and all we could see of people would be their feet. What would happen? How would this change life on earth? Write down your ideas and guesses on the next page (page 11). Go ahead.

(TIME: 5 minutes)

Concluding Remarks:

That's all the activities we have to do. I'd like to thank you for your help with my research project. And in the next week or so, I'll be doing some more work with some of you. Please hand in your booklets.

Appendix D

Administration of Screening Measures and Experimental Tasks

Order of Administration	Format of Administration	Time Required
I. Screening Measures		
1. TTCT	group	60 minutes
2. SRBCSS	teacher	5 min./child
II. Experimental Session 1		
	individual	75-85 minutes
1. recall/sorting task (Study #2)	individual	20-30 minutes
2. first half of association-decision task (Study #3)--practise and first 60 trials	individual	9 minutes
3. WISC-R Short Form	individual	20 minutes
4. WRAT-R	individual	20 minutes
5. second half of association-decision task (Study #3)--second 60 trials	individual	6 minutes
(minimum one-week interval)		
III. Experimental Session 2		
	group	15 minutes
1. associability-rating task (Study #1)	group	15 minutes

Instructions for Administration of the Experimental TasksRecall Task (Study #2)

We're going to be working with some words. I'm going to present some words to you. Pay attention to each of the words because afterwards, I'll ask you to tell me all the words you can remember. Try as hard as you can to remember the words. Are you ready? Watch and listen closely.

[The experimenter presents a series of words.]

Now, tell me as many words as you can remember, in any order. [Once the child has stopped saying words, the experimenter prompts the child.] **Can you think of any more words?** [If the child remains silent, the experimenter prompts him/her again.] **Think of the words I presented. Can you remember any more?** [Once the child indicates that he/she cannot recall any more words, the experimenter moves on to the second trial.]

Now, I'm going to present the same words to you, again. I want you to pay attention to the words because later, I'll be asking you what the words were. So try very hard to remember the words. Here they are.

[The experimenter presents the same series of words again.]

Okay, now tell me all the words you can remember, in any order, including ones you may have said the first time. [When the child hesitates, the experimenter prompts the child.] **Can you remember any more words?** [Once the child indicates that he/she cannot recall any more words, the experimenter praises the child for paying attention to the words and trying hard to remember them.]

Sorting Task (Study #2):Trial 1, Free Sorting

I'm going to show you some cards, and as I show you each card, I want you to tell me the word on the card. [If the child has difficulty reading the word on the card, the experimenter helps the child and may read the word for the child. Then the experimenter has the child repeat the word on the card, and makes note of the word. The experimenter places each card on the table in front of the child, such that the cards form a 4 X 4 matrix.] **Now, using all the words, I want you to put the words that you think go together in groups; your groups can be as big or as little as you want them to be. I want you to make groups of words that YOU think go together.** [Once the child has indicated that he/she is finished, the experimenter asks the following.] **Okay, now we'll go through each of your groups. First tell me the words in your group, and then tell me how you would describe that group.** [Once the child has gone through each of his/her groups, the experimenter initiates a second free sorting trial.]

Trial 2, Free Sorting

Now, I'm going to show you some different words. As I arrange the cards on the table, tell me the word on each card. [Again, if the child reads the word incorrectly, the experimenter reads the word correctly for the child and has the child repeat the word; the child's error is noted. The experimenter again arranges each card on the table in front of the child, such that the cards form a 4 X 4 matrix.] **I want you to use all the words, and put the words that YOU think go together in groups.** [Once the child has indicated that he/she is finished, the experimenter says the following to the child] **Now, we're going to go through each of your groups. First, tell me the words in your group and then tell me how you would describe that group.** [Once the child has gone through each of his/her groups, the experimenter initiates a third constrained sorting trial, with the words from the first free sorting trial.]

Trial 3, Constrained Sorting

Here are the words that you saw at the beginning. [Experimenter lays out the cards from the first free sorting trial in the same 4 X 4 matrix.] **This time, I want you to put the words that YOU think go together in groups, but make only four groups.** [As soon as the child has four groups, the experimenter asks the child to say the words in each group and to describe the group. Once this has been accomplished, the experimenter initiates a fourth and final constrained sorting trial, using the words from the second free sorting trial.]

