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ASSEMBLING THE BOX: THE ROLE OF CONSTRAINTS IN CREATIVE PROBLEM SOLVING

A DISSERTATION APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

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Abstract

Although traditional conceptions of creativity argue for the benefits of a free and unconstrained creative process, recent research suggests that implementing constraints may enhance creative problem solving. Previous studies investigating this relationship, however, primarily examine the relationship between constraints and idea generation. The present effort aimed to add to our understanding of this relationship by examining the role of constraints at the process level. Approximately 300 undergraduate students completed an experimental task in which the type, number, and timing of constraints were manipulated. All participants engaged in four processes: problem identification, conceptual combination, idea generation, and idea evaluation prior to developing a final solution. Each process and the final proposal were coded and used as dependent variables in the analysis. Results suggest that introducing constraints prior to problem identification improves creative performance on final proposals and that constraints encourage engagement in evaluative processing. Findings regarding effects of types and amount of constraints on specific processes, as well as the implications of these results, are discussed.

Keywords: creative problem solving, constraints, problem identification, conceptual combination, idea generation, idea evaluation

Assembling the box: Constraints and creative problem solving

The phrase "thinking outside the box" saturates popular conceptions of creativity with the idea that the creative process requires unbridled freedom. Osborn's (1957) seminal work in brainstorming typifies this thinking, calling for wild and unevaluated idea generation. Similarly, the "blue-sky" technique (Buzan, 1993; De Bono, 1992) calls for free association when generating ideas, and encourages individuals to follow their instinct and avoid systematic investigations of problems. Recently, however, these ideas have been increasingly challenged by studies (e.g., Litchfield, 2008; Paulus, Nakui, Putman, & Brown, 2006; Rietzschel, Slijkhuis, & Van Ypere, 2014) revealing the benefits of structure or rules to creative performance. Still others have argued that perhaps creativity isn't about thinking outside the box, but instead, developing a creative solution that fits *inside* the box (Medeiros, Watts, & Mumford, in press). The rules, structure, and our metaphorical box, act as a constraint on creativity. Each inherently limits or restricts what is possible, a concept incompatible with traditional views of creative problem solving. These changing perceptions of creativity have led to a burgeoning area of research focusing on what, when, and how constraints may influence creative problem solving.

For instance, Hoegl, Gibbert, and Mazursky (2008) argued that although resource slack is often considered an important factor for creativity and innovation (e.g., Amabile, 1996; Damanpour, 1991), a lack of resources may be compensated for by team and project characteristics such as cohesion, potency, domain-relevant skills, and exciting project goals. Similarly, in an experimental study, Medeiros, Partlow, and Mumford (2014) found creative problem solving was not hindered when certain constraints were presented and participants were high in Need for Cognition (Cacioppo & Petty, 1982). In other words, if participants were willing to work with the constraints presented, their solutions were not harmed by the presence of constraints.

While experimental studies have made it possible to isolate certain effects that constraints impose on creativity, the bulk of the evidence directly examining this relationship stems from case studies. For example, Stokes and colleagues (e.g., Stokes, 2001, 2008, 2009; Stokes & Fisher, 2005) conducted a series of studies reviewing artists, musicians, sculptors, and architects. Contradicting stereotypes, they found that many of these great artists imposed constraints upon themselves. Further, in an analysis of Monet's work, Stokes (2001) found that Monet regularly shifted task constraints in order to increase the variability in his work. Along these lines, Onarheim (2012) found that constraints played a pivotal role in the design process for Coloplast engineers. However, Onarheim notes that how engineers viewed these constraints varied across individuals, with some viewing them as helpful and others viewing them as harmful.

Although the body of evidence suggests a generally positive relationship between constraints and creativity, much of the experimental work investigating this relationship focuses primarily on generative processes. For example, studies have examined participants' production of marketing plans (Medeiros, Partlow, & Mumford, 2014), novel sentences (Haught & Johnson-

Laird, 2003), and tool development (Finke, Ward, & Smith, 1992). The creative problem-solving literature, however, suggests that creativity is not solely a generative process. In fact, some have theorized that up to eight processes are involved in producing creative ideas (Mumford, Mobley, Reiter-Palmon, Uhlman, & Doares, 1991). In order to better understand how constraints influence creative problem solving, it is important to examine the process more globally. Therefore, the present effort aims to examine the role of constraints across multiple creative problem-solving processes.

Creative Problem Solving

Although definitions of creative problem solving vary slightly in the literature, researchers tend to agree that creative problem solving involves producing high quality and original solutions to new, ill-defined problems (Amabile, 1996; Mumford & Gustafson, 1988; Runco & Jaeger, 2012). Quality refers to the logic and usefulness of a proposed solution while originality refers to a proposed solution's novelty and uniqueness. Additionally, some research (e.g., Besemer & O'Quin, 1999; Cropley & Cropley, 2008) emphasizes the importance of solution elegance, which refers to the refinement and flow of components within a solution.

Several models of creative problem solving detailing the processes by which individuals develop solutions requiring creative thought have been proposed. For instance, based on Osborn's (1952) conceptualization of creative problem solving, Treffinger and Isaksen (1992) proposed three primary stages. These stages include (a) understanding the problem, (b) generating ideas, and

(c) planning for action. For a review of these processes and their development, see Isaksen and Treffinger (2004). Amabile (1996) described a similar model, which includes (a) problem identification, (b) preparation, or gathering of relevant information and resources, (c) idea generation, and (d) validation and communication. Mumford and colleagues (1991) proposed a more specific, eight-stage model including (a) problem identification, (b) information gathering, (c) concept selection, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) monitoring. Although these models are not necessarily linear, they are cyclical, and somewhat dependent on earlier processes. For instance, one cannot evaluate an idea without the existence of generated ideas. Similarly, without a problem, one cannot generate targeted solutions. Furthermore, if during the idea evaluation stage, someone notices a new problem, it may require a return to the start to find solutions to this newly identified problem.

Despite variations in specificity, these models share at least three processes – problem identification, idea generation, and idea evaluation. Indeed, many studies stress the importance of problem identification (e.g., Mumford, Reiter-Palmon, & Redmond, 1994) and idea evaluation (e.g., Gibson & Mumford, 2013) in creative problem solving. Additionally, given that something cannot be developed from nothing, conceptual combination, or the creation of new knowledge structures based on extant concepts (Mumford et al., 1991), is an important step in the creative process. Unfortunately, experimental work on constraints and creative problem solving fails to account for these different processes. Thus, examining the impact of constraints at the process level, rather than an overall solution level may offer unique insights into how constraints influence creative problem solving. To that end, the present study manipulated the timing of constraint delivery, type of constraint, and number of constraints in an experimental, multiple time-point design in order to investigate the influence of constraints on problem identification, conceptual combination, idea generation, idea evaluation, and the final proposal.

Constraints in Problem Definition

The *Green Eggs and Ham* Hypothesis, proposed by Haught-Tromp (in press), earned its name based on a bet made between Theodore Geisel, more commonly known as Dr. Seuss, and his publisher. Faced with his publisher's challenge to write a children's story in 50 words or less, Mr. Geisel developed his famed book, *Green Eggs and Ham*. Mr. Geisel's success with such a limited set of words suggests that perhaps, creativity can flourish even when constrained. The *Green Eggs and Ham* hypothesis argues just this – that constraints may positively influence creative performance. Further, the hypothesis suggests that this impact occurs through problem definition activities, whereby constraints narrow the potential problem space. This narrowed problem space limits the number of potential solutions and allows for deeper processing of each.

Similarly, the dual-pathway model (De Dreu, Baas, & Nijstad, 2008; Nijstad, De Dreu, Rietzschel, & Baas, 2010) argues that there are two potential paths leading to creative performance: flexibility and persistence. Flexibility aligns most closely with traditional conceptions of creativity, associating creative performance with a diversity of ideas, or a wider search across multiple domains and categories. Conversely, the persistent pathway limits the number of potential search categories, thereby activating a deeper category search as opposed to a wider search. Aligning with the persistence pathway, the *Green Eggs and Ham* hypothesis argues that when presented with constraints, one will persist deeper into a limited set of ideas meeting the prescribed requirements rather than activate a wider search.

