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The *Green Eggs and Ham* Hypothesis: How Constraints Facilitate Creativity

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Two experiments tested the hypothesis that constraints imposed on a common writing task yield more creative outputs. In the 1st study, participants were asked to include a given noun in a 2-line rhyme for a special occasion. In the 2nd study, they generated their own nouns, which they then had to include in their rhymes. Both studies show a main effect of constraints on creativity and an interaction with order of presentation, which suggests a carryover effect: Mere practice with constraints can stimulate creativity. The *Green Eggs and Ham* model is put forth to explain the current findings and why Dr. Seuss's best-seller, written using only 50 words, was such a creative and commercial success.

Keywords: creativity, constraints, language, creative writing

The concept of creativity conjures up open fields with unlimited possibilities. Yet, when people face such vast openness, be it a new Word document, a blank canvas, or a blue-sky business proposal, they often fail to deliver. In fact, many have a hard time getting started, let alone getting creative.

The challenges inherent in creative undertakings do not come as a surprise. Literary composition, for example, is notoriously difficult, and writer's block is a common phenomenon. John McPhee (2013), the American nonfiction writer, confessed this initial challenge: "For me, the hardest part comes first, getting something—anything—out in front of me" (para. 6). His solution may seem surprising: "Sometimes in a nervous frenzy I just fling words as if I were flinging mud at a wall. Blurt out, heave out, babble out something—anything—as a first draft. With that, you have achieved a sort of nucleus" (para. 6). Judging by McPhee's Pulitzer Prize, his use of arbitrarily selected words to anchor creative writing seems to work. What is most interesting from a psychological perspective is that McPhee's "nucleus" effectively arises from limitations.

The idea of constraints stimulating rather than inhibiting creativity might appear counterintuitive, but further anecdotal evidence has suggested that this facilitative effect could be real. Charles Baudelaire (1959/1981) viewed "rhetorics and prosodies" not as "arbitrarily invented tyrannies," but as tools that have "aided the flowering of originality" (p. 306). Cubist painter Georges Braque (1947) also praised the value of constraints: "Limited means beget new forms, invite creation, make the style. Progress in art does not lie in extending its limits, but in knowing them better" (p. 33). In a similar vein, composer Igor Stravinsky (1956) lamented the "anguish into which an unrestricted freedom plunges [him]" and believed that "the more art is controlled, limited, worked over, the more it is free" (p. 64). Modern graphic designer Paul Rand (1985) reflected on the role of constraints across a range of creative undertakings:

> The earth colors of Africa, the ice of the polar regions, the bamboo of Japan, are among the many challenging materials with which artists and artisans create their idols, their utensils, and their houses—all natural limitations which provide their own built-in disciplines which, in turn, contribute to the creative solution. (p. 201)

Marissa Mayer (2006), the CEO of Yahoo, observed constraints at work, and came to believe that "[they] shape and focus problems and provide clear challenges to overcome. Creativity thrives best when constrained".

Such anecdotes and opinions about the role of constraints in creativity abound. Although until recently the topic has received only marginal attention in psychology, the existing studies and theoretical articles paint a similar picture. Johnson-Laird's (1987, 1988, 1993) NONCE analysis of creativity explicitly mentions the role of constraints: creativity is *N*ovel for the individual, *O*ptionally novel for society, *N*ondeterministic, dependent on *C*riteria or constraints, and based on *E*xisting elements (Johnson-Laird, 2002, p. 420). The effort of modeling creativity in artificial intelligence depends on the clear specification of constraints, and Johnson-Laird's (2002) computer model of jazz improvisation provides evidence that with the right set of such specifications, some creative tasks can be successfully modeled. Constraints also play a central role in Boden's (1990) rich and elegant analyses of creativity. She proposed three ways of producing novel ideas: combination, exploration, and transformation. In combinational creativity, existing concepts and ideas are brought together in a new and meaningful way. Exploratory creativity involves surveying the broad space of a particular domain, be it a style of painting or a

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theory in physics, with all its rules and constraints. Occasionally, such explorations lead to transformative creativity, in which the space is altered by modifications to at least one of its core dimensions or constraints.

In the existing studies where constraints were manipulated experimentally, the findings are revealing. On the one hand, at the situational level, a variety of extrinsic constraints in which social control is salient have been shown to diminish creativity: surveillance (Amabile, Goldfarb, & Brackfield, 1990), the expectation of evaluation (Amabile, 1979), and contracted reward (Amabile, Hennessey, & Grossman, 1986). On the other hand, when constraints are not conceptualized as social factors and are instead directed at limiting the task at hand, they have a facilitative effect. For example, when participants played around with preinventive forms, such as cylinders and hooks, which could be combined and reorganized in order to form new objects, imposing a constraint helped: Outputs of greater quality and originality were generated when the objective was to develop a useful tool (Finke, Ward, & Smith, 1992). In a verbal conceptual combination task, the participants' skills in working with constraints were positively correlated with their performance on the conceptual combination problem (Costello & Keane, 2000). When first graders were taught math using an explicit base-10 count, modeled after Asian (Korean, Chinese, Japanese) counts, this constraint yielded remarkable results: The children in the experimental condition outperformed those in the comparison group, who had been taught using the standard curriculum, on measures of place value, addition and subtraction of single- and double-digit numbers, and number line estimation (Stokes, 2014). When college students were asked to generate creative sentences prompted by concrete nouns, such as *lion* or by the corresponding, more constrained visual representations of the concepts, they were more creative given the pictures (Haught, 2015).

