EMPIRICAL STUDIES OF LITERAL DIVERGENT THINKING

by

SELCUK ACAR

(Under the Direction of Mark A. Runco)

ABSTRACT

In spite of voluminous research on the usefulness of divergent thinking (DT), true divergence (i.e., thinking that goes in all directions) has not yet been studied. The current studies aimed to capture true divergence, thus, *Literal Divergent Thinking* (LiDT) was preferred as the overarching term. The first study focused on associative processes in DT relying on the idea that DT allows associations in all directions. Studies indicated that remote and close associations can be reliably identified through different sources of social associations. The second study investigated the usefulness of 13 dimensions of DT that constituted *hyperspace*, a multidimensional space in which ideation takes place. The analyses indicated that LiDT can be quantified as the number of categories employed by an individual and it is significantly related to originality attitudes. The third study involved think aloud (TA) instruction that required participants to orally verbalize their thinking while responding to the DT tasks. When the hyperspace categories from the standard and TA procedures were compared, some of the categories that are related to originality were found more in the TA than the standard procedure.

INDEX WORDS: Divergent thinking, Divergence, Literal divergent thinking, Associative processes, Remote and close associations, Hyperspace, Think aloud.

EMPIRICAL STUDIES OF LITERAL DIVERGENT THINKING

by

SELCUK ACAR

B.A., Bogazici University, Turkey, 2004

M.A., Istanbul University, Turkey, 2007

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2013

EMPIRICAL STUDIES OF LITERAL DIVERGENT THINKING

by

SELCUK ACAR

Major Professor:	Mark A. Runco
Committee:	Bonnie Cramond
	Seock-Ho Kim
	Margaret E. Hines

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
December 2013

ACKNOWLEDGEMENTS

I am pleased to express my appreciation to a number of people without whom this dissertation would not have been possible. I have always felt very lucky to study under the supervision of Dr. Mark A. Runco, who has wisely advised me along the way and provided invaluable scholarly perspective since I started working with him. In addition to great mentorship, his kind, positive, constructive, and considerate attitudes made my doctoral education a productive and pleasant experience. I have enjoyed learning from him. He deserves much of the credit for what I was able to do so far.

I have greatly benefited from the feedback and advisement of Dr. Bonnie Cramond who has welcomed me to UGA, encouraged me in my works, and resolved many difficulties I have encountered. I have seen the soul of Dr. E. P. Torrance in her approach to the students. I am also indebted to Dr. Seock-Ho Kim, Dr. Meg E. Hines, Dr. Tarek Grantham, and Dr. Tom Hébert, who were not only great teachers but also collaborative, flexible, and polite.

This dissertation has been supported by the Graduate School of The University of Georgia. This generous support facilitated the implementation and completion of the subsequent studies in a shorter period of time. In addition, I am thankful to my friend Mustafa V. Nural for developing text search software that I used in this dissertation. Another great friend Alicia Welch helped with editing and proofreading. I am also grateful to my wife Nur Cayirdag Acar for her patient support and direct and indirect help throughout the dissertation research. Lastly, I would like extend my gratitude to all who cooperated with me in this process and participated in my research.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Divergent thinking (DT) has been the focus of many researchers studying creativity (Guilford, 1950; Wallach & Kogan, 1965; Torrance, 1995; Runco, 1991) and research over several decades has provided evidence about DT tests' strengths and weaknesses as indicators of creative potential (see Kim, 2011; Baer, 2011; Runco & Acar, 2012; Plucker & Runco, 1998 for reviews). In spite of all the controversy surrounding tests of divergent thinking, they are still the most popular tools for identification and research (Callahan, Hunsaker, Adams, Moore, & Bland, 1995). The traditional tests of DT have used three or four indices, including fluency, originality, flexibility, and elaboration. Those indices have been shown to be psychometrically useful, but there are several issues such as scoring methods (see Runco & Acar, 2012 for a review of different methods) and the "contaminating influence" of fluency (Clark & Mirels, 1970; Hocevar, 1979). Another major problem is that those indices seem to revolve around different ways to capture the outcome rather than the process of DT.

The current literature review addresses three aspects of DT in pursuit of filling some gaps: the definitions of and the theory behind DT, associational processes underlying DT, and the internal processes that may not be reflected in traditional assessment.

The Definitions of and Theory behind DT

The idea of divergent thinking was recognized in early mental ability tests (Runco, 2011), but J. P. Guilford (1967, 1968) was the first researcher who introduced the concept of "divergent production" as one of two production factors in his well-known Structure of Intellect (SOI)

theory. He defined it as "generation of logical alternatives from given information, where the emphasis is upon variety, quantity, and relevance of output from the same source" (Guilford & Hoepfner, 1971, p. 20). According to Guilford (1959), DT involves thinking in different directions through searching and seeking variety. Other researchers have also echoed that point in their definitions of DT. For example, Taylor (1988) viewed DT as "one's ability to go off in different directions when faced with a problem" (p. 119). Runco (1999a) concurred, describing it as "cognition that leads in various directions" (p. 577). Torrance and Harmon (1961) defined DT as "the generation of new information from known information and remembered information…that leads to new and untested solutions" (p. 207).

In the latest revision of SOI (Guilford, 1977), Guilford argued that DT is not a uniform ability but rather that there exists 30 different DT abilities that were combinations of five categories of content and six categories of products. Higher order factor analytic studies indicated that there were different DT abilities, but intercorrelations among those abilities provided support for a general DT ability. Guilford and his colleagues developed several divergent thinking tasks such as Alternate Uses (Guilford, Christensen, Merrifield, & Wilson, 1958), Unusual Uses (Wilson, Guilford, Christensen, & Lewis, 1954), and Consequences (Christensen, Merrifield, & Guilford, 1953). An essential unique characteristic of those and other DT tasks was that they had no single right answer, which is corollary to the nature of DT.

In line with Runco's (2011) recommendation of using multiple indices, tests of DT were often scored for the indices of fluency, flexibility, originality, and elaboration. All of these qualities and indices are operational and, therefore, useful as estimates of creative potential, but such operational definitions do not necessarily fully capture the process of DT. Brown (1989) pointed to the gap between the operational definitions of creativity and the phenomenon itself.

He argued that operational definitions that only tap into the construct of creativity, yet fail to address the phenomenon, can yield an assessment that is internally cohesive but irrelevant to reality. This argument may apply to DT more specifically. Although DT tasks have often been used as an indicator of creative potential, the nature of divergent thinking as indicated in its definition (i.e., thinking in different directions) has not been studied. The traditional indices of DT focus on the outcomes of DT, but the process of DT itself is quite complex.

Associative Bases of DT

Although the importance of associative processes for creative thinking was underlined long ago (Russ & Dillon, 2011), Mednick (1962) was the first to develop an associative theory of creativity thinking. Mednick defined creativity as "the forming of associative elements into new combinations which either meet specified requirements or are in some way useful. The more mutually remote the elements of the new combination, the more creative the process or solution" (p. 321). Mednick argued that having a large repertoire of responses facilitates the combination of different concepts and enables creative thinking. He proposed that the organization of associational hierarchy influences the speed of getting to the creative idea. Creative people have more ideas that are weaker in associative hierarchy, and their response curve is rather flat. Less people have fewer ideas that are strongly attached to the stimuli and, once those ideas are attained, further search is ceased. The greater the associative strength, the more unlikely it is to find a creative idea.

Mednick and Mednick (1967) developed the Remote Associates Tests (RAT) with 30 items to be responded to in 40 minutes. The test requires participants to find the fourth word that connects three distinct words. Thus, it is not open ended and quite different from DT tasks. However, Mednick's theory is quite useful for the study of DT. For example, he pointed to the

role of making remote associations in creative thinking, and this terminology (i.e., remote and close) implies *distance* between any two ideas. This is an operational term and can be useful for a scientific study of DT. Second, he emphasized the ability to produce a large number of ideas. This point is important for DT because in many DT tasks (i.e., Wallach & Kogan, 1965, Torrance, 2008), participants are instructed to generate as many ideas as possible. Third, and probably most important, DT is open ended and may elicit associations. Responses to DT can be treated as associations with varying degrees of distance from the stimulus.

Empirical studies about the associative bases of DT often focused on associative hierarchies of responses (Christensen, Guilford, & Wilson, 1957; Parnes, 1961; Ward, 1969a; Milgram & Rabkin, 1980; Runco, 1986; Beaty & Silvia, 2012). They found that remote and creative ideas are generated later in the response sets. Alternative cognitive theories may be helpful for further empirical inquiries. Torrance (1995) recognized the ability of mental leaps as an aspect of DT. Likewise, Perkins (1994) also mentioned the role of mental leaps in creativity and viewed them as a cognitive operation that takes place on a conceptual landscape. This perspective calls attention to the theories of spreading activation and associative networks. They are intertwined and complementary to each other.

According to *spreading-activation theory*, memory search is defined as "an activation spreading from two or more concept nodes in a semantic network until an intersection was found" (Collins & Loftus, 1975, p. 407). *Semantic networks* refer to the dynamic structures in human cognition involving the generalization and abstraction of information from personal experiences into the network of concepts. According to this perspective, human memory is made up of an associative structure connecting different concepts regardless of their actual relevance. The terminology is the same for spreading activation theory and semantic networks: each

concept or the information sets are represented by a *node*, which is associated with other nodes via *links*.

Creative potential can be related to the number of nodes, and the complexity and strength of the links with other nodes (Findlay & Lumsden, 1988). The constituents of the semantic networks exhibit clustering and sparsity because they are stored in memory based on meaning and similarity. Related concepts are closer to each other on the associative network. Thus, the generation of dissimilar ideas can require making distant mental leaps on the associative network. Also, individual differences in semantic networks can explain the speed of relatedness judgments, different perceptions of relevance, and originality of the combinations.

Contemporary research on divergent thinking and associational processes has utilized the semantic networks approach. Bossomaier, Harre, Knittel, and Snyder (2009) used the Wordnet lexical database (Miller, Beckwith, Fellbaum, Gross, & Miller, 1990) to calculate a creativity quotient (CQ) by combining fluency and flexibility through quantifying paths and path likelihoods between concepts. Snyder, Mitchell, Bossomaier, and Pallier (2004) compared Bossomaier et al.'s method that rewarded generating ideas from more categories with the traditional method on the responses of two individuals. The scores of the two sample sets of responses were markedly different. The usefulness and psychometric value of this approach have not yet been examined.

Internal Processes in DT

In an effort to be as objective as possible, the scientific study of creativity usually focused on creative behavior or creative performance. This is at odds with a common recognition of creativity as an "[…] extremely complex phenomenon that manifests itself as a set of processes within the individual" (Feldhusen & Goh, 1995, p. 234). This paradox is valid for DT, as well.

Some aspects of DT are individual specific, thus, subjective. There are internal processes that take place in DT, but there is limited knowledge of them.

In order to take internal experiences into account, Moshman and Lukin (1989) suggested taking a more constructivist point of view rather than the traditional positivist approach, which relies too much on objectivity. They believed that it is not possible to know reality from a perspective outside one's own knowledge. Therefore, it is necessary to delve into one's subjective knowledge and cognitive processes. That is what they call reflective abstraction, defined as one's reflection on one's own subjectivity. This metasubjectivity is very similar to introspective method, and Perkins (1981) considered it a useful method to reveal creative thinking processes.

Examples of reflective abstraction are not available in DT, but some researchers employed a similar technique called *think aloud* (TA). TA can be in two different forms: retrospective and concurrent (Ericsson & Simon, 1980). Retrospective TA is similar to reflective abstraction or other introspective techniques in that it instructs individuals to reflect back on their prior experience. Concurrent TA sessions instruct participants to think out loud while in the process of thinking or solving a problem. In terms of accuracy of data and objectivity, the latter is more defensible (Ericsson & Simon, 1984).

Ericsson and Simon (1984, 1998) argued that people can verbalize their thinking and this does not necessarily change the course of thinking unless they are expected to explain their thoughts or provide additional information. The major finding of Ericsson and Simon's research was that the sequence of thinking is not different from silent conditions of thinking. They argued that verbalized cognitive processes in the form of TA protocols can be used as data because cognitive processes yielding verbalizations are the same as those that generate other forms of

concrete data. Furthermore, the information provided in the TA protocols is auspiciously rich with contextual and temporal data. In that regard, they can better represent the complexity of human cognition (Newell & Simon, 1972).

Fonteyn, Kuipers, and Grobe (1993) reviewed the TA methodology and provided guidelines for its implementation. They affirmed that the TA studies include small sample sizes because the data provided are more detailed and allow in-depth analysis. To keep distraction at a minimum, they suggested avoiding interaction with the participants during the session except to remind them to think aloud when they were silent for a while. They acknowledged that TA protocols are incomplete in the sense that they are unable to demonstrate the full course of thinking. Therefore, no assumptions should be made about unreported data.

Nisbett and Wilson (1977) were critical of the use of verbal reports as a valid technique because direct access to higher cognitive processes is not possible, and self-reported information cannot be accurate. Also, there were studies indicating that TA can undermine task performance (e.g., van den Haak, De Jong, & Schellens, 2003). This could be because of verbal overshadowing, which refers to the fact that verbalization of thoughts interferes with thinking (Fleck & Weisberg, 2004). In spite of these concerns, TA provides researchers with unique advantages in analyzing internal processes and can be useful for understanding the processes involved in divergent thinking.

Objectives of the Current Studies

The present studies offer a new approach to DT. This new approach reflects the definition of divergent thinking as that which follows multiple paths or moves in multiple directions (Guilford, 1959, Runco, 1999a). As this definition clearly reflects the term of "divergence," literal divergent thinking (LiDT) is used as an umbrella term. LiDT refers to cognition that goes

in all directions. It is best expressed by a hyperspace, a multidimensional space in which ideation takes places. A major goal is to capture different directions employed in the process of DT through identifying different conceptual categories. Hyperspace is designated as sum of all conceptual categories. This method is different from and goes beyond traditional indices of DT. Current methods simply count the number of ideas or themes on a given response sheet according to different criteria. They fail to represent actual divergence.

LiDT reflects the range of ideational pathways; however, DT involves more than that. Ideational capacity can be improved by making mental leaps within any certain category, or pathway. Therefore, identifying the extent to which ideas are distant or far removed from what led up to them is an important aspect of DT. Very likely, these two processes (i.e., generating ideas representing different hyperspace categories and generating ideas within a category but far removed from the starting point) go hand in hand.

With those in mind, the first approach (Chapter 2) utilizes the perspectives and principles of associative processes in DT, focusing on quantification of the distance between ideas. In this approach, several computer software programs and lexical databases were used to determine if the responses generated for the DT tests can be reliably quantified. In a way, this can be seen as a new method of defining remote and close associates. The second approach (Chapter 3) will follows a dimensional perspective with each dimension representing a different direction in DT. Thirteen dichotomous dimensions, which were proposed to explain divergence, were sought in the responses to DT questions. Third study (Chapter 4) replicated Study 2 with a different method known as “think aloud” in order to examine possibly unexplored aspects of LiDT. The studies presented above briefly attempt to answer the following questions:

1. Can distance be objectively quantified using different sources of social associations?
2. How can literal divergent thinking be captured?
3. How can internal processes help to understand literal divergent thinking?

These studies are promising for the field in several ways. First, they can introduce new ways of measuring creativity such as using computer software or databases and scoring ideas on several dichotomous dimensions. These methods have been discussed, and some used, in creativity research but not for the purpose of creativity measurement. Second, these studies reflect the process of DT rather than the outcome. This is important because assessment focusing on the outcomes is less likely to capture creative potential. Third, they utilize and compare internal processes. As a result, the focus of creativity assessment hopefully will be broadened. Details of each study will be provided in the following chapters.

CHAPTER 2

ASSOCIATIVE PROCESSES IN DIVERGENT THINKING: USEFULNESS OF SOCIAL ASSOCIATIONS IN IDENTIFYING REMOTE AND CLOSE ASSOCIATES[1]

[1] Acar, S. To be submitted to the *Journal of Creative Behavior*

Abstract

The purpose of the present study was to investigate the associative processes in DT. Similar to open-ended questions, DT tests serve as prompts leading to associations that vary with respect to their distance from the prompt, question, or problem. Therefore, this study focused on distance between the DT question and the responses given to them. Some associations are remote and some are close. Remote and close associations were identified through three different sources of social associations: WordNet (WN), Word Associations Network (WAN), and IdeaFisher (IF). Each of these provided a list of associations and they served as the criteria for distinguishing if an idea is a remote or close associate.

Statistical analyses indicated that remote and close associations can be reliably measured when different sources of social associations were used. Inter-item reliability (alpha coefficients) of remote associations, which is particularly important for creativity assessment, was higher than close associations. When the reliability indices were compared across three sources of social associations, inter-item reliability values were higher in the WAN and IF, which provided shorter lists, than the WN. Therefore, longer association lists did not necessarily produce better indices of remote and close associations. Also, Creative Attitudes and Values were significantly related with remote, but not with close, associations across all three methods. The highest correlation was obtained with the WAN. Inter-item correlations among three sets of remote associations were higher than their correlations with close associations.

Introduction

The role of associative processes in creative thinking has attracted attention since Mednick's (1962) seminal work. Mednick proposed that creative individuals exhibit a flat associative hierarchy, which allows the production of more original ideas, whereas less creative individuals have a steep associative hierarchy, which initially leads to the creation of many closely related ideas that eventually run out. To test his proposition, he developed the Remote Associates Test (RAT), which includes 30 items. The test requires participants to generate a word that connects three distinct words or concepts. This test is still used in the field, and its norms were revised recently (Bowden & Jung-Beeman, 2003). However, the RAT may very well measure abilities outside of creative talents. For example, Taft and Rossiter (1966) found that the RAT is largely related with convergent thinking rather than divergent thinking, and Jones, Caulfield, Wilkinson, and Weller (2011) used it as a measure of convergent thinking. In some other studies, it was used as a measure of insight rather than originality (DeYoung, Flanders, & Peterson, 2008; Kounios & Beeman, 2009).

Another way of measuring associational thinking is through the Word Association Test (WAT; Gough, 1976; Whitman, Holcomb, & Zanes, 2010). In this method, a list of concepts or word pairs is presented, and respondents rate their association. These ratings are compared with normative data on associative strength. The commonality of RAT and WAT is that they require one single solution for answering each of the questions. In this regard they differ from the more common tests of creativity, which consist of open-ended stimuli and require ideational fluency and originality.

Benedek, Könen, and Neubauer (2012) investigated the associative processes underlying creative thinking by administering divergent thinking and associative thinking tasks. They found

that four associative thinking tasks explained about half of the variability in divergent thinking tasks. Even though this finding is important in terms of showing how associative and divergent thinking processes are intertwined, this study measured these two processes differently. A direct focus on the associative processes involved in DT tasks would help to understand more about the processes of DT. It would be useful to explore the relationship of associative processes and divergent thinking when there is no "method variance" to explain differences. Method variance refers to the variability among scores resulting from the test format rather than from individual differences in the targeted processes (i.e., associative and divergent thinking).

Several studies tested Mednick's (1962) hypotheses about associative processes using DT questions. These usually focused on response hierarchies and order effects. Ward (1969a) administered DT questions to 7 and 8 year-old children and found that their response rates decreased as the test progressed, although original ideas increased over time. Contrary to Mednick's contention, those who initially generated more ideas did not lose their ability to produce ideas later or even overall. Unusual responses were generated late in the exercises, but usual responses were often the first responses given. Milgram and Rabkin (1980) administered DT tests (from Wallach & Kogan, 1965) to 9, 12, and 17 year-olds. They tested the order effect by splitting the responses into first or second halves and found that the number of unusual responses were higher in the second half. Forty five percent of the unusual ideas were generated in the first half. The discrepancy between the first and second half was larger (41% to 59%, respectively) when the quality of ideas was considered. Milgram and Rabkin also found that the order effect was present after 12 years of age.

Runco (1986) compared flexibility and originality scores of high and low originality groups with respect to the first and second halves of their responses. He found that in the high

originality group, both flexibility and originality scores were higher in the second half than in the first half, on both Uses and Pattern Meanings tests (Wallach & Kogan, 1965). In the low-originality group, a significant difference was found in the flexibility and originality scores in the Pattern Meanings test but not in the Uses test scores. This is not all that surprising, given other differences among verbal and figural DT tasks (Richardson, 1986; Runco & Albert, 1985).

Associative processes may be involved when a person is faced with an open-ended problem. DT may in fact rely or at least benefit from associative processes (Wallach & Kogan, 1965). This does not mean that tests of associative processes are valid predictors of creative performance. Recall here that the RAT (Mednick & Mednick, 1967) does not allow divergence. It does not say much, if anything, about originality. But it should be possible to consider the associations that are involved when presented with a DT task, or any ill-defined problem.

The studies summarized above used DT questions to test Mednick's hypotheses, some of which found empirical support. Associational processes and Mednick's hypotheses can, however, be reconsidered within the framework of DT. As open-ended questions, DT tests serve as prompts leading to associations, which can have varying degree of distance from the DT item. This point is important, because ideational capacity is improved by thinking of alternative ways of generating ideas as well as going far from the prompt. Then, identifying the extent of mental leap or distance is a key step toward understanding ideational capacity. The present research is unique in its focus on the distance between ideas given to DT tasks. It is a different approach of investigating associational processes within the context of DT.

Mednick (1962) defined creativity as the ability to combine associated elements into new forms. Creativity increases as the distance between the combined ideas increases. The distance between the ideas generated can indicate the extent of the leaps that individuals achieve in

thinking, and this can potentially result in making more fertile combinations. Barron (1975) used the concept of "interstices" when he said, "Poetic creation is sensitive precisely to the interstices of experience" (p. 52). Importantly, distance is an operational concept, which can help to improve the measurement of creative potential.

One way to operationalize distance is through the relatedness of concepts and words. Perkins (1994) argued that creative solutions may require mental leaps in the conceptual landscape. Torrance (1995) considered the mental leap from stimulus to the response as one of the DT qualities. The distance of such leaps must be optimal: it should be far enough to be creative but close enough for the relationship to be recognized. Gough (1976), for example, found that moderately infrequent responses were more strongly related with creativity as measured by peer reviews of scientists than the extremely uncommon or common responses. Some associations can be too far off and in the context of DT, irrelevant responses are often dismissed. For example, responses to the items in the Torrance Tests of Creative Thinking (TTCT) are first evaluated in terms of relevancy and only relevant ideas (fluency) are scored for other indices. Some of the relevant responses are close associations and others are remote. Therefore, higher distance in relevant ideas can imply higher probability of creativity.

Figure 1 was created to show how the ability to make remote associations and distant mental leaps can indicate higher creative potential. Some of the responses (shorter arrows) represent close associations because they are within the primary periphery of the stimuli whereas some other responses (longer arrows) fall within the outer periphery, and therefore, imply remote associations. The longest arrows represent irrelevant associations. The ability to make remote but relevant associations can be seen as an indicator of superior creative potential.