Together, the *Green Eggs and Ham* hypothesis and the dual-pathway model suggest the importance of problem identification to creative problem solving, an idea which is supported by previous investigations. Examining artists, Getzels and Csikzentmihalyi (1975, 1976) found that those with better problem identification and construction produced more favorably-rated paintings in terms of originality and aesthetics. In a study using an undergraduate sample, Finke et al. (1992) asked participants to develop new tools based on pictures of extant objects (e.g., cylinders, cones, hooks). When asked specifically to develop a *useful* tool, a constraint on their solution search, participants produced higher quality and more original tools compared to those who were asked to simply generate a new tool. In both studies, instructions provided to participants more clearly defined the problem, which ultimately resulted in more creative solutions. Thus, it is expected that constraining a problem from the start will result in higher quality and narrower problem definitions, which should, in turn, result in higher quality, more original, and more elegant problem solutions. These findings led to our first two hypotheses.

Hypothesis 1a: Those receiving constraints prior to defining the problem will produce higher quality and narrower problem definitions compared to those who do not receive constraints prior to defining the problem.

Hypothesis 1b: Those receiving constraints prior to defining the problem will produce higher quality, more original, and more elegant final proposals compared to those who receive constraints at a later stage.

Constraints in Conceptual Combination and Idea Generation

As previously noted, a majority of experimental evidence regarding the relationship between constraints and creativity stems from studies examining idea generation. Indeed, idea generation, or the production of new ideas, is a key component of creative problem solving across all models. Mumford and colleagues (e.g., Mumford, Baughman, Maher, Costanza, & Supinski, 1997) argue that idea generation relies, in part, on the reorganization of existing knowledge structures – a process they term, conceptual combination (Baughman & Mumford, 1995; Mumford et al., 1991). Although distinct, the similarity in outcomes, creating something new, suggests that constraints may have a similar influence across both processes.

Some researchers have argued that constraints influence idea generation through the elimination of conventional solutions. For instance, Haught-Tromp (in press) argues that narrowing the problem space thereby reduces the number of potential solutions which precludes conventional ideas from consideration. Thus, introducing constraints should, in theory, force one to consider novel solutions more quickly than if constraints were not presented.

Stokes (2007) introduced a similar argument, which suggested that introducing constraints when faced with ill-defined problems, a key characteristic of creative problem solving, decreases one's reliance on expected solutions, activating a search for novel and surprising solutions.

Along these lines, Onarheim (2012) found that new constraints were regularly introduced during the design process. While attempting to revise current solutions to fit new constraints, designers often identified new ideas as well as rediscovered previous ideas, which were initially dismissed as inappropriate, that now fit the new constraints. New ideas also appear to be formulated out of a desire to retain those ideas in which one has invested significant amounts of time. By introducing constraints later in the creative process, one may attempt to fuse working solutions with new constraints, leading to new solutions, which may not have been formulated if constraints were imposed from the start. Thus, introducing constraints later in the process, may result in more creative ideas. This led to our next set of hypotheses:

Hypothesis 2a: Those receiving constraints prior to conceptual combination will produce higher quality, more original, and more elegant solutions when asked to engage in conceptual combination compared to those who receive constraints prior to problem identification, idea generation, idea evaluation, or not at all.

Hypothesis 2b: Those receiving constraints prior to idea generation will produce higher quality, more original, and more elegant solutions when asked to generate ideas compared to those receiving constraints prior to problem identification, conceptual combination, idea evaluation, or not at all.

Related to this notion, Mumford and colleagues' (1991) model of creative problem solving suggests that idea generation is influenced by conceptual combination and problem identification performance. This suggests that introducing constraints prior to being asked to combine concepts may not only improve conceptual combination performance but it may also improve idea generation. Improved idea generation should in turn, improve final proposals. This leads to our next hypothesis:

Hypothesis 2c: Those receiving constraints prior to problem identification and conceptual combination will produce higher quality, more original, and more elegant solutions compared to those receiving constraints prior to idea generation, idea evaluation, or not at all.

Further still, Onarheim's (2012) findings suggest another important effect of introducing constraints at later stages. Late-stage constraints encouraged engineers to evaluate their ideas with regard to the constraints presented and to revise solutions to align with these constraints. Thus, introducing constraints at later stages may spur evaluation and revision. This led to our next set of hypotheses:

Hypothesis 2d: Those receiving constraints prior to conceptual combination will simultaneously evaluate solutions while generating ideas more frequently when compared to those receiving constraints prior to problem identification or not at all.

Hypothesis 2e: Those receiving constraints prior to idea generation will simultaneously evaluate solutions while generating ideas, and will revise previous solutions more extensively, when compared to those receiving constraints prior to problem identification, conceptual combination, or not at all.

Constraints and Idea Evaluation

Idea evaluation is a core component of nearly all proposed models of creative problem solving, and it refers to the process by which individuals appraise alternative solutions to certain standards and forecast their implications (Vincent, Decker, & Mumford, 2002). Mumford, Lonegran, and Scott (2002) argue that successful forecasting depends on the range and number of consequences examined. As such, high quality evaluations include a myriad of potential consequences associated with idea implementation. Constraints may provide one set of performance standards by which solutions may be evaluated (Johnson-Laird, 1988). For instance, a solution should be evaluated according to its usefulness within a particular setting, domain, or field (Csikszentmihalyi, 1999). More clearly, a designer may consider how the intended target market, a non-trivial constraint in and of itself, will react to a potential product. Thus, introducing constraints at any point prior to idea evaluation should positively relate to the evaluation quality. This led to our next hypothesis:

Hypothesis 3a: Those receiving constraints at any time will produce higher quality evaluations compared to those who do not receive constraints.

What's more, Mumford et al. (2002) argue for a dynamic process between evaluation and generation whereby critical evaluations should spur a revision process, or perhaps the generation of new ideas, in order to meet certain standards (Goor & Somerfield, 1975; Lubart, 2001). This notion, in tandem with the finding that people do not like to let go of ideas in which they have invested, suggests that introducing constraints so late in the process may result in heavy revisions to extent ideas. This led to our next hypothesis:

Hypothesis 3b: Those receiving constraints at any time will revise their solutions during idea evaluation more, and generate more new ideas, than those who do not receive constraints.

Constraint Type and Creative Performance

In addition to the timing of constraints, it is also important to consider the type and amount of constraints presented. For instance, Stefan (2008) proposed several constraints including deadlines, required outputs, communication, and budget requirements. Similarly, Onarheim and Nijkstad (2015) argued that many different types of constraints exist at Coloplast, including (a) individual (e.g., skills), (b) social (e.g., team dynamics), (c) process (e.g., time), (d) technical (e.g., regulations), (e) source (e.g., user needs), (f) domain (e.g., internal requirements), and (g) purpose (e.g., quality). Moreover, based on a review of the literature, Medeiros, Watts, and Mumford (in press) proposed four primary categories of constraints – (a) market, (b) organizational, (c) field, and (d) project. There is significant overlap between the three typologies. For example, Medeiros et al. (in press) subsumes Onarheim and Nijkstad's individual, social, and process constraints, and all of Stefan's noted constraints under the project constraint heading. Perhaps more directly relevant to the present effort, each of these has been linked to constraints present in modern organizations. Further, previous work suggests that multiple different constraints may be present at any given time (e.g., Medeiros, Watts, & Mumford, in press). For instance, a project may be limited to a certain budget while also needing to meet consumer demands for quality, organizational demands for efficiency, and abiding by legal requirements.

