CREATIVITY AND COGNITIVE INHIBITION:

A NEW INTERPRETATION OF THE DEVELOPMENT OF CREATIVITY

by

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(Under the Direction of Katherine Kipp)

ABSTRACT

This experiment was conducted to examine a possible relationship between the development of creativity and the development of intentional cognitive inhibition. Creativity was defined as the creation of something novel and useful and was theorized to be an ability that all people possess to varying degrees. Cognitive inhibition was defined as the suppression of irrelevant items from working memory. It was hypothesized that a decrease in creative ability would occur during the fourth grade, reflecting a beginning understanding and overuse of cognitive inhibition, which would reduce the number of irrelevant items in working memory to such a degree that creative ability would suffer. Forty participants from second grade, fourth grade, sixth grade and college completed two tasks from the Torrance Tests of Creative Thinking (TTCT) and a directed forgetting task designed to measure intentional cognitive inhibition. The hypotheses were not supported. Methodological concerns are discussed as a possible reason for the results.

INDEX WORDS: Creativity, Cognitive Inhibition, Development, Children, Testing

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DEDICATION

I dedicate this dissertation to the two most important people in my life, my wife and my son. Without you, I never would have made it. Erlenmeyer flask.

I also dedicate this to the memory of my sister Ellee Mae Smathers and my brother (in spirit) Jay P. West. I love you both and will miss you always.

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CHAPTER 1

INTRODUCTION

This paper defines creativity and discusses the current research on how creativity develops. It briefly discusses the construct of cognitive inhibition and then reinterprets the developmental research on creativity using the construct of inhibition as a means of explaining the differences in creative ability across development. Finally, the details of a research study directly comparing the pattern of development of creativity with the pattern of development of cognitive inhibition are discussed. By looking at these two abilities, I hoped to shed new light on the development of creativity, especially the decrease in creative ability during the fourth grade year that has been documented in previous literature (Albert, 1996; Milgram 1990; Torrance, 1962).

Although there are divergent views on what creativity is, with some choosing to focus on creativity as a special trait that only few possess, this paper focuses on the contemporary view of creativity as a trait that all people possess to some degree (Cropley, 1999). To this aim several theoretical standpoints are discussed, with Torrance's (1962) divergent thinking theory of creativity, Mednick's (1962) associative theory, and the generation and selection model of creativity highlighted as examples of this viewpoint.

CHAPTER 2

LITERATURE REVIEW

Contemporary Cognitive Views of Creativity

Contemporary research on creativity often focuses on what some have termed everyday or mundane creativity, a trait that all people possess to some extent (Cropley, 1999). This type of creativity is something that people engage in everyday during activities as simple as deciding what to cook for dinner. Some researchers even go as far as saying that every use of language is creative, given that people are using novel language constructions almost every time they utter a sentence (Ward, Smith & Vaid, 1997).

Everyday creativity is defined as the creation of something original. To be original a thing must be both novel and useful. A thing which is only useful or only novel is not considered creative. In other words, if you are asking participants to name all the possible uses for a spatula and they come up with using it to flip pancakes, this is clearly not creative. Whereas this answer is useful, it is not novel. If they instead say that you can use a spatula to change a tire, you again have not demonstrated creativity. Whereas this answer is clearly novel, it is not useful. True creativity will have both elements, as in saying that you can use a spatula to kill flies.

Torrance's theory of creativity. Torrance (1962) defines creativity as "the process of sensing gaps or disturbing missing elements; forming ideas or

hypotheses concerning them; testing these hypotheses; and communicating the results" (p. 16). This theory suggests that creativity is actually a number of abilities, including fluency (the ability to produce a large number of responses), originality (the ability to produce novel responses), elaboration (the ability to use multiple components when coming up with a response), and flexibility (the ability to change categories or ways of thinking about something) (Torrance, 1995). Torrance also stressed the importance of the environment in which creativity takes place, advocating that creative behavior be given more support in educational settings (Torrance, 1962).

Torrance created the widely used Torrance Tests of Creative Thinking (TTCT) to assess creativity in children and adults (Torrance 1962, 1995). When creating these tests, Torrance attempted to include complex tasks that would tap into the many facets of creative thinking. The TTCT consists of 25 tasks. It includes both verbal tasks which use verbal stimuli and require either verbal or nonverbal responses and nonverbal tasks which require nonverbal responses. An example of a verbal task included in the TTCT is the Ask-and-Guess Test in which participants are shown a picture and asked to do several things. First, they are asked to generate questions that will allow them to learn more about what is occurring in the picture. Second, they are asked to come up with possible causes for the action in the picture. Last, they are asked to come up with possible results of the action in the picture. From the participants' responses, measures of fluency, originality, elaboration, and flexibility are taken. There are several other verbal tasks included in the TTCT, such as the

Product Improvement Task in which participants think of ways to improve a toy, the Unusual Uses Task in which participants must give unusual uses for common items, and the Just Suppose Task in which participants are required to think about the results of an improbable situation occurring (Torrance, 1995; also, see Torrance 1962 for a complete list of tasks and instructions).

The TTCT also includes nonverbal tests of creative thinking. An example of a nonverbal test is the Picture Construction Test in which participants are asked to use a small colored shape as the basis for a complete drawing. Other nonverbal tasks include the Figure Completion Test which requires participants to complete several incomplete pictures and the Repeated Closed Figures Test which requires participants to construct several different drawings based on the same closed shape (Torrance, 1995; also, see Torrance 1962 for a complete list of tasks and instructions).

The TTCT has been validated in a number of studies (Torrance, 1972, 1995) and has shown correlations with later creative ability. In a review of several short and long range prediction studies, Torrance found strong positive correlations between performance on the TTCT and measures of creative ability taken between a few days and 12 years after the original testing. However, despite the wide use of these tests and the fact that predictive validity has been established in some studies (Torrance, 1972, 1995), the TTCT continues to be criticized (Johnson & Fishkin, 1999; Baer, 1993). One complaint is that the TTCT is easily affected by minor irrelevant factors, such as the room in which a person is tested (Johnson & Fishkin, 1999).

Baer (1993) has also criticized the TTCT as being a measure of divergent thinking instead of overall creative ability. Divergent thinking is the ability to think of many, varied, novel solutions to a problem (Cropley, 1999). Research by Baer (1993) challenges the use of divergent thinking tests as measures of creativity. He conducted five studies on creativity with different age groups, ranging from second grade to college students. These studies used performance measures of creativity that were designed to mimic authentic and applied creativity better than the Torrance test. In addition to IQ tests measuring mathematical, verbal, and reading skills, Baer measured the participants' creativity in writing poems, short stories, word problems and math equations. He then correlated these "real life" creativity measures with tests of divergent thinking. His results indicated that divergent thinking did not predict applied creativity, as measured by these more ecologically valid tasks. Baer concluded that divergent thinking may not even be an important component to creativity.

Baer (1993) did find, however, that training in divergent thinking led to increases in creativity, especially in particular domains. In another study, he tested participants' creative abilities on the same "real life" creativity tasks mentioned above and then trained them on divergent thinking. After the training, participants were more creative on the "real life" tasks. Clearly, then, divergent thinking is having some effect on creativity. Baer suggested that divergent thinking may be important to creativity but only when produced at appropriate times. According to Baer, the skill of knowing when to use divergent thinking may be the most important component of creativity. This

skill, however, may be learned only through specific instruction, explaining why training in divergent thinking (which includes knowing when to use it) can increase creativity. Baer also mentioned that there may be a complex relationship between divergent thinking and creativity in which a moderate (or small) amount of divergent thinking is good for creativity but too much would actually be detrimental.

Other research has shown a correlation between divergent thinking measures and applied creativity (Milgram, 1990). Milgram studied creativity by examining performance on two tasks. The first task, which is the most similar to typical divergent thinking tests, did not require participants to provide answers to defined problems. Their answers were not scored on their ability to solve a problem, but rather, on their subjective quality and the frequency with which they were given by other respondents. The second task was more stringent in that it required participants to solve a particular problem. The answer was then judged not just for quality and frequency, but also for being a valid solution to the problem. Milgram then collected self-report data with the Tel-Aviv Inventory of Activities. This measure consists of two scales: one measures culturally acknowledged creative performance (i.e., how many awards have been won for creative achievements) and one measures leisure activities (i.e., how much free time is spent in creative pursuits). When the two measures of divergent thinking were correlated with the Tel-Aviv Inventory, Milgram found that they were positively correlated. It is not clear, therefore, what (if any) role divergent thinking plays in creative ability.

Mednick's Associative Gradient Theory. Another theory of creativity is the Associative Gradient Theory proposed by Mednick (Mednick, 1962; Baer, 1993; Eysenck, 1997; Martindale, 1995). Mednick defined creative thinking as the combining of two (or more) previously unrelated items into a product that is novel and useful. The more remotely associated the original items are, the more creative the product can be considered (Mednick, 1962). To explain individual differences in creativity, Mednick proposes differences in types of associative gradients. According to Mednick, all people have associative networks between concepts or ideas. When one idea is activated, that activation spreads to all of the ideas connected to it. Ideas that are strongly connected get the most activation, whereas ideas that are only loosely connected get little activation. When a concept is introduced, a person with a steep associative gradient has only a few ideas that are activated and they all receive a large amount of activation. These people are less likely to have creative ideas, as all of their activation is focused on a few highly salient ideas. When a person with a relatively flat associative gradient has an idea, however, the activation is spread out so that many concepts receive a low level of activation. These people are more likely to have creative ideas because the original concept activates many other concepts, both those that are typically associated with it and those that are only loosely related.

In addition to these differences, Mednick also proposed differences in the response time and number of responses between a highly creative person and a less creative person. Because more commonly associated concepts receive more

activation, they will be produced faster than remotely associated concepts. Mednick believed that this would result in less creative people producing responses at a rapid rate (as their responses would be common overall) but then quickly running out of new responses as they exhausted their supply of common associates. Highly creative people, on the other hand, were expected to produce responses slowly and to produce a greater number of responses.