Trial 4, Constrained Sorting

This is the last time we're going to do this. These are the words that you saw before. [The experimenter arranges the cards from the second free sorting trial in the same 4 X 4 matrix.] **Again, I want you to put the words that you think go together in groups, but make only four groups.** [After the child has completed the sorting task, the experimenter praises the child for his/her efforts, and goes on to administer the Block Design and Vocabulary subtests of the WISC-R.]

First Half of Association-Decision Task (Study #3)

Now, we're going to work on the computer, so come over here and sit by the computer.

[The experimenter stands a YES and NO card upright on the computer keyboard.] **What's going to happen is this. You're going to see pairs of words come up on the computer screen, one at a time. And your job is to decide whether or not the two words go together. You make your decision, by pressing a button, here** [the experimenter points to the response box]. **If you think that the two words go together, you press this button for YES** [the experimenter demonstrates]. **But if you think that the two words do not go together, you would press this button for NO** [the experimenter demonstrates]. **It's a good idea to keep your hands like this** [the experimenter demonstrates] **so that you use this hand to press this button** [the experimenter demonstrates] **and this hand to press this button** [the experimenter demonstrates].

Think about each pair of words that you see, and then try to decide as quickly as you can, whether or not they go together. If you're not sure, just guess. There are no right or wrong answers. If you press a button that you didn't want to press, just keep going. Also, pay attention to the + sign when it comes on the screen; the + sign shows you where to look for the words. Make sure that you look at the pairs of words on the screen, and try to decide quickly if they go together or not. Okay? Are you ready?

Let's try some for practice, so you get the hang of it. It says on the screen... [The experimenter then reads the instructions on the screen and instructs the child to press a button on the response box. As the child proceeds through a series of five practise trials, the experimenter quickly reads the words as they appear on the screen and reinforces the child for responding, by saying, "**That's right**" or "**Good**". If the child hesitates for a long time, the experimenter prompts him/her to press a button. At the end of the practise trials, the experimenter says, "**Good work**," and reads the next set of instructions on the screen. The child then proceeds through 60 trials. At the end of 60 trials, a message appears on the computer screen saying that it is time to take a short break. The experimenter then instructs the child that they are going to do some different things; the WISC-R Short Form and the WRAT-R are administered.]

Note. For each consecutive child, the buttons designated as YES and NO were reversed, to control for response bias related to handedness. In general, children with odd subject numbers received the order YES--NO, and children with even subject numbers received the order NO--YES.

Second Half of Association-Decision Task (Study #3)

Okay, now let's go back to the computer and finish what we were doing. [The child sits in front of the computer.] **Do you remember what we were doing? We were looking at pairs of words, and we were trying to decide quickly if the words go together or not. You press this button for YES** [the experimenter points] **if you think the words go together, and you press this button for NO** [the experimenter points] **if you think the words don't go together. Remember, if you're not sure, just guess. And if you press a button you didn't want to, just keep going. Are you ready?** [The experimenter reads the message on the computer screen and presses the space bar to continue. After the child has made a decision on the 60th trial, a feedback message, accompanied by a cartoon, appears on the screen saying, "Congratulations! You made a lot of decisions. Thank you for your help." The experimenter reads the message to the child, praises the child for working hard throughout the session, says that she enjoyed working with the child, and thanks the child for his/her help. Also, the experimenter tells the child that the last thing he/she will do will be to complete a worksheet in about a week's time.]

Associability-Rating Task (Study #1)

[The researcher displays an example lettraset on 50 cm x 75 cm foam board, so that the entire group can see.] **This is the last thing we have to do. Please put your name and the date at the top of the sheet.**

I'm interested in how well you think certain pairs of words go together. The pairs of words will look like the examples on the sheet in front of you, and like this [the researcher points]. Below each pair of words is a line going from zero to ten [the researcher points]. What I want you to do is to put a mark on the line, to show how well you think the words go together [the researcher demonstrates]. Zero [the researcher points] means that the words don't go together at all, five [the researcher points] means that the words sort of go together, and ten [the researcher points] means that the words go together very well. I want you to show how well YOU think the words go together by putting a mark on the line.

