THE BALANCING ACT: AN EMPIRICAL STUDY INTRODUCING AND REMOVING CONSTRAINTS IN IDEA GENERATION

by

ADAM DAMADZIC

Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE IN PSYCHOLOGY

THE UNIVERSITY OF TEXAS AT ARLINGTON

AUGUST 2019

Supervising Committee:

Kelsey E. Medeiros, Ph.D., Supervising Professor

Amber N. Schroeder, Ph.D.

Jared B. Kenworthy, Ph.D.

TABLE OF CONTENTS

ABSTRACT

THE BALANCING ACT: AN EMPIRICAL STUDY INTRODUCING AND REMOVING CONSTRAINTS IN IDEA GENERATION

Adam Damadzic, M.S.

The University of Texas at Arlington, 2019

Supervising Professor: Kelsey E. Medeiros, Ph.D.

To stay competitive in today's economy, organizational leaders are making creativity and innovation a key business priority. As such, organizations have become particularly interested in how to become more innovative while managing obstacles or constraints. The relationship between constraints and creativity in the literature provides two avenues of thought. Traditionally, constraints are thought to inhibit creativity. However, an emerging line of work suggests that constraints may in fact facilitate creativity. To address the debate around the role of constraints in creative efforts, the present effort examined how adjusting "constraindness" during idea generation influenced creativity. To test this, participants were asked to design a marketing campaign for a NCAA Division One football program and were presented with constraints at multiple time points during the design process. Results suggested that the introduction of constraints early on during the idea generation phase may be beneficial to creative endeavors, while also finding that being overly constrained may hinder creative performance. This work adds to a growing body of literature regarding the constraint-creativity relationship and provides insight to practitioners regarding how constraints may be managed for optimal creative performance.

Keywords: creativity, constraints, innovation, creative designs, idea generation

CHAPTER 1: INTRODUCTION

Previous research suggests that creativity flourishes through freedom (Amabile, 1983; Amabile & Gryskiewicz, 1987). The idea follows that for one to be creative, one must be unburdened by barriers or limitations (Amabile, 1979) so that intrinsic motivation could be unencumbered and freely drive effort toward the creative endeavor (Amabile, 1979, 1983). Amabile (1979) argued that a constraint, or limitation, may negatively impact creativity by increasing external control, which may override one's intrinsic motivation (Amabile, 1983; Amabile & Gryskiewicz, 1987; Friedman, 2009). An emerging body of work, however, challenges this notion, suggesting that constraints may increase creative performance (e.g., Medeiros, Partlow, & Mumford, 2014; Stokes, 2007). Scholars (e.g., Haught-Tromp, 2017) have argued that constraints positively influence creativity by narrowing the potential problem space and, thus, force the individual to develop novel ideas by molding their process to meet the requirements of the constraint. This newer line of research has promoted a questioning in the consensus surrounding constraints and creativity. The present effort aims to contribute to this emerging body of work by exploring how fluctuations in constraints throughout a creative problem solving task influence creative performance.

1.1 Creativity

The current business environment necessitates that organizations place an emphasis on employee creativity to encourage innovation and, ultimately, stay competitive (Shalley & Gilson, 2016). Coined the driving force of positive change (George, 2007), creativity can be defined several ways. Traditionally, creative thought was understood as the open, unconstrainted, generative process of ideas (Eysenck, 1977). Recently however, many scholars propose

creativity be defined under the umbrella of creative problem solving, whereby individuals undergo an attempt to formulate a solution to a certain type of problem which calls for creative thought (Mumford, Medeiros, & Partlow, 2012).

In the present effort, creativity is defined as the generation of potentially viable solutions to complex, original, and ill-defined problems as evidenced by the quality, originality, and elegance of these solutions (Mumford & Gustafson, 1988; Runco & Jaeger, 2012). Specifically, quality refers to the usefulness of a solution. The solution is useful if it solves the problem, is generative such that it leads to other ideas or things, or expands an area of knowledge (Csikszentmihalyi, 1990). A novel solution is characterized as original or innovative with originality suggesting unusual or rare responding (Baer, 1993; Guildford, 1950; Runco, 1999) and innovative suggesting appropriateness (Copley, 1999).

1.2 Constraints and Creativity

Constraints are defined as a limitation or restriction (Medeiros et al., 2014). For example, when developing a marketing campaign, a small budget may be considered constraining as it limits the number of potential designs to only those that are feasible within the prescribed budget. Similarly, a specific goal such as a target market in a marketing campaign may be a constraint, as the user will have to develop campaigns specific to that target market. Several attempts have been made to develop a taxonomy of constraints. For instance, Onarheim (2012), while conducting a case study at Coloplast (i.e., a medical device engineering firm), classified constraints into seven categories: (a) individual (e.g., habits, mood, ambition), (b) social (e.g., expectations, team, chemistry communication), (c) process (e.g., time, cost, tools), (d) technical (e.g., requirements, regulations, production), (e) source (e.g., user needs, subject, client, task), (f) domain (e.g., internal, external, inherent), and (g) purpose (e.g., validity, non-functional,

quality). Medeiros, Watts and Mumford (2017) proposed a broader classification of constraints into market (e.g., stakeholder expectations), organization (e.g., features of the organization itself), field (e.g., norms or profession itself), and project (e.g., work or team characteristics) constraints. Although both taxonomies present categories of constraints to consider, Onarheim and Biskjaer (2015) note the importance of not viewing these lists as exhaustive.

Both Onarheim (2012) and Medeiros, Watts and Mumford (2017) argued for the importance of understanding the unique relationship between creativity and specific types of constraints and their characteristics. For example, the constraints formed by the organization may differ to the constraints formed by the project and may thus impact creativity in different ways. Further, many constraints exist in a number of ways dependent on the nature of the problem and domain the individual is working within (Csikszentmihalyi, 1999). For instance, Stokes and Fisher (2005) examined the value of goal constraints, source constraints, and task constraints, on artistic creativity and found differences in the artists' products based on the focus of each constraint. More so, Pool (1997) found in engineering a focus on materials and infrastructure induced creative problem solving. Thus, different constraints may uniquely impact projects both across and within fields.

1.3 The Constraint-Creativity Relationship

Amabile (1983) argued that an intrinsically motivated state is beneficial to creativity, whereas an extrinsically motivated state hinders creativity. An intrinsic state suggests one is motivated by their interest and engagement in a task whereas an extrinsic state suggests that external forces such as external goals and pay are the motivating force behind task engagement. Evidence of constraints hindering creative performance stems from the notion that external constraints, such as rewards, decrease intrinsic motivation and subsequently reduce creativity

(Deci, 1971; Lepper, Green & Nisbett, 1973). Theories such as Self-Perception Theory (Bem, 1972) which suggest that individuals develop attitudes or emotional responses by observing their own behavior and learning what attitudes drove that behavior, further support this claim by proposing that intrinsic motivation is hindered by the imposition of salient extrinsic constraints. Experimental work on creativity also supports this notion. For instance, Amabile (1979) examined the role of extrinsic constraints in women completing an artistic task. Women who expected an external evaluation demonstrated less creative artwork compared to women who did not expect an external evaluation. Friedman (2009) provided further support, demonstrating that rewarding creative efforts reduced intrinsic motivation and, in turn, reduced creative performance.

In contrast to these theories, more recent scholars have proposed and found that constraints may have a positive influence on creativity (Haught-Tromp, 2007; Nijstad, De Dreu, Rietzschel, & Baas, 2010). Underlying this work is the dual-pathway model of creativity (Nijstad, De Dreu, Rietzschel, & Baas, 2010) which proposes that creative performance may arise from two potential paths – flexibility and persistence. The flexibility route suggests that creative solutions develop similarly to the traditional notion, in which creative solutions emerge from a broad search across multiple categories. Along this pathway, constraints that limit the breadth of the search would be detrimental to creative performance. The persistence route, however, proposes that creative solutions stem from a thorough search in a limited space. The persistence route aligns with Haught-Tromp's (2017) recent *The Green Eggs and Ham Hypothesis*, which proposed that constraints increase the potential for creative solutions by narrowing the problem space and encouraging a deeper exploration of a limited number of potential solutions. Together, these arguments suggest that constraints may help formulate new

and novel ideas by activating the persistence pathway. This pathway may facilitate the jumpstart of new ideas by reducing the time spent generating less novel, existing ideas, thereby engaging the individual to develop original solutions more quickly (Haugh-Tromp, 2016).