Such latter evidence from math education and composition supports the preclude–promote model of paired constraints (Haught-Tromp & Stokes, in press; Stokes, 2008): One constraint specifies which elements to avoid, and the other which elements to seek out. Both Haught-Tromp (Haught, 2015; Haught-Tromp, 2016a, 2016b; Haught-Tromp & Stokes, in press) and Stokes (2005, 2007, 2008) place constraints at the heart of both competency and creativity. This article seeks to solidify and enhance this explanatory framework.

The *Green Eggs and Ham* Hypothesis

Why is searching for creative solutions challenging? Is it possible that perhaps the proverbial open field of creative exploration may benefit from metaphoric fences? If so, how do constraints work?

The *Green Eggs and Ham* hypothesis proposes that working with constraints can yield more creative outputs. The *Green Eggs and Ham* story itself is an excellent example of the successful use of constraints. Theodore Geisel, well known as Dr. Seuss (1960), wrote the book in response to a challenge from his publisher: Write a compelling children's story using the same 50 words or less. The hypothesis also advances a possible explanation for the challenges associated with creativity and how the creative process unfolds.

If the goal is to find a solution within a search space (Newell & Simon, 1972), what happens when one seeks a particular type of solution, such as a creative output? The initial tendency is to first look where it is easiest. There is an informal name for this phenomenon: the streetlight effect (Freedman, 2010). It is also known as the principle of the drunkard's search (Kaplan, 1964): A drunk has lost his keys and is searching for them under a streetlight. A policeman joins in the search, and after a futile effort, he asks the drunk if he is certain he lost his keys here. The drunk responds: no, he lost them in the park. Then why is he searching here, the policeman asks? Because this is where the light is.

In a sense, the combing of semantic networks for solutions can also be (mis)guided, by the distinct patterns of association among stored concepts (e.g., Anderson, 1983, 1995). The strength of the connections between concepts, which are represented as nodes, determines the pattern of the spreading activation: When a node is triggered, it is more likely to reach nodes that are strongly connected to the initial one (Collins & Loftus, 1975). This explains why searching where it is easiest, that is, where the associations are strongest, often yields disappointing solutions to a creative task (Bristol & Viskontas, 2006; Gabora, 2010). It should be replaced with looking wherever the search is most likely to reach a successful end. In the case of a task that requires creativity, be it writing a birthday card greeting or a fugue (Reitman, 1965), this means overriding the tendency to go with the familiar, which will likely yield only clichés. This is how constraints can help: Focusing the creative energy on a narrower field of exploration allows for a more in-depth processing of fewer alternatives. Once a frame is in place, the focus can shift to creating something memorable within it.

Research on decision-making has also informed the current hypothesis about constraints. The *paradox of choice* (Schwartz, 2004) refers to a curious, yet widespread effect: Too many options can be overwhelming, even paralyzing, with detrimental effects on the quality of decisions, postdecisional satisfaction, and overall wellbeing (e.g., Huberman, Iyengar, & Jiang, 2007; Iyengar & Lepper, 2000). Too much choice may have similarly unfavorable effects on creativity. For example, Creative Problem Solving, an empirically validated method for improving creativity (Basadur & Thompson, 1986; Cramond, Martin, & Shaw, 1990; Rose & Lin, 1984; Schack, 1993), relies on many constraint-based techniques, such as the presentation of arbitrarily selected or randomly generated images, which stimulate original solutions. By contrast, in its original form, Osborn's (1957) popular brainstorming method, which is based on freedom from constraints, has been shown to be largely ineffective as a creativity-promoting tool (Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991). It turns out that imposing rules on brainstorming can in fact make group creativity more effective (Paulus & Brown, 2003; Paulus, Nakui, Putman, & Brown, 2006). Moreover, electronic brainstorming has been shown to circumvent some problems of production loss that stem from evaluation apprehension or the inability to process and speak at once (e.g., Dennis & Williams, 2003; Gallupe et al., 1992). One could argue that when inputs from other brainstormers are fully processed, they provide new, much-needed constraints for the participants, and these starting points for novel cognitive explorations end up yielding more unique outputs.

The following two experiments used a common and familiar creative thinking task to test the *Green Eggs and Ham* hypothesis: More creative outputs should emerge after constraints are imposed. Who hasn't faced the challenge of writing a creative greeting card

message to a friend, a family member, or a coworker? Would constraints help?