Let's try an example. On your sheet and in this example, we have the words, *cherry* and *banana*. [The researcher points to the words on the board.] You might say that these words go together very well, so you'd place a mark on the line, around or on the 10, like this [the researcher indicates the mark on the first line of the example]. Now, place this mark on the first line of your sheet. [The researcher waits.] Or you may think that these words sort of go together; then, you'd place a mark on the line, around or on the 5, like this [the researcher indicates a mark on the second line of the example]. Place this mark on the second line of your sheet. [The researcher waits.] Or maybe, when you see the words *cherry* and *banana*, you might think that these words don't go together at all; if that's the case, you'd place a mark on the line, around or on the 0, like this [the researcher indicates a mark on the third line of the example]. So, place this mark on the third line of your sheet. [The researcher waits.]

For each pair of words, I want you to show how well YOU think the words go together, by making a mark on the line. Your mark can be anywhere on the line, not just on the 0, 5, or 10. There are no right or wrong answers. If you're not sure about a pair of words, then just guess. It's really important that you make a decision for all word pairs, and don't skip any. Are there any questions?

Once you finish all the sheets, you can go back to class. At this point, I'd like to thank you for participating in this research project, for working hard and for thinking about the words. You can turn the sheet and begin. Once you finish the first sheet, go on to the next one and keep going, until you're done. [The researcher waits for individual children to hand their completed rating sheets to her.]

Appendix F

Mean Associability Rating for Each of 120 Word Pairs

Type of Word Pair	Word Pair	Mean Rating ^a
Within Category (<i>N</i> = 24)	<i>spring--fall</i>	8.20
	<i>hotel--apartment</i>	8.33
	<i>cabin--apartment</i>	7.47
	<i>wind--fall</i>	7.46
	<i>sun--wind</i>	7.34
	<i>hotel--cabin</i>	7.18
	<i>subway--bus</i>	7.09
	<i>sun--spring</i>	7.02
	<i>tractor--bus</i>	6.85
	<i>bus--airplane</i>	6.76
	<i>spring--wind</i>	6.42
	<i>subway--airplane</i>	5.66
	<i>airplane--tractor</i>	5.57
	<i>fall--sun</i>	5.51
	<i>school--hotel</i>	5.39
	<i>school--apartment</i>	5.22
	<i>tractor--subway</i>	5.10
	<i>bed--desk</i>	4.97
	<i>television--bed</i>	4.87
	<i>school--cabin</i>	4.83
	<i>stove--television</i>	4.51
	<i>bed--stove</i>	4.19
	<i>television--desk</i>	3.69
	<i>stove--desk</i>	3.62

Type of Word Pair	Word Pair	Mean Rating ^a
Within Theme (<i>N</i> = 24)	<i>desk--school</i>	8.54
	<i>bus--school</i>	7.71
	<i>bed--hotel</i>	6.90
	<i>apartment--television</i>	4.81
	<i>cabin--stove</i>	4.43
	<i>fall--school</i>	3.39
	<i>airplane--sun</i>	2.83
	<i>spring--cabin</i>	2.78
	<i>tractor--cabin</i>	1.99
	<i>subway--apartment</i>	1.98
	<i>fall--bus</i>	1.55
	<i>spring--tractor</i>	1.44
	<i>subway--wind</i>	1.44
	<i>bed--airplane</i>	1.37
	<i>airplane--hotel</i>	1.27
	<i>hotel--sun</i>	1.25
	<i>bus--desk</i>	1.20
	<i>wind--apartment</i>	.96
	<i>sun--bed</i>	.93
	<i>tractor--stove</i>	.81
	<i>fall--desk</i>	.79
	<i>stove--spring</i>	.73
	<i>subway--television</i>	.58
	<i>television--wind</i>	.43