After designing this theory of creativity, Mednick, like Torrance, designed a test to measure creative abilities. The Remote Associates Test (RAT) is a test of creativity in which participants are required to give the common link between three words. For example, if the words “out”, “dog”, and “cat” were given, the correct answer would be “house” because it is the common link between the three stimulus items (Mednick, 1968). Mednick believed that this test would tap into the ability to link remote concepts that he hypothesized was the basis for creative behavior.

In support of Mednick’s theory, research has found that creative people have a flatter associative gradient, which means that they give more lower frequency words in response to word association tasks (Mednick, Mednick, & Jung, 1964). When participants were given a word association task in which they were required to think of as many associates to a stimulus word as possible in 2 minutes, participants who scored higher on the RAT gave a greater number of associates than participants who scored in the low or medium ranges.

In another study examining Mednick's theory, Brown (1973) found that participants who scored high on the RAT learned items of strong or weak associative strengths with equal ability. Participants were instructed to learn a list of paired items, some of which were strongly associated and some of which were weakly associated. They were then given the RAT and divided into groups based on their scores. Participants who scored lower on the RAT showed a difference in their ability to learn the paired associates, with the strongly associated items more likely to be retrieved than the weakly associated items. Participants who scored higher on the RAT showed no difference in their ability to learn the paired associates, retrieving the strongly and weakly associated items at the same rate. This supports Mednick's theory of associative hierarchies in that participants who scored higher on a test of creativity appear to have a flatter associative hierarchy in which both strongly and weakly associated items receive similar levels of activation. If all items receive similar amounts of activation, the strength of association would not affect these participants during their attempt to learn the associative pairs.

Generation and Selection Theories. Other theories of creativity address the processes in which people engage when generating creative solutions to problems. Many researchers agree that creative thinking is a multi-stage process, although the number of stages proposed varies across theories (see Arieti, 1976, for some examples). The most common stages are generation and selection (Bink & Marsh, 2000). In the generation stage, people allow all possible solutions to come to mind, without censoring them, regardless of how

unusual they may be. During the next stage, selection, solutions are evaluated and either dismissed as inappropriate for the problem at hand or selected as viable solutions. These stages may not be enacted, however, depending on the situation. If there is a time limit on the creative response, for example, the generative stage may have to be combined with the selection stage, allowing for fewer possible solutions to be generated with all of these solutions highly appropriate for the question.

Conclusion. The one thing that can be said with certainty about the field of creativity is that it is lacking cohesion. There is not a single theory of creativity that has been universally embraced and researchers continue to debate the nature of creativity. While researchers pursue their own theories of creativity, ignoring or criticizing other theories, the field remains disjointed and full of unanswered questions. Before real progress can be made on determining the underlying process of being creative, researchers need to come to a consensus on what creativity is, and what is the best way to measure it.

The Development of Creativity

Introduction. One way to address these inconsistencies is to examine the development of creativity for clues that indicate which of the theories about the nature of creativity are most useful. Evaluating the different tasks designed to measure creativity from a developmental perspective may reveal whether they are all measuring the same underlying construct. It may be, for example, that the TTCT and Mednick's Remote Associative Test are measuring completely different underlying abilities, even though they both are argued to be

measuring creative ability. If these tasks were examined across age and different developmental trajectories were uncovered it would suggest that the tasks are not both measuring the same ability. Both tests may be tapping into components of creativity, with these components developing at different rates. Discovering this can help us to formulate a more cohesive theory of creativity that includes all the relevant components and also reveals something about the development of the creative process.

Research on the development of creativity. The course of the development of creativity is unclear at this point. Researchers have different theories of how creativity develops based, mainly, on which tasks were used in their studies. There are three main developmental paths that have been hypothesized.

The first developmental path that has been suggested is a steady increase in creative ability that begins in early childhood (Cacciari, Levorato & Cicogna, 1997). Studies of children's ability to draw imaginary objects and animals, for example, find that younger children are limited in their ability to produce novel drawings (Cacciari, Levorato & Cicogna, 1997). Children under eight years old are unable to draw new objects without relying heavily on features that these objects typically possess. If asked to draw a novel type of house, for example, young children are able to vary the size and placement of the features yet they continue to include typical features such as doors and windows. Older children appear to be better at including elements of novel categories in their drawings (such as giving a house legs, for example).

The second developmental path that has been suggested is a period during middle childhood during which creativity declines sharply before rebounding in adulthood (Albert, 1996; Milgram 1990; Torrance, 1962). Milgram (1990) found that very young children produced a wide variety of novel responses on divergent thinking measures and also scored high on authentic or applied creativity measures. As children got older, the number of novel responses dropped sharply. Children in elementary school produced fewer novel responses than those in preschool. Adults showed a rebound in the number of responses and in fact had very similar patterns to those of the pre-school-aged children. Torrance (1962) found a similar decline in performance on the TTCT. In his longitudinal studies, he found that creativity declines sharply in the fourth grade, rebounds in the fifth and sixth grades, drops again in seventh grade, and rebounds again in adulthood (Torrance, 1962). Other researchers also claim a decrease in creative ability in elementary school, although they place this decrease at a later age, from 9 to 12 years of age (Albert, 1996).

The final developmental path suggested is that young children do not possess the capabilities to be truly creative (Keegan, 1996). Keegan claims that whereas children possess the same cognitive mechanisms that allow the greater creativity of adults, they lack the expertise to use those mechanisms as well as adults. Keegan proposed that great creativity can only be achieved after a field is mastered so that the creator has enough background knowledge to know what is lacking in the area and how to fill that gap. Children, while able

to create novel ideas, will never be truly creative simply because they have not had the time necessary to learn all of the background knowledge of any given area, which, according to Keegan, takes at least 10 years. This does not tell us much about the development of mundane creativity, however, which may not require an extensive knowledge base.

Why are there different developmental trajectories? The differences found in this research area may be an artifact of the different measurements of creativity used by different researchers. For example, Cacciari et al. (1997) used drawing ability as a measure of creativity and then examined the drawings to determine the creative abilities of their participants. Milgram (1990) used divergent thinking tests as a measure of creativity and examined the number of novel responses his participants offered. In other words, Cacciari et al. (1997) used a visual task whereas Milgram used a verbal task. These tasks may be measuring different constructs. Taking the task differences into consideration, it is not surprising that different developmental timelines were proposed.

Another possible explanation for different developmental trends may be revealed by considering Piaget's stage theory of development. Piaget proposed that all children develop cognitively through invariant stages (Piaget, 1967). Children start out as reflexive creatures, gradually developing the ability to use symbols and think abstractly over childhood. It may be that only once the ability to think about abstract concepts develops can children be creative on certain tasks. Piaget proposed that children in the concrete operational stage

(which according to him lasts until late childhood) were unable to think of things that can exist outside of reality (Piaget, 1971). They cannot conceptualize things that are outside of their past experiences or think logically about things that contradict their knowledge of the real world (Piaget, 1971).

If we apply Piaget's ideas to the study of creativity, we can infer that children who have not reached the formal operational stage will be unable to be creative about things that do not exist in their understanding of the real world. Therefore, when presented with the task of drawing a novel object (such as a house, as in Cacciari, et al.'s 1997 study), concrete operators will be constrained by their inability to think abstractly about this concept. Instead of drawing a novel house, they will rely heavily on concepts with which they are familiar, thus basing the "novel" house on their ideas of real houses. A similar study, based on preliminary work by Shaffer (2000), examined children's placement of a third eye on the body (see also Low & Hollis, 2003). Shaffer found that younger children tended to place the third eye on the face, somewhere near the normal location for eyes. They were also unable to give logical reasons for their placements. Older children, on the other hand, placed the eye in a variety of creative places, such as on the palm of the hand, and were much better at giving reasons for their placements (Shaffer, 2000).

In their related work, Low and Hollis (2003) found that children were consistently less creative with their placement of the eye and in their explanations than were adults. However, by modifying the task and instructions, Low and Hollis found a slight increase in children's creativity.

When given specific instructions to place the eye where they could "see more," for example, 12-year-old children improved their performance significantly. Nine-year-old children did not improve until the task was changed from a drawing task to a task in which they actually placed a cardboard eye on a cut-out human figure. In this situation they placed the eye somewhere other than the natural eye-line, although they still did not move the eye from the facial region and did not offer very good reasons for their placements. Finally, 6-year-old children were able to improve their performance only when they were able to actually put the eye on themselves, by sticking a cardboard eye to their bodies, but like the 9-year-olds their improvements were limited. Even with the changes in the ease of the task, 6- and 9-year-old children rarely put the eye anywhere other than the face.

How does this study fit with Piaget's concrete operational stage? If children are constrained in their creativity by an inability to think about abstract concepts like a third eye (cf., Piaget, 1971), it follows that they would do poorly on this task. It also follows that as the task gets less and less abstract, with the researchers taking it from a drawing, to a model, to the children themselves, the children will improve on the task.

How do other measures of creativity map onto Piaget's theory? If children are simply constrained by reality, creativity tasks designed to measure divergent thinking or remote associations should be unaffected by the child's cognitive developmental stage. Divergent thinking tasks, for example, do not require thinking about abstract concepts; they instead tap into the child's

ability to think of novel responses to everyday words or objects. Children should be able to do this even if they are constrained by immature abstract thinking.

Indeed, young children perform well on tests of divergent thinking (Milgram, 1990); there is no need to go beyond reality. In the unusual-uses task, for example, children are sometimes asked to think of uses for a cardboard box, which is a familiar object to them. Their responses may be more concrete, relying on the appearance of the box and its usual functions, but they may still generate many novel uses.