The role of the distance between ideas has rarely been studied with DT questions other than simply testing Mednick's hypothesis. In one of these studies, Malaga (2000) compared the responses to remotely and closely related stimuli. He found that the associative distance of the stimuli did not make a difference in the number or creativity (as judged by others) of ideas generated. In this study, distance was predetermined by the researchers (not generated by the

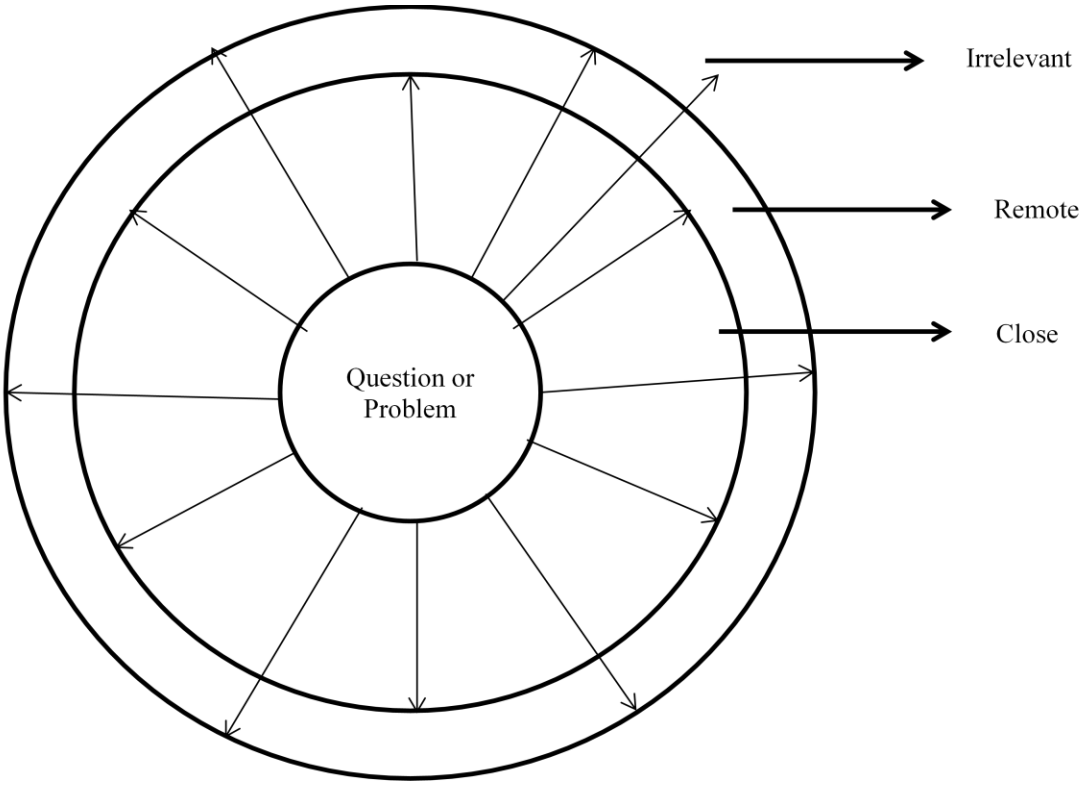

Figure 2.1. Theoretical demonstration of close, remote, and extremely remote (irrelevant) associations involved in DT.

participants). In this study, it is proposed that the distance between the stimuli and responses can be defined and measured. This method – defining remote and close associations- has yet to be examined. The only research along these lines was that of Wilson, Guilford, and Christensen (1953). They administered six Uses tests and asked participants to generate six *additional*

responses to elicit remote ideas. The current study, however, uses the traditional instructions (details are provided in the Method).

Associative distance is not easy to operationalize. The present study relied on social associations. Social associations have been identified and used in various kinds of research (e.g., Steyvers & Tenenbaum, 2005; Bossomaier, Harré, Knittel, & Snyder, 2009; Snyder, Mitchell, Bossomaier, & Pallier, 2004), though not for the investigation of DT with a focus on distance. The merit of social associations is their objectivity and, therefore, contribution to the psychometric assessment of creativity. Social associations imply a relationship between concepts or ideas that can be objectively, or at least conventionally, defined or explained. One way to measure the semantic similarity between ideas is possible through calculating the agreement of "lexical neighborhoods" of any two or more concepts (Rapp, 2002; Ruge, 1992). This calculation relies on the co-occurrences of concepts or words. If two or three words are often used together, one of them will often remind the other very easily. Such networks are suggestive of close and remote associations. Research in other fields, including artificial intelligence and linguistics, has yielded lexical databases. A good example of this is the WordNet (http://wordnet.princeton.edu/) (Cognitive Science Laboratory, 2002; Miller, Beckwith, Fellbaum, Gross, & Miller, 1990).

The WordNet (WN) is a lexical ontology consisting of nouns, verbs, adjectives, and adverbs which are classified as sets of cognitive synonyms (synsets) based on human judgments. Those synsets (=117,000) are linked to others through semantic and lexical relations. There are several characteristics of the WN. First, a majority of the cognitive synonyms have a super-subordinate relations (i.e., hyperonymy, hyponymy or "is-a" relation). Other relations include meronymy (part-whole relation), holonymy, frequency counts, and part of speech (Cross-POS) relations. Verbs were organized in hierarchies and adjectives with antonyms. As a result of all

those links, the WN has become a large lexical database that can serve as a basis for associational relationships.

Paletz, Peng, and Li (2011) used the WN to cluster semantically related terms given to a question asking to list traits of a creative person. Bossomaier, Harre, Knittel, and Snyder (2009) used the WN lexical database to calculate a "creativity quotient" (CQ) from the DT tasks. They combined fluency and flexibility by quantifying paths and path likelihoods between concepts. Likewise, Snyder, Mitchell, Bossomaier, and Pallier (2004) compared two response sets from two different individuals. The first person generated 19 responses in two categories, and the second person generated 23 responses in 7 categories. When calculated in traditional ways, 19 and 23 would be their fluency scores. When Snyder et al. used their own scoring formula, combining fluency and flexibility, which rewards the person for utilizing different categories, the first person had 6 points, and the second person had 17. The merit of this approach is the objective scoring which is critical for open-ended tests. However, the usefulness and psychometric value of this approach to explain the criteria of creativity have not yet been examined.

The second instrument is the Word Associations Network (WAN) (http://wordassociations.net/about?hl=en) developed by Yuriy A. Rotmistrov. The website provides associations for words and concepts under the categories of nouns, verbs, adverbs, and adjectives in addition to the dictionary definitions of the main entry as provided by the WN. Currently, approximately 3 million associations are provided for 41,476 word concepts. The WAN was developed to compile associations that arise in human memory for any given word. This was achieved by a software module that analyzes the classical and contemporary works of English.

The third instrument that should be useful for studies of literal DT is the IdeaFisher (http://www.thoughtrod.com/). The IdeaFisher (IF) is an idea generation support system that relies on the principles of associative thinking. The underlying idea is that original ideas are already stored in human cognition, and they can be accessed through successive chains of associations. This support system, then, aims to help individuals retrieve concepts and establish new relationships (Fisher, 1996). A useful function of the IF is the "Associated Words", which provides different number of associations for each word. In total, it includes 700,000 associations (Robbin, 1990). Several reports which used the IF to stimulate creativity are available (Cannon, Carroll, & Seamons, 1993), and its usefulness was indicated (Massetti, 1996).

The purpose of the present study was to investigate the associative processes in DT and more specifically, the usefulness of three different methods (The WN, WAN, and IF) to objectively identify the distance between ideas given to DT tasks. This research should provide useful information about the processes underlying DT and original thinking.

Research Questions

The present study aims to answer the following research questions:

1. Can the distance between any two ideas be reliably quantified?

    1.1. Can the distance between the stimuli (DT question) and each idea in the list of responses be used as a reliable index when the WN is used?

    1.2.Can the distance between the stimuli (DT question) and each idea in the list of responses be used as a reliable index when the WAN is used?

    1.3. Can the distance between the stimuli (DT question) and each idea in the list of responses be used as a reliable index when the IF is used?

2. Are the attitudes and values toward creativity related with remote and close associations obtained by using the WN, WAN, and IF?

Method

Sample

The sample consisted of 54 (34 female and 20 male) undergraduate and graduate students majoring in various fields. Broadly speaking, 37 participants majored in a field of social sciences, arts, or humanities, and 17 in hard sciences. The mean age of the participants was 26.28 years (*SD* = 9.35) and the average GPA was 3.54 on 4-point scale (*SD* = .46).

Data Collection

Several professors were contacted to invite their students to take part in the study. As an incentive, participants received $5 for their participation. After being presented with brief information about the content and purposes of the study, participants were provided a web address to a website which included all tasks and prompted responses to tasks. The participants had 5 minutes to complete each DT task.

Instruments

DT tasks and the *Attitudes and Values Scale* (A & V) were administered along with the personal information form. The A & V was included to determine if associative distance could be explained, in part, by individual differences in the attitudes or values that are relevant to creative thinking. The DT tasks used here were three Uses items (i.e., "List different uses for a bowl", then, "tire", and then "nail.") from the Runco Creativity Assessment Battery (rCAB, 2011). The following instructions were used for each DT task:

> List different uses for a bowl [or tire and nail, respectively]. Give as many ideas about uses as you can. The more uses you think of, the better. You will have 5 min to complete

this question. There are no grades and spelling does not matter. This is a game, not a test. Have fun!

Then, the personal information form including questions about age, gender, GPA, and major was given. Lastly, the A & V was administered. The A & V was also part of the rCAB with 25 items. Example items from A & V are as follows:

Item 1: "Even if a method has worked well in the past, it is a good idea to question and perhaps change it on a regular basis."

Item 2: "One of the advantages of developing expertise is that you can make useful assumptions and work more quickly."

Item 3: "Time is often wasted when everyone involved in a project shares each of his or her own ideas."

The A & V is a 5-point Likert-scale self-report. A higher score from A & V implies that the individual holds attitudes and values that make creative behavior very likely. Participants had to choose one of the five levels (i.e., totally DISAGREE, mostly disagree, Neutral, Mostly agree, totally AGREE) after reading the following instructions:

> Use the A & V scale (given below) to indicate how much you agree or disagree with a certain statement. You may need to approximate. Please indicate how you really think and behave; not how you would like to. Remember--no names are used. All of your individually identifiable information is confidential. Again, you may need to approximate. For each item, circle the response option that is THE CLOSEST to being accurate. Here are the options: 1. totally DISAGREE; 2. Mostly disagree; 3. Neutral; 4. Mostly agree; 5. Totally AGREE.
>
> *To what degree to you agree with each of the following?*

Procedure

Participants' answers to DT tasks were scored on three different criteria: The WN, WAN, and IF. The scoring was categorical when the WN, WAN, and IF were used. The lists derived from the WN included 919 words or concepts for bowl, 351 for tire, and 1,241 for nail. The lists from the WAN and the IF were smaller: 316 and 413 for bowl, 248 and144 for tire, and 371 and 211 for nail, respectively.

The WN lists were obtained by retrieving all sorts of associations, such as hyponymy (i.e., subordinate), sister term, hypernymy (i.e., superordinate), meronymy (i.e., part of a whole), and holonyms (i. e., whole with different parts). All words provided by the WN were included in the lists except "the," "a/an," "someone," "something," "things," "stuff," "oneself/themselves/yourself," "to," as well as all propositions and pronouns. The WAN lists were compiled from the website (http://wordassociations.net/). All nouns, adjectives, adverbs, and verbs were included in addition to the relevant definitions taken from the WN. The IF lists were obtained by using the Associated Words function in the ThoughtOffice software.

Remote and close associations were determined by comparing ideas produced with the WN, WAN, and IF lists. A response was defined as a close associate if it was included in the corresponding list. However, the WN lists were larger than the WAN and The IF lists and this could influence the capability to capture the close and remote responses. Therefore, three levels of association (i.e., close, moderately remote, and highly remote) were defined for the WN, and two levels of associations (i.e., close and remote) were defined for the WAN and the IF.

Close associates were defined as the responses in which all words or concepts were found in association lists retrieved from the WN. Moderately remote associates were defined as those

in which at least one of the associates was found in the list, but not all. Highly remote associates were defined as the responses in which none of the words was found in the list.

New software was developed for this research to screen the responses and to find matching words and concepts provided in the lists from the WN, WAN, and IF. Sample responses for three indices were provided below for the DT item asking all possible uses for a bowl. Words in the parenthesis indicated those found in the list.

Close: (food), (cooking), (boat) in a (bath) (tub), (scoop)er, (liquid) (hold)er, (hat)

Moderately remote: dust (collect)or, as a mountain while (play)ing, (store) nuts and bolts.

Highly remote: to catch leaks, umbrella, shield, ceramic title if broken up, trapping bugs.

There were only two categories defined for the WAN and IF lists. Close associations were defined as the responses in which at least one of the words was matched in the list; all others were remote. Examples of the close and remote associations are provided below. Words in parenthesis were found in the association list from the WAN and The IF.

(WAN) Close: to (hang) a picture to (hang) a (paint)ing, to repair broken (wood).

(WAN) Remote: to build a deck, to build furniture, in modern artwork.

(The IF) Close: (hold) (water) to (wash) car, to (hold) cleaner for cleaning, to (hold) (punch) at a party.

(The IF) Remote: as a hat for my son, to soak feet, to store leftovers.

Analyses

Several statistical analyses were conducted for each method. First, reliability analyses were investigated for all indices defined using coefficient alpha. Second, Pearson product-moment correlations with the A & V and the bivariate correlations among all indices were

analyzed. Lastly, the first and the second halves of the response lists were compared via Paired samples *t*-tests. SPSS 16.0 were used in all analyses.

Results

Descriptive statistics of the three verbal DT tasks and the A & V were provided in Table 2.1.

Alpha coefficient was .90 for the three fluency scores (Bowl, Tire, and Nail) and .67 for the A & V Scale. Item-total statistics indicated that three items (2, 3, and 8) decreased the inter-item reliability. Alpha coefficient increased to .73 when those three items were removed. Further analyses were conducted with the 22-item version.

Table 2.1

Descriptive Statistics for the Divergent Thinking Tasks.

	Min.	Max.	*M*	*SD*	Skewness	Kurtosis
Bowl	3	37	13.39	7.68	1.45	2.09
Tire	3	40	10.35	7.34	2.57	8.45
Nail	2	40	8.61	6.69	2.40	8.33
A & V Scale	60	105	85.21	7.42	-0.31	2.12

Results for three different methods (the WN, WAN, and IF) are reported in Table 2.2. The following analyses were conducted for each method: descriptive statistics, reliability (alpha coefficient), correlations with the A & V, comparison of the first and second halves, and the comparison of the remote and close associations.

The WordNet (WN)

The descriptive values of the three indices (i.e., close, remote, and highly remote) are provided in Table 2.2. Alpha coefficient was calculated for close, moderately remote, and highly remote associates, as well as fluency and the A & V. Alpha coefficient was .86 for moderately remote associates, .62 for highly remote associates, and .66 for close associates. These alpha coefficients were within the acceptable range according to George and Mallery (2003). The composite measures were created for fluency, moderately remote associates, highly remote associates, and close associates for further analyses.

Alpha coefficient was .86 for moderately remote associates, .62 for highly remote associates, and .66 for close associates. These alpha coefficients were within the acceptable range according to George and Mallery (2003). The composite measures were created for fluency, moderately remote associates, highly remote associates, and close associates for further analyses.

First, close associations were compared with the moderately and highly remote associations using those composite scores. Paired *t*-tests indicated that close associations were significantly lower than the moderately remote associations ($t(53) = -2.44$, $p < .05$), but higher than highly remote associations ($t(53) = 7.28$, $p < .01$).

More creative attitudes and values could be related to the tendency to generate more ideas and to make more remote associations. Therefore, the relationships between composite indices and the A & V were investigated. Bivariate correlations were reported in Table 2.3. The A & V was significantly correlated with fluency ($r = .29$, $p < .05$), moderately and highly remote associations (rs = .28 and .27, $p < .05$), but not with close associations ($r = .24$, $p = .09$).

Table 2.2

Descriptive Statistics for All Indices Defined Using the WN, WAN, and IF.

	WN Indices	Min.	Max.	*M*	*SD*	WAN Indices	Min.	Max.	*M*	*SD*	IF Indices	Min.	Max.	*M*	*SD*
Bowl	Highly remote	0	15	3.02	3.25										
	Mod. Remote	0	28	7.56	5.92	Remote	0	28	6.93	5.39	Remote	2	26	8.09	5.05
	Close	1	16	5.83	2.81	Close	1	15	6.46	3.50	Close	0	19	5.28	3.75
Tire	Highly remote	0	25	5.17	4.77										
	Mod. Remote	2	38	8.46	7.13	Remote	1	27	5.87	5.11	Remote	2	34	7.91	6.31
	Close	0	5	1.89	1.49	Close	1	14	4.48	3.25	Close	0	7	2.44	1.83
Nail	Highly remote	0	15	1.93	2.79										
	Mod. Remote	0	23	4.61	4.71	Remote	0	19	4.09	3.84	Remote	1	28	5.74	5.1
	Close	1	17	4.00	2.84	Close	0	21	4.52	3.93	Close	0	12	2.81	2.31

Note: WN = WordNet; WAN = Word Associations Network; IF = IdeaFisher; Mod. Remote: moderately remote.

Table 2.3

Bivariate Correlations Between the Attitudes and Values Scale and Composite DT Scores

	A&V	1	2	3	4	5	6	7
1.Fluency	.29*							
2.WN Close	.24	.76**						
3.WN Mod. Remote	.28*	.97**	.59**					
4.WN Highly Remote	.27*	.91**	.67**	.89**				
5.WAN Close	.15	.88**	.63**	.87**	.67**			
6.WAN Remote	.35*	.94**	.74**	.91**	.94**	.67**		
7.IF Close	.20	.87**	.58**	.87**	.67**	.93**	.70**	
8.IF Remote	.31*	.97**	.77**	.94**	.94**	.78**	.97**	.73**

Note: A & V= Attitudes and Values Scale; WN = WordNet; WAN = Words Associations Network; IF = IdeaFisher

*$p < .05$ level (2-tailed).

**$p < .01$ level (2-tailed).

When moderately and highly remote associations were regressed on the A & V, R^2 values were .08 ($p < .05$) and .07 ($p < .05$), respectively. In other words, creative attitudes and values explained about 8% of variability in the ability to make remote associations. Then, the first and second halves of the response lists were compared. It is expected that there would be more close associates in the first half than the second half of the responses if this method can successfully identify close associates. This, of course, is the method used by Mednick (1962), Milgram and Rabkin (1980), and Runco (1986) in their work on associative tendencies. Paired *t*-tests indicated that the mean of close associates in the first half (M = 3.26, 1.22, and 2.28, SD = 1.84, 1.06, and 1.64) was significantly higher than the second half (M = 2.35, .59, and 1.39, SD =

1.57, .74, and 1.47) in Bowl ($t(53) = 3.46$, $p < .01$), Tire ($t(53) = 4.26$, $p < .01$), and Nail ($t(53) = 4.82$, $p < .01$).

The Word Associations Network (WAN)

The descriptive values for the close and remote associates from the WAN were provided in Table 2.2.

Alpha reliability of the three DT items was .77 for close and .85 for remote associates. Composite values were generated to conduct further analyses. A paired-*t* test compared remote and close associations and the difference was not significant ($t(53) = -1.11$, $p = .27$).

The A & V was significantly related with remote associations ($r = .35$, $p < .05$) but not with close associations ($r = .15$, $p = .29$). A regression analysis using the A & V as predictor and the composite DT as criterion showed that the A & V explained a significant amount of variation in remote associations ($R^2 = .12$, $p < .05$). Remote associations from the WAN were also significantly related with moderately remote and highly remote associations from the WN (rs = .91 and .94, ps < .01) and close associations from the WAN were significantly related with close associations from the WN ($r = .63$, $p < .01$).

When the first and second halves of the responses were compared, the means were higher in the first halves (Ms = 3.30, 2.61, and 2.20, SDs = 2.14, 1.78, and 2.16) than the second halves (Ms = 2.89, 1.65, and 2.02, SDs = 1.83, 1.70, and 2.24), but the difference was significant only in tire ($t(52) = 5.84$, $p < .01$).

The IdeaFisher (IF)

Only two indices (i.e., close and remote) were defined with the IF and the descriptive values were provided in Table 2.2.

Alpha coefficient was .83 for remote associations, and .75 for close associations, which were acceptable values (George & Mallery, 2003). Composite scores were obtained by combining three close and remote associations. Close and remote associations were compared using those scores. Remote associations were significantly higher than the close associations ($t(53) = 7.91$, $p < .01$).

Correlations between the composite scores of close and remote associations, and the A & V were investigated. The A & V was significantly related with remote associations ($r = .31$, $p < .05$) but not with close associations ($r = .20$, $p < .10$). When the remote associations were regressed on the A & V, the A & V explained a significant amount of variation in remote associations ($R^2 = .10$, $p < .05$). Further correlational analyses on the relationship among the same indices from different methods indicated that close associations from the IF was significantly related with the close associations from the WN and the WAN ($r= .59$ and $.93$, $p < .01$). Remote associations from the IF was significantly related with moderately and highly remote associations from the WN ($r = .94$ and $.94$, $p < .01$) and remote associations from WAN ($r = .97$, $p < .01$).

When the first and the second halves were compared in terms of the number of close associates, the mean associates from the first half were significantly higher ($t(53) = 2.83$, $p = .01$) in the first half ($M = 1.41$, $SD = 1.19$) than the second half ($M = .91$, $SD = 1.01$) in Tire, but not in Bowl ($t(53) = .95$, $p = .34$) and nail ($t(53) = -1.19$, $p = .24$).

Discussion

The associative processes underlying divergent thinking have been investigated in several studies (Ward, 1969a; Milgram & Rabkin, 1980; Runco, 1986, Benedek, Könen, & Neubauer, 2012), but the focus of this study is on the distance between the ideas employing different

external criteria as the media of social associations. A particular merit of this approach is its objectivity due to its use of social associations as the criteria of distance rather than subjective ratings as Christensen et al. (1957) and Silvia (2008) used. Because this is the first study of this kind, reliability analyses were initially conducted.

Alpha coefficient indices defined in this study ranged from .61 (highly remote associations from the WN) to .86 (moderately remote associations from the WN). Highly remote associations had a stringent definition (i.e., responses in which none of the words was captured) compared to moderately remote associations (i.e., responses in which one or several responses were captured, but not all). When the binary scoring (i.e., close vs. remote) was employed using the WAN and IF, alpha coefficients were above .75 in remote and close associations. Those results indicated that remote and close associations can be reliably measured when association lists from the WN, WAN, and IF were used. The indices were relatively higher (above .83) for all indices of remote associations than they were for the close associations with the exception of highly remote associations from the WN.

As the alpha coefficient values indicated, longer association lists do not necessarily yield superior indices. Actually, the lowest alpha coefficient was found in highly remote associations from the WN, which was provided by the longest association list. However, the alternative index of remote associations (i.e., moderately remote associations) showed the highest reliability of all indices of remote associations investigated. These findings indicated that different definitions of close and remote associations may need to be examined for different lengths of association lists. In order to get sufficient statistical variability, stringent and sensitive definitions of close and remote associations were necessary because of the superior capability of some methods with larger association lists to capture the words used in the responses. Otherwise, the number of

close associations would get very close to fluency and could cause false positives whereas the variability of the remote associations would be restricted. The use of two alternative associations was warranted by those results.