Another line of evidence pointing to the potential positive influence of constraints is found in research examining instructions and creative performance. For example, Haught-Tromp and Stokes (2017) examined the influence of instructions demonstrating how college students were able to become more creative in literacy composition when beginning the assignment with a specific word rather than freely choosing with which word(s) to begin. Haught-Tromp and Stokes (2017) argued that language in general (a prime example of creativity) operates within a set of constraints and that although an unconstrained field does invite *freedom,* the constrained field encourages a deeper exploration. This deeper exploration was necessary to avoid the tried and tested, unoriginal, cognitive scripts. This argument has been supported by research in other domains as well (Onarheim, 2012; Torrents Martín, Ric & Hristoviski, 2015). In line with these arguments, an empirical study conducted by Torrents Martín, Ric, and Hristoviski (2015) on contact dance improvisation (a form of dance improvisation that involves two bodies continuously in contact with one another) found that instructions increased creative performance. The study asked dancers to perform in one condition with no instructions, and two other conditions with two different instructional constraints (i.e., when dancing keep your pelvis as close as possible to your partner). Results revealed a significant effect of the instructional conditions with regard to increased creativity. That is, the dancers who received instructions prior to performing were judged as more creative compared to those who received task constraints or no constraints (Torrents Martín et al., 2015).

Whereas the above studies have examined constraints at a specific stage of the creative process, the creativity literature proposes various models of up to eight processes involved in producing creative solutions (Mumford, Mobley, Reiter-Palmon, Uhman, & Doares, 1991). Treffinger and Isaksen (1992) proposed a conceptualization of three processes in the creative problem solving literature including (1) understanding the problem, (2) generating ideas, and (3) planning for action. Similarly, Mumford et al. (1991) developed a cyclical model composed of eight processes consisting of (1) problem identification, (2) information gathering, (3) concept selection, (4) conceptual combination, (5) idea generation, (6) idea evaluation, (7) implementation planning, and (8) monitoring. Additionally, Amabile (1996) proposed a smaller model consisting of (1) problem identification, (2) preparation, (3) idea generation, and (4) validation and communication. Although each process unique, the proposed models of creative problem-solving all contain processes in idea generation, idea evaluation, problem identification, and some information gathering. Intriguingly, Medeiros et al. (2017) addressed a void in the research, examining the timing of constraints at various stages of the creative process, finding that multiple constraints at the onset of a project may positively influence problem definitions and in turn, the quality of the final proposal. Further, this research found that constraints sparked idea evaluation processes when introduced later on in the process. This suggests that constraints may uniquely influence different creative problem solving processes. Stokes (2007) provides an argument in tandem with the above findings, suggesting that the correct placement of constraints may decrease an individual's reliance on expected solutions and instead, activate a search for novel solutions.

Whereas some scholars (e.g., Amabile 1983) stress the value of unconstrained, unrestricted field, others (e.g., Medeiros, Watts & Mumford, 2016) have argued the presence of

constraints in nearly all creative endeavors, stemming from the market, team, project, individual, or organization. If all creative projects are in fact inherently constrained, it stands to reason that in practice, individuals must be able to be creative under these conditions. In fact, leading industry figures such as Marisa Mayer (Mayer, 2006) and Biz Stone (Stone, 2014) have argued that constraints are essential to creativity. Thus, with more recent research looking into the plausible factors that influence the positive relationship of constraints and creativity (e.g., Litchfield, 2008, Medeiros, Partlow, & Mumford, 2014), it highlights the importance of the present and similar efforts to understand the specific nuances with when and how to incorporate constraints effectively.

Another line of evidence examined the impact of training individuals to manage constraints. Peterson and colleagues (2013) found that educating individuals on how to manage constraints resulted in solutions of higher quality, originality, and elegance when compared to individuals who received no prior training on handling constraints. Thus, this line of research suggests people can work effectively with constraints and that constraints can contribute to elicit higher creative performance, when used appropriately.

Based on the empirical evidence, it is plausible to suggest that the introduction of constraints on creative problems has the potential to yield higher creative performance. This led to the first hypothesis.

> *Hypothesis 1:* Those receiving constraints during a creative problem-solving task will develop higher quality, more original, and more elegant solutions compared to solutions by those who receive no constraints.

In addition to understanding the broad influences of constraints, it is also essential to understand how they may be managed to maximize creative output. Previous research suggests a

complex picture. For example, Medeiros, Partlow, and Mumford (2014) found that being over constrained led to lower creative performance, suggesting that there may be a limit to how constrained a task should be to avoid negatively influencing creativity. Specifically, these findings echo a similar point by Onarheim (2012), suggesting that leaders of creative efforts must find a balance between too many and too few constraints – i.e., the "sweet spot." Additionally, Medeiros et al. (2017) found that introducing constraints later in the creative process appeared to disrupt creative problem solving, as participants in conditions which were constrained at a later stage in the creative process developed lower quality and less novel solutions compared to those who received constraints early on or not at all. Along these lines, Onarhiem (2012) noticed that when constraints were imposed during the idea generation process, some ideas were dismissed, as they did not meet the requirement of the new constraint. Similarly, he found that as constraints were introduced during idea generation, individuals adapted their existing ideas to align with the new constraints or re-introduced ideas that had been dismissed earlier in the idea generation process. By adapting and reintroducing ideas to meet the new constraints, individuals may internally evaluate their ideas to fit the new constraints. This process, in turn, may assist with the existing dilemma that generally, only a select few of the ideas generated are selected and implemented (Sharma, 1999). The process of introducing and removing constraints, therefore, may spark new ideas by activating the evaluative process involved in creative problem solving. This, in turn, suggests that the timing and order in which constraints are introduced may influence creativity.

An additional line of research found that bilingual participants demonstrated more creativity when they first conversed in their secondary language followed by their primary language (Blot, Zárate, & Paulus, 2003). Thus, as the language constraint was removed,

creativity increased. Another avenue of research argues for the use of constraints as a method to avoid familiar solutions based on the premise that familiar solutions to creative problems arise sooner than novel ones (Maltzman, 1960; Runco, 1986; Ward, 1969). These studies suggest that removing the initial constraint may increase creativity.

Further support from Tversky and Kahneman (1974) in the judgment heuristics literature highlights how people rely on a number of heuristic principles to reduce the complexity of tasks. Specifically, the anchoring heuristic is a cognitive bias that causes individuals to focus and guide themselves on subsequent tasks based on the principles or heuristics of the available information on a previous task. Despite the vast literature on anchoring effects in numerical tasks, there has been little research in the use of anchoring in creativity (Berg, 2014). In terms of creative problem solving, this line of evidence suggests that individuals who are constrained initially may anchor themselves to the initial constraint even after it is removed from a creative task. Similarly, those who are unconstrained and have new constraints introduced, may be "anchored" to a previous unconstrained field. This argument aligns with the findings of Medeiros and colleagues (2018) whereby the introduction of constraints early on in the creative process produced higher creative performances than individuals who received late cycle constraints. However, research is needed to explore how subsequent constraints introduced in the idea generation cycle may influence creative performance. Testing the anchoring effect, Berg (2014) examined the role of a "primal mark" (a term from painting theory which suggests the first bit of content in a design shapes the subsequent content) on novelty and usefulness, finding that new primal marks introduced after the start of the task led to final ideas that were more novel than designs which did not receive a subsequent mark. One plausible explanation for these findings may be caused by an ownership bias to early generated ideas. Ownership bias toward ones

individually generated ideas has been prevalent in the engineering design industry (a staple of creativity endeavors; Cooper & Lucas, 2006). As such, Toh, Patel, Strohmetz, and Miller (2015) found that engineering students exhibited an ownership bias to their own ideas, despite lower scores compared to team members. Thus, it is plausible to suggest that the introduction of new constraints that impede existing ideas may uniquely influence the generation of new ideas by activating processes that force the individuals to develop new or incorporate new ideas into their existing idea.