Study 1

The *Green Eggs and Ham* hypothesis yields the following specific predictions. First, when participants must work with a given constraint, their outputs should be more creative than when the constraint is not present. Second, order of presentation should interact with constraints such that the facilitative effect of constraints would carry over to the nonconstrained condition, after the participants first have a chance to work with constraints. Even though constraints may make the task appear more challenging and harder to embrace—"You do not like them, So you say", "Try them! Try them! And you may" (Dr. Seuss, 1960).

Method

Participants. Sixty-four Rider University undergraduate students participated in the study for extra credit. They were all native English speakers.

Materials and procedure. Participants were asked to generate eight creative two-line rhymes that convey a given message: *Happy birthday, Thank you, Good luck, I am sorry, Happy New Year, Congratulations, Feel better,* and *I love you*. They were allowed as much time as they needed to complete the task, and the instructions encouraged them to think of rhymes that are unusual and striking, as well as appropriate for the given task.

The constraint imposed on the participants was the requirement to incorporate given concrete nouns into their greeting card rhyming messages. These given words were selected from Battig and Montague's (1969) category norms. They were all concrete, one-syllable, nonpolysemous nouns, denoting concepts at their basic level of representation (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), of matched frequency, from four different semantic categories: article of clothing (*shirt* and *vest*), four-footed animal (*dog* and *frog*), toy (*doll* and *kite*), and musical instrument (*drum* and *harp*). Across participants, each of the eight given nouns was paired with each of the eight topic prompts.

Design. A 2 (constraints, within-subject) × 2 (order of presentation, between-subjects) design was employed. In the constrained condition, the rhymes had to include a given word, and in the nonconstrained condition they did not. Order of presentation was manipulated between-subjects, in a block design, such that half of the participants saw the constrained block of trials first, followed by the nonconstrained one, and the other half saw the nonconstrained block first, followed by the constrained one. Within each block, the order of the trials was different.

Results

Data from five participants out of the sample of 64 were excluded from analysis. These participants either completed fewer than half of the trials or did not follow instructions: The messages they generated were irrelevant to the prompt, did not rhyme, or did not include the given word.

Three independent judges, who were Rider undergraduate psychology majors, condition- and hypothesis-blind, rated all the rhymes, which were presented in a random order by greeting card prompt category, on a 10-point scale ranging from 1 (*not at all creative*) to 10 (*extremely creative*). Each judge was compensated with a $100 Amazon gift card. The ratings were positively and significantly correlated (Intraclass correlation [ICC] = .624, $p < .0001$).

Analyses of the creativity ratings, averaged across the raters, revealed a significant main effect and a significant interaction. The rhymes in the constrained condition ($M = 5.18$, $SD = .93$) were judged to be more creative than the rhymes in the nonconstrained condition ($M = 4.29$, $SD = 1.08$), $F(1, 57) = 62.87$, $p < .0001$, $\eta_p^2 = .53$. Order of presentation interacted with constraints, such that the nonconstrained rhymes were rated more highly when they followed the constrained condition ($M = 4.80$, $SD = 1.12$) than when they preceded it ($M = 3.83$, $SD = .83$), whereas the constrained rhymes yielded similar ratings, regardless of whether they were generated first ($M = 5.23$, $SD = 1.12$) or second ($M = 5.14$, $SD = .73$), $F(1, 57) = 16.19$, $p < .0001$, $\eta_p^2 = .221$.

There was also a significant main effect of order, $F(1, 57) = 5.566$, $p = .022$, $\eta_p^2 = .089$: When the participants saw the constrained condition first, followed by the nonconstrained one, they generated more creative rhymes ($M = 5.015$, $SD = .163$) than when the order was reversed, that is, nonconstraints first, followed by constraints ($M = 4.486$, $SD = .155$).

Discussion

The participants generated more creative rhymes when they had to work with the externally imposed constraint of a given noun (underlined in the rhymes to follow). For example, when they were asked to express *I love you,* two participants wrote:

> I love you as much as a dog loves his bone
> And a teen loves his phone.

> Your smile has the power to embrace me like a vest
> In your arms, for the rest of my life I want to rest.

Even after the constraint of a given noun was removed, the participants generated more creative rhymes than when the constraint was not introduced first. Here are two examples of rhymes generated when the nonconstrained condition followed the constrained one. The first rhyme expresses *I am sorry*, and the second conveys *Feel better:*

> A hippo with no fat, the sun without light
> Cannot compare to me—what I did was just not right.

> I hope that you soon feel better
> Than a mouse with 1,000 lbs. of cheddar.

By contrast, when no constraints were provided, the responses were less creative, as illustrated by the next two examples, the first one in response to the *I am sorry* prompt, and the second in response to *Feel better:*

> I sincerely apologize,
> I am not telling lies.

> I will write you a letter
> To help you feel better.

Not only do explicit constraints seem to enhance creativity, but mere practice with a constraint also appears to help, even immediately after it has been formally removed. Would these results hold when the constraint is self-imposed? The second experiment was designed to replicate the results from the first study, within a modified writing task: The concrete nouns were no longer imposed by the experimenter but were selected by the participants. In effect, this protocol is the empirical equivalent of author John McPhee's (2013) method of "fling[ing] words as if I were flinging mud at a wall," which can anchor the creative process.