Research has examined several of these constraints and their influence on creative performance. Broadly, Nohria and Gulati (1996) found an inverse-U relationship between organizational slack, or an excess of necessary resources, and creativity. Specifically, several researchers have investigated the role of process constraints including time pressure (e.g., Baer and Oldham, 2006; Amabile, Hadley, & Kramer 2002; Ohly, Sonnentag, and Pluntke, 2006) and financial resources (e.g., Katila & Shane, 2005; Scopelliti, Cillo, Busacca, & Mazursky, 2013; Weiss et al., 2012). These efforts identified a curvilinear relationship between time pressure and financial resources on creative performance. In their review of leading creative efforts, Shalley and Gilson (2004) discuss findings regarding time, material resources, and people reaching a similar conclusion: too many resources may negatively impact creative performance. These findings fall in line with Onarheim and Biskjaer's (2015) proposed "sweet spot" for constraints, whereby a moderate balance of constraints may be key for creativity. These findings suggest that introducing a moderate amount of constraints may improve creative problem solving. How the amount of constraints and the timing of introduction interact to influence creative problem solving, however, is a key question. Thus, this led to the development of the next hypothesis and first research question:

Hypothesis 4a: Those receiving few constraints will produce higher quality, more original, and more elegant solutions compared to those receiving many constraints or no constraints.

Research Question 1: How will the amount of constraints interact with timing to influence problem identification, conceptual combination, idea generation, idea evaluation, and final proposals?

Although a number of constraints have been proposed in the literature, the present effort examines two common types of project constraints – resources and goals. Medeiros et al. (2014) found varying results based on the type of constraint and its flexibility. Specifically, information bearing on organizational concerns (e.g., company goals) did not hinder creative problem solving when participants were high in need for cognition. However, introducing resource and fundamental constraints reduced the quality, originality, and elegance of proposed solutions. Similarly, in a study of scientists' creativity, Mumford et al. (2005) found that the availability of necessary resources was positively related to creative achievement. Additionally, Onarheim (2012) found that Coloplast designers ignored certain constraints at particular times in order to reduce complexity. Specifically, designers ignored production and time constraints in the early stages of new product development.

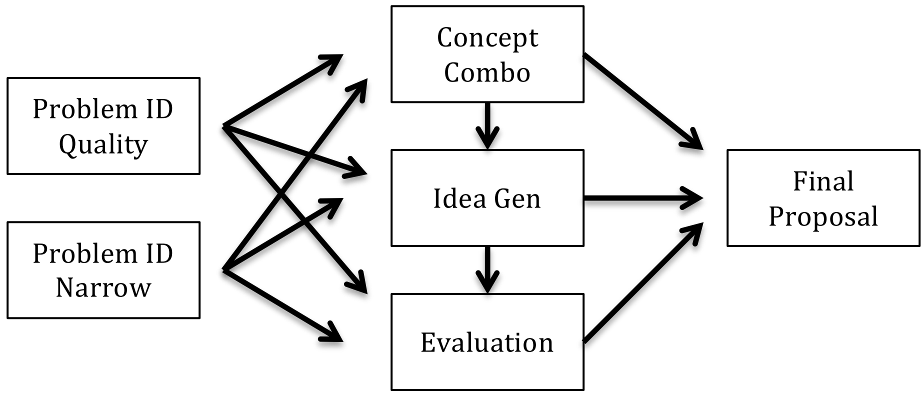
However, Coloplast designers did discuss constraints bearing on key user needs. These were often termed “corner flags” to represent the outermost boundaries of a project. This finding suggests that some constraints may be harmful at particular times, while others may be helpful boundaries. Based on these results, it is expected that overall, resource constraints will negatively influence performance while goal constraints will positively influence performance. Exactly how the introduction of resource and goal constraints interacts with the timing of delivery, again, remains a key question. Therefore, we propose the final two hypotheses and research question:

> Hypothesis 4b: Resource constraints will negatively influence problem identification, conceptual combination, idea generation, idea evaluation, and final proposals.
>
> Hypothesis 4c: Goal constraints will positively influence problem identification, conceptual combination, idea generation, idea evaluation, and final proposals.
>
> Research Question 2: How will constraint type interact with constraint timing to influence problem identification, conceptual combination, idea generation, idea evaluation, and final proposals?

Model Testing

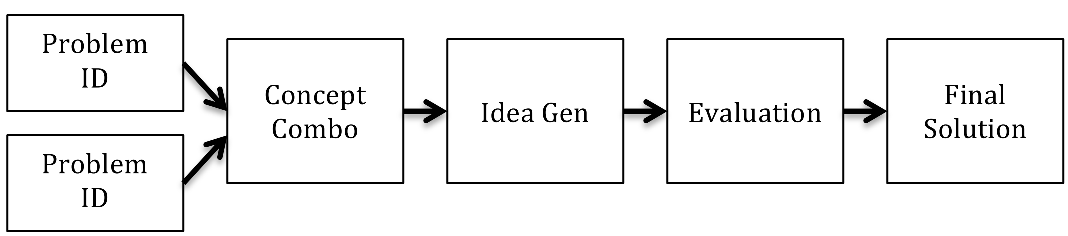
Based on the specified expectation that constraining the problem space from the beginning will result in the highest quality, most novel, and most elegant solutions, an important question comes to fore – how does problem identification impact conceptual combination, idea generation, and idea evaluation to influence the final proposal? Although examining discrete processes may provide insight into this relationship, it may also be beneficial to examine creative problem solving as a whole. To answer this question, we plan to conduct a path analysis for quality, originality, and elegance based on the model proposed in *Figure 1.* As noted throughout, this model generally argues that problem identification will influence conceptual combination and idea generation, by activating a deep and narrow search (e.g., Haught-Tromp, in press), and evaluation, by providing clear standards by which to evaluate ideas. As laid out by Mumford et al.'s (1991) model of creative problem solving, these processes should in turn, influence one another with conceptual combination impacting idea generation, and idea generation influencing idea evaluation. Furthermore, these processes are expected to directly influence the final proposal. Given that the final proposal requires the generation of ideas, it is logical to infer a direct relationship between generation and final proposals. Similarly, Mumford et al. (1991) argues that generation relies on the reorganization of extent knowledge through conceptual combination. This reorganization process may therefore, also directly influence the final proposals.

Figure 1. Model 1 (Proposed Model)



Based on best practices in path analysis (e.g., Loehlin, 2004), the present effort tested an alternative model and compared the fit statistics. For the alternative model, a modified version of Mumford et al.'s (1991) more traditional model of creative problem solving was used. Given that information gathering, concept selection, implementation planning, and monitoring were not measured, these variables were dropped from the model. *Figure 2* presents this modified model which suggests an impact of each process solely through later processes.

Figure 2. Model 2 (Traditional Model)



Method

General Procedure

First, participants completed a set of timed control measures including a measure of intelligence (Employee Aptitude Survey; Ruch & Ruch, 1980) and divergent thinking (Consequences; Guilford & Hoepfner, 1971). Second, participants took on the role of New Product Development Manager for O'Toole Restaurants, a national restaurant consulting firm. After reading background information regarding their role and the company, participants read a series of emails and completed the subsequent experimental tasks intended to measure four creative problem-solving processes - 1) problem identification, 2) conceptual combination, 3) idea generation, and 4) idea evaluation. After providing responses to these four prompts, participants were asked to develop a final restaurant proposal. Third, participants completed a set of untimed control measures including demographic information, restaurant interest, personality (NEO-FFI; Costa & McCrae, 1989), and need for cognition (Cacioppo & Petty, 1982).

Sample

The sample consisted of 338 participants. All participants were recruited from undergraduate psychology courses using an online recruitment system and in-class visits at a large southwestern university. Participants received research credits or extra credit for completing the study. Sixty-five percent of participants were female and the average age was 19.

Experimental Task

Participants completed a restaurant development task adapted from Peterson, Thiel, and Mumford. Research suggests that undergraduate students eat at restaurants frequently, signifying at familiarity with the industry (Debervec, Schewe, Madden, & Diamond, 2013; National Restaurant Association, 2012, 2013). Given the importance of expertise to creative problem solving, it was important to use a task in which undergraduates would be mildly familiar.

The task was delivered to participants in an email-based format. These emails, however, were printed and compiled into a paper packet. The first email came from Peyton Thatcher, the Research and Development Administrator. This email welcomed the participant to their new role of New Product Development Manager and included two attachments: 1) the history of O'Toole Restaurants as a restaurant consulting firm which helps clients open world-class restaurants across the US and 2) a job description listing the role's duties and reporting structure.