The correlations with the A & V and the remote and close associations indicated that the A & V was significantly related to all indices of remote associations but none of the close associations. Pearson *r* values of remote associations were slightly higher when the WAN was used (r = .39 vs. r = .31, .32, and .33). This finding is very important because it shows that people with a higher tendency of creative attitudes and values are more likely to make remote associations rather than close associations. Those results are consistent with Mednick's (1962) suggestion that creativity is more likely to be found in remote associations. Those findings also support previous accounts (e.g., Schaefer & Bridges, 1970; Davis, Peterson, & Farley, 1974; Woodman & Schoenfeldt, 1990; Basadur, Runco, & Vega, 2000; Basadur & Basadur, 2011) that underscored the role of attitudes and values in divergent and creative thinking.

The creative attitudes are related to creative behaviors and performance, and some research focused on the changes in attitudes as a result of creativity training. Basadur, Graen, and Green (1982) found that creativity training made an improvement in preference for and practice of ideation in problem solving as well as practice and performance of problem finding. In another study, Basadur and Hausdorf (1996) found that creativity training reduced the attitudes of creative individual stereotypes and tendency not to make premature critical evaluations, and increased preference for ideation. Attitudes can also influence the impact of creativity training. For example, Runco and Basadur (1993) found that specific attitudes (e.g., preference for active divergence) moderated the impact of creativity training.

The higher instances of remote associations among those with higher tendency of creative attitude and values reinforce the expectation that creative people can see connections between seemingly unrelated things (Mednick, 1962). This could be the reason why creative people report more connections between two remote word pairs than less creative people (Necka, 1994). The higher tendency of attitudes and values toward creativity can exhibit itself in a preference for remote associations over close associations (Duchene, Graves, & Brugger, 1998). According to this point of view, people make remote and close associations, but particular attitudes and values might allow creative people to accept those that are more remote.

Those results can be interpreted from the angle of semantic networks. The basic principle of the semantic networks is that human knowledge can be represented through interconnected nodes and arcs (Sowa, 1992). Some connections are remote and some are close. Heilman, Nadeau, and Beversdorf (2003) argued that activation of the remote networks is important in divergent thinking because it allows generating alternative solutions. Positive attitudes and values toward creativity can inhibit the activated networks with semantically similar information (i.e., close associations), and activate those that are minimally activated (remote associations).

Highly significant correlations among the remote associations from different indices are especially important for creativity assessment because remote associations, rather than close, should be the focus of assessment. All correlations among different indices of remote associations from different methods were within the range of .89 to .97 and the correlations with close associations were relatively lower (.67 to .87). Those findings show that the indices of remote associations obtained from different methods associations were highly related even though they differ in magnitude with different sources of social associations.

The analyses of response hierarchies of the close associations were conducted by comparing the first and the second halves of each participant's responses to the DT tasks. Milgram and Rabkin (1980) and Runco (1991) used this method to compare the common and uncommon responses. Paired *t*-tests indicated that significantly higher close associations were found in the first halves than the second halves in all three DT tasks when the WN was used and in Tire item in all three methods (WN, WAN, and IF). Those results can be explained with the possibility that the length of association lists can influence the method to capture the close associations. The associations lists were longer in the WN than the WAN and IF. Corollary to this, significantly more significant associations were found in the first halves than the second halves in all DT items when the WN was used. On the other hand, the IF provided fewer associations and provided less consistent results among three items. Significantly more close associations were found in the first halves than the second halves in Tire item contrary to the Nail item in which more (but not significant) close associations were found in the second halves.

These findings are especially important in terms of the potential implications in creativity assessment. The distance between the ideas is not currently used in the mainstream assessment of creativity (using the DT items). These findings indicate that this component can be incorporated into creativity assessment with additional refinements to include careful selection of association lists and appropriate operationalizations of close and remote associations. To build on the earlier mention of the merits of this method is that the scoring can be easily computerized. Given the limited use of computerized testing of creativity (e.g., Cheung, Lau, Chan, & Wu, 2004) and the need for relatively subjective and laborious scoring, this method can easily be implemented to computerized evaluation of the responses with limited or no involvement of external evaluation. The current indices used simple software developed for this study and required a quick review

for the validity of the words and concepts captured. However, it can be improved and can be used without any human judgment in the future.

CHAPTER 3

THINKING IN MULTIPLE DIRECTIONS: HYPERSPACE CATEGORIES IN DIVERGENT THINKING[2]

[2] Acar, S. To be submitted to *Psychology of Aesthetics, Creativity, and the Arts.*

Abstract

Although divergent thinking (DT) has been recognized as one of the key components of creative thinking, the nature of divergent thinking as the ability to think in various directions, (so, *literal divergent thinking*) has not been studied yet. In the present study, thirteen dimensions and categories underlying DT has been proposed and the responses given to DT tasks have been evaluated for those categories. It was proposed that the utility of more hyperspace categories implies superior creative potential because literal divergent thinking refers to thinking in all directions. The proposed 11 hyperspace categories (two merged with other dimensions) were located in the responses to DT tasks. The inter-item and inter-rater reliability analyses indicated that hyperspace categories can be reliably identified with the exception of TUMAI and playful responses, which had low alpha coefficients. Bivariate correlations indicated that higher number of ideas from each category was positively related with originality and fluency. When fluency was controlled, categories such as impractical, synthetic, breadth, non-natural, infeasible, playful, and remote associations were positively related with originality and whereas their complementary categories (i.e., impractical, non-synthetic, depth etc.) were negatively related in the verbal as well as in the figural DT tasks in the majority of the applicable categories.

More importantly, it was indicated that literal divergent thinking (LiDT) can be quantified using those categories. The LiDT was positively related with the originality attitudes even after controlling for fluency.

Introduction

Divergent thinking (DT) is a good estimate of creative potential (Guilford, 1962, 1968; Wallach & Wing, 1969; Torrance & Hall, 1980; Davis, 1989; Runco, 1991; Runco & Acar, 2012). An essential characteristic of DT is that it involves open-ended tasks. That is important

because open-ended tasks allow individuals to follow idiosyncratic pathways to generate ideas and solutions. This feature of DT gives researchers a fertile but complex output to analyze. It is fertile because there is no correct or incorrect answer, nor any other limitation for thinking. For this reason, divergent thinking has been defined as thinking in multiple ways, or in all directions (Runco, 1999a). This kind of thinking is, after all, implied by the label "divergent thinking." It is complex as well because absence of a correct or incorrect answer and lack of limitation for thinking makes objective measurement quite challenging. Resolving this complexity is partly contingent upon further efforts to recognize and identify numerous dimensions that can be addressed as a result of "thinking in all directions."

Very likely, the more directions employed in thinking, the higher the probability of finding an original and creative idea. However, DT research has yet to really study divergence per se. DT is often visualized as moving in many directions from a single point (which can be an idea, concept, or question) whereas convergent thinking implies moving into a single point (i.e., the correct solution) from different points or directions. After Guilford's (1950, 1967, 1968) seminal works on DT where he suggested and used popular indices consisting of fluency, originality, flexibility and elaboration, creativity researchers usually focused on the counts of ideas generated and did not really investigate the pathways and cognitive mechanisms taking individuals to creative ideas. Although fluency and those indices have served as reliable indices, they cannot capture the whole process of DT, or at least not literal DT. There are numerous ways to come up with creative ideas, but some are more useful and can be operationalized. The new approach, proposed here, will be called *literal divergent thinking* (LDT). It goes beyond the traditional indices of DT by tracking down possible directions that lead to original ideas. In this

approach, then, it is important to identify the dimensions underlying creative ideas or directions that individuals follow in their thinking.

Guilford's seminal work (Guilford, 1950, 1968) did not capture literal DT but did recognize dimensionality. Wilson, Guilford, and Christensen (1953), for instance, defined three different definitions of originality. The first definition is the statistical infrequency of the ideas generated. This definition turned out to be the most often used operational definition of originality either using the national norms (Torrance, 2008) or the study group itself (e.g., Runco & Acar, 2010). The second definition is remote, unusual or unconventional associations that are generated in associational tests. They asked respondents to generate additional responses after answering for the first time. This definition led to another commonly used test of creativity, which is the Remote Associates Test (Mednick & Mednick, 1967). The third definition is the cleverness of the responses to be rated by judges. Guilford's approach is interesting in that it recognizes different dimensions underlying the same construct. In this study, there is an attempt to explore more dimensions than have been previously studied. The overarching objective is to examine ideas elicited by DT tests in an effort to operationalize literal divergence. The dimensions defined in an attempt to capture LDT will then be tested, the prediction being that they will be highly correlated with originality and actual creative thinking.

Guilford's (1968) ideas about originality will be helpful. Another interesting aspect of literal divergent thinking is the ability to think in opposite and conflicting directions. Theories of creative personality often underlined this characteristic. In Barron's (1963) own statements, "the creative person may be more primitive and more cultivated, more destructive and more constructive, occasionally crazier and yet adamantly saner, than the average person" (p. 234). Maslow (1976) argued that creative individuals are able to manage the conscious and

unconscious, the primary and secondary processes together. May (1984) maintained that creative individuals do superior work in the presence of rigidity and spontaneity.

Similar accounts were put in different terms by others. McMullan (1976), for instance, proposed that the creative person possesses two thinkers, or two modes of thinking, jointly. He identified eight paradoxical characteristics: delay in closure vs. systematic closure, divergent thought vs. convergent thought, relaxation vs. attention, discontented attitude vs. constructive attitude, mindless perception vs. understanding based upon memory, emotional involvement vs. emotional detachment, disinterested motivation vs. selfish motivation, and humble self-concept vs. confident self-concept. In all of those categories, each dichotomy consisted of flexibility and persistence factors, respectively. He argued that creative individuals swing from one pole to another.

Torrance and Hall (1980) also suggested that creative individuals can successfully integrate polar opposites such as masculinity and femininity, conforming and non-conforming, independence and dependence, serious and playful, timid and bold, certain and uncertain, receptive and self-acting at higher levels than less creative people. They argued that creative people can integrate those opposites, and called this characteristic "ability to solve collision conflicts" as one of the further reach abilities.

Csikszentmihalyi (1996) concurred, suggesting that creative individuals have complex personalities and they can move from one extreme to another on the continua of personality traits rather than being neutral. He mentioned ten of them: high physical energy vs. being quiet and rest; smart vs. naïve; playfulness, discipline and responsibility vs. irresponsibility; imagination and fantasy vs. reality; extraversion vs. introversion; humble and selflessness vs. proud and

ambition; masculine vs. feminine, traditional and conservative vs. rebellious and iconoclastic, passionate vs. objective, suffering and pain vs. high enjoyment.

Based on those theoretical and empirical accounts discussed above, it is possible to suggest several dimensions that may be tapped if someone does think in literally divergent fashion. This perspective can introduce a new way of measurement of creative potential. Specifically, a personalized display of divergence could be obtained through empirically proven dimensions involved in DT. This hypothetical visualization of several dimensions of creative thinking was called "hyperspace" (Runco, 2010). Those dimensions will be discussed in the next section. Before turning to the specific dimensions, something should be said about the format of the dimensions.

This study is unique in that it analyzes DT outputs that imply literal DT. Each of these is defined as a dichotomy. In some of those dimensions, one end represents the conventional, convergent, and normative way of thinking whereas the opposite pole reflects an unconventional, divergent, and unusual way of thinking. It is hypothesized that creative individuals will be able to generate ideas in both ends compared to less creative individuals, who might tend to generate ideas predominantly in one end. Indeed, someone producing ideas only towards one end of the continuum may not have notable capacity for literal DT. And someone who only produced ideas in the conventional direction would be expected to have the least creative potential. Not only are they unable to think in a fashion that suggests literal DT; they are also thinking only in the conventional direction.

An attempt was made to identify a number of dimensions and dichotomies. After all, the more possible directions, the closer one gets to literal divergence. Yet there was a constraint that

the only dimensions that were included were entirely operational. Below are the dimensions to be examined in this study:

1. Originality versus conventionality. Although originality is a must for creativity (Runco & Jaeger, 2012), creative individuals can think in unoriginal and usual ways, too. In fact, those who generate only original ideas may fail to be creative because their thinking may be somewhat disconnected from the reality. Creative thinking involves specific cognitive processes leading to conventional responses such as convergent and evaluative skills. The importance of those skills has been highlighted in Basadur's (1995) ideation-evaluation model, Moneta's (1993) model of scientific creativity, Campbell's (1960) blind variation-selective retention model, and Brophy's (1998) review on individual creative problem solving. Generating conventional and usual responses are corollary to such processes, and therefore, creative individuals should be able to generate both original and unoriginal ideas.

There are different ways to define originality but most focus on the infrequency of the given responses. Some define original ideas as those given only by less than 10 percent of participants whereas others use unique ideas as original (Runco, 1991). In this study, unique ideas were defined as original and all others conventional.

2. Amoral, unethical, illegal, malevolent versus moral, ethical, legal, benevolent: Recent creativity literature included more empirical and theoretical works on the dark side of creativity (e.g., Cropley, Kaufman, & Cropley, 2008; McLaren, 1993; Stein, 1993; James, Clark, & Cropazano, 1999). Walczyk, Runco, Tripp, and Smith (2008) found that number of lies was correlated with DT and ideational behavior. Gino and Ariely (2012) examined the relationship between creativity and dishonesty. They proposed that a creative personality motivates individuals to think creatively, which in turn, can lead to unethical behaviors. They found that

people with creative personalities who had high DT scores cheated more and dispositional creativity predicted unethical behaviors more than intelligence. Moreover, participants who were primed to think creatively were more likely to behave dishonestly and more able to successfully justify their dishonest behavior.

Empirical studies and history clearly indicated that creativity may lead to unfortunate things. However, it is also possible to approach such ideations as part of the creative potential. Actually, amoral, unethical, and illegal ideas can enhance the horizons of ideation. So, Runco (2010) argued that creativity has no dark side, but creative products or impact of creativity can be harmful. Some unconventional responses could be destructive or unethical, but this is not necessarily bad at the ideational level. In a way, those "dark" responses can be seen as a positive thing for creative potential because they imply that the person is using a large number of options and ideas. Thus, it is proposed that creative individuals are able to generate ideas that are moral, ethical, legal, and benevolent as well as amoral, unethical, illegal, and malevolent ideas.

3. Taboo versus non-taboo responses. Similarly, thinking outside-of-the-box is sometimes achieved by considering "socially taboo" issues in ideation. Socially unacceptable ideas that crossed one's mind might actually constitute some of the creative ideas when they are retained. Some people can do it easily, some cannot.

Rawlings and Toogood (1997) argued that so-called taboo responses to DT tasks are related to psychoticism. They scored the DT tasks with respect to fluency and originality as well as whether the response would be considred a taboo response or not. Taboo responses, in their definition, contained themes of sexuality or aggressiveness. Analyses with the total scores indicated a significant relationship between psychoticism and the *taboo but not original*, *taboo and original*, and *all taboo and original*" scores (rs=.30, .29 and .28; ps<.01). The Schizotypal

Personality Scale was also correlated with the *taboo and original* scale (r =.27, p <.01). The most interesting finding was the lack of significant relationship between psychoticism and *original but not taboo* responses, whereas all other scores, including taboo responses, were significant. Those findings indicated that the relationship between originality and psychoticism is low or spurious when the taboo responses are removed from the total scores. Therefore, taboo responses could be a useful direction, which lead to more and unusual ideas.

The definition of taboo responses was broadened in the present study to include magical ideation, (Schuldberg, French, Stone, Heberle, 1988; Weinstein & Graves, 2002) as well. Individuals are often expected to think logically and reasonably and this can restrict ideation. Magical ideation, which is defined as thinking that includes irrational beliefs and that goes beyond the reality, can help individuals to break this limitation. Therefore, taboo responses were defined as responses that include sexuality, aggression, and magical ideation.

4. Primary versus secondary processes: The distinction of primary versus secondary processes could be useful for the empirical studies of creativity, specifically for DT. The primary processes have been described as crude, primitive, non-logical, drive and affect driven, inspirational, egocentric, pleasure-oriented, and analogical mode of thought. These are different from secondary processes, which are associated with socialized, reality-oriented, logical, practical, realistic, analytic, elaborative, synthetic thinking (Pine & Holt, 1960; Dudek & Verreault, 1989, p. 65).

Primary process thinking has been linked to creativity (Kris, 1952; Freud, 1955), and later studies provided empirical support. To mention a few, Dudek (1984) found that creative architects produced more libidinal content than less creative but successful architects. Russ and Grossman-McKenzie (1990) examined the relationship between primary process thinking on the

Rorschach and DT tests and affective expression in children's fantasy play. The percent of primary process thinking in Rorchach test was highly correlated with DT tasks in boys (r=.72, p<.001), but not in girls (r=.27, ns). Martindale and Dailey (1996) administered Alternative Uses and Word Association tests and had subjects write stories to be evaluated for creativity. Then, they analyzed those stories by using a content analysis program called COUNT (Martindale, 1973), which relies on Regressive Imagery Dictionary (Martindale, 1975, 1990) that consisted of primary process content. They found that primary process content is related to scores from the Uses test, remoteness of associations, story creativity and the composite creativity score.

Based on summarized theoretical and empirical evidence, it was expected that responses of the creative individuals would include both primary and secondary content. For the operationalization of creativity, the Regressive Imagery Dictionary was used to identify responses involving primary and secondary processes. The Regressive Imagery Dictionary provided word lists for primary and secondary processes. Responses that include words or concepts from the primary processes were coded as "primary" and those involving the words and concepts from the list of secondary processes were coded as "secondary."

5. Experience versus non-experience: Creative individuals often take the advantage of their experiences. Ward (1969b) found that creative individuals perform better in cue-rich testing environment than cue-poor testing environments. Runco, Dow, and Smith (2006) examined the role of experience and knowledge in DT. Some DT questions allowed original responses and some were factual. They found a significant correlation between those two types of tasks when they shared the same domain. They concluded that there was an experiential bias depending on type of the test. Runco and Acar (2010) examined the role of experience in the Uses and Problem

Generation tasks. They asked participants to indicate the ideas that they experienced before. They found that experience explains more than 30% of the fluency and 65% of the originality.

The role of experience and memory were empirically indicated, but creative individuals can also generate ideas without experiencing them. They can use their imagination or some particular strategies to be creative. As a result, both experienced and inexperienced ideas are expected in creative individuals' responses. The method that Runco and Acar (2010) used in their study was used in this study.

6. Functional, practical versus impractical, aesthetics, artistic: Responses to the DT tasks can be functional and practical as well as impractical, aesthetic, and artistic. These characteristics are important particularly while designing an object. Bonnardel and Marmèche (2005) argued that functional and structural properties are not sufficient to solve a design problem. They identified other aspects including aesthetic and affective characteristics. They also asserted that experienced designers utilize more of these aspects than novices.

In the present study, responses were evaluated to determine if they have a functional and practical purpose, and provide some sort of utility to individuals; or merely possess an impractical, aesthetic, and artistic value.

7. Synthetic versus non-synthetic: Combining different elements into new forms has been shown to be helpful for creative thinking. Sternberg (1999) defined creativity as the novel and useful combination of seemingly unrelated concepts and words. Welling (2007) regarded combination as one of four basic mental operations in creative cognition. According to Finke, Ward, and Smith (1992), the combination of objects, words or concepts lead to mental synthesis. Several processes resulting in syntheses or combinations were emphasized in the literature,

including homospatial and Janusian thinking (Rothenberg, 1979) as well as counterfactual thinking (Kray, Galinsky, & Wong, 2006)

It is quite likely to find ideas generated through one of those cognitive processes. Some of the ideas in response to DT questions might be syntheses of two or more ideas. One way to distinguish synthetic ideas from non-synthetic ones is to examine if an idea consists of parts or units brought together to form a new whole. This is an obvious synthesis but there could be other ways to make a synthesis. Synthetic ideas have been defined as the responses that involved two components, merged two different ideas, combined with an additional component, or ideas that are part of something larger; and non-synthetic ideas were those simple ones. As was the case with other dimensions, creative individuals generate both synthetic and non-synthetic responses.

8. Breadth versus depth: Ideational productivity can be enhanced by following hierarchical and categorical pathways. Some individuals focus on a category and generate ideas within this category by going down the hierarchies in thought. Others, however, explore different categories, jumping from one category to another. The former refers to *depth* in thinking whereas the latter is *breadth*. If a cognitive hierarchy is conceived as general levels or categories of ideas which contain subcategories, with those subcategories themselves also containing more specific subcategories, thought might move only within a category (i.e., from level to level) or it might move from category to category. The ability to generate ideas in both ways can lead to superior divergence. Therefore, creative individuals are more likely to follow both hierarchical and categorical pathways, having depth as well as breadth rather than one of them.

Troyer, Moscovitch, and Winocur (1997) formulized this distinction as switching and clustering. They counted the number switches from one category to another for switching; and

the number of uses in a category for clustering. They found that older adults made fewer switches, and divided attention manipulation had a negative influence on switching.

Torrance (2008) also used switching (shift) as a measure of flexibility on the final activity on the verbal test.

9. Feasible, realistic, possible versus infeasible, hypothetical, unrealistic responses. Individuals learn to adapt to norms as they mature and begin to recognize limitations (Runco, 1999b). As a result, ideas become more and more rational and reasonable. This, however, may restrict creativity because people are more likely fail to go beyond the objective world and their preconceptions (Runco, 1996). Practically speaking, the technological advancements of today were impossible in the past. For this reason, it is important to identify those who can think of feasible, realistic and possible ideas and infeasible, hypothetical, and unrealistic ideas. Coexistence and interplay of ideas on either side may enable creative ideas to emerge. This way, one can swing from one extreme to the other and experience the cycles of exploration and evaluation.

Hypothetical thinking is important for creativity and some DT questions are hypothetical. For example, "What would be the consequences of having an extra thumb on each hand?" (Houtz, Jambor, Cifone, & Lewis, 1989, p. 119), or the Just Suppose test (Torrance & Safter, 1989). Creative individuals can generate both kinds of ideas in each type of DT question. To distinguish feasible, realistic and possible ideas from infeasible, hypothetical, unrealistic responses, each idea will evaluated with respect to the question of "Is this idea feasible and doable today under current conditions."

10. Natural vs. Unnatural: The act of thinking in all directions benefits from the consideration of all alternatives in the environment. Ward (1969b) found that creative individuals

generate more ideas in a rich environment than a poor environment whereas less creative individuals underperformed in both conditions. In any environment, it is possible to list natural, and unnatural, artifical, or man-made things. Thus, it is possible that responses can consist of only natural or unnatural things, but the presence of both yields more ideas.

11. Humorous versus serious and sober. Humor and creativity have been often associated with each other (Wicker, 1985; Cundall, 2007). At the theoretical level, Murdock and Ganim (1993) analyzed theories and definitions of humor and concluded that humor can be regarded as a subset of creativity and the similar theoretical frameworks can help to study both. Empirical studies supported this link. Humke and Schaefer (1996) also found a very high (r =.77) correlation between the scores from Multidimensional Scale of Humor and nonverbal test of creativity. Humor can also facilitate creative thinking as Ziv (1976) showed that those who listened to humorous records scored higher than those who did not.