Study 2

In the second experiment, the participants were first asked to generate their own concrete nouns, which they then had to incorporate in their rhymes. The predictions remained the same: More creative rhymes were expected in the constrained condition, and the effect of the constraints would carry over to the nonconstrained condition, yielding more creative rhymes than when the nonconstrained condition preceded the constrained one.

Method

Participants. Forty-eight Rider University undergraduate students participated in the study for extra credit. They were all native English speakers who had not participated in another creativity study.

Procedure and design. The participants' task was similar to the one employed in the first experiment, and so was the design: 2 (constraint vs. nonconstraint, within-subject) × 2 (order of presentation, between-subjects). The instructions asked participants to generate creative two-line rhymes in response to eight greeting card prompts: *Happy birthday, Thank you, Good luck, I am sorry, Happy New Year, Congratulations, Feel better,* and *I love you*. For half of the trials, the participants were first asked to write down the first four concrete nouns that came to their mind. After they did so, they were instructed to incorporate each of the four nouns in a creative rhyme using the given prompts. The nonconstrained condition simply required the participants to produce creative rhymes in response to the prompts. The order of presentation of the constrained block was counterbalanced, and the order of the greeting card prompts differed within each block.

Results

One participant did not follow the instructions, and another participant completed fewer than half of the trials, so their data had to be discarded and were not included in the analysis. The rhymes generated by the remaining 46 participants for each greeting card prompt were presented in random order to three independent judges, whose task was to rate them on a 10-point creativity scale ranging from 1 (*not at all creative*) to 10 (*extremely creative*). Their ratings were significantly correlated (ICC = .52, $p < .0001$).

Participants generated more creative rhymes when they had to include a self-generated noun ($M = 5.13$, $SD = 1.05$) than when they did not ($M = 4.36$, $SD = .81$), $F(1, 44) = 38.14$, $p < .0001$, $\eta_p^2 = .464$. A significant interaction revealed a carryover effect: The rhymes were more creative when the nonconstrained condition followed the constrained trials ($M = 4.6$, $SD = .80$) than when it preceded them ($M = 4.14$, $SD = .78$), $F(1, 44) = 9.66$, $p < .003$, $\eta_p^2 = .180$. The main effect of order was not significant.

Discussion

The results from the second experiment replicated the findings from the first study. Creativity seems to improve when a constraint is introduced and after the constraint is first introduced and then removed. This is what two participants wrote in response to the *Feel better* prompt, in the constrained condition (the underlined words were generated by the participants):

> Close your eyes and imagine the Florida <u>sun</u>;
> That will make any problem seem like fun.
>
> No matter what storms you may weather,
> Just remember, bad days come and go like a <u>feather</u>.

When the nonconstrained trials followed the constrained ones, two participants generated these two rhymes to express *Happy birthday:*

> Today is the day you left the womb,
> And one day closer to the tomb.
>
> I love you to the moon and back,
> More than I love drinking a six-pack.

As these examples illustrate, after removing the constraint of an arbitrarily selected noun, the rhymes were more creative than when the constraint was never introduced. Without any constraints, many rhymes looked like the next two examples, the first produced to convey *Happy birthday*, and the second to express *Feel better:*

> Happy birthday to you all,
> I hope you have a ball.
>
> I know that you haven't been feeling very well,
> But soon you'll feel better—you'll be feeling swell!

This interaction suggests a possible lingering benefit of working with constraints. Arbitrarily selected nouns used within a given task can help constrain the search field, anchor the creative process, and yield more original outputs, even after they have been removed.

General Discussion

The *Green Eggs and Ham* hypothesis proposes that constraints facilitate creativity, and two empirical studies tested its predictions. The writing exercise used in these studies has the advantage that is it a common task with which most people are familiar. Both studies show that having to include a specific concrete noun in a greeting card rhyming message leads to more creative outputs than does a corresponding less-constrained writing task. This type of constraint, whether externally or internally imposed, stimulated creativity and yielded more creative rhymes. The second result, an interaction with order of presentation, suggests that when participants were exposed to thinking within a given constraint, they might have continued to seek out their own constraints in subsequent tasks, which translated into more creative outputs relative to when they did not first get exposed to working with constraints. This result aligns itself well with recent findings on global pro-

cessing, one of the key correlates of creativity. After completing a difficult maze, participants were better at solving items from Mednick's (1962) Remote Associates Test than after completing an easier maze (Marguc, Förster, & Van Kleef, 2011). It is possible that in the present study, the challenging task of working with a constraint—it is not that easy, after all, to include an arbitrarily selected noun, such as *frog,* in a birthday greeting—led participants to make more connections between items that are not obviously or naturally associated. In other words, this global processing mode may have encouraged them to explore new associative paths.