Type of Word Pair	Word Pair	Mean Rating ^a
Between Category and Theme (<i>N</i> = 72)	<i>bed--cabin</i>	6.37
	<i>apartment--bed</i>	6.24
	<i>stove--apartment</i>	4.69
	<i>hotel--television</i>	4.48
	<i>airplane--wind</i>	4.12
	<i>desk--hotel</i>	3.94
	<i>desk--apartment</i>	3.61
	<i>hotel--stove</i>	3.16
	<i>cabin--television</i>	2.87
	<i>cabin--desk</i>	2.82
	<i>school--spring</i>	2.52
	<i>fall--cabin</i>	2.45
	<i>cabin--wind</i>	2.40
	<i>cabin--sun</i>	2.27
	<i>hotel--subway</i>	2.19
	<i>subway--school</i>	2.09
	<i>tractor--fall</i>	1.92
	<i>school--television</i>	1.91
	<i>spring--bed</i>	1.86
	<i>cabin--airplane</i>	1.86
	<i>school--sun</i>	1.85
	<i>stove--school</i>	1.84
	<i>airplane--television</i>	1.83
	<i>hotel--bus</i>	1.79
	<i>airplane--apartment</i>	1.76
	<i>cabin--subway</i>	1.60
	<i>bus--apartment</i>	1.59
	<i>apartment--spring</i>	1.48
	<i>spring--bus</i>	1.48
	<i>tractor--sun</i>	1.46
	<i>school--wind</i>	1.38
	<i>school--bed</i>	1.28
	<i>tractor--wind</i>	1.26
	<i>cabin--bus</i>	1.26
	<i>hotel--fall</i>	1.24
	<i>bus--wind</i>	1.24
	<i>fall--bed</i>	1.19
	<i>sun--stove</i>	1.19

Type of Word Pair	Word Pair	Mean Rating ^a
Between Category and Theme (<i>N</i> = 72)	<i>television--fall</i>	1.19
	<i>spring--hotel</i>	1.17
	<i>spring--television</i>	1.17
	<i>subway--spring</i>	1.16
	<i>desk--spring</i>	1.15
	<i>sun--bus</i>	1.13
	<i>spring--airplane</i>	1.13
	<i>fall--subway</i>	1.12
	<i>airplane--school</i>	1.12
	<i>bus--bed</i>	1.12
	<i>sun--apartment</i>	1.04
	<i>television--sun</i>	1.04
	<i>wind--hotel</i>	1.02
	<i>fall--airplane</i>	.98
	<i>stove--subway</i>	.91
	<i>fall--apartment</i>	.90
	<i>television--tractor</i>	.89
	<i>sun--subway</i>	.87
	<i>fall--stove</i>	.82
	<i>stove--airplane</i>	.74
	<i>bed--wind</i>	.74
	<i>television--bus</i>	.73
	<i>bed--subway</i>	.69
	<i>desk--airplane</i>	.66
	<i>bus--stove</i>	.64
	<i>tractor--hotel</i>	.63
	<i>apartment--tractor</i>	.63
	<i>stove--wind</i>	.62
	<i>sun--desk</i>	.52
	<i>bed--tractor</i>	.52
	<i>desk--tractor</i>	.50
	<i>tractor--school</i>	.49
	<i>subway--desk</i>	.46
	<i>wind--desk</i>	.42

^aRatings were made on a scale of 0 to 10.