Some support for this hypothesis comes from a study examining children's divergent thinking about familiar versus unfamiliar stimuli (Sawyers, Moran, Fu, Milgram, 1983). Sawyers et al. examined the number and originality of responses in a divergent thinking task with 4- to 6-year-old children. They found that manipulating the familiarity of the stimulus affected the number of responses. When the stimulus was familiar to the children they performed significantly better than when it was unfamiliar, giving more responses overall and more original responses. Sawyers et al. concluded that using more familiar items in the unusual-uses task would improve the study of children's creativity (whereas using unfamiliar items would mask the creativity of the highly creative children). Once again, as the task becomes more concrete (and familiar) children are better able to respond creatively.

Whereas this idea explains why children are able to perform well on the divergent thinking tasks, it does not address the finding that children show a

creative “slump” in early childhood. The development of cognitive inhibition may offer an explanation of this phenomenon.

The Construct of Cognitive Inhibition.

Cognitive inhibition refers to the process by which a person suppresses information that was previously activated in working memory (Harnishfeger & Bjorklund, 1994; Harnishfeger & Pope, 1996). The ability to use cognitive inhibition develops over childhood, with children in the fifth grade performing as well as adults on some tasks that measure inhibitory ability and improvement continuing into adolescence on other tasks.

The construct of cognitive inhibition relies on the limited resource model to explain cognition. According to the limited resource model, each person has a limited amount of mental resources with which to perform cognitive operations (Case, Kurland & Goldberg, 1982). Cognitive development occurs as children become more efficient at using these resources. As children mature, they develop better inhibition skills, which in turn affect their total processing abilities by allowing some of the resources that were once devoted to irrelevant information to now be devoted to processing and storing relevant information. Therefore, inefficient inhibition has been hypothesized to contribute to developmental changes in processing abilities (Harshinfeger & Bjorklund, 1994).

Harnishfeger (1995) distinguishes between two types of cognitive inhibition: automatic and intentional. In automatic inhibition, conscious thought about inhibiting items is not required. Inhibition occurs at an

automatic, unconscious level. This type of inhibition is thought to mature as children age, reaching complete maturation sometime in adolescence. Selective attention tasks such as the Stroop task, in which participants are required to say the ink color of color words, are given as examples of tests of automatic inhibition. Negative priming, a specific condition used in some versions of the Stroop task allows researchers to measure automatic inhibition (Harnishfeger, Nicholson, & Digby, 1993). In the original version of the Stroop task, the ink colors participants are asked to name do not match the color words themselves. This creates interference due to the automatic nature of reading: participants must ignore the interference that occurs from automatically reading the word in order to name the ink color correctly. In the negative priming condition this becomes more difficult because the color word that was suppressed due to the interference it caused becomes the ink color of the following item. Participants must release that item from inhibition to respond correctly on the second trial. If their inhibitory abilities are strong, they will be slower to respond during the negative priming condition because of the extra time required to release the items from inhibition before responding correctly (Harnishfeger, Nicholson, & Digby, 1993).

Research using the negative priming condition shows a gradual increase in automatic inhibitory abilities as children age (Harnishfeger, Nicholson, & Digby, 1993). First grade children showed no difference in their speed of responses on the original Stroop condition and the negative priming condition. This suggests that they were unable to suppress the color words and hence

had no need to release them from inhibition during the negative priming condition. Children in 5th grade, however, performed like adults on the negative priming condition, with decreased speed indicating that they had successfully inhibited the color words (Harnishfeger, Nicholson, & Digby, 1993).

Another example of an occurrence of automatic cognitive inhibition is in the process of choosing between the meanings of polysemous words, such as bank (Simpson & Foster, 1986). When a person must choose the correct meaning of a polysemous word they are thought to go through a three step process. First, all meanings of the word are activated. Second, the correct meaning is chosen. Automatic inhibition occurs during the last step, in which all of the inappropriate meanings are suppressed (Onifer & Swinney, 1981).

Research with children using polysemous words provides additional support that automatic inhibition is an ability that increases with age (Simpson & Foster, 1986). In research examining processing of polysemous words by second-, fourth-, and sixth-grade children, only the sixth grade children showed evidence of inhibiting the irrelevant meanings of the polysemous words (Simpson & Foster, 1986). This provides further evidence that automatic inhibitory abilities develop over childhood (Harnishfeger & Bjorklund, 1993).

Although cognitive inhibition typically has been discussed as an ability that simply matures with age, it may also be a strategy that children must learn and then practice to become proficient. This conceptualitization is similar to Harnishfeger's (1995) concept of intentional cognitive inhibition. In intentional cognitive inhibition, some cognitive awareness of the process of

inhibiting occurs. Tasks that measure this type of inhibition typically instruct participants to actively suppress information. Directed-forgetting tasks are an example of this paradigm. In these tasks participants are instructed to forget some previously studied words while remembering others. This process is active and intentional, unlike the automatic process of choosing between meanings of polysemous words (Harnishfeger & Bjorklund, 1993). In directed forgetting tasks, participants are given a list of words to remember. After half of the words have been presented, participants are given instructions to forget the first half of the list and only remember the second half of the list. The forget instruction requires participants to inhibit those items in order to remember the following to-be-remembered items. After the entire list is presented participants are given a free recall test that asks them to remember both the items they were instructed to remember and those they were instructed to forget. If participants inhibited the to-be-forgotten words, fewer of these words are recalled than the words that they were asked to remember (Bjork, 1970). In most experiments, participants are then given a recognition test that includes words from both the to-be-forgotten and to-be-remembered lists (Geiselman, 1974). The recognition test allows the items that were inhibited to be released from inhibition. Participants are usually able to recognize the previously inhibited words even though they could not recall them. The recognition test results offer further evidence that the inhibited items were processed and then inhibited, rather than simply not processed (Geiselman, 1974).

Developmental trends in the directed forgetting paradigm have been examined in a number of studies (see Harnishfeger, 1995, for a review). Most directed forgetting studies find evidence of inefficient intentional inhibition in young children (Harnishfeger & Pope, 1996). When first-, third-, and fifth-grade children are tested with the directed forgetting paradigm, first- and third-grade children have similar patterns of recall for the to-be-forgotten and to-be-remembered words (Harnishfeger & Pope, 1996). This suggests that these children are not inhibiting the to-be-forgotten items, despite instructions to forget those words. Children in first- and third-grade appear unable to intentionally inhibit words in this task. Fifth-grade children, on the other hand, have patterns of recall similar to adults: the to-be-forgotten items are not remembered as well as the to-be-remembered items (Harnishfeger & Pope, 1996). Thus, intentional inhibition appears to develop over the elementary school years, with mature ability achieved before adolescence.

It is possible that this intentional form of inhibition is strategic and can be improved with practice. Perhaps the increases in inhibitory abilities that occur over the childhood years in directed-forgetting tasks are due to the implementing and perfecting of a strategy of suppressing irrelevant stimuli. If inhibition is conceptualized in this way it can be applied to the study of creativity to explain some of the developmental differences.

Creativity and Cognitive Inhibition: A New Interpretation of Creativity

Introduction. Research on the link between cognitive inhibition and creativity is scarce. The few studies published on this topic all focus on the

links among creativity, cognitive inhibition, and mental illness (Green & Williams, 1999; Stavridou & Furnham, 1996; Wuthrich & Bates, 2001). Because these are the only published studies that examine how inhibition relates to creativity, it is important to examine them before turning to a discussion of how cognitive inhibition may relate to the development of creativity. Before describing this research, it may be helpful to discuss mental illness and creativity in general.

There are many lines of research that investigate the link between mental illness and creativity. People who score high on traits associated with certain mental disorders (especially bipolar disorder and schizophrenia) also score high on measures of creativity (Eysenck, 1997; Green & Williams, 1999; Richards, 1996). People who demonstrate high levels of schizotypy also score high on tests of creative ability (Wuthrich & Bates, 2001). Even family members of bipolar patients are more creative than people without bipolar disorder in their family (Richards, 1996). Why these connections between creativity and mental illness exist is still debated. Researchers do seem to agree that the connection may be due to underlying traits that are common to both creative people and people with mental illnesses. What these traits are is unknown. Eysenck (1993; 1997) suggests that both highly creative individuals and those with mental illness engage in "overinclusive thinking," in which they possess loose associations between irrelevant concepts and have fuzzy boundaries between categories and concepts that most people would clearly separate. In other words, it may be that both people with certain mental illnesses and those with

creative potential have wider associative networks with a flatter associative gradient. It may be possible that one thing that separates creative, mentally healthy people from those with mental illness is the degree to which they engage in overinclusive thinking.

Research on mental illness and creativity has focused on isolating the exact cognitive ability (or lack of ability) that underlies creativity and mental illness. One candidate is cognitive inhibition (Green & Williams, 1999; Stavridou & Furnham, 1996; Wuthrich & Bates, 2001). Borrowing from Mednick's associative network hypothesis, it is possible that a lack of cognitive inhibition is the key to a flat associative gradient. Lowered inhibition may allow thoughts that usually would be inhibited by most people to receive attention in working memory in the creative and mentally ill, thus allowing these terms to be associated with concepts that most people would not associate.