To understand creative thinking, one should first examine the different sorts of problems and the proposed mechanisms for solving them. There are two broad categories of problems, each with their corresponding approaches to the search for a solution: deterministic and nondeterministic. Creativity tasks fall in the latter category: Many alternative outcomes can emerge from the same starting point. For deterministic problems, narrowing down the search space keeps one on the predetermined path to the correct solution. At each step in the process, all the possibilities are excluded except for the correct one. Why wouldn't a similar approach work for nondeterministic problems, be they ill structured or well structured (Reitman, 1965; Simon, 1973)? The main difference, of course, is that there are many different possible "correct" solutions from which to choose. Imposing constraints on the task eliminates many alternatives, anchors the search, and zooms in on a smaller set of options that can be explored in more depth.

Nijstad and Stroebe's (2006) Search for Ideas in Associative Memory theory proposes that idea generation occurs by retrieving relevant information from long-term memory and manipulating it in working memory in an attempt to find a suitable solution. In the writing task used in the present experiments, the semantic constraint of the arbitrarily selected noun activated a set of associations, and the specific greeting card prompt activated another. From among the infinite number of ways in which one could express, for example, *Happy birthday*, the search was then constrained to those in which, say, a *dog* or a *vest* was also included. Even when the strongest *birthday* associations, such as *cake*, *candles*, and *gift*, are activated, they must be altered in a creative way to include the imposed constraint. If the main challenge in the search for solutions is the vastness of the conceptual space, which would explain phenomena such as writer's block, then anchoring that space, even by "flinging words" (McPhee, 2013) or other such arbitrarily selected constraints, makes sense.

Creative thought likely emerges as a result of a continuous oscillation between unconscious creative processes and conscious critical ones, or between what Kahneman (2011) calls System 1 and System 2 (in the context of this article, Dr. Seuss's (1960) *Thing 1* and *Thing 2* may be even better labels). In a similar vein, Finke et al. (1992) distinguished between generative and exploratory processes. System 1 generates ideas by way of associations, whereas System 2 monitors and evaluates them, essentially vetting the most promising candidates for a creative output. Familiar solutions are known to be generated faster than novel ones: When participants are given Mednick's (1962) Remote Associates Test, both originality scores, which measure the "uncommonness" of the responses, and flexibility scores, which measure the heterogeneity of the functional categories produced, increase over time, with more uncommon ideas being generated in the second half of the set of produced responses than in the first half (Christensen, Guilford, & Wilson, 1957; Runco, 1986; Ward, 1969). For a task that requires creative thinking, the lazier, instinctive, intuition-driven System 1 first yields familiar, clichéd solutions, which represent the strongest associations. The next steps vary, as a function of a wide range of factors (e.g., Kaufman, 2009, 2011). Motivation, personality differences, time constraints, level of expertise for the task at hand, and how well developed an individual's System 2 is—all these variables play a role.

Under time constraints, or if the motivation to generate something truly creative is low, or if an individual's System 2 is not fully developed, such that it cannot evaluate the true creative value of a solution, the search ends quickly. The novice searcher simply settles for one of the initial, often clichéd solutions. The role of motivation in particular has been shown to be crucial for creativity. For example, Medeiros, Partlow, and Mumford (2014) showed a facilitative effect of task constraints but only when participants were motivated. In a similar vein, intrinsic motivation has been amply documented as an important contributing factor to creativity, and conversely, lack of intrinsic motivation or the introduction of extrinsic rewards has been shown to have a negative impact on creativity (e.g., Amabile, 1983; Amabile et al., 1986; Amabile et al., 1996). Persistence in particular is a key factor for increased creative performance (Lucas & Nordgren, 2015), because creative solutions often require reiterative search and resilience in the face of cognitive failures (Nijstad & Stroebe, 2006).

Provided that the motivation to continue searching is strong and System 2 deems the initial solutions to be uncreative or not creative enough, then playful System 1 will be pushed to explore new, less traveled paths. But which of the many trails that lie ahead are more likely to yield a creative solution? The task, from an algorithmic perspective, is daunting and is perceived as such. For nondeterministic tasks in particular, the search for a creative output can become a monumental challenge. Because creativity appears difficult, individuals routinely underestimate the value of persistence in solving creative problems (Lucas & Nordgren, 2015). One approach is to shoot random darts into thin air, hoping that one of them would, by accident or serendipity, hit a target. This method is hardly encouraging, and the odds of success are low. In inverse theory, this is called a Monte Carlo search. Another approach is to introduce constraints. They restrict the search space to a narrower field, within which one can zoom in. In other words, this constrained search space allows a deeper exploration of fewer alternatives. The conventional ones are removed faster (there are fewer of them), and the constraints focus the search for a creative solution: They force System 1 to play around with unconventional options, to explore less familiar paths, to diverge in previously unknown directions.

Granted, the carryover effect documented in these two experiments is specific to the rhyming task, and it was only tested when the creative writing task remained the same across both sets of trials. Therefore, it remains to be seen whether working with constraints in one task also yields more creative responses in a subsequent unrelated task. Existing evidence has suggested that, overall, creativity does not seem to lend itself to easy transfer across domains (e.g., Runco, 1987; Stokes, 2001). Perhaps the mere knowledge that constraints are not detrimental but can in fact help could encourage individuals to experiment more, even with

limitations, within a given domain. It is also impossible to tell at this point whether the type of constraint used here, that is, arbitrarily selecting a stimulus relevant to the task at hand, can be used with similar success to enhance creativity across other domains. These questions relate to the broader debate about whether creativity is domain-specific or not (e.g., Ambrose, 2006, 2009; Baer, 1998, 2012; Silva, Kaufman, & Pretz, 2009).