However, not all ideas of creative people are humorous. In fact, they can generate both humorous and non-humorous ideas, and this is likely how humor becomes effective.

12. Playful, childlike, spontaneous vs. mature, serious and responsible: Playful mindsets can also facilitate creativity (Langer, 1989). According to Torrance and Safter (1999), play has a central role in making a creative leap, and playfulness is an important personality characteristic. Bruner (1975) maintained that playful approach helps creativity because it allows one to resist social pressures and eschew reality. Analyses of famous creative individuals underlined the role of playful mode of thinking. Picasso often played with ideas and Einstein was described as "perennial child" (Gardner, 1993, p. 87-95). Baudelaire saw children's drawings related to those of creative adults. Such examples supported the view that minds of children and creative adults

tend to be similar. Thus, a mind that resists the changes that come along with growth could produce divergence at higher rate. Einstein's introspection coincides with this suggestion:

> How did it come that I was the one to develop the theory of relativity? The reason, I think, is that a normal adult never stops to think about problems of space and time. These are things he has thought of as a child. But my intellectual development was retarded, as a result of which I began to wonder about space and time only when I had already grown up. Naturally, I could go deeper into the problem than a child with normal abilities (cited in Gratzer, 2002, p. 3).

Playful, childlike, and spontaneous responses were defined as those including games, play, fun, and those reflecting a child's perspective, reaction or attitude. All others would be mature, serious, and responsible responses.

13. Close versus remote: Creativity was defined as the ability to make remote associations (Mednick, 1962). However, remote associations can be made by psychotic, but not necessarily creative, individuals as well. Creative individuals can make remote associations not because they are disconnected from reality, but because they have the rational pathways to see relations between seemingly unrelated things. However, creative individuals can also see close associations as they are able to generate appropriate responses to DT tests. This perspective can be superior to a more binary close *or* remote association perspective in that it can discriminate healthy creative individuals from psychotics.

To operationalize this dimension, the responses were investigated to determine if they are found in the associations list given by the Word Associations Network (WAN). The associations for the words and concepts were provided on the following website:

http://wordassociations.net/about?hl=en. Currently, approximately 3 million associations are provided for 41,476 word concepts.

Research Questions

The following questions were investigated in this study:

1. Which of the proposed hyperspace categories can be successfully identified in the responses to DT tests?
2. Which hyperspace categories can serve as reliable indices?
3. What is the relationship between the hyperspace categories and fluency and originality?
4. Can literal divergent thinking be captured using the dimensions and categories proposed?

Method

Sample

The sample consisted of 54 (34 female and 20 male) undergraduate and graduate students majoring in various fields. Broadly speaking, 37 participants majored in a field of social sciences, arts, or humanities, and 17 in hard sciences. The mean age of the participants 26.28 years (*SD* = 9.35) and the average GPA was 3.54 on 4-point scale (*SD* = .46).

Data Collection

Several professors were contacted to invite their students to take part in the study. As an incentive, participants received $5 for their participants as an incentive. After brief information about the content and purposes of the study, a web address including all tasks was provided and participants were prompted to respond to tasks. The participants had 5 minutes to complete each DT task.

Instruments

The DT tasks used here were three Many Uses items (i.e., "List different uses for a bowl", then, "tire", and then "nail.") from the Runco Creativity Assessment Batterry (rCAB, 2011). The following instructions were used for each of the Many Uses item:

"List different uses for a bowl (or tire and nail, respectively). Give as many ideas about uses as you can. ***The more uses you think of, the better.*** *You will have 5 min to complete this question. There are no grades and spelling does not matter. This is a game, not a test. Have fun!"*

Then, the personal information form including questions about age, gender, GPA, and major was given followed by the Figural DT tasks. The following instructions were given for the Figural DT tasks:

"This is a visual game. Below you will find a line drawing. We would like you to make a list of all of the things that each drawing could be. The more things you write down, the better! There are no incorrect answers, no grades, no points, and spelling does not matter. This is game, NOT a test. You have 5 min. to complete this question. Now look at the first below and ***write down as many things as you can*** *for what that figure might be. What does it look like? What could it be?"*

Lastly, the A & V was administered. The A & V was also part of the rCAB (2011) with 25 items, but six items on originality (Items 13, 17, 19, 23, 24, and 25) were used in the analyses to test a specific hypothesis. Example items on originality from the A & V are as follows:

Item 17: "There is clear benefit to thinking about ideas that other people will not consider."

Item 23: "Originality can be very useful at work or in school."

DT tasks and the Attitudes and Values Scale (A & V) were administered along with the personal information form. The A & V is a self-report using a 5-point Likert-scale. After the

reading the instructions below, participants had to choose one of the five levels (totally DISAGREE, mostly, disagree, Neutral, Mostly agree, totally AGREE). Then, those levels were converted to numbers from 1 to 5 respectively.

"Use the A & V scale (given below) to indicate how much you agree or disagree with a certain statement. You may need to approximate. Please indicate how you really think and behave, not how you would like to. Remember--no names are used. All of your individually identifiable information is confidential. Again, you may need to approximate. For each item, circle the response option that is THE CLOSEST to being accurate. Here are the options: 1. totally DISAGREE; 2. Mostly disagree; 3. Neutral; 4. Mostly agree; 5. Totally AGREE.

To what degree to you agree with each of the following?"

Procedure

Responses were coded if they fell into one of the categories of the above dimensions. Each response given to DT tasks was evaluated consecutively for all dimensions except for the dimension of experience versus non-experience. Because three of the dimensions were not applicable to the figural DT tasks, they were evaluated only for the verbal tasks: 1) Experience versus non-experience, 2) Feasible, possible, realistic versus infeasible, impossible, unrealistic, and 3) Close versus remote associations.

After an initial review of ideas, several dimensions were merged into others because of insufficient responses in a given dimension. The dimension of taboo versus non-taboo was combined with the dimension of amoral, unethical, illegal, and malevolent versus moral, ethical, legal, and benevolence. The combined dimension will be shortly phrased as the acronyms of TUMAI and NEMBL. Also, the dimensions of playful, childlike, spontaneous versus mature,

serious responsible was combined with the dimension of humorous versus serious and sober. This new dimension will be shortly phrased as playful versus serious.

Each idea was evaluated by the researcher for all dimensions except three. Additionally, a subset of responses was also evaluated by another reviewer to investigate inter-rater reliability. The results were provided in the Results. External criteria were used for the dimensions of primary versus secondary processes and close versus remote associations through software developed for this purpose. The Regressive Imagery Dictionary (RID; Martindale, 1975, 1990) was used to determine if primary and secondary processes were involved in the responses. The English version of the RID involved lists of concepts and words associated with the primary and secondary processes and emotions. Some examples of the words associated with the primary processes that were captured in responses were included in Table 3.1 in parenthesis.

Association lists provided by the Word Associations Network (WAN) were used to determine if a response involved closely related words or concepts. The responses including none of the words in the corresponding lists were coded as remote associations and those including at least one of the words in those lists were coded associations.

To identify the responses that may have been influenced by experiences, participants were contacted again after the data collection to ask which of the responses given to the three Many Uses items they experienced before. They were asked to mark "E" if they have experienced a response. Twenty five participants responded. The total number of ideas experienced was noted as the responses coming from the experiences; and all others were non-experience.

Sample responses for each dimension for all categories were provided in Table 3.1 and 3.2. Although each dimension and category was defined as clear as possible, ideas were scored

by the researcher and therefore, there is room for subjectivity. Because of this, inter-rater reliability was examined and provided in the Results.

Analyses

The statistical analyses were four-fold: First, the inter-rater reliability was examined using Cohen's (1960) Kappa for all dimensions proposed to see the agreement between two raters on the scoring of the randomly selected sample of responses. Second, descriptive statistics were conducted for all categories (e.g., originality, conventionality, playful, serious) from each DT task, 6-item originality scale from A & V (named AVO), and the new measure entitled Literal Divergent Thinking (LiDT). Third, bivariate correlations between the categories and originality and fluency were examined followed by partial correlations between the proposed hyperspace categories and originality controlling fluency. Fourth, correlation between the LiDT and AVO was examined and the correction for attenuation was made for the obtained correlation value.

Results

Inter-rater Reliability

Responses to six divergent thinking tasks have been evaluated for each dimension successively, and this process was subjective to a varying degree. The inter-rater reliability was not needed for the dimension of Experience versus Non-experience because participants themselves indicated the ideas they experienced. Therefore, it was a purely objective method. A randomly selected subset of responses was rated by two raters for the remaining dimensions. This subset involved 120 responses from six DT tasks (20 from each task), and the second rater evaluated those responses after a brief training about the detailed description of the dimensions, and the scoring methods. Two raters scored each idea for all dimensions categorically (1 or 0).

Table 3.1

Sample Responses for the Verbal Items.

		Bowl	Tire	Nail
1	Originality	- ash tray - burn things in it	- heavy tutu - kinetic energy	- anti theft device - example for a metal
	Conventionality	- cereal - to eat out of	- hula-hoop - driving	- hang a picture on the wall - flatten a tire
2	TUMAI	- weapon - toilet	- burning, roadblock - hit someone with it	- boomerang - booby trap
	NEML	- cleaning - fly to moon in	- hold down tent corner - keep spare	- carve things in wood - clippers
3	Primary	- (food) - (water) for pets	- a (swing) - (door) (handl)es	- (Hang) a (picture) - Make a (hole)
	Secondary	- dust (collect)or - to (build)	- mosquito (catch)er - (construct)ion material	- (build) a deck - (repair) broken wood
4	Experience	- eating soup - water glass	- on a car - on a bike	- hang pictures - build things
	Non-experience	- hat - holder of yarn	- swing - play hide & seek	- weapon - pick a lock
5	Functional	- bell - candy dish	- hat - shock absorber	- fix something - hang a coat
	Impractical	- allegory - artwork	- decoration - to exemplify the smell of rubber	- accessory - figure of speech
6	Synthetic	- break it in celebration at weddings - connect it with another bowl to make globe	- place mosquitoes lay their eggs when water gathers in the tire - Build muscle by pumping air in it	- add an S make it a word describe an animal with a shell - nail in 1/2 way and bend it use hook
	Non-synthetic	- color coder - cup	- anchor - airplane	- mounting - art
7	Breadth	- drink out of → to store items - to stand on → throw up in	- make a car run → swing - seat → floatation device	- keep something on a wall → give a friend tetanus

	Depth	- serve food → drinking - hold fruit → hold decorative items	- make a purse → make a wallet - obstacle course: step in center → obstacle course: crawl through	- hang a picture → hand a clock - earrings → necklace charm
8	Feasible	- bang spoon on - for cat food	- barrier - airplane	- adhesion - hang something on a wall
	Infeasible	- bathroom in - bowling ball	- ankle weight - chair	- aerate a field - boomerang
9	Natural	- put almonds in - hold fruit	- breed mosquitoes - sleep in it	- used for biting (fingernails) - spread tetanus
	Non-natural	- Helmet - Ice-skates	- stroller - spare	- bed of nails - booby trap
10	Playful	- bowling ball - drum	- bad joke - bouncy toy	- monopoly game piece - play jenga
	Serious	- bridge - burn things in	- agility training - armor	- crucifixion - crude surgical instrument
11	Remote	- to store toys - painting walls	- on a stroller - as a buffer on a dock	- to build furniture - to make a building
	Close	- (hold) (punch) at a party - (clean)ing	- on a (car) - on a (bike)	- (hang) a picture - Repair broken (wood)

Table 3.2

Sample Responses for the Figural DT Tasks.

		Rectangles	Star	Tornado
1	Originality	- carrot sticks - cereal boxes	- eyelashes - AutoCAD cursor	- caterpillar - confetti
	Conventionality	- cage - buildings	- cartesian plane - Christmas decoration	- corkscrew - curl
2	TUMAI	- killer robots - knives	- boom/crash - target	- hurricane - plane crushin
	NEML	- knife stand - instagram	- heart of man - top of a pyramid	- hair - half carrot

3	Primary	- (ladder) - (brush)	- Star - Tunnel	- curly (hair) - squiggly line
	Secondary	- sideways (jail) (bar)s - railroad carriers	- Snowflake (pattern) - A diagram of (time)	- To hook dog leash to - Labyrinth (finish)
4	Experience	- NA	- NA	- NA
	Non-experience	- NA	- NA	- NA
5	Functional	- Comb - Cross-walk	- Clock - Compass	- door stopper - funnel
	Impractical	- bar graph - different patterns	- abstract tree - angles	- boredom - brand logo
6	Synthetic	- one big rectangle if joined together - square if you squint	- intersecting intersections - absolute value functions reflected over the x-axis on the coordinate	- blanket with fancy stubs lining the edges - diagram of water as it goes down the drain
	Non-synthetic	- chalk - classroom	- army insignia → astrology - snowflake → target	- drawing - doodle
7	Breadth	- climbing wall → flag - buffet lines → conference tables	- a mountain - a symmetric figure	- #3→ rope - String → slinky
	Depth	- tower → building blocks - book case → floating shelves	- a star → the star of Bethlehem - cross → spider	- #2 → #3 - Ear hair → nose hair
8	Feasible	- NA	- NA	- NA
	Infeasible	- NA	- NA	- NA
9	Natural	- strands of hair - teeth	- mountain - black hole	- bacteria - animals
	Non-natural	- tiles - lanes	- bullet point - axis	- art piece - hose
10	Playful	- dominoes - lego	- pinwheel - spinning top	- cartoon character's frustration - confetti
	Serious	- equality - fence	- spider - spider web	- cloud - coil
11	Remote	- NA	- NA	- NA
	Close	- NA	- NA	- NA

A response was coded as original or conventional, natural or non-natural, synthetic and non-synthetic and so on. One exception to this was the dimension of primary versus secondary. Because primary and secondary processes were investigated independently, each was rated independently. In this category, a response either involved the primary processes or not; and then, either secondary processes or not.

Cohen's (1960) Kappa statistic was used to determine the agreement among two raters. The inter-rater agreement was found to be Kappa = .86 for the dimension of originality versus conventionality, Kappa = .86 for the dimension of TUMAI versus NEML, Kappa = .93 for the dimension of primary processes, Kappa = .97 for the dimension of secondary processes, Kappa = .88 for the dimension of functional, practical versus impractical, aesthetic responses, Kappa = .89 for the dimension of synthetic versus non-synthetic, Kappa = .77 for the dimension of breadth versus depth, Kappa = .74 for the dimension of feasible versus infeasible, Kappa = .92 for the dimension of natural versus non-natural, Kappa = .86 for the dimension of playful versus serious, and Kappa = .97 for the dimension of remote and close associations.

These values indicated that the agreement among two raters was "substantial" or "almost perfect" (Landis & Koch, 1977).

Descriptive Statistics and Inter-item Reliability

Descriptive statistics (mean, standard deviation, maximum, and minimum) and alpha coefficient values were provided for each dimension below.

1. Conventionality versus originality:

Originality has been defined in different ways including infrequency counts based on different percentages or uniqueness (Runco, 2013; Torrance, 1995). Given the small sample size in this study, only unique ideas (i.e., those generated by only one participant) were defined as

original ideas and all others were conventional. Based on that definition, the following descriptive values were found.

According to Table 3.3, original and conventional were both located in the responses. 16.43 % of the ideas were original in Bowl, 22.03% in Tire, 26.48% in Nail, 26.32% in Rectangles, 23.89% in Star, and 15.44% in Tornado. Alpha coefficient values of the original and conventional responses were .80 and .85 for the verbal and .86 and .91 for the figural DT tasks.

Table 3.3.

Descriptive Statistics for Conventional and Original Ideas.

		Min.	Max.	*M*	*SD*
Bowl	Originality	0	17	2.20	2.99
	Conventional	2	28	11.19	5.66
	Total	3	37	13.39	7.68
Tire	Originality	0	24	2.28	3.74
	Conventional	2	28	8.07	4.39
	Total	3	40	10.35	7.34
Nail	Originality	0	18	2.28	3.36
	Conventional	1	27	6.33	4.33
	Total	2	40	8.61	6.69
Rectangles	Originality	0	13	2.78	2.91
	Conventional	1	27	7.78	4.51
	Total	2	40	10.56	6.76
Star	Originality	0	18	2.19	2.92
	Conventional	2	22	6.96	3.79

	Total	3	40	9.15	6.18
Tornado	Originality	0	11	1.52	2.00
	Conventional	3	29	8.30	4.54
	Total	3	40	9.83	6.09

2) Taboo, malevolent, unethical, amoral, illegal versus non-taboo, moral, benevolent, benevolent:

The descriptive statistics provided in Table 3.4 indicated that the number of TUMAI responses were much lower than the NEMBL and original ideas. TUMAI responses were 7.05% of total ideas in Bowl, 5.72% in Tire, 16.34% in Nail, 2.46% in Rectangles, 8.30% in Star, and 12.99% in Tornado. Alpha coefficient values were .76 for the TUMAI and .89 for NEMBL responses in the verbal items; and .39 for the TUMAI and .95 for the NEMBL in the figural DT tasks. Those findings showed that TUMAI responses can be identified at different rates and task types are related to the number of TUMAI responses generated. Also, an index of TUMAI can be reliably obtained from the verbal tasks but not from the figural.

Table 3.4.

Descriptive Statistics for TUMAI and NEMBL Ideas.

		Min.	Max.	*M*	*SD*
Bowl	Taboo	0	4	0.94	1.07
	Others	3	35	12.44	7.07
	Total	3	37	13.39	7.68
Tire	Taboo	0	10	0.59	1.47
	Others	3	38	9.76	6.36

	Total	3	40	10.35	7.34
Nail	Taboo	0	9	1.41	1.73
	Others	1	31	7.20	5.35
	Total	2	40	8.61	6.69
Rectangles	Taboo	0	3	0.26	0.62
	Others	2	39	10.30	6.51
	Total	2	40	10.56	6.76
Star	Taboo	0	3	0.76	0.95
	Others	2	37	8.39	5.95
	Total	3	40	9.15	6.18
Tornado	Taboo	0	4	1.28	0.94
	Others	3	38	8.56	5.78
	Total	3	40	9.83	6.09

3) Primary versus secondary:

Using simple computer software developed for text mining, the total number of words associated with primary and secondary processes was counted. The descriptive values were provided in Table 3.5. The mean primary processes were higher than the secondary processes in all six items. Words or concepts associated with primary processes were found in 50.35% of responses in Bowl, 37.92% in Tire, 42.15% in Nail, 40.18% in Rectangles, 52.43% in Star, and 35.78% in Tornado. Secondary processes were higher in the verbal items than the figural DT tasks. They were involved in 15.63% of the responses to the Bowl, 24.83% in the Tire, 24.95% in the Nail, 14.91 in Rectangles, 10.12% in Star, 6.97% in Tornado. Alpha coefficient values

were .83 and .74 for the primary and secondary processes in the verbal items; and .81 and .70 for the figural DT tasks, respectively.

Table 3.5
Descriptive Statistics for Primary and Secondary Processes.

		Min.	Max.	*M*	*SD*
Bowl	Primary	1	21	6.74	4.95
	Secondary	0	15	2.09	2.52
	Total	3	37	13.39	7.68
Tire	Primary	0	21	3.93	4.06
	Secondary	0	15	2.57	3.18
	Total	3	40	10.35	7.34
Nail	Primary	0	20	3.63	3.73
	Secondary	0	9	2.15	2.17
	Total	2	40	8.61	6.69
Rectangles	Primary	0	15	4.24	3.01
	Secondary	0	6	1.57	1.41
	Total	2	40	10.56	6.76
Star	Primary	1	22	4.80	3.35
	Secondary	0	8	0.93	1.44
	Total	3	40	9.15	6.18
Tornado	Primary	0	17	3.52	3.01
	Secondary	0	3	0.69	0.82
	Total	3	40	9.83	6.09

4) Experience versus non-experience:

After the data collection, participants were contacted again to indicate which responses they listed are those they experienced before. This was only applicable to the verbal items asking uses for bowl, tire, and nail. The descriptive statistics were provided in Table 3.6. The proportion of experienced responses was 62.39% of the responses in the Bowl, 51.23% in the Tire, and 62.55% in the Nail.

Alpha coefficients were .83 for experience and .81 for non-experience.

Table 3.6

Descriptive Statistics for Experience and Non-experience.

		Min.	Max.	*M*	*SD*
Bowl	Experience	0	20	8.56	4.95
	Non-experience	0	26	5.16	5.98
	Total	3	37	13.72	8.03
Tire	Experience	0	12	5.00	3.27
	Non-experience	0	28	4.76	6.00
	Total	3	40	9.76	7.72
Nail	Experience	0	20	5.88	4.28
	Non-experience	0	35	3.52	6.81
	Total	2	40	9.40	7.96

5) Functional, practical versus impractical, aesthetics, artistic:

Responses to six DT tasks were evaluated to determine if they are purely functional and practical, or impractical, aesthetics, and artistic. Descriptive statistics were provided in Table 3.7. The number of functional responses was remarkably higher than impractical responses in all

items except the Star item. 8.99% of the responses were impractical in Bowl, 12.70% in Tire, 18.71% in Nail, 20.18% in Rectangles, 57.89% in Star, and 32.02% in Tornado.

Alpha coefficient values were .80 and .86 for the impractical and functional responses in verbal items, and .75 and .88 for the figural DT tasks.

Table 3.7

Descriptive Statistics for Functional and Impractical Responses.

		Min.	Max.	*M*	*SD*
Bowl	Impractical	0	8	1.20	1.45
	Functional	3	35	12.19	6.90
	Total	3	37	13.39	7.68
Tire	Impractical	0	14	1.31	2.04
	Functional	2	37	9.04	6.20
	Total	3	40	10.35	7.34
Nail	Impractical	0	8	1.61	1.73
	Functional	1	34	7.00	5.71
	Total	2	40	8.61	6.69
Rectangles	Impractical	0	11	2.13	2.27
	Functional	0	34	8.43	5.65
	Total	2	40	10.56	6.76
Star	Impractical	1	20	5.30	3.43
	Functional	0	20	3.85	3.67
	Total	3	40	9.15	6.18
Tornado	Impractical	0	13	3.15	2.82
	Functional	1	27	6.69	4.50

	Total	3	40	9.83	6.09

6) Synthetic versus non-synthetic:

The descriptive values for the synthetic and non-synthetic ideas were provided in Table 3.8.

Synthetic responses were 15.21% of the total number of responses in Bowl, 23.61% in Tire, 13.76% in Nail, 17.19% in Rectangles, 24.70% in Star, and 22.60% in Tornado. Alpha coefficient values were .87 and .85 for the synthetic and non-synthetic responses from the verbal items; and .79 and .95 in the figural DT tasks.

Synthetic responses were 15.21% of the total number of responses in Bowl, 23.61% in Tire, 13.76% in Nail, 17.19% in Rectangles, 24.70% in Star, and 22.60% in Tornado. Alpha coefficient values were .87 and .85 for the synthetic and non-synthetic responses from the verbal items; and .79 and .95 in the figural DT tasks.