Together, these studies provide some evidence that both introducing and releasing constraints during the creative process may spark creativity. Thus, the present effort looks to examine if reintroducing and removing constraints throughout idea generation may positively influence creativity. Thus, we propose the following hypothesis.

Hypothesis 2: Introducing or releasing constraints during idea generation will result in higher quality, more original, and more elegant solutions compared to solutions produced by those who receive a consistent constraint or no constraints.

Although there is some support to suggest the introduction or release of constraints throughout idea generation may positively influence creativity, there is scarce literature on unique differences between introducing, releasing, and adjusting constraints. Thus, our first research question looks to provide insight into this complex relationship.

Research Question 1 (RQ1): How does introducing, removing, and adjusting constraints influence quality, originality, and elegance?

Creativity involves more than just idea generation, and it is important to consider the effects of constraints on other processes such as idea evaluation. A restaurant design study found that when constraints were introduced the quality of idea evaluations and the extent to which

participants revised earlier ideas during the idea evaluation process (Medeiros, Partlow & Mumford, 2014). Thus, this led to our second research question.

Research Question 2 (RQ2): How does introducing and removing constraints influence the quality and valence of idea evaluations?

CHAPTER 2: METHOD

2.1 Experimental Study

Sample

The study included 301 psychology undergraduate students in five conditions who were selected from a large southwestern university. Students were recruited via an online recruitment system and were given course credit in exchange for their participation. The study was advertised as a "Marketing Design Study." After screening out participants who failed to adhere to study guidelines, screening checks, or failed to complete the study, 45 participants were removed. Thus, the final sample was 256 participants. The sample was 70.0 percent female, and the mean age was 19.87. Also, 89.90% of the sample reported having no marketing experience. However, the average years of work experience was 4.51.

General Procedure

First, participants completed timed divergent thinking and intelligence measures. Second, participants were randomly assigned to one of five conditions in which they took on the fictional role of a Marketing Coordinator for their university. After reading a brief background of the current situation, participants read an email from their new fictional supervisor who requested that they develop a marketing campaign for the university's new football program. Participants were then assigned a level of financial constraint (in a dollar amount). After their initial designs, participants received a follow up email providing more, fewer, or the same financial resources and were instructed to further develop their ideas. Participants then received a third email with more, fewer, or the same financial resources and were instructed to further develop their marketing campaign. Participants were then asked to evaluate the strengths and weaknesses of

each of their campaigns. Finally, participants were asked to develop one final design after their evaluations. These designs contained the same constraint amount as the third design. Participants then completed a set of control measures including marketing experience, need for cognition, personality, and several demographic questions.

Experimental Task

Participants designed a marketing campaign for a new football team at their university, as the university from which the sample was drawn did not have a college NCAA football team during the time of the study. Previous studies have successfully used marketing tasks to assess creativity (e.g., Hester et al., 2012; Medeiros, Partlow, & Mumford, 2014). The experimental task included emails sent from Riley Tee, a fictitious supervisor for the marketing campaign. Although in an email format, the emails were printed and included in a paper packet. After each email, a space was provided to describe the design for a marketing campaign. The initial email provided background on the university's football program and presented information regarding a brief interest from the student population to promote a new football team. The initial email also contained the first constraint from the Board of Directors regarding the project's initial budget. Participants were then asked to design an initial marketing campaign. Next, a second email containing the second constraint manipulation of an increased, decreased, or the same budget were presented. Participants were then directed to continue to further develop their ideas. Finally, a third email containing the third constraint and manipulation of an increased, decreased, or the same budget was presented. Participants were again instructed to further develop their ideas.

The last email thanked the participant for their efforts in designing the marketing campaign and asked the participant to assess the strengths and weaknesses of each of their designs. Participants were also asked to rate how constrained they felt during each idea

generation task on a Likert scale of (1) not at all, to (7), extremely. Finally, participants were asked how they managed their constraints throughout the design in three open-ended questions. Importantly the note, the participants completed the experimental task at their own pace (i.e., once they felt they had finished their designs, they flipped the page to the next email).

Manipulations

The independent variable, financial constraints, had five levels – (1) constrained, (2) increasing constraint, (3) decreasing constraint, (4) adjusting constraint, and (5) unconstrained. Specifically, participants were presented one of three budgets ($0 – most constraining, $5,000 – moderately constraining, $100,000 – least constraining) at each of the three time points. All condition groups are displayed in Table 1.

Table 1

Condition Groups by Constraint at each Time Point

Condition	Time 1	Time 2	Time 3
1. Constrained	$0	$0	$0
2. Decrease Constraint	$0	$5,000	$100,000
3. Increase Constraint	$100,000	$5,000	$0
4. Adjusting Constraint	$0	$100,000	$5,000
5. Unconstrained	$100,000	$100,000	$100,000

A financial constraint was selected due to research in a number of literatures that has revealed creative individuals can benefit from various constraints such as time and financial constraints (e.g., Baer & Oldham, 2006; Gilson, Mathieu, Shalley, & Ruddy, 2005; Hargadon & Sutton, 1996; Moreau & Dahl, 2005; Stokes, 2006; Weiss, Hoegl, & Gibbert, 2012). The value of the constraint was chosen from a pilot study that was conducted on a class of 30 psychology undergraduates who answered a series of questions in regard to what monetary amount was considered constraining. Participants answered questions such as "This University's Athletic Department has asked you to develop a marketing campaign. Below indicate several budget options. Please indicate how constrained you would feel by each dollar amount to develop a marketing campaign." Participants were then provided six options of $0, $1,000, $5,000, $10,000, $50,000, and $100,000. Participants answered on a 5-point scale ranging from (1) Not Constrained at All, (2) Not Very Constrained, (3) Neutral, (4) Somewhat Constrained, (5) Extremely Constrained. Due to the lack of a parsimonious definition of constraint, this question was asked three times replacing the word constraint with "restricted" and "limited." The results across all three questions were consistent such that $0 was considered the most constraining (M = 5.57, SD = 2.62), $5,000 was considered moderately constraining (M = 3.71, SD = 1.85), and $100,000 was considered the least constraining (M = 2.10, SD = 2.32). These results were consistent when replacing the word "constrained" with "restricted" and "limited."

2.2 Study Measures

Dependent Variables

Based on the work of Besemer and O'Quin (1999), marketing designs were assessed for quality (i.e., the degree to which participants presented a complete, coherent, and logical response), elegance (i.e., the extent to which ideas are refined and all pieces flow well together),

and originality (i.e., the degree to which the response was novel and unique). The participant evaluations of their designs were coded for quality (i.e., how useful, logical, and coherent were the evaluations) and positive and negative valence. All variables were coded on scale of (1) low to (5) high. An example of the scale is displayed in Table 2. To develop the rating scales, two graduate students familiar with the creativity literature rated a sample of marketing plans to identify exemplars of low, medium, and high responses. These samples were then paraphrased and used as scale anchors.

Table 2

Example Scale for Originality

Originality Definition: Degree to which the response was novel and unique.

1 (Low)	2	3 (Medium)	4	5 (High)
The design is predictable and does not provide any unique ideas.		The design has a few original elements; however, it still contains many predictable concepts		The plan is clearly unique and has core elements that appear wholly original.