The type and number of constraints and their impact on creativity in general or on specific creative tasks merits future investigations. Is the relationship between constraints and creativity linear, or curvilinear? The present two experiments used a binary design. Future investigations could manipulate more than one constraint at a time. Is there an optimal number of constraints? Obviously, if too many constraints are specified, then the task risks turning into a deterministic endeavor, where at each step along the way the input can yield only one possible output. This is no longer a creative task. Moreover, both the number and the type of constraints may impact creativity differently. For example, Stokes (2005; Stokes & Fisher, 2005) distinguished between goal, source, subject, and task constraints, each of which define domains and promote creativity. For a creative writing task, a semantic constraint of the sort introduced in the present experiments seems to help. Would the introduction of a formal constraint, such as starting the message with a given letter of the alphabet, also help? The members of the constrained writing group OuLiPo (Ouvroir de Littérature Potentielle), who have experimented with such techniques, even producing a 300-page novel that excluded the letter *e* (Perec, 1969), would certainly think so. Moreover, the use of the same constraints may interact differently with other factors, such as level of expertise or motivation. By achieving competence in a domain, experts have already internalized the constraints specific to their area. For example, skill levels appear to be an important moderator of perceptions of the creative experience: For participants with higher skill, task enjoyment and perceptions of competence and autonomy declined in the constrained condition, when the target outcome was specified (Dahl & Moreau, 2007). Alas, the creativity of the outputs in that study was not assessed. Finally, do constraints on Big C creativity have effects similar to those on little c creativity? Anecdotal evidence, some of which is reviewed at the start of this article, has suggested that constraints can be and often are also used for Pulitzer Prize–worthy literary composition (McPhee, 2013) and transformative musical creativity (Stravinsky, 1956).

Conclusions

On the theoretical side, creativity stems from choices and does not thrive under boundless conditions. First, a person must choose to search for a creative solution—and to continue that search instead of settling for a familiar one. Second, creativity depends on constraints, which limit the overwhelming number of available choices to a manageable subset within which a deeper exploration of unusual associations is more likely to occur.

On the practical side, instead of following the same old paths, machete your way through uncharted territory. Venture out deeper into the forest of associations, off the well-trodden paths, away from the safety of well-lit streets. The search may be tougher, but it is ultimately worthwhile, when persistence pays off. In the end, constraints may turn out to be liberating.

References

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

Amabile, T. M., Goldfarb, P., & Brackfield, S. C. (1990). Social influences on creativity: Evaluation, coaction, and surveillance. *Creativity Research Journal, 3,* 6–21. http://dx.doi.org/10.1080/10400419009534330

Amabile, T. M., Hennessey, B. A., & Grossman, B. S. (1986). Social influences on creativity: The effects of contracted-for reward. *Journal of Personality and Social Psychology, 50,* 14–23. http://dx.doi.org/10.1037/0022-3514.50.1.14

Ambrose, D. (2006). Large-scale contextual influences on creativity: Evolving academic disciplines and global value systems. *Creativity Research Journal, 18,* 75–85. http://dx.doi.org/10.1207/s15326934crj1801_9

Ambrose, D. (2009). *Expanding visions of creative intelligence: An interdisciplinary exploration*. Cresskill, NJ: Hampton Press.

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior, 22,* 261–295. http://dx.doi.org/10.1016/S0022-5371(83)90201-3

Anderson, J. R. (1995). *Cognitive psychology and its implications* (4th ed.). New York, NY: Freeman.

Baer, J. (1998). The case for domain specificity in creativity. *Creativity Research Journal, 11,* 173–177. http://dx.doi.org/10.1207/s15326934crj1102_7

Baer, J. (2012). Domain specificity and the limits of creativity theory. *Journal of Creative Behavior, 46,* 16–29. http://dx.doi.org/10.1002/jocb.002

Basadur, M., & Thompson, R. (1986). Usefulness of the ideation principle of extended effort in real world professional and managerial creative problem solving. *Journal of Creative Behavior, 20,* 23–34. http://dx.doi.org/10.1002/j.2162-6057.1986.tb00414.x

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology: General, 80,* 1–46. http://dx.doi.org/10.1037/h0027577

Baudelaire, C. (1981). *Baudelaire: Selected writings on art and artists* (P. E. Chavret, Trans.). Cambridge, United Kingdom: Cambridge University Press. (Original work published 1859)

Boden, M. A. (1990). *The creative mind: Myths and mechanisms*. London, United Kingdom: Weidenfeld and Nicolson.

Braque, G. (1947). *Cahier de Georges Braque*. New York, NY: Valentin.