Table 3.8
Descriptive Statistics for Synthetic and Non-Synthetic Responses.

		Min.	Max.	*M*	*SD*
Bowl	Synthetic	0	13	2.04	2.92
	Non-synthetic	3	32	11.35	6.16
	Total	3	37	13.39	7.68
Tire	Synthetic	0	13	2.44	3.20
	Non-synthetic	1	30	7.91	5.24
	Total	3	40	10.35	7.34
Nail	Synthetic	0	9	1.19	1.91
	Non-synthetic	1	34	7.43	5.85

	Total	2	40	8.61	6.69
Rectangles	Synthetic	0	10	1.81	2.24
	Non-synthetic	0	39	8.74	6.46
	Total	2	40	10.56	6.76
Star	Synthetic	0	9	2.26	2.40
	Non-synthetic	1	37	6.89	5.62
	Total	3	40	9.15	6.18
Tornado	Synthetic	0	11	2.22	2.45
	Non-synthetic	1	39	7.61	5.82
	Total	3	40	9.83	6.09

7) Breadth versus depth:

Responses were also evaluated to determine if there is a switch from a category to another (breadth); or if the ideation goes deeper within a category (depth). Responses were evaluated sequentially with that in mind, and the first score was not evaluated for this category. Also, an idea that is related to an earlier category was considered under the category of depth. This scoring is consistent with what (Nusbaum & Silvia, 2011) used. The descriptive statistics were provided in the Table 3.9.

Breadth was higher than depth in all tasks. Breadth was 60.86% of the responses in Bowl, 68.34% in Tire, 71.61% in Nail, 72.81% in Rectangles, 58.30% in Star, and 72.32% in Tornado. Alpha coefficient values were .89 and .64 for breadth and depth from the verbal items; and .90 and .87 from the figural DT tasks. Alpha coefficient of verbal depth increased to .67 when the Bowl item was removed.

Table 3.9

Descriptive Statistics for Breadth and Depth.

		Min.	Max.	*M*	*SD*
Bowl	Breadth	0	33	8.15	5.69
	Depth	0	27	4.24	4.46
	Total	3	37	13.39	7.68
Tire	Breadth	1	37	7.00	5.94
	Depth	0	12	2.35	2.83
	Total	3	40	10.35	7.34
Nail	Breadth	1	32	6.17	5.12
	Depth	0	14	1.44	2.57
	Total	2	40	8.61	6.69
Rectangles	Breadth	0	29	7.69	5.49
	Depth	0	10	1.87	2.07
	Total	2	40	10.56	6.76
Star	Breadth	1	23	5.33	3.78
	Depth	0	17	2.83	3.21
	Total	3	40	9.15	6.18
Tornado	Breadth	1	27	7.11	4.53
	Depth	0	12	1.70	2.48
	Total	3	40	9.83	6.09

8) Feasible, realistic, possible versus infeasible, hypothetical, unrealistic responses:

Responses to the verbal DT tasks were evaluated if they are feasible, realistic, possible; or infeasible, hypothetical, and unrealistic responses. Feasible responses were 76.92% of the total

number of responses in Bowl, 84.62% in Tire, and 83.66% in Nail. Alpha coefficient values were .84 and .77 for the feasible and infeasible responses, respectively.

Table 3.10

Descriptive Statistics for Feasible and Infeasible Responses.

		Min.	Max.	*M*	*SD*
Bowl	Feasible	2	29	10.30	5.67
	Infeasible	0	14	3.09	3.44
	Total	3	37	13.39	7.68
Tire	Feasible	2	32	8.76	5.73
	Infeasible	0	11	1.59	2.18
	Total	3	40	10.35	7.34
Nail	Feasible	1	29	7.20	5.42
	Infeasible	0	11	1.41	2.25
	Total	2	40	8.61	6.69

9) Natural versus non-natural:

Idea generation can benefit from thinking of natural and non-natural things. Each idea was evaluated to determine if it is man-made or not. Descriptive statistics for natural, non-natural, and total ideas were provided in Table 3.11.

21.44% of the responses were coded as natural in Bowl, 8.05% in Tire, 15.70% in Nail, 7.54% in Rectangles, 46.36% in Star, and 41.62% in Tornado. Alpha coefficient values were .45 and .90 for the natural and non-natural responses from the verbal items; and .70 and .87 from the

figural DT tasks, respectively. Alpha coefficient of verbal depth increased to .56 when the Bowl item was removed.

Table 3.11.
Descriptive Statistics for Natural and Non-Natural Responses.

		Min.	Max.	*M*	*SD*
Bowl	Natural	0	16	2.87	2.45
	Non-natural	1	34	10.52	6.79
	Total	3	37	13.39	7.68
Tire	Natural	0	7	0.83	1.30
	Non-natural	2	37	9.52	6.48
	Total	3	40	10.35	7.34
Nail	Natural	0	7	1.35	1.67
	Non-natural	1	38	7.26	6.38
	Total	2	40	8.61	6.69
Rectangles	Natural	0	4	0.80	1.12
	Non-natural	1	36	9.76	6.33
	Total	2	40	10.56	6.76
Star	Natural	0	23	4.24	3.50
	Non-natural	0	18	4.91	3.61
	Total	3	40	9.15	6.18
Tornado	Natural	0	16	4.09	2.43
	Non-natural	0	24	5.74	4.50
	Total	3	40	9.83	6.09

10) Humorous, playful, naïve, childlike, and spontaneous versus Serious, mature, responsible, and expert:

The descriptive statistics for the playful and serious responses were provided in Table 3.12. Playful responses were 7.05 % of the total ideas in Bowl, 24.87% in Tire, 6.02 % in Nail, 5.96 % in Rectangles, 7.09 % in Star, and 10.36 % in Tornado. Alpha coefficients for playful and serious responses were .61 and .88 in the verbal items and .58 and .88 in the figural DT tasks.

Table 3.12.
Descriptive Statistics for Playful and Serious Responses.

		Min.	Max.	*M*	*SD*
Bowl	Playful	0	5	0.94	1.14
	Serious	3	33	12.44	7.02
	Total	3	37	13.39	7.68
Tire	Playful	0	8	2.57	1.72
	Serious	2	34	7.78	6.20
	Total	3	40	10.35	7.34
Nail	Playful	0	3	0.52	0.79
	Serious	1	40	8.09	6.77
	Total	2	40	8.61	6.69
Rectangles	Playful	0	2	0.63	0.81
	Serious	2	38	9.93	6.39
	Total	2	40	10.56	6.76
Star	Playful	0	5	0.65	0.99
	Serious	2	38	8.50	5.73
	Total	3	40	9.15	6.18

Tornado	Playful	0	4	1.02	1.17
	Serious	3	37	8.81	5.47
	Total	3	40	9.83	6.09

11) Remote versus close:

The ability to make close and remote associations is another way to generate more and original ideas. The descriptive values were obtained using the associates list from the Word Associations Network. A response was considered to be a close associate if any of the words in the associates list was used in the responses. This method was only applicable to verbal items.

The percentage of remote and close associations, as identified by the WAN, was similar to each to each other for the three items. 51.73% of the responses were remote associations in Bowl, 56.71% in Tire, and 47.53% in Nail. Alpha coefficient values were .85 and .77 for the remote and close associations, respectively.

Table 3.13

Descriptive Statistics for Remote and Close Associations.

		Min.	Max.	*M*	*SD*
Bowl	Remote	0	28	6.93	5.39
	Close	1	15	6.46	3.50
	Total	3	37	13.39	7.68
Tire	Remote	1	27	5.87	5.11
	Close	1	14	4.48	3.25
	Total	3	40	10.35	7.34
Nail	Remote	0	19	4.09	3.84

Close	0	21	4.52	3.93
Total	2	40	8.61	6.69

Correlation between the Categories from the Dimensions and Originality

Most of the inter-item (alpha coefficients) statistics provided above were within the acceptable to good range (George & Mallery, 2003). Then, a verbal and a figural composite index were computed for all categories and fluency. These composite indices were used in all correlational analyses.

The first correlational analyses examined the relationship between all proposed dimensions, originality, and fluency. A positive correlation was expected with both originality and fluency because the more dimensions used the higher probability of generating more ideas, some of which should be original. A second analysis examined the relationship between the above dimensions and originality when the fluency was controlled. Fluency used to be highly correlated with originality and flexibility, and its influence on other indices was highlighted in the literature (e.g., Hocevar, 1979). The purpose for this analysis was to see the unique relationship between the categories from the proposed dimensions and originality.

Table 3.14 provided bivariate correlations of the categories with originality, fluency, and partial correlations with originality controlling fluency. Bivariate correlations between the categories of the proposed dimensions and originality and fluency were very high in both verbal (above .45 and .55, *p*s < .01) and figural DT tasks (above .42 and .35, *p*s < .01). Partial correlations controlling fluency indicated that secondary, experience, impractical, synthetic, breadth, infeasible, and remote responses had significantly positive correlation with originality from the verbal items (above $r = .28$) whereas their counterpart categories (i.e., non-experience, practical, non-synthetic, depth, feasible, and close) had significantly negative correlations with originality

(above r = -.29). Originality had marginally significant positive correlation with TUMAI (r = .25, p < .07) and marginally negative correlation with NEMBL (r = -.25, p < .07).

Table 3.14

Bivariate and Partial Correlations of the Hyperspace Categories with Originality and Fluency.

	Verbal			Figural		
	Originality	Fluency	Originality [f]	Originality	Fluency	Originality [f]
TUMAI	.80**	.81**	.36**	.49**	.51**	.05
NEMBL	.88**	.99**	-.36**	.94**	.99**	-.05
Primary	.82**	.93**	-.11	.89**	.90**	.28*
Secondary	.90**	.86**	.60**	.58**	.49**	.39**
Experience	.79**	.71**	.48*	NA	NA	NA
Non-experience	.72**	.88**	-.48**	NA	NA	NA
Impractical	.85**	.76**	.68**	.82**	.86**	.08
Practical	.85**	.99**	-.68**	.89**	.96**	-.08
Synthetic	.77**	.75**	.33*	.42**	.35**	.29*
Non-synthetic	.81**	.95**	-.34*	.86**	.94**	-.29*
Breadth	.92**	.93**	.51**	.92**	.96**	.17
Depth	.50**	.71**	-.50**	.79**	.87**	-.16
Feasible	.85**	.97**	-.23	NA	NA	NA
Infeasible	.84**	.84**	.23	NA	NA	NA
Natural	.45**	.55**	-.09	.82**	.87**	.03
Non-natural	.90**	.98**	.09	.91**	.97**	-.03
Playful	.65**	.69**	.14	.68**	.68**	.14

Serious	.89**	.99**	-.14	.93**	.99**	-.14
Remote	.91**	.94**	.43**	NA	NA	NA
Close	.71**	.88**	-.44**	NA	NA	NA

*p < .05; **p < .01 level (2-tailed).

[f] = Partial correlations with originality controlling fluency; N/A=Not applicable

For the figural DT tasks, partial correlations of originality had significantly positive values with synthetic, primary, and secondary responses, and significantly negative value with the non-synthetic responses. The direction of correlations was consistent across verbal and figural DT tasks except for the primary and natural responses. Correlations with the primary processes were negative (rs = -.11 and -.09, ps < .46 and .40) for the verbal tasks and positive (rs = .28 and .03, ps < .04 and .83) for the figural DT tasks whereas they were positive for the verbal and negative for the figural DT tasks (rs = .09 and -.03, ps <.40 and .83) with non-natural responses.

Literal Divergent Thinking

The proposed dimensions could also be converted into a measure of literal divergent thinking, an index showing divergence potential. High correlations between the categories and originality and fluency supported the idea that utilization of the proposed dimensions results in higher number of ideas. Then, this index could be the total number of categories employed across all six DT tasks. The experience categories were excluded because of a low response rate. Each item had a score of 0 if it was not used and a score of 1 when it was used. Then, when the scores for the categories used in DT were added up, a total score was obtained for each participant. Some dimensions were only applicable to verbal tasks and the experience dimension

was removed from this analysis. The remaining items constituted a 108 item index, which was named as the Literal Divergent Thinking (LiDT).

Alpha coefficient for the LiDT was .88. The mean was 90.17 (Min = 69; Max = 107) with a standard deviation of 9.19. The skewness value of -.05(*SE* = .33) and kurtosis value of -.59 (*SE* = .64) were within the acceptable range, which indicates that the LiDT was close to normal distribution.

LiDT could be related to the attitudes and values toward originality. The total score from a subset of items (i.e., 13, 17, 19, 23, 24, and 25) from the A&V related to originality was examined in terms of inter-item reliability. Alpha coefficient was .68. The mean and standard deviation of this scale was 23.40 and 3.05, respectively. The distribution of the scale was close to normal with skewness of -.30 (*SE* = .33) and kurtosis of -.35 (*SE* = .64).

Bivariate correlation between the LiDT and the attitudes and values toward originality (AVO) was significant ($r = .39$, $p = .004$). Partial correlations between LiDT and AVO, controlling fluency (two composite scores from verbal and figural DT tasks), indicated that the relationship was still significant ($r = .29$, $p = .042$).

The inter-item correlations of LiDT were consistently zero in some of the categories (i.e., conventionality, non-taboo, non-synthetic, feasible, serious, and practical) consistently across all DT tasks as well as inconsistently in few other cases with other categories. When those categories were removed, the mean value was 43.46 with a standard deviation of 9.10, and alpha coefficient of the remaining items ($n = 46$) increased slightly (.90). The distribution was still normal (skew = -.09; kurtosis = -.63). This reduced scale had the same correlation with AVO ($r = .39$, $p < .004$), indicating that the retained categories were more likely the ones that lead to original responses rather than those removed.

Finally, correction for attenuation (Nunnally, 1978) was made to see the correlation between LiDT and AVO after adjusting for weakening influence of the measurement error. The correlation between LiDT and AVO was (r = .50) after the adjustment, if the scales were perfectly reliable (alpha = 1).

Discussion

DT has been traditionally studied through three indices: fluency, originality, and flexibility (Guilford, 1968, Torrance, 1995, Runco, 1991), which relied on the counts of responses and categories. In this study, responses were scored in terms of the processes that might have been involved in the generation of those responses. This method is different in that it attempts to get at processes underlying DT rather than the product taking into account the suggestion that ideas are also products in the sense of ideation (Runco, Plucker, & Lim, 2000-2001). DT involves many cognitive and personality-related processes and this study aimed to investigate which of the proposed operational dichotomous dimensions can be located in the responses given to the DT tasks. Usefulness of those dimensions could also help to operationalize literal divergent thinking. Those dichotomous dimensions, along with other dimensions not included in this study because they were less operational, constitute the *hyperspace* on which ideation takes place.

In this study, 13 theory-based operational dimensions have been proposed and 11 were investigated after two were merged to others. Cohen's Kappa and alpha coefficients indicated that many of those dimensions can be reliably identified and measured. Exceptions to this were TUMAI and playful responses in figural DT tasks (alpha = .39 and .58) and, Natural in verbal tasks (alpha = .45).

The descriptive values indicated that the categories from the dimensions had varying amount of utility in DT: some (i.e., conventionality, functional, feasible, etc.) are often employed, some are not. The categories, or two ends, of the dimensions were equally employed in some (i.e., remote versus close), but not in the majority (i.e., play versus serious).

The descriptive statistics also showed that the hyperspace is influenced by the task type because some tasks trigger some categories more often than the others. An example of this was observed in the TUMAI responses. Higher instances of TUMAI in the Nail item (16.34%) compared to Bowl and Tire (7.05 and 5.72%); and in the Tornado item (12.99%) compared to the Rectangles (2.46%) were observed in this data. This is probably because of the structural characteristics of nail: A nail, as metal with a sharp point, is easier to use as a weapon than a tire. Harris (2013) investigated the role of task type on the malevolent creativity and found that negatively-valenced tasks were related to malevolent creativity. Other than this, the mean number of TUMAI ideas was similar to those reported by Lee and Dow (2011) who investigated the malevolent responses given to two Uses items (i.e., Brick and Pencil) and reported that 12.6 and 6.6 percent of responses were malevolent.

Correlational analyses indicated that generation of more ideas in each category is highly related with both originality and fluency as expected. This finding is consistent with the very basic idea that divergent thinking implies thinking in all directions (Runco, 1999a) and the use of more directions lead to generating more and more ideas. However, an interesting pattern was observed on the correlations between the categories (the individual dichotomies from each dimension) and originality when the fluency controlled: Though some were not significant, one pole of the two opposing categories (TUMAI and NEMBL, Practical and Impractical, Breadth and Depth, etc.) had a positive relationship with originality; and the other category had a

negative relationship. The only exception to this was Primary and Secondary processes for the figural DT tasks. Those findings implied that some categories (secondary, experience, impractical, synthetic, breadth, infeasible, and remote) are more likely to lead to originality, and therefore, to fluency, whereas others (NEMBL, non-synthetic, feasible, depth, close, non-experience) can only contribute to fluency, but not originality. Hence, those dimensions can also be seen as different ways to generate original ideas.

There is theoretical support for these findings. As for the TUMAI, Rawlings and Toogood (1997) distinguished taboo responses from the original responses when they investigated the relationship between DT and psychoticism. They found that the relationship between originality and psychoticism is negligible without the taboo responses. This implies that there is a significant overlap of original and taboo responses.

The findings also indicated that both primary and secondary processes are related to fluency and originality although the latter was true for the figural DT tasks only. Primary process thinking has been linked to creativity (Kris, 1952; Freud, 1955). Russ and Grossman-McKenzie (1990) examined the relationship between primary process thinking on the Rorschach and DT tests and affective expression in children's fantasy play. The percent of primary process in Rorchach test was highly correlated with DT tasks in boys (r =.72, p < .001), but not in girls (r=.27, ns). The frequency of primary process from the Affect in Play Scale was significantly correlated with DT for both boys and girls (rs =.38, and .48). Notably, frequency of non-primary process affect was nonsignificant for both boys and girls.

Pine and Holt (1960) administered several tests including Thematic Apperception Test rated for literary quality, the Science Test rated for neutral and drive related responses, Rorschach rated for creativity, Humor Test, Animal Drawing rated for originality and drawing

ability, Brick Uses rated for flexibility, and the Consequences Test rated for originality. Also, a total creativity score was also calculated. Then, three indices on the Rorschach test were defined: the amount of expression of primary process, the effectiveness of controls over primary process, and adaptive versus maladaptive regression, which was the combination these two indices. The results indicated that correlations were significant only in one case for the female group between total creativity score and the effectiveness of control. With regard to male group, none of the amount of expression of primary process was significant and some were negative. Control and adaptive regression ratings were significantly correlated with all scores except for the Science Test, Rorschach and the Humor test. The flexibility scores from the Uses tests was only related to adaptive regression ratings. This last finding is important because it supports the hypothesis that both primary and secondary processes are involved in creativity, but what is critical is effective modulation of the two (Dudek & Vereault, 1989, p. 46). Suler (1980) hypothesized that creativity is a "special form of interaction between primary and secondary process thinking in which a novel idea or insight is generated by the loose, illogical, and highly subjective ideation of primary process and is then molded by secondary process into a context that is socially appropriate and meaningful to others" (p. 144). Kris (1952) posited that it is the concept of regression in the service of ego that utilized both primary and secondary processes.

The findings also underlined the usefulness of impractical, aesthetic, and artistic thinking for originality, and functional and practical responses for fluency. The ability to think of functional as well as aesthetic and impractical uses is important for creativity because it can help, for example, with superior product design (Bonnardel & Marmèche, 2005). They also represent two major criteria for creativity of a novel product (Cropley & Cropley, 2005). Jackson and Messick (1965) put forward that novel products can be evaluated in terms of the external and

internal criteria. The external criteria are about the effectiveness of a novel product that is addressed by the question of "does it work?" and internal criteria are related to if "the elements fit together in a pleasing way." This overlaps with Taylor's (1975) aesthetic criteria.

Likewise, synthetic responses are more likely to lead to original ideas rather than non-synthetic ideas. Ideas are synthesized in different ways including combination of two different, sometimes opposing, ideas (Finke, Ward, & Smith, 1992; Baughman & Mumford, 1995; Scott, Lonergan, & Mumford, 2005), making modifications (Estes & Ward, 2002), adding or subtracting something (Clapham, 2003), using diverse schemas (Dane, 2010; Hunter, Bedell-Avers, Hunsicker, Mumford, & Ligon, 2008) or associating with another idea (Mednick, Mednick, & Jung, 1964). This study indicated that those synthetic processes, which lead to originality and fluency, can be identified in DT and can be distinguished from non-synthetic responses that lead to fluency only.

Correlational analyses also indicated that breadth is more related with originality and fluency, whereas depth is only related with fluency. Depth had a negative correlation when fluency was controlled. This is consistent with the findings of Nusbaum and Silvia (2011), who investigated role of switching (breadth) and clustering (depth) in the relationship between fluid intelligence (Gf) and creativity. They found that switching was positively correlated with creativity whereas clustering was negatively correlated. Also, switching, but not clustering, mediated between Gf and creativity scores. The findings reported here differ from the study of Nusbaum and Silvia, in that they specify that this reversal relationship of breadth and depth is only true for originality rather than the larger concept of creativity. In their study, creativity was measured by raters' scoring of the best two creative responses (aka "snapshot scoring" or

"ideational pools"; Silvia, Martin, & Nusbaum, 2009; Runco & Mraz, 1992) provided by the participants.

The results also indicated that thinking of the infeasible is related with originality even after controlling for fluency, whereas thinking of the feasible was only related to fluency. Feasibility is one of the major criteria of novel things (Dean, Hender, Rodgers, & Santanen, 2006) but consideration of infeasible, unrealistic and hypothetical solutions is critical for creative solutions. For example, Liapis, Martinez, Togelius, and Yannakakis (2013) used the strategy of feasible-infeasible novelty search (FINS) for the exploration phase where novelty search takes place by having two groups of individuals. In this technique, a feasible group aimed to satisfy all constraints and an infeasible group deliberately failed to meet one or multiple constraints.

Concerning close and remote associations, the findings indicated that both close and remote associations are involved in DT and remote associations were related to fluency and originality even after controlling fluency whereas close associations were related with fluency only. They are also consistent with the results showing that creative people accept close and remote associations more than less creative people under specific priming conditions (Gruzska & Necka, 2002). A theory of divergent thinking involving both close and remote associations is also consistent with the brain-related research asserting that the right hemisphere is more involved in processing the remote associates and the left hemisphere in the processing of close associations (Jung-Beeman, 2005).

Probably the most interesting finding was about the usefulness of the new measure, LiDT, which was related with the attitudes and values toward originality. This study indicated that literal divergent thinking can be captured by evaluating responses given to the DT scores on the 11 dimensions and 22 categories; and the ability to use those categories and dimensions can

be reliably measured. Moreover, the results indicated that those who have higher favorable attitudes and values toward originality are more likely to think in a literally divergent manner. They use more of the proposed categories and dimensions proposed, which let them generate more and original ideas.