Rater Training

Three undergraduate judges familiar with the purpose of the study but blind to the experimental conditions coded the participants' designs and evaluations. The judges coded each response relevant to the dependent variables listed above. The three judges who were familiar with the creativity literature underwent a frame-of-reference training lasting approximately 15 hours in total. The initial part of the training included a training explaining the variable definitions and benchmark rating scales for each of the dependent variables. After reviewing the variable definitions and benchmark scales, the judges coded a sample of five responses. Here, any discrepancies in ratings and any questions that arose during this sample coding process were resolved. Judges then completed a larger sample (i.e., 20) of responses and a second consensus meeting was held. Finally, the judges content coded the remaining responses over a 12-week period. A final consensus meeting was held to resolve any final discrepancies in the coding. Inter-rater agreement was assessed using $r^*_{WG(J)}$ (Lindell & Brandt, 1999; LeBrenton, James, & Lindell, 2005). All variables fell to an acceptable standard of .71 and .90.

Screening Check

Prior to completing the second set of covariate measures, participants responded to a screening check. Participants responded to a series of questions asking what role they played, their position, and what they were told to design. Participants who failed to answer two out of three responses correctly were removed from the analyses. In combination with the number of individuals who failed to adhere to study guidelines, failed to complete the study, and didn't answer the screening checks correctly, 45 participants were removed.

Manipulation check

To assess that the manipulation was successful, a one-way ANOVA was conducted to examine the constraint manipulation on how constrained the participant felt. As expected, there was a significant main effect of the constraint manipulation on how constrained the participant felt, $F(4, 250) = 35.59$ $p < .001$, $\eta_p^2 = .36$. Specifically, those in the constrained group ($M = 4.83$, $SE = .23$) (condition 1) reported feeling significantly more constrained than those who had the decreasing constraint (condition 2) ($M = 2.37$, $SE = .23$) and those who were unconstrained (condition 5) ($M = 3.84$, $SE = .23$). Further, those in the constrained group (condition 1) reported feeling significantly less constrained than those who had the increasing constraint (condition 3) ($M = 6.14$, $SE = .23$). Additionally those in the decreasing constraint (condition 2) were significantly less constrained than all other conditions including the adjusting condition (condition 4) ($M = 4.21$, $SE = .23$). Those who had the increase constraint (condition 3) were significantly more constrained than all other conditions. Last, those who were unconstrainted (condition 5) were significantly different than all other conditions except the adjusting condition (condition 4). Thus, we can conclude the manipulation was successful.

Covariates

Divergent thinking has long been associated with creativity (Guildford, 1959; Mumford, 2001). Thus, the present study assessed divergent thinking using the Consequences Test (Christensen et al., 1953). This measure presented participants with five questions in which they generated as many answers as possible within two minutes. A sample question included “What would happen if there was mass flooding?” The number of responses were then coded for a fluency score. Previous studies have provided evidence for the construct validity of this measure (Guildford, 1967; Mumford, Marks, Connelly, Zaccaro, & Johnson, 1998).

Previous research, such as that by Vincent, Decker, and Mumford (2002), has indicated that intelligence is related to creativity. To measure intelligence, participants completed the Employee Aptitude Survey (Grimsley, Ruch, Warren, & Ford, 1985). This measure presents four to five factual statements which the participant then decides whether a conclusion, based on these statements, is true or false. Grimsley et al. (1985) have provided evidence for the predictive and construct validity of this measure of intelligence.

Demographic data was also collected at the end of the study to examine the characteristics of the sample as well as to gauge a level of interest in the university's football team. Participants reported their age, gender, year in college, major and Grade Point Average (GPA).

Previous research by Vincent, Decker, and Mumford (2002) indicate that experience is related to creative problem solving. To measure the participants' marketing experience, participants reported their years of experience in marketing, experience designing marketing campaigns, and interest in the need for a football team. The scale measuring their interest in the need for a football team was developed from a scale used by Longeran, Scott, and Mumford (2004) measuring marketing expertise. A total of six questions asked the participants to respond to statements such as "How often do you think about your university having a football team" or "How likely is it you will go into the marketing industry for football?" In the present effort, this measure displayed a Cronbach's Alpha of .79.

Previous work by Batey and Furnham (2006) highlights the role of personality traits in creative problem solving. Thus, the NEO-FFI was used to measure the Big Five personality traits (Costa & McCrae, 1989). The NEO-FFI requires participants to respond to 60 statements indicating the extent to which they agree or disagree with each statement. Sample items include

"I laugh easily," "I often feel tense and jittery," and "I like to be where the action is." Previous validation studies (e.g., Costa & McCrae, 1992; Robins, Fraley, Roberts, & Trzesniewski, 2001) provide evidence bearing on the reliability and validity of this measure. In this effort, the following Cronbach's Alpha's were reported; Extraversion = .77, Openness = .73, Agreeableness = .67, Conscientiousness = .82, and Neuroticism = .75.

Additional research suggests the importance of need for cognition to creative performance, and specifically, creative performance under constraints (e.g., Medeiros, Partlow, & Mumford, 2014). Thus, need for cognition was used using Petty, Cacioppo, and Kao's (1984) measure. This measure asks participants to agree or disagree with 18 statements including items such as "I would prefer complex to simple problems," and "I really enjoy a task that involves coming up with new solutions to existing problems." Cacioppo, Petty, Feinstein, and Jarvis (1996) presented construct validity evidence for this measure. Additionally, reliability evidence has been produced in other studies. In the present effort, the Need for Cognition measure displayed a Cronbach's Alpha of .86.

2.3 Study Analyses

To examine the impact of constraints on the quality, originality, and elegance of the designs, multiple analyses of covariance (ANCOVAs) were conducted. The independent variable in the analyses were the constraint manipulation (constrained, increase constraint, decrease constraint, adjusting constraint, unconstrainted). The dependent variable in these analyses were the quality of the design, originality of the design, elegance of the design, the valence of the participants evaluations, and the quality of the evaluations. All significant covariates at the $p < .05$ level were retained in the model. Participants who did not complete the covariate were excluded from the analyses.

To examine the first and second hypothesis, as well as the first research question, three ANCOVAs were conducted examining the constraint manipulation on the quality, originality, and elegance of the design. Specifically, post-hoc analyses were examined in hypothesis one to compare, conditions one, two, three, and four, to condition five. In hypothesis two, post-hoc analyses were conducted to examine conditions one and five compared to conditions two, three, and four. Finally, to examine the first research question, post-hoc analyses were conducted to compare conditions two, three, and four.

To examine the second research question, two ANCOVAs were conducted to examine condition four compared to conditions one, two, three, and five on the quality of the evaluation, and the valence of the evaluation.

CHAPTER 3: RESULTS

All means, standard deviations, and correlations for all study variables are displayed in Table 3. Although conducting planned comparisons combining the conditions 1, 2, 3, and 4 against condition 5 is the most suitable test of hypothesis 1, several of the assumptions (i.e., sample size) were violated. However, the results from the planned comparisons are presented and the subsequent ANCOVA's are presented after. There was no significant difference between the combined constraint groups and the unconstrained group on the quality of the solution, $t(251) = 1.14$, $p = .257$. There was a significant difference between the constraint groups and the unconstrained groups on the originality of the solution, $t(251) = 2.65$, $p = .009$. Specifically, the unconstrained group reported higher originality than the constrained groups combined. Finally, there was no significant difference between the constrained groups combined and the unconstrained group on the elegance of the solution, $t(251) = 1.28$, $p = .200$. Thus, hypothesis 1 was not supported. To test the hypotheses and research question, three one-way ANCOVAs were conducted. All assumptions of an ANCOVA were met, thus the analysis was subsequently performed. There was a significant main effect of constraint manipulation on the quality of the solution between the condition groups while controlling for the participants' football marketing experience, $F(4, 250) = 4.02$, $p = .004$, $\eta_p^2 = .06$. Bonferroni post-hoc analyses were performed to examine the specific group differences. Specifically, participants in the decreasing constraint condition group (Condition 2) produced significantly higher quality solutions than those in the consistently constrained group (Condition 1), $p = .027$. Further, those in the decreasing constraint group produced higher quality solutions than those in the increasing constraint group (Condition 3), $p = .005$. Finally, the difference between the adjusting group (Condition 4) and the decreasing

constraint group approached significance (p = .051), such that those in the decreasing constraint group produced higher quality solutions than the adjusting group. There were no further significant differences between the groups with regard to quality. Means and standard errors for all condition groups are presented in Table 4. Thus, these results failed to support the first hypothesis that those who received constraints would develop higher quality solutions than those who did not receive constraints. However, results do provide partial support for the second hypothesis such that individuals who had constraints removed during the idea generation phase developed higher quality solutions than those who received only one constraint (Condition 1). These findings also provide some guidance in answering the first research question of how constraints that fluctuate influence creativity such that it may be ideal to remove constraints once they have been introduced, suggesting that constraints may be beneficial in the design process.