Bristol, A. S., & Viskontas, I. V. (2006). Dynamic processes within associative memory stores: Piecing together the neural basis of creative cognition. In J. C. Kaufman & J. Baer (Eds.), *Creativity and reason in cognitive development* (pp. 60–80). Cambridge, United Kingdom: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511606915.005

Christensen, P. R., Guilford, J. P., & Wilson, R. C. (1957). Relations of creative responses to working time and instructions. *Journal of Experimental Psychology, 53,* 82–88. http://dx.doi.org/10.1037/h0045461

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82,* 407–428. http://dx.doi.org/10.1037/0033-295X.82.6.407

Costello, F. J., & Keane, M. T. (2000). Efficient creativity: Constraint-guided conceptual combination. *Cognitive Science, 24,* 299–349. http://dx.doi.org/10.1207/s15516709cog2402_4

Cramond, B., Martin, C. E., & Shaw, E. L. (1990). Generalizability of creative problem solving procedures to real-life problems. *Journal for the Education of the Gifted, 13,* 141–155. http://dx.doi.org/10.1177/016235329001300203

Dahl, D. W., & Moreau, C. P. (2007). Thinking inside the box: Why consumers enjoy constrained creative experiences. *Journal of Marketing Research, 44,* 357–369. http://dx.doi.org/10.1509/jmkr.44.3.357

Dennis, A. R., & Williams, M. L. (2003). Electronic brainstorming: The-

ory, research, and future directions. In P. B. Paulus & B. A. Nijstad (Eds.), *Group creativity: Innovation through collaboration* (pp. 160–178). New York, NY: Oxford University Press.

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology, 53,* 497–509. http://dx.doi.org/10.1037/0022-3514.53.3.497

Dr. Seuss. (1960). *Green eggs and ham*. New York, NY: Random House.

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

Freedman, D. H. (2010). Why scientific studies are so often wrong: The streetlight effect. *Discover Magazine, 2010* (July–August). Retrieved from http://discovermagazine.com/2010/jul-aug/29-why-scientific-studies-often-wrong-streetlight-effect

Gabora, L. (2010). Revenge of the "neurds": Characterizing creative thought in terms of the structure and dynamics of memory. *Creativity Research Journal, 22,* 1–13. http://dx.doi.org/10.1080/10400410903579494

Gallupe, R. B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., & Nunamaker, J. F., Jr. (1992). Electronic brainstorming and group size. *Academy of Management Journal, 35,* 350–369. http://dx.doi.org/10.2307/256377

Haught, C. (2015). The role of constraints in creative sentence production. *Creativity Research Journal, 27,* 160–166. http://dx.doi.org/10.1080/10400419.2015.1030308

Haught-Tromp, C. (2016a). Creativity and constraint: Friends, not foes. In J. C. Kaufman & J. Baer (Eds.), *Creativity and reason in cognitive development* (2nd ed., pp. 211–225). Cambridge, United Kingdom: Cambridge University Press. http://dx.doi.org/10.1017/CBO9781139941969.011

Haught-Tromp, C. (2016b). Facilitating creative thinking in the 21st century: When constraints help. In D. Ambrose & R. J. Sternberg (Eds.), *Creative intelligence in the 21st century: Grappling with enormous problems and huge opportunities* (pp. 107–117). Rotterdam, the Netherlands: Sense Publishers.

Haught-Tromp, C., & Stokes, P. D. (in press). Constraints, competency and creativity in the classroom. In R. Leikin & B. Sriraman (Eds.), *Creativity and giftedness: Interdisciplinary perspectives from mathematics and beyond*. Rotterdam, the Netherlands: Springer Science and Business.

Huberman, G., Iyengar, S. S., & Jiang, W. (2007). Defined contribution pension plans: Determinants of participation and contribution rates. *Journal of Financial Services Research, 31,* 1–32. http://dx.doi.org/10.1007/s10693-007-0003-6

Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology, 79,* 995–1006. http://dx.doi.org/10.1037/0022-3514.79.6.995

Johnson-Laird, P. N. (1987). Reasoning, imagining, and creating. *Bulletin of the British Psychological Society, 40,* 121–129.

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

Johnson-Laird, P. N. (1993). *Human and machine thinking*. Hillsdale, NJ: Erlbaum.

Johnson-Laird, P. N. (2002). How jazz musicians improvise. *Music Perception, 19,* 415–442. http://dx.doi.org/10.1525/mp.2002.19.3.415

Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Farrar, Straus & Giroux.

Kaplan, A. (1964). *The conduct of inquiry: Methodology for behavioral sciences*. San Francisco, CA: Chandler.

Kaufman, J. C. (2009). *Creativity 101*. New York, NY: Springer.

Kaufman, J. C. (2011). Individual differences in creativity. In T. Chamorro-Premuzic, S. von Stumm, & A. Furnham (Eds.), *Wiley-Blackwell handbook of individual differences* (pp. 679–698). New York, NY: Wiley.