Next, participants received a series of emails from their boss, the Vice President of Research and Development. These emails, and subsequent activities, were developed to prompt engagement in four creative problem-solving processes - problem identification, conceptual combination, idea generation, and idea evaluation. The second email explained that O'Toole Restaurants was considering "using our consulting knowledge and experience to create our own restaurant." The email also summarized a report regarding industry trends. This report was “attached” to the email. The email concluded by requesting participants to review the attached report and to subsequently identify key challenges for the project. This was intended to prompt problem identification. Given that this is a new and unclear venture for this company, participants needed to address new challenges the company may face.

The attachment included descriptions of a recent study by the National Restaurant Association regarding current trends and outlook in three critical areas: customer experience, service approach, and cuisine. It was explained that customer experience “is created by both the food and beverages offered and such things as theme (e.g., sports, trendy, ethnic), look, feel, lighting, furniture, music, staff uniforms, and more.” Additionally, the report noted results from a recent survey suggesting that customers believe that the food and service quality, and convenience are the most important restaurant attributes. Customers also noted a preference for restaurants “fitting their lifestyle.” Regarding service approach, the report provided an overview of five service approaches commonly used in restaurants including fine dining, casual dining, fast-casual, quick-service, and hybrid. Lastly, the report listed the top 10 cuisine trends for the next 5 years according to a national survey of professional chefs. The trends are as follows: 1) locally sourced meats and seafood, 2) locally grown produce, 3) healthful kid’s meals, 4) hyper-local sourcing, 5) Sustainability, 6) children’s nutrition, 7) gluten-free/good allergy conscious, 8) locally-produced wine and beer, 9) sustainable seafood, and 10) whole grain items in kids’ meals.

The third email thanked the participants for identifying potential challenges. Additionally, this email stated that the executive board recently met to discuss ideas for the restaurant and requested that the participant incorporate each of their ideas into one proposal. The executive ideas were as follows: 1) "I would like to see an idea that incorporates the newest technologies. It should have a high-tech feeling from the moment a customer walks in the door," 2) "I want a strong emphasis on customer service. Customer service is a key competitive advantage these days and I want to make sure that it is a focus here. This new restaurant should place high value on positive interactions with customers and leaving a lasting impression," and 3) "We need unique food here. I don't want to see another pasta chain open – we have seen that, eaten that, done that. Let's combine people's favorite foods to make something unique and memorable." To prompt conceptual combination, participants were then asked to generate a proposal incorporating all three of these suggestions.

The fourth email stated, "the board has reviewed [your idea] and likes the idea. However, they would also like to hear if you have any other ideas for this new restaurants." The email continues noting that the participant is free to consider ideas outside of those presented by the executive board. After reading this request, Reese Teagan, the boss, requests a new proposal with the participant's own ideas. This prompt was intended to encourage idea generation.

Next, participants read through a fifth email, stating that Reese is currently finishing up another project and does not have the time to thoroughly review the proposal. Thus, Reese requests that the participant provide an evaluation of up to 3 restaurant concepts previously proposed by the participant. Additionally, the email notes that participants should include both strengths and weaknesses so the executive board can give the idea a fair assessment. This request is intended to elicit participants' idea evaluation.

The sixth and final email reads: "Thank you for your evaluation of the concepts. I agree with your assessment and trust your judgment. The next step is to prepare a final proposal that I can bring to the executive board. Please prepare your final proposal and I will take it to the meeting next week." This allowed participants the opportunity to provide one final restaurant proposal after considering potential strengths and weaknesses.

Manipulations

Consistent with the experimental materials, constraint manipulations were delivered via email from the Vice President of Research and Development. The email requested that participants take into account the information provided in all subsequent development activities. The content of the email, as well as the timing, were manipulated.

Timing. The email containing constraint information was delivered during one of four time points. Participants read the email immediately prior to engaging problem identification, conceptual combination, idea generation, or idea evaluation. In all conditions, the email was presented after the regular email from the Vice President of Research and Development requesting information from the participant. For instance, those in the problem identification condition, read the email summarizing the National Restaurant Association's report, requesting key challenges, and the attached report. It was after this email but prior to generating key challenges that the participant received the constraint email. Across all conditions, the email read, "New information came to light yesterday in our executive board meeting. This information is based on recent research and is critical to our effort. Therefore, you must consider the following information in the development of our new restaurant concept. Please take into account the following concerns for all work on this project. It is CRITICAL that you consider all of this information in all assignments related to this project."

Additionally, to ensure that this manipulation remained salient throughout subsequent processes, all emails following the constraint manipulation included the statement: "Again, do not forget to consider the previous concerns that I emailed you about." The constraints included in that condition were then listed to clearly remind participants of the previous concerns.

Content. The present effort manipulated the type and number of constraints. Participants received one of four conditions – no constraints, three goal constraints, three resource constraints, or three goal and three resource constraints. Participants in the control, or no constraint, condition did not receive an additional email. Those in the goal only constraint condition were told that they must consider the following information in the development process: casual dining service style, college student target market (18-24 years old), and moderate menu pricing ($8-$15 a plate). Participants in the resource only condition were given a limited budget ($25,000), a short timeframe (6 months) and minimal staff (2 project team members) to execute this project. Context was provided to participants to emphasize the limiting nature of these constraints. For instance, it was stated that $25,000 "is much less than the average $200,000 designated to new restaurant development projects, however, the board feels that this budget is appropriate given that this is a new venture." Lastly, participants in the goal and resource constraint condition were told to consider all of the previously listed constraints: casual dining service style, college student target market, moderate menu pricing, limited budget, short timeframe, and minimal staff. Thus, these manipulations served to compare fewer constraints (3) to more constraints (6) and goal constraints to resource constraints.

Covariates

Intelligence. Previous work (e.g., Silvia, 2008) suggests a relationship between intelligence and creative problem solving. Thus, the present effort controlled for participant intelligence using the Employment Aptitude Survey (EAS, Ruch & Ruch, 1980). A general logical test, the EAS presents a series of four to five facts and five conclusions. Participants judge whether each conclusion is true, false, or if there is not enough information to determine the accuracy of the conclusion. The test is time, allowing Previous research by Ruch and Ruch (1980) the validity and reliability of this instrument.

Divergent Thinking. Divergent thinking has long been associated with creative problem solving (e.g., Guilford, 1959; Mumford, 2001). The current study measured divergent thinking using the Consequences Test (Christensen, Merrifield, & Guilford, 1953). The Consequence Task presents five questions and participants must generate as many responses as possible to each question. Participants are given two minutes to respond to each question. A sample question is, “What would be the results if people no longer needed or wanted sleep?” Based on previous work by Hocevar (1979) the number of ideas was summed to create a single fluency score for each participant.

Demographics. Demographic information was collected to examine sample characteristics, provide an additional measure of intelligence, and estimate participant restaurant experience. Participants reported their gender, age, year in and college, and college major. GPA and SAT/ACT scores were used as proxy measures of intelligence. Additionally, participants were asked to report the number of years of experience working in restaurants and the frequency with which they dine at restaurants in a given week. Given domain expertise’s relationship with creative performance (e.g., Vincent, Decker, & Mumford, 2002), these questions were used to estimate participants’ expertise in the restaurant industry. Previous studies have used similar methods for measuring expertise in domains such as education (e.g., Scott, Lonergan, & Mumford, 2005) and marketing (e.g., Medeiros, Partlow, & Mumford).

Restaurant Interest. To provide an additional estimate of participant restaurant expertise, the present effort included a measure of restaurant interest. This measure asks participants to rate, on a scale of one to five, the frequency or likelihood of engaging in a task. For instance, sample item include: "How often do you think about how you could make restaurants better?" and "How likely is it that you will go into the restaurant industry as a career?" Results form the present effort produce a Cronbach's Alpha of .67.