Blair and Mumford (2007) found that people tend to avoid original and risky ideas and preferred those that are easy to understand and that provide short-term benefits. Sharma (1999) suggested that people consider negative outcomes while evaluating the ideas. Licuanan, Dailey, and Mumford (2007) found that people often underestimate the originality of novel ideas but this error can be diminished through active analysis of product originality and appraisal of interactional processes. Creative people, however, tend to think of, recognize, and prefer original ideas. Chapman and Carrigan (1993) reported a positive correlation between attitudes toward originality and the number of original responses. Creative people also implement strategies (i.e., deferred judgment) that let them recognize and value original ideas (Basadur, Runco, & Vega, 2000). It is no coincidence that some creativity training programs focus on the creative attitudes (Basadur, Graen, & Green, 1982; Basadur & Hausdorf, 1996) because they can trigger creative behavior and performance. Significant correlation between the AVO and LiDT underlines this link.

The findings can also be evaluated in terms of the theory of spreading activation of semantic networks (Collins & Loftus, 1975). According to this theory, memory is organized in a way that related concepts are stored together, therefore, close to each other, in the memory. When a concept is activated, other concepts are also activated in proportion of their semantic similarity to the target concept. Therefore, activation of diverse pathways (which resemble categories and dimensions defined in this study), allows access to utilization of multiple

categories of ideas. From this perspective, creative people could be those that can activate multiple pathways on the semantic network.

CHAPTER 4

THE ANALYSIS OF THE HYPERSPACE CATEGORIES THROUGH VERBAL PROTOCOLS[3]

[3] Acar, S. To be submitted to *Psychology of Aesthetics, Creativity, and the Arts.*

Abstract

Divergent thinking DT usually has been studied by focusing on the evaluation of the responses on three or more indices (fluency, originality, and flexibility). What more could we know if we would take internal processes into consideration? This study used the Think Aloud (TA) method to go into the internal processes in DT. Participants were instructed to think aloud while responding to DT tasks and encouraged to say whatever came into their minds. The analyses compared the hyperspace categories as identified in the standard procedure (reported in Chapter 3) with the TA procedure that provided additional contextual information about the ideas generated.

Comparisons of the standard and TA procedures indicated that fluency was higher in the TA sessions than the standard procedure, which was contrary to the possibility of verbal overshadowing in the TA procedure. Therefore, the analyses comparing the hyperspace categories from the two methods controlled fluency in all categories except for the categories of primary, secondary, remote, and close in which word counts were covariate. Series of ANCOVAs indicated that more original, impractical, infeasible, synthetic, depth, and playful ideas were generated in the TA procedure than the standard procedure, but this difference was significant only in the Bowl item for original and playful ideas. TUMAI, breadth, natural, primary responses, and remote associations were higher in the standard procedure, although the first three were limited to the figural DT tasks and the last two were true only for the verbal item.

These findings implied the possibility that the data from the standard procedure may not demonstrate the full course of ideation. Moreover, the ideas that are not provided in the standard procedure are more likely to be the ideas from the categories related to originality.

Introduction

Responses to DT tests are usually transformed to indices, such as fluency (i.e., the total number of ideas), originality (i.e., the number of infrequent or unique responses), and flexibility (i.e., the number of cluster of ideas). These three indices are common to almost all mainstream tests of creativity. They are consistent with Guilford's (1968) Structure of Intellect theory, as well as more general theories of what is required for creativity (Runco & Jaeger, 2012). In spite of their usefulness and merits, these methods do not provide much information about the internal processes that take place while thinking divergently. A more qualitative approach might be more appropriate for such examinations of the creative thinking process.

Some researchers used the *think aloud* (TA) method to investigate internal cognitive processes. The TA yields verbal protocols from a session in which people are required to verbalize their thoughts while performing a task (Ericsson & Simon, 1984). It is rooted in the introspective psychological methods (van Someren, Barnard, & Sandberg, 1994), but it is still an objective method in that it is not typically used to study inner observations (Ericsson & Fox, 2011). The verbal protocols serve as the data for the analyses. The seminal work of Newell and Simon (1972) on the process of problem solving, for example, used the TA protocols to test different problem solving models. They found support from the TA protocols for a theory of problem solving consisting of the *problem state* and *operator* components.

The TA method has been used in creativity research, too. For example, researchers asked participants to think aloud (TA) while responding to DT tasks in order to investigate the cognitive processes involved in divergent and creative thinking. This line of research is important because it has provided important evidence about the *process* of divergent and creative thinking, the most intriguing component of the famous four P's of creativity (Rhodes, 1961).

Studies that Used the TA Method

Khandwalla (1993) examined the processes of DT that were proposed by theories of creativity, specifically, sequential thinking. He conducted a protocol analysis of 21 participants. They were asked to think aloud while trying to solve a DT question (i.e., "list objects that are green, liquid and funny") and were encouraged to express whatever comes to their mind. Several problem solving categories and micromechanisms were identified through content analysis of the 10 longest protocols. Also, the nature of transition from one idea to another, and pathways to creative and objective ideas were scrutinized. Initially, he identified five major categories: problem structuring, search, feeling, ideating, and evaluating, with each category having several subcategories. The scores on each major category were the sum of identified subcategories in a particular major category. Counts of categories on the protocols indicated that ideating was the most frequently used process (present in 37.1 of the protocols) followed by evaluating (21.3), search (15.9), problem structuring (14.4), and feeling (11.2). Bivariate correlations indicated that ideating is negatively correlated with feeling (r=-.67), search (-.31), and structuring (-.49) and positively correlated with evaluating (.24). Khandwalla argued that those who were stuck in ideating might express more of their feelings and start structuring the problem again; or those who felt blocked and structured the problem further might ideate less.

The investigation of the pathways between categories and their sequential nature revealed that there are several ways to start a process of productive DT. Ideating followed by evaluating was the most often used path. When each category's frequency was counted in the initial, middle and later phases of the session, problem structuring was observed most often in the initial stage but was present in later stages, too. Search was relatively constant. Feeling had a slight increase in the end and ideating and evaluating had slight increase in the middle phase. Those findings

provided limited support for the sequentiality as proposed in some theories of creativity (e.g., Wallas, 1926). When the types of ideas were analyzed in terms of their antecedents, creative ideas were preceded by the use of problem redefining, listing, elaborating, and expressing whereas objective ideas came after the use of analytical, scanning and checking mechanisms. Based on the descriptive results of the protocols, Khandwalla proposed three clusters. The first cluster was intuitive ideators who used ideating and evaluating frequently, search moderately and structuring and feeling rarely. The second cluster was anxious analysts who structured the problem and expressed feelings quite often, with a limited use of search, ideating and evaluating. The third cluster was random scanners who often searched, though, unsuccessfully, were less analytical and non-evaluating.

Jausovec (1991) used the TA protocols to see the use of flexible strategy in gifted (n=15) and average problem solvers (n=15) on six different questions. Two of them were closed-ended (convergent thinking), two open-ended (divergent thinking), and two open-question but closed-solution (insight). Participants were encouraged to think aloud whatever came to their minds, even if they felt it was unimportant. Based on a pilot study, 10 different strategies were identified: breaking the problem into sub-goals, working backward starting from the goal, modeling through an abstract description of the problem, making inferences through digging out the implicit facts from the explicit statements, trial and error, goal discovery by redefining open goals more precisely, increasing structural knowledge by memory recall, generating an analogy via transformation, and via association, intuition and insight. The gifted group performed significantly higher in all six questions except one problem than the average group. The performance was still higher in this question in the gifted group. Moreover, gifted students used

appropriate strategies for different type of questions, and were better at judging their own performance.

Brandoni and Anderson (2009) also instructed their participants to think aloud while answering open ended questions about a work of art. This study employed a neuroscience orientation to figure out individual differences in DT. They found that TA responses allow assessing several DT coefficients such as category switching, the proportion of times that a new subject was introduced in the narrative, number of different brain area categories involved in switching, the extent to which individuals used reasoning, perspective switching, percent of total responses involving a switch in perspective, and higher cognitive category response. Bartlett (1978) suggested that protocol analysis can be used to train individuals about creative problem solving. He recorded the verbal expressions and let individuals introspect on this process. He found this method effective because it bridges the gap between the problem and responses.

Ruscio, Whitney, and Amabile (1998) used the TA protocols and taped behaviors in problem solving, art, and writing tasks to test the consistency of the mechanisms in different domains. Based on a subset of the protocols, they developed one behavioral and one verbal coding scheme. Those codes were used by several judges, and the inter-rater reliability ranged from .69 to .98. The analyses of behavioral codes for the problem solving task indicated that creativity ratings were significantly and positively correlated with involvement, set-breaking, pace, and progress and negatively correlated with checks height and self-initiated backtracks. Verbal codes included problem with task, negative exclamation, open question, laugh, goal statement, mention time, analogy, strength in self, talks about task, and describing materials. Goal statement, strength in self, and describing materials were positively correlated and talks about task negatively correlated with creativity ratings. When a factor analysis was conducted,

those verbal statements were more heavily loaded on the factors of nervousness, thinking ahead, hesitance, and concrete focus. Among those, concrete focus factor, consisting of talking about the task and not describing the materials, was a marginal predictor of creative ratings. In the art task, many of the behavioral codes including, confidence, pace, planning, involvement, playfulness, enjoyment were positively correlated with creativity ratings whereas difficulty, negative affect, and "look at what done" were negatively correlated. Sloppiness was not correlated. Of the verbal codes, talks about materials, "aha", transition, goal statement, and irrelevant to task were positively related with creativity ratings and problem with self was negatively correlated. Strength with self, analogy, describing collage, and negative exclamation were unrelated. The verbal codes such as exploration, enjoyment, concentration, difficulty, repeat something, and evaluation, were positively correlated with the creativity ratings in the writing task. Transition, question how, exclamation, and mention time were nonsignificant.

In another study, Jausovec and Bakracevic (1995) used the data from TA protocols to see if heart rate (HR) differs in different types of problems across time. HR was relatively stable in DT question, and had decline in the last interval whereas during insight question, HR had gradual decrease in the first three intervals, and then increased in the last interval. Fleck and Weisberg (2004) used the TA method to examine the presence of impasse and restructuring in the verbal protocols of 52 university undergraduates who successfully resolved Duncker's (1945) candle problem. They found that restructuring frequently takes place in the protocols of those who found the right solution, but impasse rarely did, and was not related to the production of the right solution. Okada and Simon (1997) asked their participants to think aloud while working on a discovery problem to compare their performance to those who worked in pairs through conversational discourse. Pairs did better than those working individually and thinking aloud.

Strengths and Weaknesses of the TA Method

As the studies summarized above indicated, the TA method was often used to explore different processes involved in DT. However, there are some limitations with this method. First, it is not a direct access to mental operations and protocols may not clearly and fully reflect higher order mental processes (Nisbett & Wilson, 1977). Second, some of the processes and thoughts may not be disclosed because of the processing difference in verbalizing and thinking, the latter being more complex than the former. Thus, this method can undermine some individuals' performance. This is also known "verbal overshadowing" (Fleck & Weisberg, 2004). Some participants in Jausovec's (1991) study, for example, were excluded from the analyses because they failed to think out loud while responding. The evidence from the research on insight (Ball & Stevens, 2009; Gilhooly, Fioratou, & Henretty, 2010; Schooler & Melcher, 1995) has shown that the interference led by TA instruction can have differential impact on the performance on problem solving tasks (Weisberg, 2013). Third, only a limited portion of conscious material can be accessed and much less or none of the unconscious. Fourth, presence of the researcher can cause self-censorship on participants' part.

In spite of some pitfalls, the TA method has unique strengths. First, the TA method eliminates retrospective recall bias (Ruscio, Whitney, & Amabile, 1998). Given that role of memory in DT (Pollert, Feldhusen, Van Mondfrans, & Treffinger, 1969), this is an important advantage in analyzing the DT. Second, participants' natural flow of thinking can be captured. In the standard method, participants may not write down some ideas because they may not see some of their ideas as a good or valid response; or censor them. This kind of data is particularly important for creative thinking that welcomes eccentric and unconventional ideas. Third, TA protocols allow analyzing of cognitive mechanisms, processes, and strategies involved in DT,

which provide advantage in evaluating the outcomes. This gives researchers the chance to evaluate and score ideas more accurately with the contextual cues provided in TA protocol. As a result of this, for example, seemingly very original ideas in the standard procedure (counts based on infrequency) could be considered unoriginal when internal processes and the way individuals attain an idea are identified. Likewise, seemingly irrelevant ideas can be actually related, and this can be seen when the processes involved are considered.

The TA protocols are particularly important for understanding divergence because the ideas (the "what") cannot be most accurately evaluated without knowing the processes and the context (the "how"). An appeal of the TA method is that it is an objective method that treats the verbal protocol as the data (van Someren, Barnard, & Sandberg, 1994). Those crucial strengths pinpoint the purpose of this study, which is to compare the TA and standard procedure with respect to each of the hyperspace dimensions while taking the whole verbal protocol into account in the analyses. This study differs from the other studies using the TA method in DT in that its focus is not the processes involved. The focus of this study is the utilization of TA verbal protocols in order to evaluate the responses more accurately taking advantage of additional and context information and, when appropriate, treat the TA protocol as the object of data analysis.

Research Questions

1. Is there a significant difference between the total number of ideas generated when the TA and standard methods were used?

2. Is there a significant difference between the TA and standard procedures on each of the hyperspace dimensions (e.g., original versus conventional, primary versus secondary) investigated in Chapter 3?

3. Are the method-related differences, if any, consistent across verbal and figural DT tasks?

Method

Sample

Twenty-seven participants (13 males and 14 females) took part each responding to four divergent thinking items. Twenty-two of them have enrolled to a graduate program and the remaining 5 to an undergraduate program. While this sample size is only moderate, it is important to keep in mind that qualitative research is especially useful for in-depth understanding of individuals rather than generalizations across entire populations (Kuipers & Kassirer, 1984). Qualitative research is also useful in that it can identify issues that can later be studied with larger samples and quantitative methods. In the present case, qualitative research was chosen because the goal was to understand processes. This is best approached qualitatively.

Data Collection

The participants were invited to volunteer as participants through a convenience sampling method. The invitation script was shared with personal contacts and potential participants through e-mail and social media. People who previously did not take a divergent thinking test or did not attend the Torrance Tests of Creative Thinking Training were eligible to participate if they were above 18 years of age. Then, they signed the consent form and received the tasks.

Instruments

Four of DT tasks (one verbal and three figural) used in the Chapter 2 and 3 were also used in this study to be able to compare the two methods. The verbal item was one item from the Many Uses Games (i.e., “List different uses for a bowl”) and three figural DT tasks consisted of three figures that were labeled as “rectangles,” “star,” and “tornado.” All these DT tasks were part of the Runco Creativity Assessment Battery (rCAB; 2011).

Procedure

Each session was conducted individually and recorded via a voice recorder, which was saved in an mp3 audio format and transcribed by the researcher. All tasks were presented on a computer screen along with the instructions. Each session was timed for five minutes.

Participants received the following instruction for the Bowl item:

The Many Uses Game (Bowl): "*Most objects can be used for more than one thing. The Many Uses game allows you to think of different uses for everyday objects. See the item below and please list* ***as many different uses as you can****. For example, a newspaper could be used as a hat or a blanket. It could be read, or used to make a boat. And there are many other uses! Take a look at the objects below and give as many ideas about uses as you can. The more uses you think of, the better. There are no grades and spelling does not matter. This is a game, not a test. Have fun!*"

The Figural Games (Rectangles, Star, and Tornado):

"This is a visual game. Below you will find a line drawing. We would like you to make a list of all of the things that each drawing could be. The more things you say, the better! There are no incorrect answers, no grades, no points, and spelling does not matter. This is game, NOT a test. You have 5 min. to complete this question. Now look at the first below and ***say as many things as you can*** *for what that figure might be. What does it look like? What could it be?"*

In addition to the instructions provided above, the following instruction, which was modified from Ruscio, Whitney, and Amabile (1998), was provided to encourage participants to think aloud:

"While you work on each of these tasks, I would like you to think out loud. You often do this when you are alone and working on a problem. Just say the first thing that comes to mind, no matter what it may be. This will let us know what you are thinking while you are

doing each task. Even when you are stuck, just say that out loud. I will keep reminding you to think aloud."

Then, the TA sessions were transcribed by the researcher.

Scoring

The scoring of the ideas was conducted in the same way as the procedures followed in Chapter 3, with the exception that the entire TA protocol was available for the evaluation of responses. With the TA instruction, responses were sometimes provided with a context, and this context provided clues for scoring of the ideas. The context provided in the verbal protocols was especially useful for evaluations of the dimensions originality versus conventionality, synthetic versus non-synthetic, breadth versus depth, playful versus serious, primary versus secondary, and remote versus close.

Originality versus conventionality: In addition to the scoring of responses with respect of uniqueness, an additional step was taken to re-evaluate the ideas to determine if there were specific references to experiences in the verbal protocols. The responses given to the DT tasks were not scored as original if they were retrieved from memory or experiences even if they were statistically infrequent or unique. An example of this case is the following response to the Star item: "It could become a trivet to put a hot or take something from oven *like I did today.*" Although this (i.e., trivet) was a unique response, it was clearly retrieved from memory. An opposite example is the following response given to the Star item: "artists' rendition of what it feels like to fall from tall place." It is not unusual to present this idea as "falling," "an abstract thought," "a drawing" or "artistic abstract design" in standard procedure. However, this idea became a unique (original) idea with the additional information provided in the TA session.

Synthetic versus non-synthetic: The details and the context provided in the verbal protocols can help to recognize more synthetic responses, which would be regarded as non-synthetic otherwise. An example of a synthetic response is the following response given to the Tornado item: "It's a spiral and it gets bigger and bigger and bigger so it is likely continuation of life." The idea of "continuation of life" was built upon the idea of "spiral" through extending it.

Breadth versus depth: There were instances that verbal protocols indicated the transition from one idea to another. An example of this is the following response given to the Rectangles item: The idea of "stones" was followed by "equal stones are easier for fences." Because "stones" and "fences" are not related, they would be scored as "breadth" in standard procedure without the additional information between the two ideas that showed the transition. Because the idea of "stones" triggered the idea of "fences," the latter were scored as "depth."

Playful versus serious: More number of playful responses could be found in the details and the context. An example of playful responses given to the Tornado item was "hair on Simpson's head," which would be a non-playful, serious response without "Simpson's head."

Primary versus secondary and remote versus close: The whole verbal protocol, rather than the responses, was screened to identify words associated with primary and secondary processes and close associations. The total number of words related to each category were counted and used in the analyses. When a verbal protocol was screened for the secondary processes, the words in parenthesis in the following response were captured: "you can (collect) water that is falling (when) a pipe breaks." The additional information (i.e., when a pipe breaks), which would not be provided in standard procedure, involved a word related with the secondary processes and this was also identified.

The scoring of ideas for those categories was directly influenced by the utilization of the TA protocols. However, the TA process itself may influence other dimensions because the TA can reflect the natural flow of thinking. As a result, some of people's ideas, which they think of but avoid writing, may be captured. Also, the TA method was conducted as individual sessions in the presence of the researcher. This could also influence the number of responses in certain categories. Therefore, the responses were scored for other dimensions that the verbal protocols do not provide specific clues. The dimension of experience versus non-experience was omitted because the explicit references to experiences and memory were used as an additional evidence of originality or conventionality.

The TA Performance

Thinking out loud could be difficult for some participants. Actually, this was the case with the study of Jausovec (1991) who removed the data of some participants from the study because they failed to think aloud. To encourage participants to think aloud, they were reminded to think aloud when they were silent for 15 seconds. They mostly did say the ideas out aloud, but the protocols varied in terms of the internal processes revealed during the sessions. Therefore, an objective way of identifying TA performance has been employed.

TA performance has been defined as any statement in the protocols that would not typically be written in the standard format. Corollary to this, ideas in the protocols have been removed from the protocols and the word count of the remaining text was noted. Because word count is dependent on the number of ideas generated, the ratio of word count to the number of ideas has been used as the indicator of TA performance. This index was an aggregate measure including total number of ideas and word count across all tasks.

The mean TA was 13.66 (*SD* = 7.98, min = 3.24, max. = 41.69). According to this, TA performance of four participants was lower (below 5). Statistically speaking, the TA performance of these four participants was below 16th percentile (outside the 1 standard deviation from the mean). The four participants' protocols were removed from the analyses because it is possible that the TA method was inhibiting their ideation and the final sample size was 23.

Analyses

The different procedures (TA vs. standard procedure) might have influenced fluency and the production of ideas, which in turn can influence the hyperspace properties of the ideas. To control for this, and focus on changes in the qualities of the ideas, independent of productivity, fluency was controlled in the statistical analyses. Fluency score from the Bowl item and a composite index from the fluency scores of three figural DT tasks were used as covariate in the respective analyses comparing the TA and standard procedure.

Results

The first analysis compared the fluency scores from the TA and standard procedure. Independent samples *t*-tests indicated that the TA group generated significantly more responses than those in the standard procedure in all tasks except Bowl, in which the difference was marginally significant. Corresponding *t*-values were provided along with the exact *p* and Cohen's *d* values on Table 4.1. Because of the remarkable differences between the two methods, the fluency was controlled in the following analyses that compared the hyperspace categories as revealed in the TA and standard procedures.

Table 4.1

Descriptive Statistics of the DT Tasks (Fluency) for the TA (N=23) and Standard Procedure (N=54) and Independent Samples T-Tests Comparing the Two.

	Think aloud				Standard							
	Min.	Max.	*M*	*SD*	Min.	Max.	*M*	*SD*	*df*	*t*	*p*	*d*
Bowl	4	52	17.52	13.25	3	37	13.39	7.68	75	1.72	.0899	.40
Rectangles	3	38	18.30	9.79	2	40	10.56	6.76	75	4.00	.0001	.92
Star	3	34	14.91	8.47	3	40	9.15	6.18	75	3.34	.0010	.77
Tornado	3	46	16.78	10.25	3	40	9.83	6.09	75	3.70	.0004	.85

Comparison of the Hyperspace Categories

The comparisons of the hyperspace categories were conducted using a series of ANCOVAs controlling fluency. All analyses relied on the number of responses. Exceptions to this were primary and secondary processes and close and remote associations, in which all words in the verbal protocols, not just ideas, were screened. Then, the covariate for those categories was the word counts in both TA and standard procedures.

The figural DT tasks were combined to keep the analyses to a minimum and ease interpretation. Therefore, two ANCOVAs were conducted for each category; one with the Bowl item, another with a composite score of three figural DT tasks. The estimated marginal means and standard error values were provided in Table 4.2. In order to avoid redundancy on the table, only one of the opposite categories (e.g., original versus conventional, playful versus serious) was presented if the opposite categories were complementary to each other (i.e., their total is equal to fluency). The *F* values were, of course, the same when the opposite categories were compared.

Table 4.2

Estimated Marginal Means and Standard Errors for Think Aloud and Standard Procedures after Controlling for Fluency or Word Count.