Lucas, B. J., & Nordgren, L. F. (2015). People underestimate the value of persistence for creative performance. *Journal of Personality and Social Psychology, 109,* 232–243. http://dx.doi.org/10.1037/pspa0000030

Marguc, J., Förster, J., & Van Kleef, G. A. (2011). Stepping back to see the big picture: When obstacles elicit global processing. *Journal of Personality and Social Psychology, 101,* 883–901. http://dx.doi.org/10.1037/a0025013

Mayer, M. A. (2006, February 13). Creativity loves constraints. *Bloomberg Business, 2006*. Retrieved from http://www.bloomberg.com/news/articles/2006-02-12/creativity-loves-constraints

McPhee, J. (2013, April 29). Draft No. 4: Replacing the words in boxes. *New Yorker, 2013*. Retrieved from http://www.newyorker.com/magazine/2013/04/29/draft-no-4

Medeiros, K., Partlow, P., & Mumford, M. (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. http://dx.doi.org/10.1037/a0036210

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review, 69,* 220–232. http://dx.doi.org/10.1037/h0048850

Mullen, B., Johnson, C., & Salas, E. (1991). Productivity loss in brainstorming groups: A meta-analytic integration. *Basic and Applied Social Psychology, 12,* 3–23. http://dx.doi.org/10.1207/s15324834basp1201_1

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

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. *Personality and Social Psychology Review, 10,* 186–213. http://dx.doi.org/10.1207/s15327957pspr1003_1

Osborn, A. F. (1957). *Applied imagination*. New York, NY: Scribner.

Paulus, P. B., & Brown, V. R. (2003). Enhancing ideational creativity in groups: Lessons from research on brainstorming. In P. B. Paulus & B. A. Nijstad (Eds.), *Group creativity: Innovation through collaboration* (pp. 110–136). New York, NY: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780195147308.003.0006

Paulus, P. B., Nakui, T., Putman, V. L., & Brown, V. R. (2006). Effects of task instructions and brief breaks on brainstorming. *Group Dynamics: Theory, Research, and Practice, 10,* 206–219. http://dx.doi.org/10.1037/1089-2699.10.3.206

Perec, G. (1969). *La Disparition*. Paris, France: Denoël.

Rand, P. (1985). *A designer's art*. New Haven, CT: Yale University Press.

Reitman, W. R. (Ed.). (1965). Creative problem solving: Notes from the autobiography of a fugue. In *Cognition and thought* (pp. 166–180). New York, NY: Wiley.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382–439. http://dx.doi.org/10.1016/0010-0285(76)90013-X

Rose, L. H., & Lin, H. T. (1984). A meta-analysis of long-term creativity training programs. *Journal of Creative Behavior, 18,* 11–22. http://dx.doi.org/10.1002/j.2162-6057.1984.tb00985.x

Runco, M. A. (1986). Flexibility and originality in children's divergent thinking. *Journal of Psychology: Interdisciplinary and Applied, 120,* 345–352. http://dx.doi.org/10.1080/00223980.1986.9712632

Runco, M. A. (1987). The generality of creative performance in gifted and nongifted children. *Gifted Child Quarterly, 31,* 121–125. http://dx.doi.org/10.1177/001698628703100306

Schack, G. D. (1993). Effects of a creative problem solving curriculum on students of varying ability levels. *Gifted Child Quarterly, 37,* 32–38. http://dx.doi.org/10.1177/001698629303700105

Schwartz, B. (2004). *The paradox of choice: Why less is more*. New York, NY: HarperCollins.

Silva, P. J., Kaufman, J. C., & Pretz, J. E. (2009). Is creativity domain-specific? Latent class models of creative accomplishments and creative

self-descriptions. *Psychology of Aesthetics, Creative, and the Arts, 3,* 139–148.

Simon, H. A. (1973). The structure of ill structured problems. *Artificial Intelligence, 4,* 181–201. http://dx.doi.org/10.1016/0004-3702(73)90011-8

Stokes, P. D. (2001). Variations on Guilford's creative abilities. *Creativity Research Journal, 13,* 277–283. http://dx.doi.org/10.1207/S15326934CRJ1334_05

Stokes, P. D. (2005). *Creativity from constraints: The psychology of breakthrough*. New York, NY: Springer.

Stokes, P. D. (2007). Incubated cognition and creativity. *Journal of Consciousness Studies, 14,* 83–100.

Stokes, P. D. (2008). Creativity from constraints: What can we learn from Motherwell? From Mondrian? From Klee? *Journal of Creative Behavior, 42,* 223–236. http://dx.doi.org/10.1002/j.2162-6057.2008.tb01297.x

Stokes, P. D. (2014). Using a creativity model to solve the place-value problem in kindergarten. *International Journal of Creativity & Problem Solving, 24,* 101–122.

Stokes, P. D., & Fisher, D. (2005). Selection, constraints, and creativity case studies: Max Beckmann and Philip Guston. *Creativity Research Journal, 17,* 283–291. http://dx.doi.org/10.1080/10400419.2005.9651486

Stravinsky, I. (1956). *The poetics of music*. New York, NY: Vintage Books.

Ward, W. C. (1969). Rate and uniqueness in children's creative responding. *Child Development, 40,* 869–878. http://dx.doi.org/10.2307/1127195

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