Personality. Previous work suggests that personality traits such as openness (e.g., McCrae,1987; Batey & Furnham, 2006) may influence creative problem solving. Thus, the present effort measured the Big-Five personality traits using the NEO-FFI (Costa & McCrae, 1989). The NEO –FFI asks participants the degree to which they agree or disagree with 60 statements using a five-point scale. Sample items include, "I am not a worrier," "I laugh easily," and "I really enjoy talking to people." Previous validation work (e.g., Robins, Fraley, Roberts, & Trzesniewski, 2001; Costa & McCrae, 1992) provides evidence for the validity and reliability of this measure.

Need for Cognition. Creative problem solving requires a willingness to think about a problem. Thus, Need for Cognition, or the willingness to think deeply or complexly, may influence creative problem solving. Cacioppo and Petty's (1982) measure of Need for Cognition asks participants to rate the extent to which they agree or disagree with 18 statements on a one to five scale. Sample items include, "I would prefer complex to simple problems," "I prefer my life to be filled with puzzles that I must solve," and "I really enjoy a task that involves coming up with new solutions to problems." Cacioppo and Petty provide initial validation and reliability evidence. Results from the present effort produce a Cronbach's alpha of .89.

Dependent Variables

Using a five-point scale, all five responses (problem definition, conceptual combination, idea generation, idea evaluation, and final proposal) were coded for quality and all but problem definition were coded for originality. These variables are based on the definition of creative problem solving arguing that creative solutions require both quality and novelty (e.g., Mumford & Gustafson, 1988; Besemer & O'Quin, 1999). Quality was defined as the degree to which participants present a complete, coherent, and logical response. Originality was defined as the degree to which the response is novel and unique. Specific variables unique to each stage are provided below.

Problem identification was coded for narrowness, or the extent to which participants describe a specific versus broad problem based on Haught-Tromp's Green Eggs and Ham hypothesis (Haught-Tromp, in press). Conceptual combination and idea generation were coded for elegance evaluation. As previously noted, some researchers have argued for the importance of elegance in creative problem solutions in addition to quality and originality (e.g., Mumford & Gustafson, 1988; Besemer & O'Quin, 1999). Elegance was defined as the extent to which the idea is refined and all pieces flow well together. Based on Onarheim's (2012) findings, the present effort also examined the extent to which participants provided evaluative information regarding how their idea will meet requirements during conceptual combination and idea generation. For example, a participant evaluating an idea during idea generation may argue that their idea will work because it meets budget requirements and fits with the target market's interests. This variable was labeled integrated evaluation.

Based on Onarheim's (2012) findings at Coloplast, idea generation and evaluation were also coded for revision – the extent to which participants revised ideas presented in a previous task. Additionally, idea evaluation was coded for integrated idea generation. Integrated idea generation refers to the extent to which participants simultaneously generate ideas as they evaluate previous ideas. For example, participants generating while they are evaluating their ideas may suggest a new idea for a previous idea that does not meet with the requirements. Lastly, the final proposal was also coded for elegance and revision as previously defined. *Table 1* provides a list of coded variables for each process.

Table 1. Dependent Variables

1. Problem Identification	2. Conceptual Combination	3. Idea Generation	4. Idea Evaluation	5. Final Proposal
Quality	Quality	Quality	Quality	Quality
Narrowness	Originality	Originality	Revision	Originality
	Elegance	Elegance		Elegance
	Evaluation	Evaluation		
		Revision		

*All variables were coded on a 1-5 scale

Rater Training

Participant responses were content coded by four trained judges. These judges, undergraduate students familiar with the creativity literature, were trained using a frame-of-reference training spanning approximately 20 hours. First, the judges were presented with variable definitions and benchmark rating scales for each variable. After reviewing these variables, judges completed a set of five practice ratings. Discrepancies in ratings and questions regarding definitions were then discussed until the raters reached consensus. Judges then completed a larger practice set of 20 ratings to ensure understanding and agreement. A second consensus meeting was held to discuss any final questions and discrepancies. Lastly, judges content coded the remaining 370 participant responses. During the ratings process, approximately 30 participants were removed due to illegible handwriting and failure to respond to all prompts.

Analysis

To examine the role of constraints on each creative process, a series of Analysis of Covariance were conducted. The independent variables in this analysis were constraint type (goal, resource, both), amount (three, six), and timing (prior to problem identification, conceptual combination, idea generation, or idea evaluation). The dependent variables varied for each process. Table 1 provides an overview of dependent variables at each stage. Covariates significant at the $p<.05$ level were retained in the analysis. In some instances, participants did not complete the covariate. If participants did not complete covariate information for the specific variable included, they were removed from the analysis. Additionally, participants were removed if they were suspected of randomly responding. This resulted in varying number of participants depending on the covariate included in the analysis. Thus, the number of participants for each analysis ranges from 289 to 338.

Path analysis was conducted in order to examine the relationship between problem identification, conceptual combination, idea generation, idea evaluation, and final proposals. The model was tested using maximum likelihood estimation in MPlus. The initial model tested was proposed in *Figure 1*, ignoring the influence of constraints. The present effort also tested the alternative model presented in *Figure 2.*

Results

Main Effects

Timing. Results from the analysis of covariance for constraint introduction timing are presented in Table 2. Examining the relationship between delivery timing and process revealed several significant findings regarding the impact of constraint introduction on creative problem solving processes. For problem identification, significant effects were obtained for constraint introduction on both problem quality ($F(1, 290) = 7.13$, $p < .01$) and problem narrowness ($F(1, 336) = 11.85$, $p < .01$). Inspection of cell means reveals that those receiving constraints prior to identifying the problem produced higher quality ($M = 3.00$, $SD = .64$) and narrower ($M = 2.52$, $SD = .78$) problem definitions than those who did not receive constraints ($M = 2.78$, $SD = .67$; $M = 2.20$, $SD = .70$). These results provide support for hypothesis 1a.

Regarding conceptual combination, no significant effects were observed between constraints and the quality, originality, and elegance of participant solutions. Consequently, we reject hypothesis 2a. However, a significant effect was observed for simultaneous evaluation ($F(2, 330) = 11.63$, $p < .01$). Examining the cell means reveals that those receiving constraints prior to conceptual combination ($M = 2.33$, $SD = .75$) and problem identification ($M = 2.31$, $SD = .80$) evaluated their ideas during the conceptual combination process more than those who received no constraints ($M = 1.98$, $SD = .62$). This lends partial support to hypothesis 2d.

The results for idea generation mirrored those of conceptual combination, with no significant effects emerging for the quality, originality, or elegance of proposed solutions. Hence, we reject hypothesis 2b. Similar to conceptual combination, significant results were obtained for simultaneous evaluation ($F(3, 327) = 5.61$, $p < .01$). Significant results were also observed for idea revision ($F(3, 332) = 5.82$, $p < .01$). Examining the cell means reveals yet another similar pattern. Those receiving constraints immediately prior to engaging in idea generation simultaneously evaluated ($M = 2.37$, $SD = .69$) and revised previous ideas ($M = 2.36$, $SD = .62$) more than those receiving constraints prior to problem identification ($M = 2.23$, $SD = .65$; $M = 2.17$, $SD = .62$), conceptual combination ($M = 2.04$, $SD = .64$; $M = 2.17$, $SD = .62$) or not at all ($M = 2.02$, $SD = .63$; $M = 2.11$, $SD = .50$). These findings offer support for hypothesis 2e.

A significant effect of constraint timing was observed for evaluation quality (F(4, 325) = 5.96, p < .01) and revision (F(4, 325) = 2.73, p <.05). Surprisingly, those receiving no constraints demonstrated the highest quality evaluations (M = 2.96, SD = .41) followed by those receiving constraints prior to problem identification (M = 2.77, SD = .64), idea evaluation (M = 2.66, SD = .68), conceptual combination (M = 2.46, SD = .71), and lastly, idea generation (M = 2.40, SD = .73). Hence, we reject hypothesis 3a. Conversely, participants who revised their proposals the most, received constraints immediately prior to evaluation (M = 1.74, SD = .74). Participants who were not provided with constraints (M = 1.46, SD = .42) and those who received them prior to engaging in conceptual combination (M = 1.42, SD = .53) revised the least. This provides partial support for hypothesis 3b. Interestingly, a significant effect was not observed for simultaneous generation during evaluation. This suggests that constraints do not spur random idea generation but instead, spark revision of previously proposed ideas.