	Think Aloud				Standard			
	Bowl		Figurals		Bowl		Figurals	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Original	4.35	.41	3.76	.33	2.63	.27	3.05	.21
TUMAI	1.27	.25	.52	.12	1.07	.16	.87	.07
Primary	6.28	1.45	11.85	.82	12.92	.84	11.04	1.57
Secondary	9.55	1.38	3.22	.68	6.88	.80	4.94	.35
Impractical	3.31	.45	3.06	.35	1.44	.29	4.12	.22
Synthetic	6.05	.54	4.57	.42	2.55	.35	2.44	.26
Breadth	8.33	.70	6.81	.27	8.81	.46	8.01	.17
Depth	5.30	.70	4.06	.27	4.82	.46	2.88	.17
Infeasible	4.89	.55	NA	NA	3.53	.36	NA	NA
Natural	3.57	.50	2.75	.28	3.11	.33	3.57	.18
Playful	3.35	.28	1.08	.18	1.15	.18	1.00	.11
Remote	55.16	1.44	NA	NA	61.36	.84	NA	NA

NA: Not applicable

The ANCOVAs with fluency as covariate, comparing original ideas from the TA and standard procedures indicated that significantly more original ideas were generated in the TA than Standard procedures in the Bowl item, $F(1, 74) = 12.12$, $p = .001$, $\eta_p^2 = .14$, but not in figural DT tasks, $F(1, 74) = 3.05$, $p = .09$, $\eta_p^2 = .04$. Similarly, playful ideas were also found more in the

TA than the standard procedure in Bowl, $F(1, 74) = 42.36$, $p < .001$, $\eta_p^2 = .36$, but not in figural DT tasks, $F(1, 74) = .14$, $p = .712$, $\eta_p^2 = .002$.

Impractical ideas were also generated more in TA than the standard procedure in both Bowl, $F(1, 74) = 11.98$, $p = .001$, $\eta_p^2 = .14$, and in the figural set, $F(1, 74) = 6.14$, $p = .016$, $\eta_p^2 = .08$. Synthetic responses were found more in TA than the standard procedure in the Bowl, $F(1, 74) = 28.76$, $p < .001$, $\eta_p^2 = .28$, and in the figural DT tasks $F(1, 74) = 17.07$, $p < .001$, $\eta_p^2 = .19$. Likewise, infeasible ideas were found more in TA than the standard procedure in Bowl, $F(1, 74) = 4.28$, $p = .042$, $\eta_p^2 = .06$. This analysis was conducted only with the Bowl item because this dimension was not applicable to the figural DT tasks.

The ANCOVAs comparing TUMAI ideas indicated that significantly more TUMAI ideas were generated in the Standard than the TA procedures in figural DT tasks, $F(1, 74) = 6.13$, $p = .016$, $\eta_p^2 = .08$, but not in the Bowl item, $F(1, 74) = .43$, $p = .52$, $\eta_p^2 = .01$. Similarly, natural ideas were generated more in standard procedure than the non-natural responses in the figural DT tasks $F(1, 74) = 5.58$, $p = .021$, $\eta_p^2 = .07$, but not in Bowl, $F(1, 74) = .57$, $p = .453$, $\eta_p^2 = .008$.

Breadth ideas were significantly higher from the standard procedure than the TA in the figural DT tasks, $F(1, 74) = 13.39$, $p < .001$, $\eta_p^2 = .15$, but not in Bowl, $F(1, 74) = .33$, $p < .57$, $\eta_p^2 = .004$. Therefore, depth ideas were significantly more in the TA procedure than the standard procedure in figural DT tasks, $F(1, 74) = 12.98$, $p < .001$, $\eta_p^2 = .15$, but not in Bowl, $F(1, 74) = .33$, $p < .57$, $\eta_p^2 = .004$.

Word Counts

ANCOVAs controlling the word count indicated that cognition was preoccupied with remotely associated words more in the standard procedure than in the TA method, $F(1, 74) = 11.26$, $p = .001$, $\eta_p^2 = .13$. The same analyses were repeated for primary and secondary responses.

Significantly more words associated with primary responses were found in the standard procedure than TA in bowl, $F(1, 74) = 12.81$, $p = .001$, $\eta_p^2 = .15$, but not in figural DT tasks. When secondary processes were compared, no significant differences were found in the figural DT tasks, $F(1, 74) = 3.54$, $p = .064$, $\eta_p^2 = .046$, and in the Bowl, $F(1, 74) = 2.27$, $p = .14$, $\eta_p^2 = .03$.

Homogeneity of regression slopes were examined for each of the ANCOVAs. This assumption has not been met in some analyses, which indicated that some of these findings should be interpreted with caution and conducted again with a different sample.

Discussion

The comparison of TA and standard procedures indicated that more ideas (higher fluency) were generated in the TA than the standard procedure. This finding makes it unlikely that there was verbal overshadowing (Schooler, Ohlsson, & Brooks, 1993), which is a serious threat to the validity of the TA procedure. Gilhooly, Fioratou, Anthony, and Wynn administered six Uses items and found no differences between the TA and control groups. In the present study, only one Uses item was used, and the difference between the TA and standard procedure was not significant. However, the differences were significant in all three figural DT tasks and more ideas were generated in TA.

There are several possible reasons for finding more responses in the TA sessions. First, participants can generate more ideas than what is typically revealed in the standard procedure, and the undisclosed ideas can only be identified through methods that delve into internal processes. In other words, the data from the standard procedure could be a portion of individuals' full course of ideational capacity. Second, data collection was conducted individually with the TA group as usual. Therefore, participants might have tried to generate more ideas as encouraged by the researcher and, therefore, *observer effect* may have increased the responses. Third, some

of the differences may stem from the type of activity involved during the process of DT across two methods. TA involves verbal expression of thinking whereas the standard procedure involves writing or typing up the results. Participants might not type some of their ideas whereas they could easily say it out loud as soon as they think about it. The act of writing or typing may decrease the number of responses given to DT tasks because it requires an additional effort or provides additional time for censorship.

The analyses that controlled the fluency effect indicated an interesting pattern: there were more original, impractical, infeasible, and playful ideas in the TA than the standard procedure, although this difference was significant only in Bowl for original and playful ideas. It is very likely that people avoid sharing some of their ideas that can be seen as weird, impractical, infeasible, and childish. This might also stem from the possibility that they might not value those kinds of ideas as much as their conventional, practical, feasible, and serious ideas. This is not surprising, because practicality is often expected and valued over abstract value ideas (Prawat, 1993; Sanchez-Burks, 2005).

In the TA method, participants were encouraged to say whatever came into their minds. Those findings indicated that participants might disclose more of their ideas that would be omitted in the standard procedure. In case of self-censorship of ideas, this is more likely to target original, impractical, infeasible, and playful ideas. Then, it is possible to assert that some of the original and potentially original ideas might be lost in the standard procedure. It is important to note that impractical, infeasible, and playful responses were positively related to originality attitudes as reported in Chapter 3. Those results are meaningful considering the studies showing that people avoid original ideas (Staw, 1995; Westby & Dawson, 1995) under the conditions of

uncertainty even though they state creativity as a desired goal (Mueller, Melwani, & Goncalo, 2012).

There were findings contrary to this pattern. More remotely associated and primary process related content was found in the standard procedure than the TA. A commonality of these two categories was that they focused on the whole verbal protocol, not the ideas, controlling for word count. Further analyses can also investigate a comparison of the ideas only.

Synthetic and depth responses were also higher in the TA than the standard procedure. This is related to the amount of information from the TA. The verbal protocols provide cognitive context clues for the ideas that are valuable for their evaluation (Cool, Park, Belkin, Koenemann, & Ng, 1996). Additional clues provided by the verbal protocols allow seeing how some of the responses are built upon previous responses and combined with others. Otherwise, ideas are more likely to be perceived as distinct and independent of each other.

With details and contextual information provided on the verbal protocols, it was possible to see the links between seemingly unrelated ideas and therefore ideation that goes deeper within a category. Creativity is seen as the ability to see connections between seemingly unrelated things (Mednick, 1962; Ansburg & Hill, 2003). These findings also underline an important strength of the TA procedure – which is the connections between and transition from one idea to another- that might occasionally be missed in the standard procedure. The standard procedure requires a subjective evaluation of one's ideas in terms of categories, which were usually objectively defined. However, semantic networks are individual's unique constructions, in which closely related concepts are stored together (Collins & Loftus, 1975). Two seemingly unrelated concepts could actually be a close association. External evaluations without some clues about the internal processes might fail to see those connections.

Another interesting issue for consideration is that the differences were influenced by the content type. There were significant differences in only the verbal task (i.e. the Bowl item) in some categories (i.e., originality, primary, playful, remote, and infeasible) and in only the figural DT tasks in other categories (TUMAI, breadth and depth, natural). This is consistent with the suggestion that DT consists of different, but related, abilities (Guilford, 1977) and some of the variation originates from the original model of SOI that distinguishes verbal content from figural and symbolic contents. Accordingly, factor analytic studies (Torrance, 1995; Richardson, 1986) indicated that verbal and nonverbal tasks are two different factors. Runco and Albert (1985) also reported content-related differences.

This study has some limitations. For example, although the sample size was large enough for these kinds of in-depth studies, a larger sample would yield more sound results. Also, TA sessions were conducted individually in the presence of the researcher, whereas the standard procedure was not. Later studies can replicate this study with a more controlled design in terms of the context of data collection. Last, but not least, although there was no specific reason to suspect bias, given that the primary investigator scored the data, the possibility of experimenter effects should be mentioned.

CHAPTER 5

CONCLUSIONS

DT has been extensively studied in the creativity literature (Guilford, 1967; Wallach & Kogan, 1965; Runco, 1991, Torrance, 1995). It is built upon a sound theory of cognition (i.e., SOI), and DT tasks are useful as the indicators of creative potential (Runco & Acar, 2012). DT tasks are also operational; therefore, they allow testing of different abilities of creative thinking, and they have been refined over decades to obtain psychometrically strong measures (Torrance, 1995, Runco, 1991, 2013).

In spite of the voluminous research on the usefulness of DT in theory and practice, divergent thinking has not been studied literally, yet, reflecting its original definition -- thinking that goes in all directions. Because of this focus, *Literal Divergent Thinking* was preferred as the overarching term. The first study (Chapter 1) focused on associative processes in DT based on the premise that ideational capacity can be enhanced with greater mental leaps on the associative network. The usefulness of social associations was examined in the identification of remotely and closely associated ideas. The second study (Chapter 2) investigated whether the proposed hyperspace categories can be identified in the responses to DT tasks. It was proposed that the utility of more hyperspace categories implies superior creative potential as literal divergent thinking refers to thinking in all directions. The third study (Chapter 3) compared the hyperspace categories as identified in the standard procedure (Chapter 2) with the TA procedure, in which, participants were asked to think aloud while responding to DT tasks. The goal of using the TA instruction was to go into the internal processes underlying DT.

The major findings of those studies were as follows:

1) Remote and close associations can be reliably measured when different sources of social associations (i.e., the lists from the WN, WAN, and IF) were used. Inter-item reliability (alpha coefficients) of remote associations was higher than close associations.
2) Longer association lists did not necessarily produce better indices of remote and close associations. Inter-item reliability values were higher in the WAN and IF, which provided shorter lists, than the WN.
3) Creative Attitudes and Values were significantly related with remote, but not with close, associations across all three methods. The highest correlation was obtained with the WAN.
4) Inter-item correlations among three sets of remote associations were higher than the correlations between three sets of remote and close associations.
5) Comparison of the first and second halves of the responses indicated that significantly more close associations were found in the first half than the second half when WN was used. This finding was obtained when the WAN was used, too, but the difference was significant in Tire item only. The results from the IF, however, were inconsistent.
6) The eleven proposed hyperspace categories (after two were combined with the others) were located in the responses to DT tasks. The inter-item and inter-rater reliability analyses indicated that hyperspace categories can be reliably identified with the exception of TUMAI and playful responses.
7) A greater number of ideas from each category were positively related with originality and fluency. When fluency was controlled, TUMAI, experience, impractical,

synthetic, breadth, non-natural, infeasible, playful, and remote associations were positively related with originality, whereas the complementary categories (e.g., NEMBL, Non-experience, practical, etc.) were negatively related in the verbal items. This pattern was observed in the figural DT tasks in the majority of applicable categories.

8) Literal divergent thinking can be quantified using these categories. The index of Literal Divergent Thinking (LiDT), defined as the total of employed categories in each DT task, was positively related with the originality attitudes (r = .39, p = .004). It went up to r = .50 with correction for attenuation. The correlation was still significant even after controlling for fluency (r = .29, p = .042). A subscale of LiDT, which was created based on the item-total correlation values, indicated that the subscale had the same correlation with originality attitudes.
9) Fluency was higher in the TA sessions than the standard procedure, which refuted the possibility of "verbal overshadowing."
10) More original, impractical, infeasible, synthetic, depth, and playful ideas were generated in the TA procedure than the standard procedure, although this difference was significant only in the Bowl item for original and playful ideas. TUMAI, breadth, natural, primary responses, and remote associations were higher in the standard procedure, but the first three were limited to the figural DT tasks and the last two were only true for the verbal item.

These findings are promising for the field of creativity in different ways. Associative processes in DT are not currently utilized in the creativity assessment that uses DT tasks. More specifically, the distance between ideas and remote associations are not included in any of the

indices in any test of DT. Such measures can be incorporated into a creativity assessment. Moreover, such indices are highly objective and easy to computerize.

Another novelty introduced in the current research was that divergence can be analyzed through proposed hyperspace categories. More importantly, literal divergent thinking can be quantified into a LiDT index defined as the ability to utilize a greater number of categories. This perspective is quite different from the traditional indices of DT (fluency, originality, and flexibility) but more consistent with the original definition of DT.

The present studies had some limitations. First, the sample sizes of the studies were not very large. Because those studies were the first of their kind and explored the usefulness of new methods, they used data from a workable sample. Further studies can test the same hypotheses with larger samples. Second, the hyperspace categories are not limited to those included in this study. There could be other operational dimensions that could be found in DT, some of which can be revealed in other kinds of DT tasks (e.g., problem generation). Third, the difference between the TA and standard procedures can be tested in controlled designs.

REFERENCES

Ansburg, P. I., & Hill, K. (2003). Creative and analytic thinkers differ in their use of attentional resources. P*ersonality and Individual Differences, 34,* 1141-1152.

Baer, J. (2011). How divergent thinking tests mislead us: Are the Torrance Tests still relevant in the 21st century? The Division 10 debate. *Psychology of Aesthetics, Creativity, and the Arts, 5,* 309-313.

Ball, L., & Stevens, A. (2009). Evidence for a verbally-based analytic component to insight problem solving. In N. Taatgen & H. J. van Rijn (Eds.), *Proceedings of the Thirty-First Annual Conference of the Cognitive Science Society* (pp. 1060-1065). Austin, TX: Cognitive Science Society.

Barron F. (1963). *Creativity and psychological health.* Princeton, NJ: Van Nostrand.

Barron, F. (1975). The solitariness of self and its mitigation through creative imagination. In I. A. Taylor & J. W. Getzels (Eds.), *Perspectives in creativity* (pp. 146-156). Chicago, IL: Aldine Press.

Bartlett, S. (1978). Protocol analysis in creative problem-solving. *Journal of Creative Behavior, 12,* 181–192.

Basadur, M. (1995). Optimal ideation-evaluation ratios. *Creativity Research Journal, 8,* 63-75.

Basadur, M. S. & Basadur, T. M. (2011). Attitudes and creativity. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of Creativity,* (2nd ed., Vol. 1; pp. 85-95). San Diego, CA: Academic Press.

Basadur, M. S., Graen, G. B., & Green, S. G. (1982). Training in creative problem solving: Effects on ideation and problem finding in an applied research organization. *Organizational Behavior and Human Performance, 30,* 41-70.

Basadur, M. S., & Hausdorf, P. A. (1996). Measuring divergent thinking attitudes related to creative problem solving and innovation management. *Creativity Research Journal, 9,* 21-32.

Basadur, M. S., Runco, M. A. & Vega, L. A. (2000). Understanding how creative thinking skills, attitudes and behaviors work together: A causal process model. *Journal of Creative Behavior, 34,* 77-100.

Baughman, W. A., & Mumford, M. D. (1995). Process analytic models of creative capacities: Operations involved in the combination and reorganization process. *Creativity Research Journal, 8,* 37–62.

Beaty, R. E., & Silvia, P. J. (2012). Why do ideas get more creative across time? An executive interpretation of the serial order effect in divergent thinking tasks. *Psychology of Aesthetics, Creativity, and the Arts, 6,* 309-319.

Benedek, M., Könen, T., & Neubauer, A. C. (2012). Associative abilities underlying creativity. *Psychology of Aesthetics, Creativity, and the Arts, 6,* 273-281.

Blair, C. S., & Mumford, M. D. (2007). Errors in idea evaluation: Preference for the unoriginal? *Journal of Creative Behavior, 41,* 197–222.

Bonnardela, N., & Marmèche, E. (2005). Towards supporting evocation processes in creative design: A cognitive approach. *International Journal of Human-Computer Studies, 63,* 422–435.

Bossomaier, T., Harré, M., Knittel, A., & Snyder, A. (2009). A semantic network approach to the creativity quotient (CQ). *Creativity Research Journal, 21,* 64-71.

Bowden, E. M., & Jung-Beeman, M. (2003). Normative data for 144 compound remote associate problems. *Behavior Research Methods, Instruments, and Computers, 35,* 634-639.

Brandoni, C., & Anderson, O. R. (2009). A new neurocognitive model for assessing divergent thinking: Applicability, evidence for reliability, and implications for educational theory and practice. *Creativity Research Journal, 21,* 326-337.

Brophy, D. R. (1998). Understanding, measuring and enhancing individual creative problem-solving efforts. *Creativity Research Journal, 11,* 123-150.

Brown, R. T. (1989). Creativity: What are we to measure? In J. A. Glover, R. R. Ronning, & C. R. Reynolds (Eds.), *Handbook of creativity* (pp. 3-32). New York, NY: Plenum.

Bruner, J. S. (1975). The ontogenesis of speech acts. *Journal of Child Language, 2,* 1-19.

Callahan, C. M., Hunsaker, S. L., Adams, C. M., Moore, S. D., & Bland, L. C. (1995). *Instruments used in the identification of gifted and talented students* (Report No. RM-95130). Charlottesville, VA: National Research Center on the Gifted and Talented.

Campbell, D. (1960). Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review, 67,* 380-400.

Cannon, H. M., Carroll, P. G., & Seamons, B. L. (1993). Using the IdeaFisher idea generation system as a decision support system in marketing strategy courses. *Developments in Business Simulation and Experiential Learning, 20,* 27-30.

Chapman, J. G., & Carrigan, M. H. (1993). Public self-attention and personal standards: The impact of group composition. *Current Psychology, Research & Reviews, 12,* 216-229.

Cheung, P. C., Lau, S., Chan, D. W., & Wu, W. Y. H. (2004). Creative potential of school children in Hong Kong: Norms of the Wallach-Kogan Creativity Tests and their implications. *Creativity Research Journal, 16,* 69–78.

Christensen, P. R., Guilford, J. P., & Wilson, R. C. (1957). Relations of creative responses to working time and instructions. *Journal of Experimental Psychology, 53,* 82−88.

Christensen, P. R., Merrifield, P. R., & Guilford, J. P. (1953). *Consequences form A-1*. Beverly Hills, CA: Sheridan Supply

Clapham, M. M. (2003). The development of innovative ideas through creativity training. In L. V. Shavinina (Ed.). *The International Handbook on Innovation* (pp. 366-376). Oxford, England: Elsevier Science.

Clark, P. M., & Mirels, H. L. (1970). Fluency as a pervasive element in the measurement of creativity. *Journal of Educational Measurement, 7,* 83–86.

Cognitive Science Laboratory. (2002). *WordNet: A lexical database for the English language.* Princeton, NJ: Princeton University. Retrieved August 1, 2012 from http://wordnet.princeton.edu/

Cohen, J. (1960). A coefficient for agreement for nominal scales. *Education and Psychological Measurement, 20,* 37–46.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review, 82,* 407-428.

Cool, C., Park, S., Belkin, N. J., Koenemann, J., & Ng, W. B. (1996). Information seeking behaviour in new searching environments. In P. Ingwersen, & N.O. Pors, (Eds.), *CoLIS 2: Second International Conference on Conceptions of Library and Information Science:*

Integration in Perspective, Copenhagen: The Royal School of Librarianship, 13-16 October, (pp. 403-416). Bradford, CT: Emerald Group Publishing Limited.

Cropley, D. H., & Cropley, A. J. (2005). Engineering creativity: A systems concept of functional creativity. In J. C. Kaufman & J. Baer (Eds.), *Faces of the muse: How people think, work and act creatively in diverse domains* (pp. 169-185). Hillsdale, NJ: Lawrence Erlbaum.

Cropley, D. H., Kaufman, J. C., & Cropley, A. J. (2008). Malevolent creativity: A functional model of creativity in terrorism and crime. *Creativity Research Journal, 20,* 105-115.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention*. New York, NY: Harper Collins.

Cundall, M. K., Jr. (2007). Humor and the limits of incongruity. *Creativity Research Journal, 19,* 203-211.

Dane, E. (2010). Reconsidering the trade-off between expertise and flexibility: A cognitive entrenchment perspective. *Academy of Management Review, 35,* 579-603.

Davis, G. A. (1989). Testing for creative potential. *Contemporary Educational Psychology, 14,* 257-274.

Davis, G. A., Peterson, J. M., & Farley, F. H. (1974). Attitudes, motivation, sensation seeking, and belief in ESP as predictors of real creative behavior. *Journal of Creative Behavior, 8,* 31-39.

Dean, D. L., Hender, J. M., Rodgers, T. L., & Santanen, E. (2006). Identifying good ideas: constructs and scales for idea evaluation. *Journal of Association for Information Systems, 7,* 646-699.

DeYoung, C. G., Flanders, J. L., & Peterson, J. B. (2008). Cognitive abilities involved in insight problem solving: An individual differences model. *Creativity Research Journal, 20*, 278-290.

Duchene, A., Graves, R. E., & Brugger, P. (1998). Schizotypal thinking and associative processing: A response commonality analysis of verbal fluency. *Journal of Psychiatry and Neuroscience, 23,* 56–60.

Dudek, S. Z. (1984). The architect as person: A Rorschach image. *Journal of Personality Assessment, 48,* 597-605.

Dudek, S. Z., & Verreault, R. (1989). The creative thinking and ego functioning of children. *Creativity Research Journal, 2,* 64–86.

Duncker, K. (1945). On problem solving. *Psychological Monographs, 58,* (5, Whole No. 270).

Ericsson K. A., & Fox, M. C. (2011). Thinking aloud is not a form of introspection but a qualitatively different methodology: Reply to Schooler. *Psychological Bulletin, 137,* 351-354.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87,* 215-251.

Ericsson, K. A., & Simon, H. A. (1984). *Protocol analysis: verbal reports as data* (Revised ed.). London, England: MIT Press.

Ericsson, K. A., & Simon, H. A. (1998). How to study thinking in everyday life: Contrasting think-aloud protocols with descriptions and explanations of thinking. *Mind, Culture, and Activity, 5,* 178-186.