Table 3

Means, Standard Deviations, and Correlations for all Study Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
1. Quality	2.92	0.75	1.00									
2. Originality	1.92	0.87	.46**	1.00								
3. Elegance	2.55	0.78	.57**	.36**	1.00							
4. Evaluation Quality	2.98	0.79	.50**	.18**	.44**	1.00						
5. Evaluation Valence	3.04	0.65	.30**	.13*	.22**	.22**	1.00					
6. GPA	4.19	8.31	-.05	.02	-.04	.00	.02	1.00				
7. Marketing Experience	2.39	0.88	.13*	.07	.17**	.10	-.02	.00	1.00			
8. Football Marketing Experience	1.93	0.78	-.19**	-.07	-.14*	-.08	-.04	-.09	.26**	1.00		
9. Neuroticism	3.06	0.73	.03	-.09	-.06	-.05	.03	-.01	-.04	-.04	1.00	
10. Openness	3.40	0.57	.18**	.11	.15*	-.18**	-.01	.00	.22**	-.22**	-0.04	1.00
11. Agreeableness	3.55	0.54	-.01	.06	-.01	.12	-.05	-.01	-.09	.03	-.32**	0.00
12. Extraversion	3.39	0.55	-.05	.05	-.02	-.10	.01	-.01	.15*	.23**	-.41**	0.00
13. Conscientiousness	3.70	0.53	-.04	-.01	.06	.03	-.14*	-.02	.05	.11	-.29**	-.10
14. NFC	3.35	0.60	.07	.16*	.00	-.07	-.08	-.03	.13	-.04	-.16*	.34**
15. Age	19.87	4.52	.10	.10	.06	.04	-.06	-.05	.09	-.10	-.19**	0.09
16. Gender	1.70	0.46	-.03	-.07	.00	.03	-.05	-.03	-.05	.40	0.05	-0.10
17. Divergent Thinking Fluency	5.38	1.49	.11	.11	.07	.02	.05	-.08	.15*	-.01	0.01	0.08
18. EAS	22.78	5.88	.19**	.16*	.05	.12	.10	-.02	.00	-.06	0.12	.13*

Notes. * = $p < .05$; ** = $p < .001$

Table 3 (cont).

	11	12	13	14	15	16	17	18
11. Agreeableness	1.00							
12. Extraversion	.24**	1.00						
13. Conscientiousness	.26**	.17**	1.00					
14. NFC	.08	-.03	.21**	1.00				
15. Age	.11	.04	.02	.17**	1.00			
16. Gender	.27**	.07	.21**	-.14	-.04	1.00		
17. Divergent Thinking Fluency	-.03	.07	-.01	-.15*	.05	.13*	1.00	
18. EAS	-.06	-.07	-.12	.08	-.08	-.11	.02	1.00

Notes. * = $p < .05$; ** = $p < .001$

Table 4

Means and Standard Error for Study Variables

Condition	Quality			Originality			Elegance			Evaluation Quality			Evaluation Valence		
	n	*M*	*SE*	*n*	*M*	*SE*	*n*	*M*	*SE*	*n*	*M*	*SE*	*n*	*M*	*SE*
1. Constrained	51	2.80	0.10	51	2.00	0.12	51	2.72	0.11	51	3.03	0.11	51	2.90	0.08
2. Decrease Constraint	52	3.23	0.10	52	2.02	0.12	52	2.56	0.10	52	3.05	0.11	52	3.47	0.08
3. Increase Constraint	50	2.72	0.10	50	1.62	0.12	50	2.29	0.11	50	2.92	0.11	50	2.66	0.08
4. Adjusting Constraint	53	2.83	0.10	53	1.78	0.12	53	2.51	0.10	53	2.98	0.11	53	3.05	0.08
5. Unconstrained	50	2.99	0.10	50	2.20	0.12	50	2.66	0.11	50	2.94	0.11	50	3.09	0.08

There was also a significant main effect of constraint manipulation on the originality of the solution while controlling for intelligence, $F(4, 250) = 3.59$, $p = .007$, $\eta_p^2 = .05$. Specifically, the Bonferroni post-hoc tests revealed that those in the unconstrained group (Condition 5) produced more original solutions than those in the increasing constraint group (Condition 3), $p = .007$. There were no further differences between the groups with regard to originality. Means and standard errors for all condition groups are presented in Table 4. These finding fail to support hypotheses one and two. Specifically, these results suggest that being unconstrained may be more beneficial for originality than being overly constrained. However, there were no other differences between being unconstrained and the other conditions suggesting that in regard to originality, the constraint manipulation did not elicit unique differences. These findings also provide some clarification on the first research question such that being increasingly constrained appeared to negatively impact the originality of the solution.

There was also a significant main effect of constraint manipulation on the elegance of the solution while controlling for football marketing experience and general marketing experience, $F(4, 249) = 2.45$ $p = .047$, $\eta_p^2 = .04$. In examining the Bonferroni post-hoc analyses, those who were consistently constrained (Condition 1) produced significantly more elegant solutions than those who received increasing constraints (Condition 3), $p = .044$. There were no further differences between the condition groups. Means and standard errors for all condition groups are presented in Table 4. Thus, these findings do not support hypothesis one as there were no inherent differences between the constrained groups and the unconstrained group. Further, there was no direct support for hypothesis two, in fact, the relationship was in the opposite direction as expected. These findings provide some guidance in answering the first research question such that being overly constrained may inhibit the elegance of the solution.

To examine the second research question regarding how introducing and removing constraints influenced the quality and valence of idea evaluations, two one-way ANCOVAs were performed. There was no significant main effect of the constraint manipulation on evaluation quality, while controlling for openness to experience, $F(4, 250) = .27$, $p = .900$, $\eta_p^2 = .004$. Means and standard errors for all condition groups are presented in Table 4. Thus, in answering the second research question these findings suggest that there may be no effect of constraint manipulation on the quality of the evaluation.

In contrast, there was a significant main effect of constraint manipulation on evaluation valence while controlling for conscientiousness, $F(4, 250) = .12.60$, $p < .001$, $\eta_p^2 = .17$. Bonferroni post-hocs were performed to examine the individual group differences. Participants who received a decrease in constraints (Condition 2) had significantly more positive emotions regarding their evaluations than those who received the same constraint throughout (Condition 1), $p < .001$, an increase in constraints (Condition 3), $p < .001$, adjusting constraints (Condition 4), $p = .004$, and those who were unconstrained throughout (Condition 5), $p = .017$. Further, those who received an adjusting constraint had significantly more positive evaluations than those who had an increase in constraints, $p = .011$. Finally, those who were unconstrained throughout (Condition 5) also provided significantly more positive evaluations than those who received an increase in constraints (Condition 3), $p = .003$. Means and standard errors for all condition groups are presented in Table 4. Thus, there is some evidence that the manipulation of the constraint influences the valence of the evaluation such that individuals who had a decrease of constraints viewed their designs more favorably compared to the other condition groups.

CHAPTER 4: DISCUSSION

4.1 Limitations

Prior to turning to the broader conclusions of the study, it is first necessary to address the limitations. Inherent to the sample, the present study used a low-fidelity task. First, the sample reported a low experience in marketing expertise and thus, one may conclude there would be different results with a more experienced sample. However, it is important to note that despite scholars (e.g., Vincent, Decker, & Mumford, 2002) arguing expertise as a relevant factor for creative performance, the findings from this effort may still be relevant for early career professionals. Further, the task used in this situation was conducted over a maximum of two hours. Although a more realistic marketing task would unfold over multiple months, the existing task focused on the idea development, and not implementation of ideas. Over a longer period of time, it is likely that the task would introduce multiple external factors (e.g., a timeline, more constraints) that would uniquely influence the results. Thus, the results from a more realistic effort may or may not produce different results.