Appendix G

Links and Respective Weights for Generated Pathfinder Networks

Pathfinder Network	Link	<i>N</i>	Weight ^a
Grade 3 More Creative (<i>N</i> = 29)	Within Category	7	
	<i>hotel--cabin</i>		1.47
	<i>school--cabin</i>		2.64
	<i>airplane--tractor</i>		3.21
	<i>sun--wind</i>		3.65
	<i>tractor--bus</i>		4.25
	<i>school--apartment</i>		4.39
	<i>tractor--subway</i>		7.54
	Within Theme	6	
	<i>bus--school</i>		3.32
	<i>subway--wind</i>		3.55
	<i>airplane--sun</i>		4.60
	<i>subway--television</i>		5.80
	<i>stove--spring</i>		6.19
	<i>wind--apartment</i>		6.52
	Between Category and Theme	16	
	<i>spring--airplane</i>		2.44
	<i>bed--subway</i>		2.65
	<i>stove--wind</i>		3.19
	<i>sun--bus</i>		3.63
	<i>cabin--airplane</i>		3.75
	<i>bus--bed</i>		3.78
	<i>hotel--bus</i>		3.79
	<i>tractor--fall</i>		4.47
	<i>apartment--bed</i>		4.67
	<i>television--bus</i>		4.85
	<i>cabin--television</i>		5.07
	<i>desk--apartment</i>		5.25
	<i>bus--stove</i>		5.28
	<i>desk--hotel</i>		6.45
	<i>fall--stove</i>		6.57
	<i>fall--cabin</i>		7.02

Pathfinder Network	Link	<i>N</i>	Weight ^a
Grade 3 Less Creative (<i>N</i> = 28)	Within Category	6	
	<i>school--cabin</i>		2.25
	<i>hotel--cabin</i>		2.27
	<i>airplane--tractor</i>		2.73
	<i>sun--wind</i>		3.71
	<i>school--apartment</i>		4.51
	<i>tractor--bus</i>		5.28
	Within Theme	7	
	<i>bus--school</i>		3.37
	<i>subway--wind</i>		4.19
	<i>airplane--sun</i>		5.74
	<i>stove--spring</i>		6.22
	<i>wind--apartment</i>		6.96
	<i>bus--desk</i>		7.08
	<i>subway--television</i>		7.33
	Between Category and Theme	15	
	<i>spring--airplane</i>		1.50
	<i>stove--wind</i>		2.77
	<i>cabin--airplane</i>		2.91
	<i>hotel--bus</i>		3.33
	<i>sun--bus</i>		3.52
	<i>bus--bed</i>		4.74
	<i>bed--subway</i>		4.81
	<i>tractor--fall</i>		6.18
	<i>cabin--television</i>		6.21
	<i>desk--apartment</i>		6.37
	<i>hotel--stove</i>		6.38
	<i>subway--desk</i>		6.60
	<i>television--bus</i>		6.69
	<i>fall--stove</i>		7.05
	<i>desk--spring</i>		7.71

Pathfinder Network	Link	<i>N</i>	Weight ^a
Grade 7 More Creative (<i>N</i> = 30)	Within Category	6	
	<i>school--cabin</i>		.54
	<i>hotel--cabin</i>		1.28
	<i>sun--wind</i>		1.56
	<i>cabin--apartment</i>		2.40
	<i>airplane--tractor</i>		3.36
	<i>tractor--bus</i>		4.20
	Within Theme	6	
	<i>bus--school</i>		.74
	<i>subway--wind</i>		3.19
	<i>airplane--sun</i>		3.53
	<i>subway--television</i>		4.41
	<i>wind--apartment</i>		5.18
	<i>stove--spring</i>		6.60
	Between Category and Theme	18	
	<i>spring--airplane</i>		.57
	<i>cabin--airplane</i>		1.33
	<i>stove--wind</i>		1.77
	<i>bus--bed</i>		1.84
	<i>bed--subway</i>		1.86
	<i>hotel--bus</i>		1.90
	<i>apartment--bed</i>		1.98
	<i>sun--bus</i>		2.28
	<i>desk--apartment</i>		3.88
	<i>airplane--television</i>		3.91
	<i>fall--stove</i>		4.01
	<i>tractor--fall</i>		4.03
	<i>television--bus</i>		4.58
	<i>hotel--stove</i>		4.62
	<i>desk--hotel</i>		4.76
	<i>television--fall</i>		6.34
	<i>desk--spring</i>		6.76
	<i>apartment--tractor</i>		7.52