Research into the connection between inhibition, creativity, and mental illness has not been supportive of this theory, however. Two studies that examined mental illness, creativity, and cognitive inhibition failed to find correlations between inefficient inhibition, creativity, and mental illness (Stavridou & Furnham, 1996; Green & Williams, 1999). Stavridou and Furnham (1996) examined the link between psychoticism, creativity, and cognitive inhibition. Psychoticism was measured using the Eysenck Personality Questionnaire (Stavridou & Furnham, 1996), which defines psychoticism as a collection of traits that render a person more susceptible to developing psychotic symptoms (Eysenck, 1993). According to Eysenck (1993), some of

these traits included are aggression, impulsivity, antisocial behavior, and egocentricity. Stavridou and Furnham (1996) measured creativity using the Wallach-Kogan creativity test, which has several tasks similar to the Torrance tasks, including naming alternate uses of objects (for a complete list of the tasks used see Stavridou & Furnham, 1996). Finally, cognitive inhibition was examined using a negative priming Stroop task. Results indicated that there was a positive correlation between performance on the creativity tasks and scores on the Eysenck Personality Questionnaire. Results also indicated a negative correlation between scores on the negative priming task and scores on the Eysenck Personality Questionnaire. There was not, however, a correlation between scores on the creativity tasks and scores on the negative priming tasks, suggesting that cognitive inhibition was not related to creativity.

The second study that explored the link between creativity, mental illness, and cognitive inhibition examined schizotypy as the measure of mental illness (Green & Williams, 1999). Schizotypy is similar to psychoticism, but deals more specifically with traits associated with schizophrenia as opposed to psychotic disorders in general. Green and Williams (1999) examined the positive traits of schizotypy, such as aberrant perceptions and beliefs, because these are the traits that have been correlated with inefficient cognitive inhibition in past research. They administered the Schizotypal Traits Questionnaire to measure the participants' level of schizotypy. To measure creativity, they used the Wallach-Kogan creativity test, which measures divergent thinking ability. Finally, they used the negative priming Stroop task

to measure cognitive inhibition. Results revealed mixed support for the hypothesized relationship between creativity, mental illness, and cognitive inhibition. While there was a correlation between schizotopy and creativity, with participants who scored higher on the measure of schizotypic traits giving more unique responses on the measures of creativity, there was no relationship between schizotypy and cognitive inhibition or between creativity and cognitive inhibition. Once again, the hypothesis that creativity and cognitive inhibition are related was not supported (Green & Williams, 1999).

We cannot conclude, however, that lowered inhibition does not play a role in creativity, because the results found by Green and Williams (1999) and Stavridou and Furnham (1996) are inconsistent with previous research. Green and Williams (1999), for example, did not find a correlation between inefficient inhibition and schizotypy, a correlation that has been found in other studies. They also found no evidence of negative priming in any of their participants, which presents a clear problem because they were using this task as their measure of cognitive inhibition. Finally, both studies modified the negative priming task usually used in studies of cognitive inhibition to make it more stringent (Stavridou & Furnham, 1996; Green & Williams, 1999). This also may have contributed to the lack of correlation found in these studies. Because of these methodological limitations, more research on the possible link between cognitive inhibition and creativity is warranted.

Cognitive inhibition, creativity, and development. There have been no published investigations of cognitive inhibition, creativity and development. If

we assume that cognitive inhibition plays a role in creativity, which makes sense theoretically but remains to be demonstrated empirically, we may also speculate on the possible effect of the development of inhibitory abilities on the development of creativity. If we think of cognitive inhibition not as an inborn trait that simply matures with age, but instead as a cognitive strategy that children must learn and then practice to master (cf. Harnishfeger, 1995), it may explain the slump in creativity that has been found in several divergent thinking experiments (Milgram, 1990; Albert, 1996; Torrance, 1962).

Young children (second or third graders), have not begun to use inhibition as a cognitive strategy (cf. Harnishfeger, 1995). Hence, they are weak in inhibitory abilities. This allows more weakly associated words to be activated and considered in divergent thinking tasks. In this case, inhibition cannot "get in the way" and rule out highly unrelated ideas before the child has a chance to fully explore them. Without cognitive inhibition to stop them, irrelevant thoughts will intrude during creativity tasks and may provide some new ideas that are actually creative and useful by adult standards.

As children age and begin to develop cognitive inhibition, they may over use it as they are trying to learn this new strategy. This overextension can be likened to the overextension of grammar rules that children exhibit when learning language (Thompson & Chapman, 1977). When children first begin to speak, they make errors in which they extend a grammar rule or a particular word too far, continuing to use it even when it is inappropriate to do so. A child, for example, may say that the plural of foot is foots or that the past tense

of go is goed, overextending the grammar rules that they have learned about pluralizing or changing words to the past tense. Children exhibit these errors as they are learning rules of grammar, even though they may have been speaking correctly before learning the rules (Thompson & Chapman, 1977).

When applying the concept of overextension to cognitive inhibition, it can explain why children may be less creative during the time period in which cognitive inhibition is developing. If children are overextending this new strategy, they may suppress any idea that seems off task, even if that idea may have worked for the task if given a bit more thought. Their creativity will appear to decline because all ideas that are not quickly recognized as appropriate will be suppressed. Thus, better cognitive inhibition would lead to lower creativity because ideas that may be useful if pursued will be suppressed from working memory as unrelated and off task thoughts, and never reach the point at which they are given consideration for the task at hand. As children get older and their inhibitory abilities become more advanced (Harshinfeger & Bjorklund, 1994), they may stop overextending this strategy (cf. Thompson & Chapman, 1977) and will be able to inhibit the irrelevant ideas while keeping in mind the slightly off task thoughts that may have some use.

Adults with less cognitive inhibitory ability would still be expected to be more creative, however, as they would have a wider number of irrelevant items in working memory to examine during tests of creativity (cf. Harnishfeger & Bjorklund, 1994). It may be that there is an ideal amount of inhibition to

possess, with creative people having just the right amount (Harnishfeger & Bjorklund, 1994).

How does this idea fit the literature on divergent thinking and creativity? First of all, if a slump in creativity occurs during fourth grade as Milgram (1990) and Torrance (1962) have claimed, the timing fits well with the development of cognitive inhibition (Harnishfeger, 1995). Cognitive inhibition has been shown to increase over the late elementary school years, with close to adult level performance by fifth grade (Harnishfeger, 1995). It makes sense, therefore, that the drop in creativity would occur in third or fourth grade, when children are beginning to get a grasp on cognitive inhibition. By the time they show adult performance on measures of cognitive inhibition, their creativity begins to rebound to its earlier level.

Research Goals and Hypotheses

The proposed experiment examined the link between creativity and intentional cognitive inhibition from a developmental standpoint. There were three main research goals and hypotheses addressed in this study. The first research goal was to establish the developmental trajectory for creativity as measured by divergent thinking tasks. There is still some debate about the existence of a creative slump during fourth grade. While Milgram (1990) and Torrance (1962) have found evidence of this phenomenon, other researchers such as Albert (1996) and Cacciari, Levorato and Cicogna (1997) found evidence to suggest creative ability does not decrease during this time period. I believe that although the fourth grade slump in creative ability may not be

apparent on all measures of creative ability (i.e. it may be absent on measures requiring abstract reasoning), it does exist on divergent thinking tasks. Previous research using the TTCT has indicated that children show a decrease in originality, flexibility, and fluency during fourth grade, followed by an increase in ability in fifth and sixth grade (Torrance, 1962). Therefore, I hypothesized that there will be a decrease in performance on TTCT tasks from second to fourth grade, followed by an increase in performance from fourth grade to sixth grade.

My second research goal was to establish the link between creative ability and intentional cognitive inhibition in children. Although creativity and cognitive inhibition have been examined in previous literature (Green & Williams, 1999; Stavridou & Furnham, 1996), evidence has not supported a relationship between these two variables. The evidence on this matter is far from conclusive, however, because previous examinations of these abilities (i.e. Green & Williams, 1999; Stavridou & Furnham, 1996) have been inconsistent with previous research by not finding correlations between previously related variables (i.e. inhibition and schizotypy). These studies also used modified versions of the Stroop negative priming task which may have altered the results. Finally, examinations of the relationship between creativity and inhibition have previously relied on a measure of automatic cognitive inhibition (the negative priming condition of the Stroop task) instead of intentional cognitive inhibition (the directed forgetting task). I hypothesized that while previous research did not find a relationship between creative ability and

automatic cognitive inhibition, this experiment would uncover a relationship between intentional cognitive inhibition and creativity. This hypothesis was examined by correlating participants' performance on subsets of the TTCT with their performance on a directed forgetting measure of intentional cognitive inhibition.

My final research goal was to compare the pattern of the development of creativity with the pattern of the development of cognitive inhibition. I believed that the patterns of development would suggest that the development of creative ability was affected by the development of cognitive inhibition (which is occurring during the same time period). I proposed that the decline of creative abilities around fourth grade (i.e. the "fourth grade slump") is due in part to the overutilization of the newly acquired strategy of intentional cognitive inhibition. As children struggle to perfect the use of this strategy to suppress irrelevant items from working memory, I hypothesized that it would reduce their ability to combine marginally related items into new and useful ideas, hence, reducing their creative output. Therefore, it was hypothesized that while intentional inhibitory ability would show an increase during fourth grade, creative ability would decrease. To examine this, scores on intentional cognitive inhibitory ability and scores on the included TTCT tasks were examined for age effects.

CHAPTER 3

METHOD

Participants

There were 40 participants in this study. Twenty children, 10 second graders (age: M = 7.70 , SD = 0.48) and 10 fourth graders (age: M = 9.50, SD = 0.71), were selected from a local elementary school to participate in this study. Ten sixth grade children (age: M = 11.70, SD = 0.67) from a local middle school also participated. Both of these schools were located in a small, rural town in northern Georgia. A group of 10 adults (M = 18.79, SD = 0.88) was also selected from the university research participation pool at a large University. These adults were used as a comparison group thought to possess mature cognitive inhibition and creative abilities. These age groups were selected to allow comparison of the development of cognitive inhibition which develops over the early elementary years (see Harnishfeger, 1995) to the development of creativity during the period surrounding the "fourth grade slump" (Milgram, 1990; Torrance, 1962).