The relationships between constraint delivery timing and final proposal quality (F(4, 326) = 5.62, p <.01), originality (F(4, 326) = 3.91, p < .01), and elegance (F(4, 326) = 3.66, p <.01) were also significant. A review of cell means revealed that those receiving no constraints produced the highest quality (M = 3.08, SD = .50), most original (M = 2.91, SD = .57), and most elegant (M = 2.70, SD = .51) solutions. Of those groups presented with constraints, those receiving them prior to problem identification produced the highest quality (M = 2.99, SD = .73), most original (M = 2.76, SD = .65), and most elegant (M = 2.48, SD = .67) solutions compared to those receiving constraints prior to conceptual combination (*M* = 2.64, *SD* = .57; *M* = 2.45, *SD* = .65; *M* = 2.28, *SD* = .58), idea generation (*M* = 2.64, *SD* = .68; *M* = 2.56, *SD* = .74; *M* = 2.32, *SD* = .63), and idea evaluation (*M* = 2.71, *SD* = .61; *M* = 2.54, *SD* = .66, *M* = 2.29, *SD* = .62). These findings provide partial support for hypothesis 1b.

Table 2. ANCOVA Results for the Main Effect of Timing

Source	*df*	*SS*	*MS*	*F*	*p*
Main Effects (Timing)					
Problem ID Quality (ACT)	1	3.02	3.02	7.13	.00*
Problem ID Narrowness	1	6.27	6.27	11.85	.00*
CC Quality (ACT)	2	1.84	.92	2.23	.10
CC Originality (ACT)	2	.99	.49	1.02	.36
CC Elegance (ACT)	2	.03	.01	.04	.95
CC Evaluation (Openness)	2	11.12	5.56	11.63	.00*
Generation Quality (Openness)	3	.90	.30	.99	.39
Generation Originality (ACT)	3	.36	.12	.30	.82
Generation Elegance (ACT)	3	.94	.31	1.03	.37
Generation Evaluation (NFC)	3	9.06	3.02	7.38	.00*
Generation Revision	3	5.90	1.96	5.82	.00*
Evaluation Quality (ACT)	4	5.05	1.26	2.82	.02*
Evaluation Generation	4	4.40	1.10	1.90	.10
Evaluation Revision (NFC)	4	3.88	.97	2.73	.02*
Final Quality (NFC)	4	9.31	2.32	5.62	.00*
Final Originality (NFC)	4	6.95	1.73	3.91	.00*
Final Elegance (NFC)	4	5.57	1.39	3.66	.00*
Final Revision	4	1.40	.35	.77	.54

N = 289-338

Type and Amount. Results for type and amount of constraints are presented in Table 3. A similar pattern of results to those observed for constraint timing, emerged for constraint type and amount. There was a significant effect of constraint type on problem identification quality ($F(3, 288) = 4.45$, $p < .01$) and narrowness ($F(3, 334) = 3.98$, $p < .01$). In contrast to our hypotheses, those receiving resource constraints produced the highest quality ($M = 3.21$, $SD = .60$) problem definitions compared to those receiving goal ($M = 2.75$, $SD = .54$) or no ($M = 2.78$, $SD = .67$) constraints. Also in opposition to our hypotheses, those receiving many (both goal and resource) constraints produced higher quality ($M = 3.04$, $SD = .71$) problem definitions than those receiving only goal constraints. They did not, however, produce higher quality definitions than those receiving resource constraints. Regarding the narrowness of problem definitions, participants presented with multiple constraints articulated the narrowest problems ($M = 2.56$, $SD = .81$). Participants presented with goal ($M = 2.49$, $SD = .70$) or resource constraints ($M = 2.50$, $SD = .83$) produced similarly narrow problem definitions. In contrast, those in the unconstrained condition produced the broadest problem definitions ($M = 2.20$, $SD = .71$).

Results regarding conceptual combination reveal no significant relationships between constraint type, or amount, and conceptual combination quality, originality, and elegance. Nevertheless, a significant relationship was identified for idea evaluation ($F(3, 329) = 8.54$, $p < .01$) during the conceptual combination process. Participants receiving multiple constraints evaluated more ($M = 2.43$, $SD = .91$) than those receiving no constraints ($M = 1.98$, $SD = .63$) and those receiving only goal ($M = 2.23$, $SD = .73$) or resource ($M = 2.29$, $SD = .65$) constraints. Likewise, a significant relationship was observed for evaluation during the idea generation process ($F(3, 327) = 3.75$, $p < .05$). Participants presented with multiple constraints, again, simultaneously evaluated their ideas more ($M = 2.33$, $SD = .67$) than participants receiving no constraints ($M = 2.02$, $SD = .63$), only goal ($M = 2.10$, $SD = .66$), or only resource constraints ($M = 2.21$, $SD = .74$). No significant relationship was observed for idea generation quality, originality, elegance, or revision.

Table 3. ANCOVA Results for the Main Effect of Type/Amount

Source	*df*	*SS*	*MS*	*F*	*p*
<u>Main Effects (Type)</u>					
Problem ID Quality (ACT)	3	5.58	1.86	4.45	.00*
Problem ID Narrowness	3	6.36	2.12	3.98	.00*
CC Quality (ACT)	3	2.36	.78	1.90	.12
CC Originality (ACT)	3	.20	.06	.13	.93
CC Elegance (ACT)	3	.61	.20	.62	.60
CC Evaluation (Openness)	3	12.21	4.07	9.54	.00*
Generation Quality (Openness)	3	.27	.09	.30	.82
Generation Originality (Openness)	3	.49	.16	.39	.75
Generation Elegance (Openness)	3	.30	.10	.32	.80
Generation Evaluation (NFC)	3	4.86	1.62	3.75	.01*
Generation Revision	3	.71	.23	.67	.57
Evaluation Quality (ACT)	3	1.91	.63	1.39	.24
Evaluation Generation	3	1.40	.46	.80	.49
Evaluation Revision (NFC)	3	1.01	.33	.92	.42
Final Quality (NFC)	3	3.08	1.02	2.38	.06
Final Originality (NFC, Openness)	3	3.31	1.10	2.51	.05*
Final Elegance (NFC)	3	3.71	1.24	3.22	.02*
Final Revision	3	.44	.14	.32	.80

$N = 289\text{-}338$

No significant effects were observed for constraint type on evaluation quality, generation, and revision. Moreover, there was not significant effect on final proposal quality, originality, and revision. There was, however, a significant effect on the elegance of the final proposal (F(3, 327 = 3.22, p <.05). When participants were given no constraints, they produced more elegant proposals (M = 2.70, SD = .51) than participants who were presented with multiple (M = 2.33, SD = .65), goal (M = 2.33, SD = .60), or resource constraints (M = 2.39, SD = .64). Together, these findings fail to support, and often directly contradict, hypothesis 4a, 4b, and 4c.

Interactions

Results bearing on the interaction between type, amount, and timing follow a similar pattern and are presented in Table 4. Due to the nature of the timing manipulation, results for the interaction of timing and type are identical those described for the effect of constraint type. Thus, the interactive effect on problem identification quality and narrowness was significant. Results also a revealed a significant effect on evaluation during the conceptual combination process (F(6, 326) = 4.35, p <.01). Participants receiving multiple constraints immediately prior to engaging in conceptual combination simultaneously evaluated the most (M = 2.48, SD = .84) while those receiving no constraints evaluated the least (M = 1.98, SD = .62).