Notably, there were limitations inherent to the manipulation used in the experimental task. A realistic marketing campaign would likely include a multitude of constraints such as the timeline of the project, the project team, goals, and target market. As such, the present study employed only one single constraint, and although allowing for the isolation of a single effect as opposed to examining a package manipulation, further results may be found in the inclusion of a combination of constraints. Further, a multiple combination of constraints (e.g., budget, timeline, team characteristics, goals, target market) would likely fluctuate and be more dynamic with one another (Onarhiem, 2012). For example, the timeline of a project may be influenced and

fluctuate with regard to the budget of the project. As such, the dynamic nature of multiple constraints may produce different, notable effects. However, the present effort did include conditions where the budget constraint fluctuated and thus, may be able to provide some insight into expected findings. In addition, as scholars (e.g., Stokes, 2009) have proposed, individuals frequently introduce their own constraints when faced with a complex problem solving task. Thus, it is unclear how these unique processes collectively may influence creative problem solving efforts.

Additionally, for consistency and to avoid some participants being given more than one opportunity to generate ideas, participants in the unconstrained and constrained conditions both received the same fictitious budget during three design periods. Indeed, their final designs may be subject to a fatigue effect where their initial designs may have been worse. However, the study was conducted over a brief period of time and was generally representative of an idea generating task in a real-world setting.

Another potential limitation was due to participants taking the study in a group setting. Although the participants completed the work individually, the participants were exposed to other participants also completing the study in the same room. Thus, it is plausible to suggest there were some external social factors that may have influenced participants to rush to complete the study when others had finished. For example, if a participant witnessed another finish the study early, it may have caused the participant to rush to complete the study. Further studies could attempt to replicate this study with stricter control.

Finally, the present study only explored the influence of constraints on idea generation and idea evaluation. Although relevant, these findings may not generalize to subsequent processes during creative problem solving efforts. Prior work (e.g., Medeiros et al., 2017) has

established how constraints may uniquely influence problem identification such that as constraints are introduced, individuals cycled back to an early process and redefined the problem. Despite these limitations, the present study does provide unique insights into the constraint and creativity relationship.

4.2 Theoretical Implications

Although prior efforts have examined constraints and creative problem solving, this effort, to our knowledge, is the only study that has examined both the introduction and removal of constraints during idea generation. In assisting clarification to the debate on constraints and creativity, this study provides a unique contribution to the creativity literature suggesting that constraints can positively influence creativity. However, in accordance with the literature, this relationship is more complex than first expected. As such, the present study explores not whether to use or not use constraints during creative problem solving efforts but diverts the attention of the literature toward the how, and when.

In alignment with prior literature (e.g., Haught-Tromp, 2016; Medeiros et al., 2018) the results from this study do suggest that if constraints are inherent to a task, it may not be problematic to address the constraints upfront and present them at the start of the task, with the intention of working around them during the later stages of a project. Specifically, in regard to the quality of the design, removing a constraint after its initial onset may be more beneficial than introducing more constraints. Further, introducing constraints later on in the project produced lower quality solutions than solutions which had constraints removed or kept the same. These findings are in tandem with the existing literature (e.g., Medeiros et al., 2018) suggesting that introducing constraints later in the creative process disrupted creative problem solving. These results may be due to the constraints initially limiting the problem space, granting a more

definitive onset of ideas to which when the constraint is later removed, allows the individual to incorporate prior ideas that did not initially fit the constraint. Also, the present effort found no differences in quality between those who were constrained and those who were unconstrained, suggesting that constraints may not be as harmful to creativity as some scholars have proposed.

In regard to the originality of the solutions, participants who were unconstrained outperformed those who received an increase of constraints but did not differ from the other conditions. This may be due to the over use of constraints perhaps providing difficulty for the participants to integrate and generate new ideas outside of the already limited problem space, through a decrease in intrinsic motivation (Amabile, 1979). Alternatively, the participants who had constraints, a decrease of constraints, and adjusted constraints did not differ from those who were unconstrained suggesting a similar pattern to that of the quality of the idea that constraints may not necessarily be bad for creative problem solving when used appropriately. Taken together, one strategy for individuals who receive an increase of constraints may cycle back to the initial stages of idea generation rather than try to incorporate their existing ideas to fit the new constraint.

Notably, the overall means for originality were consistently low. This may be a result of the overall low marketing experience of the sample used or the type of task used in the experimental condition. Another avenue for the overall low originality means may be the inherent bias individuals have toward generating novel ideas. Despite recognizing creativity as an important goal, many decision makers have a bias toward original ideas, leading them to engage and produce more familiar solutions (Ford & Gioia, 2000; Staw, 1995; West, 2002). This may be expected and in alignment with the experience of the sample such that the originality of

the idea may promote uncertainly in the practicality, usefulness, and reproducibility of an idea (Amabile, 1996).

In regard to the elegance of the design, individuals who were consistently constrained produced more elegant designs than those who were increasingly constrained. This is likely due to the limited problem space imposed by adding constraints to a task that in theory, should produce a better flow of ideas than individuals who attempt incorporate as many ideas as possible (Haugh-Tromp, 2016). However, it may be the case that increasing the magnitude of constraints reduced the individual's intrinsic motivation to continue the logical, coherent, flow of ideas. These finds link similarly to that of the well-known paradox of choice such that too little constraint pressure leads to too many options and no way to eliminate them (Joyce, 2009).

In regard to the second research question, constraints did not seem to influence the quality of the evaluations. This may be caused by the inherent nature of the experimental design such that participants evaluated their designs at the end of three separate designs. Another possible reason for these results may be the task only including one constraint. Constraint often provide a set of standards by which an individual evaluates a solution (Johnson-Laird, 1988). With this study only utilizing one constraint, there may have been different results had multiple constraints been introduced. Scholars (e.g., Goor & Somerfield, 1975; Mumford et al., 2002) argue that the evaluation of ideas should spark a revision process by which new ideas may be generated in order to meet the evaluation standards. Thus, future research could explore further into these unique processes with multiple constraints that fluctuate at different timepoints.

Additionally, constraints did seem to impact the valence of the evaluations. Specifically, the individuals who had a decrease in constraints appeared to view their ideas more favorably than all other condition groups. One explanation for this may be receiving the constraint early on

and then removing the constraint gives the individual a longer period of time to internally evaluate their idea. Thus, they are less likely to point out flaws in their ideas by having already potentially addressed these flaws. However, this induces a unique evaluative process whereby individuals who viewed their designs less favorably may be more critical of their ideas. Therefore, more research is needed to specifically highlight these unique processes when introducing and removing constraints. Although historically, creativity research has focused on the generative processes involved in creative problem solving, few of these ideas are ever implemented (Sharma, 1999), thus, research into the evaluative processes involved creative problem solving is a critical component yet to be truly uncovered.

Last, an additional finding worth addressing was the significance of marketing experience and the specific domain relevant marketing experience. These two covariates highlight the importance of experience in the field or domain when developing novel solutions. The relationship of domain experience has been well supported in the creativity literature. However, the particular importance of domain experience may be uniquely useful when dealing with constraints such that the knowledge of the field may provide individuals novel pathways when working around constraints. For example, individuals with high domain experience may be better equipped at handling constraints and thus, respond better to their introduction early on in a task at preventing them from engaging in well-worn cognitive pathways. Thus, future research could explain the specific interaction of domain relevant experience and constraints. These findings have notable implications for case-based knowledge in education and for early career professionals such that the more relevant experience one is exposed to, the better one may be at handling and incorporating constraints.