Materials

Directed Forgetting Task. The stimuli consisted of two lists of 10 concrete nouns for the adults, and two lists of 8 concrete nouns for the children. The words were unrelated and equated for word length and word frequency. For the recognition tests, a list of 40 words was generated, which contained the 20

original words from the word lists and 20 foil words. These foils were also matched for length and frequency. Frequencies were calculated based on work done by Thordike and Lorge (1944). The children were given a shortened version of the adults' recognition task, which had sixteen words instead of twenty.

The Matching Familiar Figures Test was used as a buffer-clearing task between presentation of the stimuli and recall (Kagan, 1965).

TTCT. The TTCT consists of verbal and figural tests that are then further subdivided into seven verbal activities and three figural activities. Portions of the Verbal section of the Torrance Tests of Creative Thinking (Torrance, 1974) were used to assess the creativity of the participants. Torrance (1974) suggested that when the number of activities administered needs to be reduced, the Product Improvement activity and the Just Suppose activity should be given first priority. For this reason, these two activities were administered as measures of creativity in this experiment. There were two versions of the activities, Form A and Form B, which contained identical instructions with slightly different stimuli. These two versions were counterbalanced across participants. A small stuffed elephant was used as a stimulus item for Form A of the Product Improvement activity and a small stuffed monkey was used as the stimulus item for Form B. For complete task instructions, including the illustrations used during the tasks, see Figures 1-4.

Procedure

General Procedure. Participants were tested individually with tasks counterbalanced so that some participants completed the directed forgetting task first and some completed the TTCT first. The order of the TTCT tasks was also counterbalanced.

Directed Forgetting. Participants were read a list of 16 words (20 words for adults), at a rate of 4 seconds per word. Participants were asked to listen to the word and then repeat each word back to the experimenter. This ensured that participants heard and understood all of the words. After the first 8 (10 for adults) of these words were read, participants received the following cue to forget those words and only remember the next set of words: "Okay. The words I just read were practice words. You don't need to remember those words for later. Just forget those words and concentrate on remembering the next set of words. I'm going to read a second list of words to you now. Please try to remember them." After this cue was given, participants heard the second half of the list, an additional 8 words.

After presentation of the list, participants engaged in the Matching Familiar Figures task for 30 seconds. During this task, participants were asked to select a picture out of a group of four similar pictures that most closely resembled the target picture. This task was not scored for accuracy, but was simply included to eliminate any recency effect.

After 30 seconds passed, participants were asked to remember all of the words from the list. Participants listed the words they recalled out loud, and these words were recorded by the experimenter. There was no time limit for the

recall test. Finally, after the recall test, participants were given a forced choice recognition test which included words from both halves of the list. During this test the participants were read pairs of words which consisted of one word from the list presented earlier and one new foil. Participants were instructed to indicate which of the two words were presented during the earlier list.

TTCT. While participants over fourth grade have been tested successfully in groups (Torrance, 1974), to keep the testing conditions as similar as possible, all participants were tested individually.

During the Product Improvement task participants were given a small stuffed elephant (Form A) or monkey (Form B). During the Product Improvement activity they were allowed to examine and touch this toy and then asked to imagine possible improvements to the toy that would make it "more fun for children to play with". Participants were given ten minutes to list their ideas. Answers were given verbally and recorded by the experimenter. Answers were also audio taped to provide a backup record of the data.

During the Just Suppose activity, an improbable situation was described to participants. In Form A this situation consisted of "all clouds having strings attached to them that hang down to the earth". In Form B, this situation was "a great fog developing over the earth that only allows us to see people from the ankles down". After thinking about this improbable situation, participants were instructed to list ideas about what would happen if that situation were to occur. They were given five minutes to list their ideas. Answers were given

verbally and recorded by the experimenter. Answers were also audio taped to provide a backup record of the data.

CHAPTER 4: RESULTS

Data from the TTCT tasks was scored according to the instructions provided in the Directions Manual and Scoring Guide of the TTCT (Torrance, 1990). Each task was scored for fluency (the number of ideas given), flexibility (the number of times the participants shifted focus or changed their thinking strategy), and originality (the number of ideas produced which are different from the norm, but still useful). The scores for each TTCT task were combined into a composite score for frequency, fluency and originality. Please see Tables 1, 2, and 3 for lists of means and standard deviations for each task, by grade level.

Data from the Directed Forgetting task was used to create a score of inhibitory ability. This score was computed by subtracting the total number of words from the first half of the list (the to-be-forgotten or TBF words) that were recalled from the total number of TBF words that were recognized. Then this number was divided by the total number of TBF words presented, to give a proportional score of inhibitory ability. A proportional score was necessary to directly compare children's and adults' scores because the word lists for the adults contained 4 additional words.

To assess the first research goal, demonstrating the fourth grade slump, three one-way analyses of variance (ANOVA) were conducted to examine the effect of age on total fluency, originality, and flexibility. The alpha level was set

at p = .05 for all ANOVAs. The first ANOVA compared the total fluency scores of second grade (M = 19.00, SD = 11.09), fourth grade (M = 25.60, SD = 7.55), sixth grade (M = 15.30, SD = 7.33), and college students (M = 25.60, SD = 8.71). This test was found to be statistically significant, F (3, 36) = 3.37, p <.05. The second ANOVA compared the total originality scores of second grade (M = 11.90, SD = 6.82), fourth grade (M = 13.50, SD = 6.04), sixth grade (M = 6.60, SD = 4.86), and college students (M = 14.30, SD = 7.59). This test was also found to be statistically significant, F (3, 36) = 2.92, p <.05. Finally, the third ANOVA compared the total flexibility scores of second grade (M = 8.70, SD = 4.47), fourth grade (M =10.20, SD = 3.55), sixth grade (M= 8.50, SD = 3.47), and college students (M = 14.60, SD = 3.86). This test was found to be statistically significant, F (3, 36) = 5.40, p <.01.

To examine these results more closely a Tukey HSD test was used to compare the mean total creativity scores of each grade level at an alpha level of .05. These analyses indicated that the effect of age found in all three analyses was the same: second and sixth grade students scored significantly lower on all three tasks than college students. There were no significant differences between any of the other age groups.

To further examine these results, the total creativity scores for fluency, originality, and flexibility were broken down into separate scores for the Just Suppose and Product Improvement tasks and then were analyzed for effects due to age. The first ANOVA compared the fluency scores on the Just Suppose Task of second grade (M = 4.40, SD = 2.55), fourth grade (M = 6.60, SD = 2.91),

sixth grade (M = 4.70, SD = 2.98), and college students (M = 9.50, SD = 4.72). This test was found to be statistically significant, F (3, 36) = 4.77, p <.01. The second ANOVA compared the originality scores on the Just Suppose task of second grade (M = 2.20, SD = 1.40), fourth grade (M = 2.90, SD = 1.66), sixth grade (M = 1.70, SD = 2.00), and college students (M = 5.60, SD = 4.43). This test was also found to be statistically significant, F (3, 36) = 4.26, p <.05. Finally, the third ANOVA compared the flexibility scores on the Just suppose task of second grade (M = 2.00, SD = 1.56), fourth grade (M = 2.70, SD = 2.06), sixth grade (M = 2.30, SD = 2.16), and college students (M = 6.50, SD = 3.69). This test was found to be statistically significant, F (3, 36) = 7.09, p = .001.

To examine these results more closely a Tukey HSD test was used to compare the mean total creativity scores of each grade level at an alpha level of .05. Further examination of these results indicates that like the scores for total creativity, the age differences in the scores on the Just Suppose task are due to significantly lower scores of second and fourth grade students than college students. None of the three analyses of variance examining the effect of grade level on the Product Improvement task were significant.

These analyses suggest that the fourth grade slump did not occur as hypothesized. Instead, second and sixth grade students' performance did not differ from the fourth grade students' performance, and were significantly lower than the performance of the college students. This may suggest that a slump in creativity occurs later, during sixth grade instead of fourth as was predicted.

To assess my second research goal, demonstrating a link between creative ability and intentional cognitive inhibition, I correlated participants' scores of inhibitory ability with their fluency, flexibility, and originality scores. No significant correlations were found between any of the measures of creative ability and the score of inhibitory ability. See table 4 for a complete list of correlations. This suggests that intentional inhibition is not related to performance on these TTCT tasks.

Finally, to assess my last research goal, comparing the pattern of the development of creativity with the pattern of the development of cognitive inhibition, I examined the differences in creative ability and inhibitory ability between age groups. It was hypothesized that as intentional cognitive inhibition develops, creative ability will decrease due to the overuse of this new strategy. By overusing intentional cognitive inhibition, participants were expected to have less irrelevant thoughts in working memory giving them less ideas to combing into creative solutions. Thus, the pattern that was expected was that inhibitory ability would increase slightly during fourth grade, while creative ability would decrease during fourth grade. To determine if the results supported this hypothesis, both inhibitory ability and creative ability had to be examined for an effect of age. As already discussed, the effect of age on creative ability in this study did not follow predicted patterns. Instead of a decrease in creative ability during fourth grade, the decrease occurred later, during sixth grade. To examine age differences in inhibitory ability an ANOVA was conducted to examine the effect of grade on inhibitory ability as measured by

the proportional inhibitory score on the Directed Forgetting task. No significant differences in inhibitory ability were found, $F(3, 36) = 0.87$, $p = .46$. Participants of all age levels scored similarly in inhibitory ability. This suggests that the pattern of development hypothesized was incorrect, as there were no differences in intentional cognitive inhibition for the different age groups.

CHAPTER 5

DISCUSSION

The results suggest that the research hypotheses were not supported. A full discussion of each hypothesis, the implications of the results, and possible reasons why results were different than anticipated follows.