A similar pattern emerged for evaluation (F(9, 326) = 3.11, p <.01) and revision (F(9, 326) = 2.35, p <.05) during the idea generation process. Participants presented with multiple constraints immediately prior to engaging in the idea generation evaluated their ideas more (M = 2.43, SD = .65) than all other groups. However, those receiving resource constraints immediately prior to idea generation (M = 2.39, SD = .78), resource (M = 2.39, SD = .66) or multiple constraints (M = 2.38, SD = .69) evaluated their ideas to a similar degree. Those receiving goal constraints prior to conceptual combination (M = 1.89, SD = .56) or problem definition (M = 1.92, SD = .48), or no constraints (M = 2.02, SD = .63) evaluated their ideas the least. Regarding revision during idea generation, participants presented with multiple (M = 2.42, SD = .57) or resource (M = 2.43, SD = .63) constraints immediately prior to generating ideas revised previous ideas the most. Alternatively, those who received multiple (M = 2.00, SD = .57), goal (M = 2.00, SD = .48), or resource (M = 1.93, SD = .69) constraints immediately prior to the conceptual combination process revised their ideas the least.

Finally, analyses revealed a significant effect on the quality ($F(12, 318)$ = 2.37, $p < .01$), originality ($F(12, 318)$ = 2.10, $p < .05$), and elegance ($F(12, 318)$ = 2.47, $p < .05$) of final proposals. The highest quality (M = 3.16, SD = .65), most original (M = 2.96, SD = .49) and most elegant (M = 2.73, SD = .69) solutions were produced by participants receiving multiple constraints prior to identifying the problem. The second highest performing group with regard to these three variables was the control group. Participants receiving the lowest quality scores for their final proposals received resource constraints immediately prior to generating ideas (M = 2.56, SD = .74). Participants producing the least original proposals received resource constraints immediately prior to engaging in conceptual combination (M = 2.30, SD = .75) and goal constraints immediately prior to idea evaluation (M = 2.36, SD = .65).

Lastly, participants developing the least elegant final proposals were presented with multiple constraints immediately prior to conceptual combination (*M* = 2.20, *SD* = .55), multiple constraints immediately prior to idea evaluation (M = 2.20, *SD* = .62), or goal constraints immediately prior to idea evaluation (*M* = 2.20, *SD* = .65). These results provide some insight into research questions 1 and 2, suggesting that the presentation of more constraints is beneficial to problem identification.

Table 4. ANCOVA Results for Constraint Type and Timing

Source	*df*	*SS*	*MS*	*F*	*p*
Interactions (Timing X Type)					
Problem ID Quality (ACT)	3	5.58	1.86	4.45	.00*
Problem ID Narrowness	3	6.36	2.12	3.98	.00*
CC Quality (ACT, Openness)	3	4.85	.80	2.01	.06
CC Originality (ACT, Openness)	6	2.54	.42	.90	.49
CC Elegance (ACT, Openness)	6	.974	.16	.50	.80
CC Evaluation (Openness)	6	12.53	2.09	4.35	.00*
Generation Quality (Openness)	9	1.42	.15	.51	.86
Generation Originality (ACT)	9	3.38	.37	.94	.49
Generation Elegance (ACT)	9	1.75	.19	.62	.76
Generation Evaluation	9	11.75	1.30	3.11	.00*
Generation Revision	9	7.21	.80	2.35	.01*
Evaluation Quality (ACT)	12	6.38	.53	1.16	.30
Evaluation Generation	12	7.31	.60	1.04	.40
Evaluation Revision	12	7.13	.59	1.66	.07
Final Quality (NFC)	12	11.85	.98	2.37	.00*
Final Originality (NFC)	12	11.17	.93	2.10	.01*
Final Elegance (NFC)	12	11.04	.92	2.47	.00*
Final Revision	12	4.93	.41	.91	.53

N = 289-338

Path Analysis

The present effort tests both the proposed and alternative models describing the influence of processes on quality, originality, and elegance. Means, standard deviations, and correlations used to fit the models are presented in *Tables 5, 6,* and *7.* Fit statistics for all 6 models are presented in *Tables 8 and 9.* Based on the fit indices, it appears that the proposed model, model 1, is a better fitting model for quality (e.g., RMSEA = .10), originality (e.g., RMSEA = .07), and elegance (e.g., RMSEA = .03) than model 2 (e.g., RMSEA = .19, .23, .18). Thus, interpretations and results are only provided for Model 1. Unstandardized regression coefficients for model 1 are provided in *Tables 10 11,* and *12.* A similar pattern emerges across models for quality, originality, and elegance with narrowness generally exhibiting a negative, but non-significant, effect on conceptual combination, idea generation, and idea evaluation across all three models. Conversely, problem identification quality displayed a significant positive relationship with evaluation quality (b = .29, p <.01; b = .36, p <.01; b = .36, p <.01), idea generation quality (b = .15, p <.01) and originality (b = .13, p < .05), but not for elegance. Additionally, problem identification displayed a significant positive relationship with conceptual combination quality (b = .38, p <.01), originality (b = .36, p <.01), and elegance (b = .29, p < .01). This finding suggests that problem identification plays an important role in each subsequent stage.

Table 5. Correlation matrix - quality

	M	SD	PI-Q	PI-N	CC-Q	GEN-Q	EVAL-Q
PI-Q	2.80	.68					
PI-N	2.27	.73	.35**				
CC-Q	2.99	.67	.37**	.07			
GEN-Q	2.69	.55	.29**	.07	.37**		
EVAL-Q	2.60	.69	.38**	.04	.35**	.29**	
FIN-Q	2.77	.66	.19**	.05	.43**	.34**	.40**

N = 312-315, *p<.05, **p<.01

Table 6. Correlation matrix – originality

	M	SD	PI-Q	PI-N	CC-0	GEN-O	EVAL-Q
PI-Q	2.80	.68					
PI-N	2.27	.73	.35**				
CC-O	2.74	.71	.35**	.14*			
GEN-O	2.61	.64	.23**	.02	.38**		
EVAL-Q	2.60	.69	.38**	.04	.31**	.26**	
FIN-O	2.60	.68	.23**	.06	.52**	.46**	.36**

N = 312-315, *p<.05, **p<.01

Table 7. Correlation matrix – elegance

	M	SD	PI-Q	PI-N	CC-E	GEN-E	EVAL-Q
PI-Q	2.80	.68					
PI-N	2.27	.73	.35**				
CC-E	2.54	.60	.32**	.06			
GEN-E	2.30	.55	.22**	.05	.40**		
EVAL-Q	2.60	.69	.38**	.04	.28**	.31**	
FIN-E	2.37	.63	.24**	.01	.41**	.42**	.36**

N = 312-315, *p<.05, **p<.01

Table 8. Fit Statistics (Model 1 – Proposed Model)

	Model 1		
	Quality	Originality	Elegance
R2 – Final Proposal	.26	.36	.27
AIC	2232	2365	2138
BIC	2307	2437	2209
Chi-Square	2.18	8.63*	4.13
RMSEA	.02	.07	.03
CFI	.99	.98	.99

N = 316, *p<.05, **p<.01

Table 9. Fit Statistics (Model 2 – Alternative Model)

	Model 2		
	Quality	Originality	Elegance
R2 – Final Proposal	.16	.12	.12
AIC	2320	2500	2228
BIC	2369	2549	2277
Chi-Square	104.81**	155.23**	106.93**
RMSEA	.18	.23	.18
CFI	.63	.50	.62

N = 316, *p<.05, **p<.01

Table 10. Path Analysis Results for Quality

Effect	PE	SE	t	R^2
On final quality				.25
Conceptual combination quality	.28	.05	5.27**	
Generation quality	.16	.06	2.64**	
Evaluation quality	.24	.05	4.88**	
On evaluation quality				.18
Problem identification quality	.35	.06	6.23**	
Problem identification narrow	-.09	.05	-1.63	
Generation quality	.23	.06	3.60*	
On generation quality				.16
Problem identification quality	.15	.05	3.07**	
Problem identification narrow	-.01	.04	-.27	
Conceptual combination quality	.26	.05	5.33**	
On conceptual combination quality				.14
Problem identification quality	.38	.05	7.16**	
Problem identification narrow	-.06	.05	-1.33	