4.3 Future Research

One potential avenue for replication of this study would be to conduct the experiment with a more experienced sample. Replicating the study with a more representative sample (e.g., trained marketing promoters) may elicit further unique processes that this study was unable to capture and could provide further insight into the complex relationship experience has with constraints. Moreover, future studies should aim to examine the relationship of multiple constraints and multiple domains of constraints (e.g., goal constraints, team constraints, resource constraints) and their interactive effect on creative performance. These findings would help provide a more realistic estimate of the likely constraint during a creative problem solving effort. Insight into the interactive effect of multiple constraints may also highlight how some constraints may negatively influence creativity whereas alternative constraints may positively influence creativity.

Notably, the present effort assessed creative performance strictly bound to the individual. Most creative effort take place in project teams and thus a replication of this effort with a multiple individual's working together may provide insight into how team members manage constraints together and the key processes needed to do so effectively. Further, as scholars have argued, creative problem solving is a fundamental process associated with effective leadership (Mumford & Connelly, 1991; Mumford et al., 2000). More research is needed on the leader cognition to understand how leaders best communicate, identify, and manage constraints within teams to effectively use constraints.

Along these lines, it appears that in tandem with earlier findings on constraints and creativity (e.g., Medeiros et al., 2018), the introduction of late cycle constraints seemed to hinder creative performance. Future research should explore how to effectively handle the introduction of late cycle constraints and to incorporate existing ideas to fit the introduction of said

constraints. Given that the unplanned introduction of new constraints may emerge through a project lifecycle, this research may be essential for the practical implications of constraints and creativity.

4.4 Conclusion

Taken together, these findings suggest that constraints are not necessarily bad for creativity across quality, originality, and elegance. However, they can be leveraged to help or harm creative performance. Creative problem solving is not a singular light bulb moment, and instead, is an intentional search of improvement (Anderson & Gasteiger, 2007) comprised of many dynamic and recursive processes (Mumford, Mobley, Ulhman, Reiter-Palmon, & Doares, 1991). Future research should explore the specific balance of how, when, and where to introduce multiple constraints in the creative process solving act.

REFERENCES

Amabile, T. M. (1979). Effects of external evaluation on artistic creativity. *Journal of Personality and Social Psychology, 37*, 221-233. doi: 10.1037/0022-3514.37.2.221

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology, 45,* 357-376. doi:10.1037/0022-3514.45.2.357

Amabile, T. M. (1996). Creativity in context: Update to "the social psychology of creativity." Boulder, CO: Westview Press.

Amabile, T. M., & Gryskiewicz, N. D. (1989). The creative environment scales: Work environment inventory. *Creativity Research Journal, 2*, 231–253. doi:10.1080/10400418909534321

Baer, M., & Oldham, G. R. (2006). The curvilinear relation between experienced creative time pressure and creativity: Moderating effects of openness to experience and support for creativity. *Journal of Applied Psychology, 91*, 963–970. doi:10.1037/0021-9010.91.4.963

Batey, M., & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs, 132,* 355-429. doi:10.3200/mono.132.4.355-430

Bem, D. J. (1972). Self-Perception theory. *Advances in Experimental Social Psychology*, 1–62. doi:10.1016/s0065-2601(08)60024-6

Berg, J. M. (2014). The primal mark: How the beginning shapes the end in the development of creative ideas. *Organizational Behavior and Human Decision Processes, 125*(1), 1–17. doi:10.1016/j.obhdp.2014.06.001

Besemer, S. P., & O'Quin, K. (1999). Confirming the three-factor creative product analysis matrix model in an American sample. *Creativity Research Journal, 12,* 287–296. doi:10.1207/s15326934crj1204_6

Blot, K. J., Zárate, M.A., & Paulus, P.B., (2003). Code-switching across brainstorming sessions: Implications for the revised hierarchical model of bilingual language processing. *Experimental Psychology, 50*, 171-183. doi:10.1027//1618-3169.50.3.171

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119,* 197–253. doi:10.1037/0033-2909.119.2.197

Cacioppo, J. T., Petty, R. E., & Kao, C. F. (1984). Need for cognition scale-short form. PsycTESTS Dataset. doi:10.1037/t06602-000

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

Cooper, S. Y. & Lucas, W. A. (2006). Developing self-efficacy for innovation and entrepreneurship: An educational approach. *International Review of Entrepreneurship, 4*, 141-161

Costa, P. T., & McCrae, R. R. (1989). Neo Five-Factor Inventory (NEO-FFI). Odessa, FL: Psychological Assessment Resources.

Costa, P. T., Jr., & McCrae, R. R. (1992). Revised NEO Personality Inventory (NEO-PI-R) and NEO Five Factor Inventory (NEO-FFI) Professional Manual. Odessa, FL: Psychological Assessment Resources.

Cropley, A. J. (1999). Creativity and cognition: Producing effective novelty. *Roeper Review, 21*, 253–260. doi:10.1080/02783199909553972

Csikszentmihalyi, M. (1990). The domain of creativity. In M. A. Runco & R. S. Albert (Eds.), Theories of creativity (pp. 190–214). London: Sage.

Csikszentmihalyi, M. (1996). Creativity. New York, NY: Harper Collins

Deci, E. L. (1971). Effects of externally mediated rewards on intrinsic motivation. *Journal of Personality and Social Psychology, 18,* 105-115. doi:10.1037/h0030644

Eysenck, H. J. (1997). Creativity and personality. In M. A Runco (Ed.), The creativity research handbook (pp. 41-66). Eresskill, NY: Hampton Press

Friedman, R. S. (2009). Reinvestigating the effects of promised reward on creativity. *Creativity Research Journal, 21*, 258-264. doi:10.1080/10400410902861380

Ford, C. M., & Gioia, D. A. (2000). Factors influencing creativity in the domain of managerial decision making. *Journal of Management, 26,* 705–732. doi:10.1177/014920630002600406

George, J. M. (2007). Creativity in organizations. *Academy of Management Annals, 1*(1), 439–477. doi:10.5465/078559814

Gilson, L. L., Mathieu, J. E., Shalley, C. E., & Ruddy, T. M. (2005). Creativity and standardization: Complementary or conflicting drivers of team effectiveness? *Academy of Management Journal, 48,* 521–531. doi:10.5465/amj.2005.17407916

Goor, A., & Sommerfeld, R. E. (1975). A comparison of problem-solving processes of creative students and noncreative students. *Journal of Educational Psychology, 67*, 495–505. doi:10.1037/h0077009

Grimsley, G. L., Ruch, F. L., Warren, N. D., & Ford, J. S. (1985). Manual for the employee attitude survey, test of verbal reasoning. Glendale, CA: Psychological Services.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*, 444–454. doi:10.1037/h0063487

Guilford, J. P. (1959). Three faces of intellect. *American Psychologist, 14*, 469–479. doi:10.1037/h0046827

Hargadon, A., & Sutton, R. I. (1996). Technology brokering and innovation in a product design firm. *Administrative Science Quarterly, 42*, 716–749. doi:10.2307/2393655

Haught-Tromp, C. (2017). The green eggs and ham hypothesis: How constraints facilitate creativity. *Psychology of Aesthetics, Creativity, and the Arts, 11*, 10-17. doi:10.1037/aca0000061

Haught-Tromp, C., & Stokes, P. D. (2016). Constraints, competency and creativity in the classroom. *Creativity and Giftedness*, 105–116. doi:10.1007/978-3-319-38840-3_7

Hester, K. S., Robledo, I. C., Barrett, J. D., Peterson, D. R., Hougen, D. P., Day, E. A., & Mumford, M. D. (2012). Causal analysis to enhance 209 creative problem solving: Performance and effects on mental models. *Creativity Research Journal, 24*, 115–133. doi:10.1080/10400419.2012 .677249

Joyce, C. K. (2009). The blank page: Effects of constraint on creativity. *SSRN Electronic Journal.* doi:10.2139/ssrn.1552835

Johnson-Laird, P. N. (1988) Freedom and constraint in creativity. In R. K. Sternberg (Ed.), The nature of creativity: Contemporary psychological perspectives (pp. 202-219). New York, NY: Cambridge University Press.