Hypothesis 1: The fourth grade slump

The first hypothesis that creative ability decreases during the fourth grade was not supported. Instead, the pattern observed during the Just Suppose task and also when Total Creativity on both tasks was examined suggests that children are actually at their lowest in creative ability during the second and sixth grades, at least as measured on these tasks. Participants in these grades scored significantly lower than college students on all measures of Total Creativity and on all measures of creativity on the Just Suppose Task. Fourth grade students, on the other hand, demonstrated creative ability that did not significantly differ from any other age group. This suggests that the slump in creative ability may occur later than proposed, during sixth grade instead of fourth. See Figures 5 and 6 for a pictorial representation of these scores.

Performance on the Product Improvement task did not reflect this, however, as participants of all ages, including college students, performed equally well. This suggests that at least on this task, creativity does not develop over the elementary school years. Perhaps the skills assessed by this task are

developed at an earlier age than measured during this study. See Figure 7 for a pictorial representation of these scores.

These results do not coincide with previous research that suggests that creativity develops over the lifespan, with a slump in creative ability during fourth grade (Milgram, 1990; Torrance, 1962). Although Torrance has found that fourth grade students perform worse on the TTCT than children in other grades (Torrance, 1962), in this study students in fourth grade did not have scores that differed significantly from the other age groups. Instead, second and sixth grade students scored significantly lower than college students. This suggests that perhaps performance on these tasks does not develop until fourth grade and then undergoes a decline later, during sixth grade.

The possibility that the slump in creativity occurs slightly later than fourth grade has been considered in previous research. Torrance, for example, did find a slight decline in creativity in seventh grade, though it was not as pronounced as the decline seen in fourth grade (Torrance, 1962). Albert (1996) also suggests that creativity may change in type and degree when children undergo puberty. It may be that this study tapped into this decline in creative ability. If a decline in creativity does occur during sixth grade, it could be due to any number of factors, including both changes in cognition that occur at puberty and changes in the environment (entering middle school or junior high). It is difficult to speculate based on the data included here, however, on exactly what could be causing this decline. Because this study did not include age groups between sixth grade and college, it is also impossible to guess when

this decline reverses; however, from the college students' scores it is appears that creative ability rebounds and then surpasses earlier levels by adulthood.

These results become harder to interpret, however, when you consider the fact that scores on the Product Improvement did not undergo the same fluctuations. Unlike the total creativity score and scores on the Just Suppose task, during the Product Improvement task participants of all ages scored equally well. There were no significant differences between the mean Product Improvement scores of participants in different grade levels. This suggests that creative ability as measured on this task is already fully developed by second grade.

Having different patterns of development on the two tasks chosen from the TTCT casts doubt on the idea that these tasks were both measuring underlying creative ability. It may be, as Baer (1993) said, that the TTCT tasks are not measuring creative ability, but are instead measuring some other related trait. These results suggest that not only might that be true, but it might also be that the different TTCT tasks are measuring different abilities that develop at slightly different rates.

Further evidence for this can be found when correlations between scores on portions of the TTCT are examined. When scores of fluency, originality, and flexibility on the Just Suppose task are correlated with those same scores on the Product Improvement task, correlations are quite low, ranging from .13 to .34, as Table 4 indicates. While the correlations were significant when fluency and originality were compared, the correlation between the flexibility scores on

the two tasks was not. This adds evidence that these tasks may be measuring either slightly different aspects of creative ability or some other related ability, as one would expect correlations to be stronger between the two tasks if they were both measuring the same underlying ability.

There is also the possibility that the more concrete nature of the Product Improvement task as compared to the Just Suppose task allowed even the youngest children to score similarly to adults. On the Product Improvement task children were allowed to hold and play with the object they were thinking about. The instructions were also very concrete, calling on subject matter, toys and playing, that most children are well versed in. The Just Suppose task, however, requires children to think about situations that have never existed and imagine the consequences. The situations used, clouds with strings attached and a "great fog" that covers the earth, are things the child has never encountered and has no frame of reference for. It may be that the Just Suppose task is more difficult for children because of its abstract nature. This fits well with previous findings that indicate young children produce more creative responses as the task becomes more concrete (Low & Hollis, 2003).

Hypothesis 2: Relationship between creative ability and intentional cognitive inhibition

The second hypothesis, that creative ability and cognitive inhibition are related, was not supported. There were no correlations between any of the measures of creativity used in this study and intentional cognitive inhibitory

ability. These results do not suggest that there is a connection between these variables. It may be that these cognitive constructs are not related.

This would fit with previous research, which has examined the relationship between these two variables in adults (Green & Williams, 1999; Stavridou & Furnham, 1996; Wuthrich & Bates, 2001). Although these studies used a different measure of cognitive inhibition, negative priming, which I believe measures a different aspect of cognitive inhibition, as in this study the authors did not find a connection between cognitive inhibition and creative ability.

Hypothesis 3: The development of cognitive inhibition coincides with, and possibly affects, the development of creativity

The third hypothesis, that the development of creativity is related to and possibly affected by the development of intentional cognitive inhibition was also not supported. As discussed above, the pattern of development of creative ability was significantly different than what was expected, with the expected slump in creative ability occurring later than anticipated. In addition to this, results from the different grade levels on the directed forgetting task did not differ significantly. All grade levels performed similarly on that task, suggesting that the inhibitory ability demonstrated by the directed forgetting task is fully developed before second grade.

This does not support previous research which has found that inhibitory ability, as demonstrated on the directed forgetting task, increases over the elementary school years and is fully developed by fifth grade (Harnishfeger,

1995; Harnishfeger & Pope, 1996). This failure to replicate changes in intentional inhibition that have been well documented in previous research calls the results of this study into question. This is especially troubling because the directed forgetting task has been used successfully to document the development of intentional cognitive inhibition repeatedly in our lab.

It is important to note, however, that this study and previous examinations of directed forgetting differed in the way that inhibitory ability was calculated. In previous research, participants were given multiple conditions of the directed forgetting task. In one condition they were required to remember all the words presented, even those they were told to forget. In a second condition they were required to remember only the words they were told to recall. Differences between performance on these two conditions were then used to determine if cognitive inhibition occurred.

In this study, however, the directed forgetting task was shortened to one condition and the score of inhibitory ability was created. It was thought that simply subtracting the number of to be forgotten words that participants recalled from the number of to be forgotten words they recognized would measure the number of words successfully inhibited. If the words were recognized, but not recalled, it does suggest that those words were encoded and then inhibited, only to be released from inhibition on the recognition task. To shorten the total time needed with each participant, and thus be better able to find schools willing to participate, this shorter version of the directed forgetting task was used in place of the older method. It may be that this score

is simply not sensitive enough to distinguish between the different ability levels of the children. It may also be that this score is not actually a measure of inhibitory ability, but is instead measuring a related concept, such as memory or processing capacity.

General Concerns: Problems with testing

It is difficult to feel confident interpreting the results of this study due to the difficulties that arose during testing. Because of the extreme difficulty in securing subjects for this research, the total number of participants was very small, leading to possible problems with statistical power. In other words, some of the differences between participants might have been too small to notice with a sample size that only included 10 people in each group.

Testing minor participants is often more difficult than testing adults, as most researchers do not have a ready group of children to test. While many large universities offer researchers a large pool of undergraduate students to work with, few have access to groups of children from which to draw participants. For that reason, when working with minors, experimenters are often forced to rely on the local school system for help. This is often a time consuming process, during which researchers must not only demonstrate that their study is safe, but also demonstrate that it is important, especially in a way that relates to the school system or education. For this study, for example, I began the process of "data collection" in August of 2005. I did not actually begin data collection with the children until April of 2006. Institutional Review Board members generally require more time to examine research that includes

minors and subject such research to greater scrutiny. Most counties also require researchers to get permission from the school board before they will consider allowing their students to participate. Permission then must be granted by the principals of specific schools were the research will occur, then by the teachers whose pupils you plan to include, then by the parents of the children that will participate, and finally, by the children themselves. Because this process requires that many people be involved, it has many places where it can break down. A constant problem that plagued this study, for example, was getting signed permission slips back from the children. After sending over 200 permission slips home to sixth grade students, for example, only approximately 30 were returned.

In order to satisfy school officials and parents, who are concerned that their children not miss important class time, it behooves researchers to keep the time they spend with the children to a minimum. To address this concern, I chose to keep the length and number of tasks used to a minimum, attempting to gather information in the most efficient manner possible. Although I shortened the procedure in a way that made sense to me theoretically, this decision may have affected the results, making it very difficult to determine the true ability levels of the participants. So, although I used the tasks recommended by Torrance when shortening the TTCT, it may be that true creative ability is too difficult to asses with only two tasks. Relying only on the Just Suppose and Product improvement tasks may not have allowed the participants to demonstrate their full creative abilities. Also, although it was

assumed that the Verbal section of the TTCT would be the most closely related to cognitive inhibition as shown on the directed forgetting task (as that is a verbal task), it may be that the figural version would have yielded different results. Finally, although the inhibitory score created from the shortened version of the Directed Forgetting task appears on the surface to measure inhibitory ability, it may not be precise enough to tease out the differences between age groups, especially with such a small number of participants.

A final difficulty with testing had to do with the testing environment itself. Although when testing was originally discussed with the administration at the elementary and middle schools, I was assured a quiet, empty classroom in which to test, this was not what I received when the time for data collection arrived. Changes in the schools had necessitated using the empty rooms and at both schools, data collection was moved into different locations. These locations were either small and cramped with materials from other classes, or a corner in a large, often busy, library. The main concern in these environments was the noise, as teachers could often be heard through the walls as they taught and announcements sometimes interrupted testing. Children were often distracted by these noises, as could be inferred by pauses in their answers and looks toward the source of the noise. Testing sessions were also interrupted by lunch times, which were staggered and difficult to predict, and other school activities. Participants whose sessions were interrupted had to be thrown out, further reducing the N and decreasing statistical power.