*PE = Parameter Estimate, SE = Standardized Estimate, N=316, *p < ,05, ** p<.01*

Table 11. Path Analysis Results for Originality

Effect	PE	SE	t	R^2
On final originality				.36
Conceptual combination originality	.34	.05	7.22**	
Generation originality	.28	.05	5.43**	
Evaluation quality	.16	.05	3.42**	
On evaluation quality				.18
Problem identification quality	.36	.06	6.45**	
Problem identification narrow	-.09	.05	-1.71	
Generation originality	.19	.06	3.42**	
On generation originality				.16
Problem identification quality	.13	.06	2.35*	
Problem identification narrow	-.07	.05	-1.40	
Conceptual combination originality	.31	.05	6.22**	
On conceptual combination originality				.12
Problem identification quality	.36	.06	6.17**	
Problem identification narrow	.01	.06	.24	

*PE = Parameter Estimate, SE = Standardized Estimate, N=316, *p < ,05, ** p<.01*

Table 12. Path Analysis Results for Elegance

Effect	PE	SE	t	R^2
On final elegance				.27
Conceptual combination elegance	.27	.06	4.77**	
Generation elegance	.27	.06	4.42**	
Evaluation quality	.19	.05	4.02**	
On evaluation quality				.20
Problem identification quality	.36	.06	6.53**	
Problem identification narrow	-.09	.05	-1.86	
Generation elegance	.29	.06	4.50**	
On generation elegance				.17
Problem identification quality	.08	.05	1.70*	
Problem identification narrow	-.00	.04	-.11	
Conceptual combination elegance	.35	.05	6.85**	
On conceptual combination elegance				.11
Problem identification quality	.29	.05	6.12**	
Problem identification narrow	.05	.05	-1.05	

*PE = Parameter Estimate, SE = Standardized Estimate, N=316, *p < ,05, ** p<.01*

Discussion

Prior to discussing the findings, it is important to note several limitations of the present effort. To begin, the present study employed a low-fidelity task using an undergraduate sample. Although undergraduates do not possess the same expertise as restaurant development professionals, research suggests that they are reasonably familiar with restaurants. Different results may be obtained, however, when using a sample of seasoned restaurant development professionals. Similarly, although the problem presented to participants was moderately realistic and based on data from the National Restaurant Association, a real-world restaurant development effort would likely be much more complex. Furthermore, the current study only examined creative problem solving in a restaurant context. As different constraints may be present in other fields (Csizkszentmihalyi, 1999), it is unclear as to whether or not the same effects would be observed in different domains.

Additionally, there exist several limitations with regard to the constraint manipulation employed. First, constraints were introduced in a fixed manner, with participants only receiving one set of constraints at one time point during the process. In real-world creative efforts, constraints are much more dynamic, evolving and changing throughout a project lifecycle (e.g., Onarheim, 2012). Thus, it is unclear as to how changing constraints, or introducing multiple constraints at different time points, may influence creative problem solving. Similarly, the present effort operationalized many constraints as two sets of constraints presented simultaneously. This does not necessarily represent a heavily constrained project and thus, results may change if more constraints were introduced. Second, the present effort examined resource and goal constraints. As noted previously, other types of constraints exist and may differentially impact distinct processes as well as creative problem solving more generally. Third, as other scholars (e.g., Onarheim, 2012; Stokes, 2009) have noted, even when constraints are not introduced by others, individuals may introduce their own set of constraints to a given problem. The present effort did not measure what constraints participants may have imposed themselves. Further, the constraints introduced were not particularly powerful. More powerful constraints such as those may significantly impact the success or failure of a business, may produce different results.

The present study examined problem identification using measures of quality and narrowness. Both have been discussed and used in the literature, however, other measures may provide unique insight into the influence of constraints on problem identification and, subsequently, the influence of problem identification on creative problem solving. Lastly, only two models were tested. Other models may be theoretically justifiable and prove to be good fits. The nature of the study also limits the interpretability of the models and does not allow for an examination of how experts engage in creative problem solving. Future research should consider investigating this further and applying additional models to better understand creative problem solving.

Despite these limitations, we believe that the present effort offers unique insights into the relationship between constraints and creative problem solving.

Similar to previous findings, results from the present effort suggest that constraints do not harm creative performance as previously thought. Indeed, when examining performance on distinct processes, it appears that constraints have little to no influence on conceptual combination, idea generation, and idea evaluation. Constraints do appear, however, to have a unique and positive impact on problem identification. These findings lend credence to Haught-Tromp's (in press) *Green Eggs and Ham* hypothesis, thereby suggesting that constraints primarily influence creative problem solving through the problem definition process.

Furthermore, results suggest that the impact of constraints does not stop at problem identification. Out of the two models presented, the best-fitting model suggests that the influence of constraints on problem identification may subsequently impact conceptual combination, idea generation, and evaluation, to ultimately impact the final proposal. Interestingly, this relationship operated almost identically across quality, originality, and elegance. Thus, problem definition isn't just important for developing a useful product – it also appears critical for developing a novel and elegant solution. This provides evidence for the notion that originality and elegance, not just usefulness, may stem from bounded problem solving. When working on, or managing, creative projects, these findings imply the importance of providing constraints early on in the project. By providing constraints up front, the individual or team may be better able to define the problem at hand and develop and evaluate solutions relevant to that problem.

Although more narrowly defined problems tended to display a negative relationship with other processes in the model presented, the non-significant nature of this relationship suggests that it may not meaningfully impact creative problem solving. However, future research should further examine how narrowness may impact creative problem solving and under what circumstances it may prove beneficial and harmful.

Somewhat in contrast to our initial hypotheses, participants receiving many constraints regularly outperformed other groups. One explanation for this is that incorporating more constraints into a problem definition creates a more narrow, and clearer problem thereby allowing for a deeper search. However, this does not discount the idea that introducing too many constraints may be harmful to creative problem solving. In this instance, introducing two sets of constraints was classified as introducing many. Perhaps introducing even more would narrow the focus too much. Future research should continue investigating the role of constraints to determine the "sweet spot," or bounds in which constraints inhibit and facilitate (Onarheim & Bijskrk, 2015).

It appears that constraints also exert a unique impact by inducing evaluative processes. As seen in the surge of evaluation during requests to generate ideas, introducing constraints to a problem encourages individuals to evaluate their ideas to those constraints. Moreover, introducing multiple constraints resulted in the heaviest amount of evaluation. One explanation is that by giving people more constraints, one is giving them more requirements or standards by which to evaluate their idea, thus resulting in more and perhaps wider evaluation. With regard to practical implications, this suggests that constraints should not be introduced solely for the sake of improving problem definitions. Careful consideration should be given to which constraints should be enacted as those working to solve the problem will likely incorporate those constraints into their working definition of the problem and later, evaluate potential solutions to those constraints.

Similarly, the present study found that introducing constraints was associated with revision of previous ideas. This finding should be interpreted in conjunction with the non-significant finding regarding idea generation during evaluation. Together, these results suggest that introducing constraints does not activate a completely new set of ideas. Instead, participants appeared to hold on to their original idea, or parts of the original idea, and revise it to fit the newly introduced constraints. This aligns with Onarheim's (2012) finding that people do not like to "give up on" their ideas and will work to adjust their own ideas to fit the new circumstances.

An additional finding worth noting was the significance of intelligence, Need for Cognition, and openness to experience. The importance of these three traits to creative problem solving is well-established. However, Need for Cognition and intelligence appear particularly important when working with constraints as it requires a great deal of cognitive effort and capacity to work with, and incorporate, the information presented. Moreover, the significance of openness to experience brings to the fore a key point – narrowing the problem at hand does not imply a lack of openness. As the dual-pathway model and *The*

Green Eggs and Ham hypothesis suggest, narrowing the problem allows for a deeper search within a more limited problem space. Thus, one can still be open to new ideas and alternatives while working within a smaller search area.

The all too familiar cliché, "thinking outside the box," argues that in order to be creative, one must engage in unconstrained thinking. These results, however, paint a much different picture. It appears that creative thinking functions just fine in its box. Working within a constrained space allows one to explore the nooks and crannies within limited parameters rather than endlessly bouncing around an infinite space. Perhaps then, constraints may help to assemble the box, forming the space in which one may create.

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