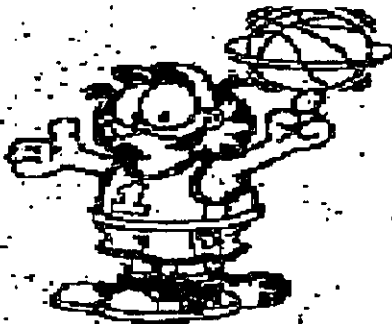
Pathfinder Network	Link	N	Weight ^a
Grade 7 Less Creative (N = 31)	Within Category	8	
	<i>school--cabin</i>		.14
	<i>cabin--apartment</i>		1.00
	<i>sun--wind</i>		1.37
	<i>hotel--cabin</i>		1.46
	<i>tractor--bus</i>		3.06
	<i>airplane--tractor</i>		3.60
	<i>fall--sun</i>		7.16
	<i>tractor--subway</i>		7.93
	Within Theme	7	
	<i>airplane--hotel</i>		1.67
	<i>bus--school</i>		2.18
	<i>subway--wind</i>		3.03
	<i>subway--television</i>		3.30
	<i>airplane--sun</i>		3.63
	<i>wind--apartment</i>		3.98
	<i>stove--spring</i>		6.47
	Between Category and Theme	16	
	<i>spring--airplane</i>		.17
	<i>bed--subway</i>		1.11
	<i>bus--bed</i>		2.29
	<i>sun--bus</i>		2.46
	<i>hotel--bus</i>		2.54
	<i>airplane--television</i>		2.62
	<i>apartment--bed</i>		2.70
	<i>hotel--stove</i>		3.04
	<i>stove--subway</i>		3.04
	<i>desk--apartment</i>		4.31
	<i>fall--stove</i>		4.46
	<i>tractor--fall</i>		4.51
	<i>desk--hotel</i>		4.75
	<i>desk--spring</i>		6.48
	<i>television--fall</i>		6.53
	<i>apartment--tractor</i>		7.28

^aLow link weights correspond to decreased distance between words in the network, whereas high link weights correspond to increased distance between words in the network.

Appendix H

Common Links Across Pathfinder Networks and Their Respective Weights

Common Links	N	Weights for Pathfinder Networks			
		Grade 3 More Creative	Grade 3 Less Creative	Grade 7 More Creative	Grade 7 Less Creative
Within Category	5				
<i>airplane--tractor</i>		3.21	2.73	3.36	3.60
<i>tractor--bus</i>		4.25	5.28	4.20	3.06
<i>hotel--cabin</i>		1.47	2.27	1.28	1.46
<i>school--cabin</i>		2.64	2.25	.54	.14
<i>sun--wind</i>		3.65	3.71	1.56	1.37
Within Theme	6				
<i>airplane--sun</i>		4.60	5.74	3.53	3.63
<i>wind--apartment</i>		6.52	6.96	5.18	3.98
<i>bus--school</i>		3.32	3.37	.74	2.18
<i>stove--spring</i>		6.19	6.22	6.60	6.47
<i>subway--television</i>		5.80	7.33	4.41	3.30
<i>subway--wind</i>		3.55	4.19	3.19	3.03
Between Category and Theme	8				
<i>spring--airplane</i>		2.44	1.50	.57	.17
<i>desk--apartment</i>		5.25	6.37	3.88	4.31
<i>bus--bed</i>		3.78	4.74	1.84	2.29
<i>bed--subway</i>		2.65	4.81	1.86	1.11
<i>hotel--bus</i>		3.79	3.33	1.90	2.54
<i>sun--bus</i>		3.63	3.52	2.28	2.46
<i>fall--stove</i>		6.57	7.05	4.01	4.46
<i>tractor--fall</i>		4.47	6.18	4.03	4.51
Total N	19				

Opening and Closing Screens for the Association-Decision Task

Hi! It's me, Garfield.
I have a game to play
and so do you.
Make a decision for all pairs of words
and see me score a basket.

Press any key to continue...



Oops! I guess I missed.

Congratulations!
You made a lot of decisions.

Thank you for your help.