Estes, Z. C., & Ward, T. B. (2002). The emergence of novel attributes in concept modification. *Creativity Research Journal, 14,* 149-156.

Feldhusen, J. F., & Goh, B. E. (1995). Assessing and accessing creativity: An integrative review of theory, research, and development. *Creativity Research Journal, 8*, 231-247.

Findlay, C. S., & Lumsden, C. J. (1988). The creative mind: Toward and evolutionary theory of discovery and innovation. *Journal of Biological and Social Structures, 11*, 3-55.

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative cognition: Theory, research, and applications.* Cambridge, MA: MIT Press.

Fisher, M. (1996). *The IdeaFisher: How to land that big idea--and other secrets of creativity in business.* Princeton, NJ*:* Peterson's/Pacesetter Books.

Fleck, J. I., & Weisberg, R. W. (2004). The use of verbal protocols as data: An analysis of insight in the candle problem. *Memory & Cognition, 32,* 990–1006.

Fonteyn, M. E., Kuipers, B., & Grobe, S. J. (1993). A description of think aloud method and protocol analysis. *Qualitative Health Research, 3,* 430-441.

Freud, S. (1955). *The interpretation of dreams.* (J. Strachey, Trans.). New York, NY: Basic Books.

Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York, NY: Basic Books.

George, D., & Mallery, P. (2003). *SPSS for windows step by step: A simple guide and reference 11.0 update*. (4th ed.). Boston, MA: Allyn and Bacon.

Gilhooly, K. J., Fioratou, E., & Henretty, N. (2010). Verbalization and problem solving: Insight and spatial factors. *British Journal of Psychology, 101,* 81–93.

Gilhooly, K.J., Fioratou, E., Anthony, S., & Wynn, V. (2007). Divergent thinking: strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology, 98,* 611-625.

Gino, F., & Ariely, D. (2012). The dark side of creativity: Original thinkers can be more dishonest. *Journal of Personality and Social Psychology, 102,* 445-459.

Gough, H. G. (1976). Studying creativity by means of word association tests. *Journal of Applied Psychology, 61,* 348-353.

Gratzer, W. (2002). *Eurekas and euphorias: The Oxford book of scientific anecdotes*. New York, NY: Oxford University Press.

Gruszka, A., & Necka, E. (2002). Priming and acceptance of close and remote associations by creative and less creative people. *Creativity Research Journal, 14,* 193-205.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5,* 444-454.

Guilford, J. P (1959). Three faces of intellect. *American Psychologist, 14,* 469-479.

Guilford, J. P. (1962). Creativity: Its measurement and development. In J. J. Parnes & H.F. Harding (Eds.), *A source book for creative thinking* (pp. 156-168). New York, NY: Scribners.

Guilford, J. P. (1967). *The nature of human intelligence.* New York, NY: McGraw-Hill.

Guilford, J. P. (1968). *Creativity, intelligence and their educational implications.* San Diego, CA: EDITS/Knapp.

Guilford, J. P. (1977). *Way beyond the IQ.* Buffalo, NY: Creative Education Foundation.

Guilford, J. P., Christensen, P. R., Merrifield, P. R., & Wilson, R. C. (1958). *Unusual uses test.* Orange, CA: Sheridan Psychological Services.

Guilford, J. P. & Hoepfner, R. (1971). *The analysis of intelligence.* New York, NY: McGraw-Hill.

Harris, D. J. (2013). *The effect of emotional intelligence and task type on malevolent creativity*. (Unpublished master's thesis). University of Nebraska at Omaha, Omaha, NE.

Heilman, K. M., Nadeau, S. E., & Beversdorf, D. O. (2003). Creative innovation: Possible brain mechanisms. *Neurocase, 9,* 369-79.

Hocevar, D. (1979). Ideational fluency as a confounding factor in the measurement of originality. *Journal of Educational Psychology, 71,* 191–196.

Houtz, J. C., Jambor, S. D., Cifone, A., & Lewis, C. D. (1989). Locus of evaluation control, task directions, and type of problem effects on creativity. *Creativity Research Journal, 11,* 88-125.

Humke, C., & Schaefer, C. E. (1996). Sense of humor and creativity. *Perpetual and Motor Skills, 82*, 544 –546.

Hunter, S. T., Bedell-Avers, K. E., Hunsicker, C. M., Mumford, M. D, & Ligon, G. S. (2008). Applying multiple knowledge structures in creative thought: Effects on idea generation and problem-solving. *Creativity Research Journal, 20,* 137-154.

Jackson, P. W., & Messick, S. (1965). The person, the product and the response: conceptual problems in the assessment of creativity. *Journal of Personality, 33,* 1-19.

James, K., Clark. K., & Cropanzano, R. (1999). Positive and negative creativity in groups, institutions, and organizations: A model and theoretical extension. *Creativity Research Journal, 12,* 211-226.

Jausovec, N. (1991). Flexible strategy use: A characteristic of gifted problem solving. *Creativity Research Journal, 4,* 349-366.

Jausovec, N., & Bakracevic, K. (1995). What can heart rate tell us about the creative process? *Creativity Research Journal, 8,* 11-24.

Jones, T., Caulfield, L., Wilkinson, D., & Weller, L. (2011). The relationship between nonclinical schizotypy and handedness on divergent and convergent creative problem-solving tasks. *Creativity Research Journal, 23*, 222-228.

Jung-Beeman, M. (2005). Bilateral brain processes for comprehending natural language. *Trends in Cognitive Sciences, 9,* 512-518.

Khandwalla, P. N. (1993). An exploratory investigation of divergent thinking through protocol analysis. *Creativity Research Journal, 6,* 241-259.

Kim, K. H. (2011). Proven reliability and validity of the Torrance Tests of Creative Thinking (TTCT). *Psychology of Aesthetics, Creativity, and the Arts, 5,* 314-315

Kounios, J., & Beeman, M. (2009). The aha! moment. *Current Directions in Psychological Science, 18,* 210-216.

Kray, L. J., Galinsky, A. D., & Wong, E. M. (2006). Thinking within the box: The relational processing style elicited by counterfactual mind-sets. *Journal of Personality and Social Psychology, 91,* 33-48.

Kris, E. (1952). *Psychoanalytic explorations in art.* New York, NY: International Universities Press.

Kuipers, B. J., & Kassirer, J. P. (1984). Causal reasoning in medicine: analysis of a protocol. *Cognitive Science, 8,* 363-385.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33,* 159-174.

Langer, E. J. (1989). *Mindfulness.* Reading, MA: Addison-Wesley.

Lee, S., & Dow, G.T. (2011). Malevolent creativity: Does personality influence malicious divergent thinking? *Creativity Research Journal, 23,* 73-82.

Liapis, A., Martínez, H. P., Togelius, J., & Yannakakis, G. N. (2013). Transforming Exploratory Creativity with DeLeNoX. In M. L., Maher, T. Veale, R. Saunders, O. Brown, (Eds.) *Proceedings of the Fourth International Conference on Computational Creativity (ICCC)*, University of Sidney, Sidney, 12 – 14 June, Retrieved at http://www.computationalcreativity.net/iccc2013/download/ICCC2013-Proceedings.pdf

Licuanan, B. F., Dailey, L. R., & Mumford, M. D. (2007). Idea evaluation: Error in evaluating highly original ideas. *Journal of Creative Behavior, 41,* 1-27.

Malaga, R. A. (2000). The effect of stimulus modes and associative distance in individual creativity support systems. *Decision Support Systems, 29,* 123-141.

Martindale, C. (1973). COUNT: A PL/I program for content analysis of natural language (abstract). *Behavioral Science, 18,* 148.

Martindale, C. (1975). *Romantic progression: The psychology of literary history*. Washington, DC: Hemisphere.

Martindale, C. (1990). *The clockwork muse: The predictability of artistic change.* New York, NY: Basic Books.

Martindale, C., & Dailey, A. (1996). Creativity, primary process cognition, and personality. *Personality and Individual Differences, 20,* 409-414.

Maslow, A. H. (1976). *The farther reaches of human nature*. New York, NY: Penguin.

Massetti, B. (1996). An empirical examination of the value of creativity support systems on idea generation. *MIS Quarterly, 20,* 83-97.

May, R. (1984). *The courage to create*. New York, NY: Bantam.

McLaren, R. B. (1993). The dark side of creativity. *Creativity Research Journal, 6,* 137– 144.

McMullan, W. E. (1976). Creative individuals: Paradoxical personages. *Journal of Creative Behavior, 10,* 265–275.

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review, 69,* 220-232.

Mednick, S. A., & Mednick, M. T. (1967). *Examiner's manual, Remote Associates Test.* Boston, MA: Houghton Mifflin.

Mednick, M. T., Mednick, S. A., & Jung, C. C. (1964). Continual association as a function of level of creativity and type of verbal stimulus. *Journal of Abnormal Psychology, 69,* 511–515.

Milgram, R. M., & Rabkin, L. (1980). Developmental test of Mednick's associative hierarchies of original thinking. *Developmental Psychology, 16,* 157-158.

Miller, G. A., Beckwith, R., Fellbaum, C., Gross, D., & Miller, K. J. (1990). Introduction to WordNet: An on-line lexical database. *International Journal of Lexicography, 3,* 235-244.

Moneta, G. B. (1993). A model of scientists' creative potential: The matching of cognitive structure and domain structure. *Philosophical Psychology, 6,* 23-37.

Moshman, D., & Lukin, L. E. (1989). The creative construction of rationality: A paradox. In J. A. Glover, R. R. Ronning & C. R. Reynolds (Eds.), *Handbook of creativity* (pp. 183-198). New York, NY: Plenum.

Mueller, J. S., Melwani, S., & Goncalo, J. A. (2012). The bias against creativity: Why people desire but reject creative ideas. *Psychological Science, 23,* 13-17.

Murdock, M. C., & Ganim, R. M. (1993). The relationship between creativity and humor: Integration and incongruity. *Journal of Creative Behavior,* 27, 57-70.

Necka, E. (1994). Gifted people and novel tasks: The creativity versus intelligence distinction revisited. In K. Heller & E. Hany (Eds.), *Competence and responsibility* (Vol. 2; pp. 68–80). Seattle, WA: Hogrefe & Huber.

Newell, A., & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.

Nisbett, R., & Wilson, T. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84,* 250-256.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York, NY: McGraw-Hill.

Nusbaum, E. C., & Silvia, P. J. (2011). Are intelligence and creativity really so different? Fluid intelligence, executive processes, and strategy use in divergent thinking. *Intelligence, 39,* 36–45.

Okada, T., & Simon, H. A. (1997). Collaborative discovery in a scientific domain. *Cognitive Science, 21,* 109–146.

Paletz, S. B. F., Peng, K., & Li, S. (2011). In the world or in the head: Internal and external implicit theories of creativity. *Creativity Research Journal, 23,* 83-93.

Parnes, S. J. (1961). Effects of extended effort in creative problem solving. *Journal of Educational Psychology, 52,* 117–122.

Perkins, D. N. (1981). *The mind's best work.* Cambridge, MA: Harvard University Press.

Perkins, D. N. (1994). Creativity: Beyond the Darwinian paradigm. In M. A. Boden (Ed.), *Dimensions of creativity* (pp. 119-142). Cambridge, MA: MIT Press/Bradford Books.

Pine, F., & Holt, R. R. (1960). Creativity and primary process: A study of adaptive regression. *Journal of Abnormal and Social Psychology, 61,* 370-379.

Plucker, J. A., & Runco, M. A. (1998). The death of creativity measurement has been greatly exaggerated: Current issues, recent advances, and future directions in creativity assessment. *Roeper Review, 21,* 36-39.

Pollert, L. H., Feldhusen, J. F., Van Mondfrans, A. P., & Treffinger, D. J. (1969). Role of memory in divergent thinking. *Psychological Reports, 25,* 151–156.

Prawat, R. S. (1993). The value of ideas: Problems versus possibilities in learning. *Educational Researcher, 22,* 5-16.

Rapp, R. (2002). The computation of word associations: Comparing syntagmatic and paradigmatic approaches. In *Proceedings of the 19th International Conference on Computational Linguistics*, Howard International House and Academia Sinica, Taipei, 24 August -1 September (Vol. 1; pp. 1-7). Stroudsburg, PA: Association for Computational Linguistics

Rawlings, D., & Toogood, A. (1997). Using a "taboo response" measure to examine the relationship between divergent thinking and psychoticism. *Personality and Individual Differences, 22,* 61– 68.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan, 42,* 305-310.

Richardson, A. G. (1986). Two factors of creativity. *Perceptual and Motor Skills, 63,* 379-384.

Robbin, A. (1990). *IdeaFisher: An introduction*. Irvine, CA: Fisher Idea Systems.

Rothenberg, A. (1979). *The emerging goddess: The creative process in art, science, and other fields.* Chicago, IL: University of Chicago Press

Ruge, G. (1992). Experiments on linguistically-based term associations. *Information Processing & Management, 28,* 317-332.

Runco Creativity Assessment Battery (rCAB). (2011). Creativity Testing Services: CTS. http://creativitytestingservices.com/

Runco, M. A. (1986). Flexibility and originality in children's divergent thinking. *Journal of Psychology, 120*, 345-352.

Runco, M. A. (1991). *Divergent thinking*. Norwood, NJ: Albex.

Runco, M. A. (1996). Objectivity in creativity research. In A. Montuori (Ed.), *Unusual associates: A festschrift for Frank Barron* (pp. 69-79). Cresskill, NJ: Hampton Press.

Runco, M. A. (1999a). Divergent thinking. In M. A. Runco & S. Pritzker (Eds.), *Encyclopedia of creativity* (pp. 577–582). San Diego, CA: Academic Press.

Runco, M. A. (1999b). Tactics and strategies for creativity. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (pp. 611-615). San Diego, CA: Academic Press.

Runco, M. A. (2010). Creativity has no dark side. In D. H. Cropley, A. J. Cropley, J. C. Kaufman, & M. A. Runco (Eds.), *The dark side of creativity* (pp. 15-32). New York, NY: Cambridge University Press.

Runco, M. A. (2011). Divergent thinking. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (2nd ed., Vol. 1; pp. 400-403). San Diego, CA: Academic Press.

Runco, M. A. (2013). *Divergent thinking and creative potential.* Cresskill, NJ: Hampton Press

Runco, M. A., & Acar, S. (2010). Do tests of divergent thinking have an experiential bias? *Psychology of Art, Creativity, and Aesthetics, 4*, 144-148.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal, 24*, 1–10.

Runco, M. A., & Albert, R. S. (1985). The reliability and validity of ideational originality in the divergent thinking of academically gifted and nongifted children. *Educational and Psychological Measurement, 45,* 483-501.

Runco, M. A., & Basadur, M. (1993). Assessing ideational and evaluative skills and creative styles and attitudes. *Creativity and Innovation Management, 2,* 166–173.

Runco, M. A., Dow, G.T., & Smith, W. R. (2006). Information, experience, divergent thinking: An empirical test. *Creativity Research Journal, 18,* 269-277.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal, 24,* 92-96.

Runco, M. A., & Mraz, W. (1991). Scoring divergent thinking tests using total ideational output and a creativity index. *Educational and Psychological Measurement, 52,* 213-211.

Runco, M. A., Plucker, J. A., & Lim, W. (2000-2001). Development and psychometric integrity of a measure of ideational behavior. *Creativity Research Journal, 13,* 393-400.

Ruscio, J., Whitney, D., & Amabile, T. M. (1998). Looking inside the fishbowl of creativity: Verbal and behavioral predictors of creative performance. *Creativity Research Journal 11*, 243–263.

Russ, S., & Grossman-McKee, A. (1990). Affective expression in children's fantasy play, primary process thinking on the Rorschach, and divergent thinking. *Journal of Personality Assessment, 54,* 756-771.

Russ, S. W., & Dillon, J. A. (2011). Associative theory. In M. A. Runco & S. R. Pritzker. *Encyclopedia of Creativity* (Vol. 1; pp. 66-71), San Diego, CA: Academic Press.

Sanchez-Burks, J. (2005). Protestant relational ideology: The cognitive underpinnings and organizational implications of an American anomaly. *Research in Organizational Behavior, 26,* 265–305.

Schaefer, C. E., & Bridges, C. I. (1970). Development of a creativity attitude survey for children. *Perceptual and Motor Skills, 31,* 861-862.

Schooler, J. W., & Melcher, J. (1995). The ineffability of insight. In S. M. Smith, T. B. Ward, & R. A. Finke (Eds.), *The creative cognition approach* (pp. 97-133). Cambridge, MA: MIT Press.

Schooler, J. W., Ohlsson, S., & Brooks, K. (1993). Thoughts beyond words: When language overshadows insight. *Journal of Experimental Psychology: General, 122,* 166-183.

Schuldberg, D., French, C., Stone, B. L., & Heberle, J. (1988). Creativity and schizotypal traits: Creativity test scores, Perceptual Aberration, Magical Ideation, and Impulsive Nonconformity. *Journal of Nervous and Mental Disease, 176,* 648-657.

Scott, G. M., Lonergan, D. C., & Mumford, M. D. (2005). Contractual combination: Alternative knowledge structures, alternative heuristics. *Creativity Research Journal, 17,* 21–36.

Sharma, A. (1999). Central dilemmas of managing innovation in large firms. *California Management Review, 41,* 65-85.

Silvia, P. J. (2008). Discernment and creativity: How well can people identify their most creative ideas? *Psychology of Aesthetics, Creativity, and the Arts, 2,* 139-146.

Silvia, P. J., Martin, C., & Nusbaum, E. C. (2009). A snapshot of creativity: Evaluating a quick and simple method for assessing divergent thinking. *Thinking Skills and Creativity, 4,* 79−85.

Snyder, A., Mitchell, J., Bossomaier, T., & Pallier, G. (2004). The creativity quotient: An objective scoring of ideational fluency. *Creativity Research Journal, 16,* 415-419.

Sowa, J. (1992). Semantic networks. In S. C. Shapiro (Ed), *Encyclopedia of artificial intelligence* (2nd ed.) (pp. 1493-1511). New York, NY: Wiley.

Staw, B. M. (1995). Why no one really wants creativity. In C. Ford & D. A. Gioia (Eds.), *Creative action in organizations: Ivory tower visions and real world voices* (pp. 161-166). Thousand Oaks, CA: Sage.

Stein, M. (1993). Moral issues facing intermediaries between creators and the public. *Creativity Research Journal, 6,* 197–200.

Sternberg, R. J. (Ed.). (1999). *Handbook of creativity.* New York, NY: Cambridge University Press.

Steyvers, M., & Tenenbaum, J. B. (2005). The large-scale structure of semantic networks: Statistical analyses and a model of semantic growth. *Cognitive Science, 29,* 41–78.

Suler, J. R. (1980). Primary process thinking and creativity. *Psychological Bulletin, 88,* 144-165.

Taft, R., & Rossiter, J. R. (1966). The Remote Associates Test: Divergent or convergent thinking? *Psychological Reports, 19,* 1313–1314.

Taylor, A. (1975). An emerging view of creative actions. In I. A. Tylor & J. W. Getzels (Eds.), *Perspectives in creativity* (pp. 297-325). Chicago, IL: Aldine.

Taylor, C. W. (1988). Various approaches to and definitions of creativity. In R. J. Sternberg (Ed.), *The nature of creativity: Contemporary psychological perspectives* (pp. 99-121). Cambridge, England: Cambridge University Press.

Torrance, E. P. (1995). *Why fly?* Norwood, NJ: Ablex.

Torrance, E. P. (2008). *The Torrance Tests of Creative Thinking—Norms—Technical Manual—Figural (Streamlined) Forms A and B.* Bensenville, IL: Scholastic Testing Service.

Torrance, E. P., & Hall, L. K. (1980). Assessing the further reaches of creative potential. *Journal of Creative Behavior, 14,* 1-19.

Torrance, E. P., & Harmon, J. A. (1961). Effects of memory, evaluation and creative sets on test performances. *Journal of Educational Psychology, 52,* 204-214.

Torrance, E. P., & Safter, H. T. (1989). The long range predictive validity of the Just Suppose test. *Journal of Creative Behavior, 23,* 219-223.

Torrance, E. P., & Safter, H. T. (1999). *Making the creative leap beyond.* Buffalo, NY: Creative Education.

Troyer, A., Moscovitch, M., & Winocur, G. (1997). Clustering and switching as two components of verbal fluency: Evidence from younger and older healthy adults. *Neuropsychology, 11,* 138-146.

van den Haak, M. J, De Jong, M. D., & Schellens, P. J. (2003). Retrospective vs. concurrent think-aloud protocols: testing the usability of an online library catalogue. *Behaviour & Information Technology, 22,* 339-351.

van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The think aloud method: A practical guide to modelling cognitive processes.* London, England: Academic Press.

Walczyk, J. J., Runco, M. A., Tripp, S. M., & Smith, C. E. (2008). The creativity of lying: Divergent thinking and ideational correlates of the resolution of social dilemmas. *Creativity Research Journal, 20,* 328-342.

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children: A study of the creativity-intelligence distinction.* New York, NY: Holt, Rinehart and Winston.

Wallach, M. A., & Wing, C. (1969). *The talented student.* New York, NY: Holt, Rinehart & Winston.

Wallas, G. (1926). *The art of thought.* New York, NY: Harcourt Brace & World.

Ward, W. C. (1969a). Rate and uniqueness in children's creative responding. *Child Development, 40*, 869-878.

Ward, W. C. (1969b). Creativity and environmental cues in nursery school children. *Developmental Psychology, 1,* 543-547.

Weinstein, S., & Graves, R. E. (2002). Are creativity and schizotypy products of a right hemisphere bias? *Brain and Cognition, 49,* 138–151.

Weisberg, R. W. (2013). On the "demystification" of insight: A critique of neuroimaging studies of insight. *Creativity Research Journal, 25,* 1-14.

Welling, H. (2007). Four mental operations in creative cognition: The importance of abstraction. *Creativity Research Journal*, *19*, 163–177.

Westby, E. L., & Dawson, V. L. (1995). Creativity: Asset or burden in the classroom? *Creativity Research Journal, 8,* 1-10.

Whitman, R. D., Holcomb, E., & Zanes, J. (2010). Hemispheric collaboration in creative subjects: Cross-hemisphere priming in a lexical decision task. *Creativity Research Journal, 22,* 109-118.

Wicker, F. W. (1985). A rhetorical look at humor as creativity. *Journal of Creative Behavior, 19,* 175–184.

Wilson , R. C. Guilford , J. P. Christensen , P. R., & Lewis , D. J. (1954). A factor-analytic study of creative-thinking abilities. *Psychometrika, 1954, 19,* 297-311.

Wilson, R. C., Guilford, J., & Christensen, P. R. (1953). The measurement of individual differences in originality. *Psychological Bulletin, 50*, 362-370.

Woodman, R. W., & Schoenfeldt, L. F. (1990). An interactionist model of creative behavior. *Journal of Creative Behavior, 24*, 279-291.

Ziv, A. (1976). The facilitating effects of humor in creativity. *Journal of Educational Psychology, 68,* 318-322.