LeBreton, J. M., James, L. R., & Lindell, M. K. (2005). Recent issues regarding rWG, rWG, rWG(J), and rWG(J). *Organizational Research Methods, 8*(1), 128–138. doi:10.1177/1094428104272181

Lepper, M. R., Greene, D., & Nisbett, R. E. (1973). Undermining children's intrinsic interest with extrinsic reward. *Journal of Personality and Social Psychology, 28*, 129-137. doi:10.37/h0035519

Lindell, M. K., & Brandt, C. J. (1999). Assessing interrater agreement on the job relevance of a test: A comparison of CVI, T, rWG(J)}, and r*WG(J) indexes. *Journal of Applied Psychology, 84,* 640–647. doi:10.1037/0021-9010.84.4.640

Litchfield, R. C. (2008). Brainstorming reconsidered: A goal-based view. *Academy of Management Review, 33,* 649–668. doi:10.5465/amr.2008.32465708

Maltzman, I. (1960). On the training of originality. *Psychological Review, 67,* 229–242. doi:10.1037/h0046364

Mayer, M. A. (2006, February 12). Creativity loves constraints…but they must be balanced with a healthy disregard for the impossible. *Bloomberg.* Retrieved from http://www.bloomberg.com/news/articles/2006-02-12/creativity-loves-constraints

Medeiros, K. E., Partlow, P. J., & Mumford, M. D. (2014). Not too much, not too little: The influence of constraints on creative problem solving. *Psychology of Aesthetics, Creativity, and the Arts, 8*, 198-210. doi:10.1037/a0036210

Medeiros, K. E., Steele, L. Watts, L. L., & Mumford, M. D. (2018). Timing is everything: Examining the role of constraints throughout the creative process. *Psychology of Aesthetics, Creativity, and the Arts*, *8*. doi:10.1038/aca0000148

Medeiros, K. E., Watts, L. L., & Mumford, M. D. (2017). Thinking inside the box: Educating leaders to manage constraints. In C. Zhou (Ed.) Handbook of Research on Creative Problem-Solving Skill Development in Higher Education (pp. 25-50). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-0643-0.ch002

Moreau, C. P., & Dahl, D. W. (2005). Designing the solution: The impact of constraints on consumers' creativity. *Journal of Consumer Research, 32*(1), 13–22. doi:10.1086/429597

Mumford, M. D. (2001). Something old, something new: Revisiting Guilford's conception of creative problem solving. *Creativity Research Journal, 13*, 267 – 276. doi:10.1207/s15326934crj1334_04

Mumford, M. D., & Gustafson, S. B. (1988). Creativity syndrome: Integration, application, and innovation. *Psychological Bulletin, 103*, 27 – 43. doi:10.1037//0033-2909.103.1.27

Mumford, M. D., Medeiros, K. E., & Partlow, P. J. (2012). Creative thinking: Processes, strategies, and knowledge. *The Journal of Creative Behavior, 46,* 30–47. doi:10.1002/jocb.003

Mumford, M. D., Mobley, M. I., Reiter-Palmon, R., Uhlman, C. E., & Doares, L. M. (1991). Process analytic models of creative capacities. *Creativity Research Journal, 4,* 91–122. doi:10.1080/10400419109534380

Mumford, M. D., Marks, M. A., Connelly, M. S., Zaccaro, S. T., & Reiter-Palmon, R. (2000). Development of leadership skills: Experiences and timing. *The Leadership Quarterly, 11*, 87–114. doi:10.1016/ S1048-9843(99)00044-2

Nijstad, B. A., De Dreu, C. K., Rietzschel, E. F., & Baas, M. (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *European Review of Social Psychology, 21*, 34-77. doi:1-.1080/10463281003765323

Onarheim, B. (2012). Creativity from constraints in engineering design: Lessons learned at Coloplast. *Journal of Engineering Design, 23*, 323-336. doi:10.1080/09544828.2011.631904

Onarheim, B., & Biskjaer, M. M. (2015). Balancing constraints and the sweet spot as coming topics for creativity research. In L. J. Ball (Ed.), Creativity in Design: Understanding, Capturing, Supporting.

Peterson, D. R., Barrett, J. D., Hester, K. S., Robledo, I. Ci., Hougen, D. F., Day, E. A., & Mumford, M. D. (2013). Teaching people to manage constraints: Effects on creative problem-solving. *Creativity Research Journal, 25*, 335-347. doi:10.1080/10400419.2013.813809

Pool, R. (1997). Beyond engineering: How society shapes technology (Vol. 600). New York, NY: Oxford University Press.

Robins, R. W., Fraley, R. C., Roberts, B. W., & Trzesniewski, K. H. (2001). A Longitudinal Study of Personality Change in Young Adulthood. *Journal of Personality, 69*, 617–640. doi:10.1111/1467-6494.694157

Runco, M. A. (1986). Flexibility and originality in children's divergent thinking. *Journal of Psychology, 120*, 345-352. doi:10.1080/00223980/1986.9712632

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal, 24*, 92-96. doi:10.1080/10400419.2012.650092

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The effectiveness of creativity training: A quantitative review. *Creativity Research Journal, 16*, 361–388. doi:10.1080/10400410409534549

Shalley, C. E., & Gilson, L. L. (2016). Creativity and the management of technology: Balancing creativity and standardization. *Production and Operations Management, 26,* 605-616. doi:10.1111/poms/12639

Sharma, A. (1999). Central dilemmas of managing innovation in large firms. *California Management Review, 41,* 146–164. doi:10.2307/41166001

Stokes, P. D. (2007). Using constraints to generate and sustain novelty. *Psychology of Aesthetics, Creativity, and the Arts,* 1, 107-113. doi:10.1037/1931-3896.1.2.107

Stokes, P., & Fisher, D. (2005). Selection, constraints, and creativity case studies: Max Beckmann and Philip Guston. *Creativity Research Journal, 17*, 283–291. doi:10.1207/s15326934crj1702&3_13

Stokes, P. D. (2009). Using constraints to create novelty: A case study. *Psychology of Aesthetics, Creativity, and the Arts, 3*, 174–180. doi:10.1037/a0014970

Stone, B. (2014). *Things a little bird told me: Creative secrets from the co-founder of Twitter.* New York: Grand Central Publishing.

Torrents Martín, C., Ric, Á., & Hristovski, R. (2015). Creativity and emergence of specific dance movements using instructional constraints. *Psychology of Aesthetics, Creativity, and the Arts, 9*, 65–74. doi:10.1037/a0038706

Tversky, A., & Kahneman, D. (1974.). Judgment under uncertainty: Heuristics and biases. Judgment Under Uncertainty, 3–20. doi:10.1017/cbo9780511809477.002

Treffinger, D. J., & Isaksen, S. G. (1992). Creative problem solving: An introduction. Sarasota, FL: Center for Creative Learning.

Toh, C. A., Patel, A. H., Strohmetz, A. A., & Miller, S. R. (2015). My idea is best! Ownership bias and its influence on engineering concept selection. Volume 7: 27th International Conference on Design Theory and Methodology. doi:10.1115/detc2015-46478

Vincent, A. S., Decker, B. P., & Mumford, M. D. (2002). Divergent thinking, intelligence, and expertise: A test of alternative models. *Creativity Research Journal, 14,* 163–178. doi:10.1207/ S15326934CRJ1402_4

Ward, W. C. (1969). Rate and uniqueness in children's creative responding. *Child Development*, *40*, 869-878. doi:10.1111/j.1467-8624.1969/tb04548.x

Weiss, M., Hoegl, M., & Gibbert, M. (2011). Making virtue of necessity: The role of team climate for innovation in resource-constrained innovation projects. *Journal of Product Innovation Management, 28*(1), 196–207. doi:10.1111/j.1540-5885.2011.00870.x

West, M. A. (2002). Sparkling fountains or stagnant ponds: An integrative model of creativity and innovation implementation in work groups. *Applied Psychology*, *51*, 355–387. doi:10.1111/1464-0597.009