General Concerns: Problems with scoring

Another reason why the results should be considered inconclusive is the difficulties that arose when scoring the TTCT tasks. Although the instructions were thorough, they were ambivalent at times, leaving room for subjectivity. Different raters often came up with wildly different scores based on the same data. To check for inter-rater reliability a subset of participants' data was scored by 4 different raters. The results were then correlated, to see how closely they overlapped. Correlations between raters for all tasks were low, ranging from .53 to .86, all below the acceptable values of .90 or above. To compensate for this inconsistency, I scored all the data sheets for the final analyses. It is probable, however, that instructions that could create such differences between raters could also create inconsistencies in a single rater's scoring that could affect the results.

No task illustrates this problem better than scoring for flexibility, especially on the Just Suppose task. The directions require the researcher to determine when participants demonstrated a "change or shift in attitude or focus" (Torrance, 1990). Although some examples of what this "shift" should look like and how large it has to be in order to be counted as true flexibility are provided for the researcher to reference, the variety in participants' responses often made it difficult to rely on the examples for objective scoring instructions. This led to what felt like very subjective judgments of when a shift occurred and I believe also led to more inconsistency in scoring. The low correlations between raters adds weight to this concern; correlations were lowest when raters were scoring flexibility. If scoring was inconsistent, differences between

age groups may have been masked or the differences that did occur may be an artifact of these inconsistencies.

Such low inter-rater reliability also calls into question the validity of the test, or at least the validity of the methods used to score these tasks. For any test to be considered valid, it must be reliable, as reliability is a necessary condition for validity. A measurement can not be accurate if it fails to provide results that are consistent across similar situations. If simply changing the person who scores the test is enough to significantly affect the results, it calls into question how accurate the test can be. This coincides with the low correlations between scores on different parts of the TTCT, mentioned earlier. If the TTCT were a valid measure of creative ability, each task it includes should measure creative ability and hence scores on different sections should be highly correlated. This was not what was found in this study, however. Instead correlations between scores on the Just Suppose and Product Improvement tasks were low, suggesting that the tests weren't measuring the same underlying ability at all.

The TTCT may indeed be measuring creative ability, however, and it may be instead that current scoring procedures weren't adequate to differentiate between creative and non-creative ideas on these tasks. Many subjects during the Product Improvement task, for example, would list ideas such as making the stuffed animal computerized so that it could repeat things you said or teach children the alphabet. Although these types of ideas were fairly common for the participants in this study, they were not listed in the scoring manual as

responses that were commonly given and hence were always counted as original. This is similar to the complaint raised by Mouchiroud (2001): If the scoring manual hasn't been updated to include newer technology that today's children have been exposed to, some responses that may really be common will look original. This possible flaw in the scoring manual, combined with the subjectivity of the scoring procedures themselves, may have reduced the validity of these two tasks as measurements of creative ability.

Directions for future research

There are many problems that must be addressed before the questions raised in this research can be answered. The failure of this study to replicate previous research on both creativity and cognitive inhibition points to serious flaws in the design and implementation of the research. For this reason, I feel it is important for future researchers to make several changes to this methodology before attempting to answer the questions raised here.

First of all, testing of creative ability must be expanded to include a much broader range of activities. Although shortening the TTCT may be desirable for time reasons, I do believe that giving the complete test is necessary to tease out differences in the rate and pattern of the development of creative ability. In addition, it would be interesting to include other measures of creativity, such as teacher evaluations, self-report measures, observations, and measures of creative production. This would broaden the scope of the research, allowing researches to determine if the underlying abilities measured by these tests develop at similar rates. This could be useful in determining the validity of

different measures of creativity as well as determining when certain aspects of creative ability develop.

I also continue to believe that longitudinal studies of creative ability are needed. In order to truly begin to understand the developmental trajectory of this ability, longitudinal studies that follow children from preschool until adulthood, and include many different measurements of creative ability must be done. Finally, in order for differences between cognitive inhibitory abilities to be examined, it may be necessary for future researchers to use the original form of the directed forgetting task. The lack of replication of established developmental differences in inhibitory ability in this study suggest that either the shorter task that was used or the score of inhibitory ability created for this study was flawed. Before either of these is used again, further research needs to be done on the validity of these methods in measuring intentional cognitive inhibition.

In order for these changes to occur, however, researchers are going to need to look outside of the school system when attempting to recruit participants. As governmental control of the school system increases in response to safety concerns and the No Child Left Behind Act, it is increasingly difficult to recruit participants through schools. Also, as testing increases and schools are under more pressure to meet the academic standards set by this policy, school officials may become less willing to let researchers take up valuable instruction time by running research projects during the school day. It will be important for future researchers to find ways to recruit participants

that allow them to increase the amount of time available for testing. This may necessitate offering incentives to parents of participants in order to increase involvement.

Although this study was inconclusive, it does not diminish the value of studying creative development in these age groups. No matter what the developmental trajectory of creative ability is, it is important that we gain a greater understanding of how people become creative. In this time in history, when flexibility of thought and originality of ideas are precious commodities, it would do us well to know the cognitive abilities and environmental conditions that promote creative thinking.

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TABLE 1

Mean Fluency, Originality, and Flexibility Scores on the Just Suppose Portion of the TTCT by Grade Level

	Fluency	Originality	Flexibility
Second	4.40	2.20	2.00
Fourth	6.60	2.90	2.70
Sixth	4.70	1.70	2.30
College	9.50	5.60	6.50

TABLE 2

Mean Fluency, Originality, and Flexibility Scores on the Product Improvement Portion of the TTCT by Grade Level

	Fluency	Originality	Flexibility
Second	14.60	9.70	6.70
Fourth	19.00	10.60	7.50
Sixth	10.60	4.90	6.20
College	16.10	8.70	8.10

TABLE 3

Mean Total Fluency, Originality, and Flexibility Scores by Grade Level

	Fluency	Originality	Flexibility
Second	19.00	11.90	8.70
Fourth	25.60	13.50	10.20
Sixth	15.30	6.60	8.50
College	25.60	14.30	14.60

TABLE 4

Correlation Between Scores of Inhibitory Ability and Scores of Fluency, Flexibility, and Originality on the TTCT

	IA	JS Flu	JS Orig	JS Flex	PI Flu	PI Orig	PI Flex	Total Flu	Total Orig	Total Flex
IA	-	-.07	.00	-.07	-.28	-.23	-.25	-.25	-.19	-.21
JS Flu		-	.90 **	.91 **	.33 *	.31	.28	.66 **	.63 **	.80 **
JS Orig			-	.85 **	.28	.34 *	.26	.58 **	.69 **	.75 **
JS Flex				-	.14	.17	.13	.48 **	.50 **	.76 **
PI Flu					-	.90 **	.79 **	.93 **	.81 **	.61 **
PI Orig						-	.65 **	.84 **	.91 **	.54 **
PI Flex							-	.74 **	.61 **	.74 **
Total Flu								-	.90 **	.81 **
Total Orig									-	.74 **
Total Flex										-

Note. IA = Inhibitory Ability; JS = Just Suppose; PI = Product Improvement; Flu = Fluency; Orig = Originality; Flex = Flexibility

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

FIGURE CAPTIONS

Figure 1. Original Instructions and illustration used during the Product Improvement section of the TTCT, form A. For this experiment, participants were not asked to list their ideas on a separate page, but instead were asked to list their ideas verbally.

Figure 2. Instructions and illustration used during the Product Improvement section of the TTCT, form B. For this experiment, participants were not asked to list their ideas on a separate page, but instead were asked to list their ideas verbally.

Figure 3. Instructions and illustration used during the Just Suppose section of the TTCT, form A. For this experiment, participants were not asked to list their ideas on a separate page, but instead were asked to list their ideas verbally.

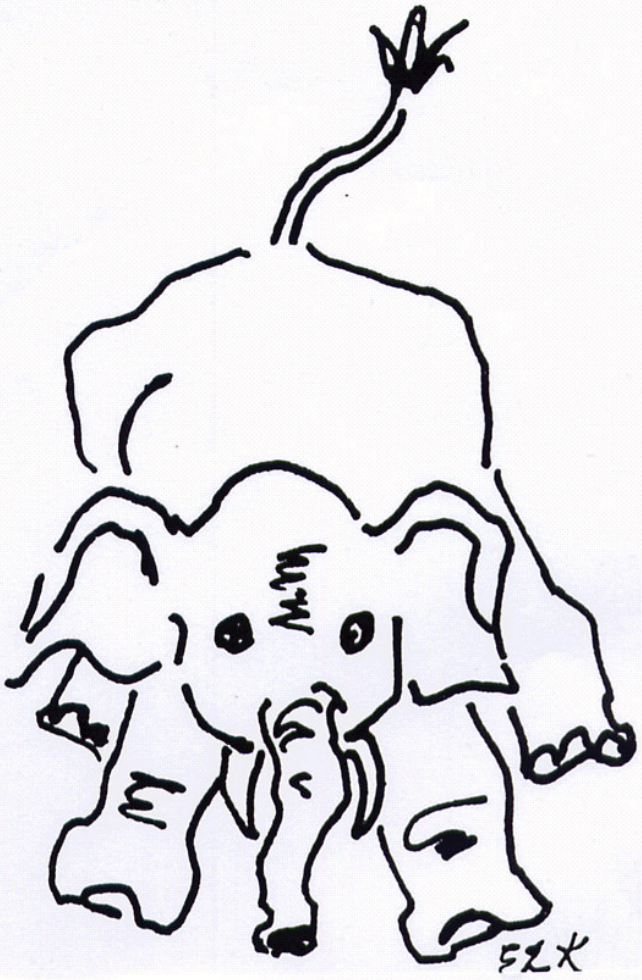
Figure 4. Instructions and illustration used during the Just Suppose section of the TTCT, form B. For this experiment, participants were not asked to list their ideas on a separate page, but instead were asked to list their ideas verbally.

Figure 5. Mean Total Scores for Fluency, Originality, and Flexibility by grade level.

Figure 6. Mean Scores for Fluency, Originality, and Flexibility on the Just Suppose task by grade level.

Figure 7. Mean Scores for Fluency, Originality, and Flexibility on the Product Improvement task by grade level.

In the middle of this page is a sketch of a stuffed toy elephant of the kind you can buy in most novelty stores for about five to six dollars. It is about six inches tall and weighs about a half pound. 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 elephant 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.



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 to 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.

You will now be given an improbable situation—one that will probably 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 exciting things that would happen IF this improbable situation were to come true.

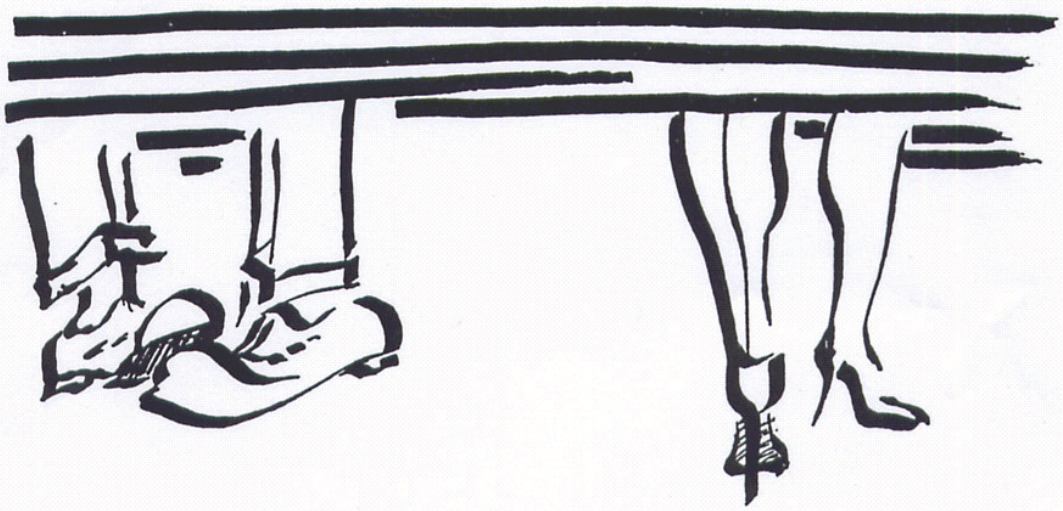
In your imagination, *just suppose* that the situation described were to happen. THEN think of all of the other things that would happen because of it. In other words, what would be the consequences? Make as many guesses as you can.

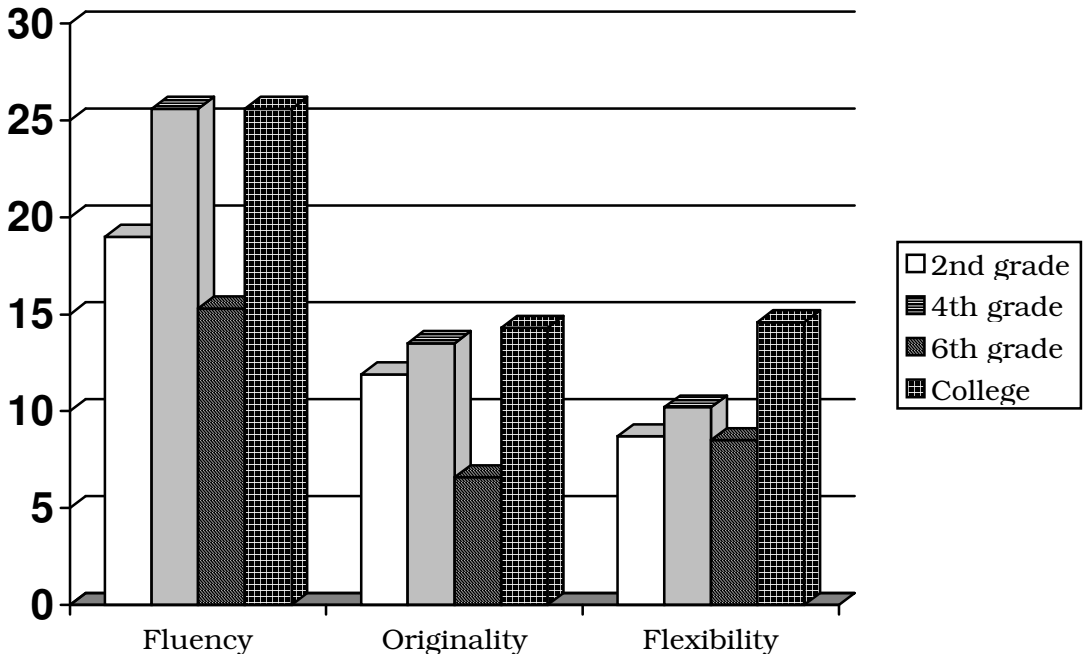
The improbable situation—JUST SUPPOSE *clouds had strings attached to them which hang down to earth.* What would happen? List your ideas and guesses on the next page.

You will now be given an improbable situation—one that will probably 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 exciting things that would happen IF this improbable 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—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? List your ideas and guesses on the next page.

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Fluency
Originality
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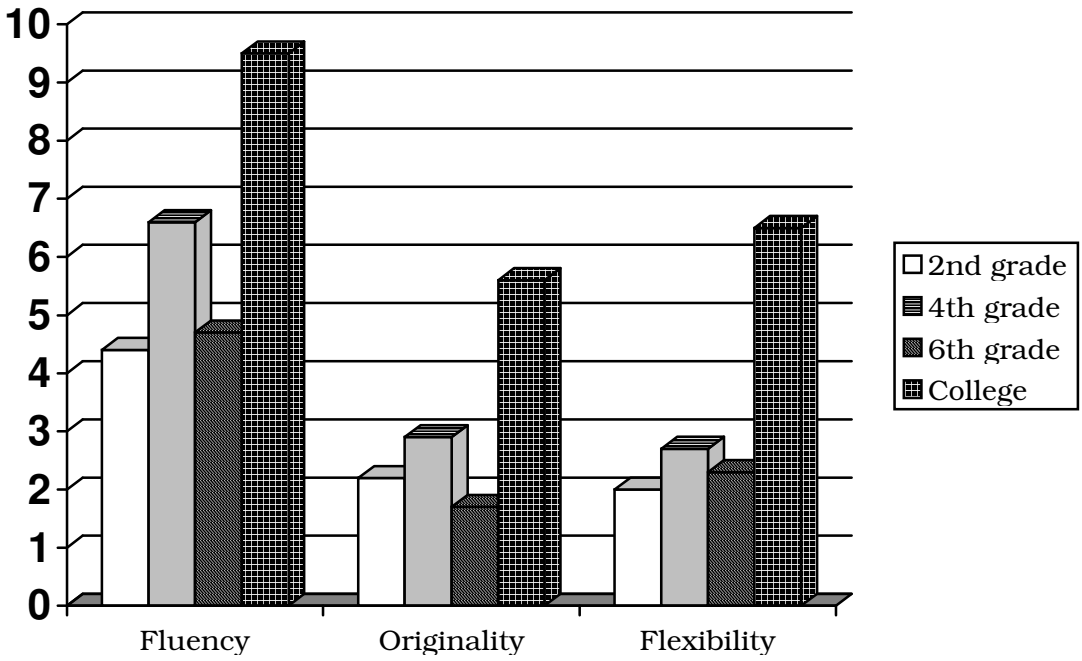
2nd grade
4th grade
6th grade
College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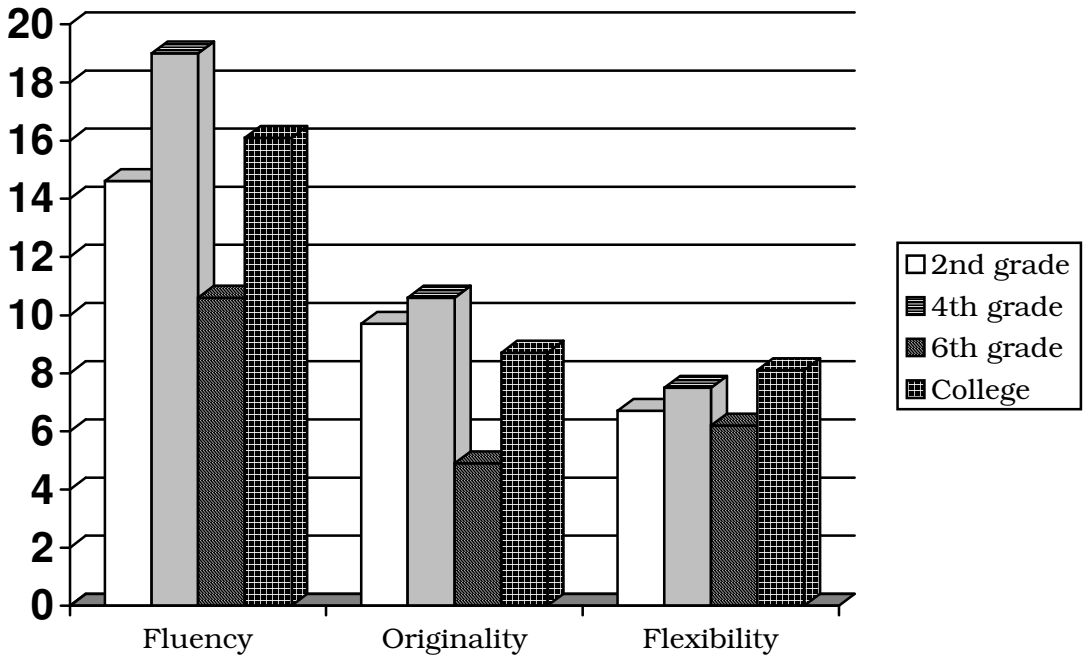
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College