CURRENT PERSPECTIVES IN SOCIAL AND BEHAVIORAL SCIENCES

Creativity and Reason in Cognitive Development

Edited by James C. Kaufman and John Baer

SECOND EDITION

CREATIVITY AND REASON IN COGNITIVE DEVELOPMENT

This book explores the development of cognitive skills related to reasoning and creativity, two strands that can intertwine to work together at times but may also be at odds. Spontaneity and freedom from constraint, characteristic of the thinking of young children, may be essential to creativity, which has prompted many to question how much we lose as we progress through childhood. Research and common sense tell us that effort, practice, and study are necessary for the highest levels of creative accomplishment, yet such intentional exertions seem antithetical to these hallmarks of creativity. In this revised and expanded second edition, leading scholars shed new light on creativity's complex relationship to the acquisition of domain-based skills and the development of more general logical reasoning skills. *Creativity and Reason in Cognitive Development* will be an essential reference for researchers, psychologists, and teachers seeking to understand better the most up-to-date work in the field.

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CREATIVITY AND REASON IN COGNITIVE DEVELOPMENT

Second Edition

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For Nicole and Josh Herman,
Creative and brilliant in their personal and professional lives,
With love –
James C. Kaufman

To Sylvia –
John Baer

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CHAPTER 11

Creativity and Constraint
Friends, Not Foes

Catrinel Haught-Tromp

The complex and sometimes elusive concept of creativity has inspired many creative approaches to its study. Despite competing accounts and progressively more methodical empirical scrutiny, creativity still seems surrounded by a fuzzy aura of ambiguity. Its very definition remains open to debate, and many other related issues risk to be buried under a similar state of inconclusiveness: Is creativity domain-specific or not (Ambrose, 2009; Baer, 1998, 2011, 2012; Silva, Kaufman, & Pertz, 2009)? Does it refer to a process, a set of aptitudes, or the resulting product? How is creativity assessed (e.g., Kaufman & Baer, 2012)? Is creativity restricted to only a few geniuses, or does creative potential exist in everyone? Does gender (e.g., Baer, 1997) or mental illness 2001 play a role (e.g., Kaufman, 2001)? Is creativity important (Kaufman, Davis, & Beghetto, 2012; Runco & Abdullah, 2014; Sternberg & Lubart, 1995)? If so, how does one best study it (Ambrose, 2006; Ambrose, Sriraman, & Pierce, 2014)? From a neuroimaging perspective (see Arden, Chavez, Grazioplene, & Jung, 2010 for an overview), how does creative thought develop in the brain, and where?

One of the less debated claims is that creativity can and does manifest itself in virtually all areas of human life. Creative instances range from a moving piano sonata to an original fashion show, from a major scientific breakthrough to witty dialogue in a novel, from an innovative business initiative to an inspired soccer game. Indeed, the adjective *creative* can precede a vast number of nouns: a creative experiment, creative architecture, a creative poem, creative landscaping.

Although creativity is often extolled in domains such as music, painting, and literature, few of us would readily associate it with more mundane tasks, such as making dinner or writing a note for someone's birthday. Why are we generally reluctant to apply the label *creative* to the production of an original meal or a sentence? The reason is a widespread intuition that "true" creativity must bring about, via its outcome, some

major change or important contribution in an acknowledged field. For example, Sternberg, Kaufman, and Pretz (2002) put forth a Propulsion Theory of Creative Contributions to describe the processes by which a creative act can impact an entire field. Boden (1990) discussed this difference between two types of creativity: psychological (P-creativity) and historic (H-creativity). Moreover, the common belief is that not everyone has the ability to generate such influential results, so creativity seems to be a privilege that only a select few enjoy, using cognitive processes that are radically different from those employed by "ordinary," hence generally uncreative, people in everyday activities.

These a priori assumptions suggest that creativity might involve cognitive processes that are radically different from those employed by "ordinary," hence generally uncreative, people in everyday activities. From this perspective, creativity is mostly inscrutable and the privilege of very few lucky individuals, that is, geniuses. For many of these highly creative people, their creativity is very task-specific and built on a long period of gaining expertise in one particular area. But some creative persons do seem to have been able to turn their skills to unrelated areas. Leonardo DaVinci, whose extraordinary multifaceted creativity spanned science and the arts, is a well-known example. Gioachino Rossini is another: a remarkably creative composer as well as a virtuoso cook. In Braus's (2006, p. 48) aptly titled book *Classical Cooks: A Gastrohistory of Western Music*, culinary historian J. F. Revel extols Rossini's gastronomic talents:

> As for Rossini, the method of preparing filet of beef that bears his name, Tournedos Rossini, reminds us even today that he was a militant connoisseur. Though apparently a simple dish, Tournedos Rossini has the whole of grand cuisine behind it: it is first necessary to pour over fried croutons a melted meat glaze, already a difficult basic element to prepare; then place on top of the tournedos a whole slice of foie gras with truffles, and then make a sauce with Madeira and a demi-glace with essence of truffles. What restaurateur, even a relatively honest one, can make this demiglace with essence of truffles today?

It is undeniable that certain individuals do display a higher level of creativity in one or more fields of expertise than others (see, e.g., Simonton, 1990, 2013). It is also clear that there are large variations in the degree of influence exerted by a creative product. Nonetheless, it also cannot be disputed that creative capacity is a trademark of human cognition. From this theoretical perspective (e.g., Finke, Ward, & Smith, 1992; Haught, 2015), instances of creative behavior can be observed in everyone, beginning with children (see the "everyday creativity"

perspective, e.g., Richards, 1999; Eisenman, 1999), and all relevant processes are open to experimental investigations (e.g., Runco & Sakamoto, 1999). The *creative cognition* and *everyday creativity* paradigms attempt to demystify creativity and shift the focus from what Howard Gardner (1993) called "Big-C Creativity," that is, studying a few highly creative individuals and elaborating on the differences between them and ordinary people, to "little-c creativity," which in cognitive psychology is probed by exploring the processes that underlie all creative behavior. Kaufman and Beghetto (2009) further proposed a more comprehensive Four C model, adding to the taxonomy two important categories: "mini-c," the creativity involved in the learning process, and "Pro-c," the creativity that emerges after mastery of professional-level expertise.

If one is to study creativity systematically using an empirical approach, a working definition of creativity is needed. Considering the wide spectrum of instantiations of creativity, it is challenging to propose a solid, all-encompassing definition. Nonetheless, in general, there is agreement that at least two criteria must be met. One criterion is novelty, but this is not enough. For this chapter, I could draw cartoons, which would certainly be a novel response to the editors and the readers, but I'm inclined to think that it would not be considered appropriate. So the other criterion is usefulness, in the sense that a creative outcome must be meaningful or otherwise appropriate for the task at hand. Johnson-Laird (2002) put forth a more comprehensive analysis of creativity, according to which a creative outcome must be novel at least for the individual producing it, if not for society at large, and it must stem from a creative process that is nondeterministic, constrained by criteria, and based on existing elements. His analysis is known as NONCE: a product should be Novel, Optionally Original for society, Nondeterministic, Constrained by Criteria, and formed from Existing Elements.

I believe that three important points should guide any working model of creativity. First, a creative product does not have to represent an original contribution to society. In other words, a child or a college student could generate a creative sentence that is appropriate and new to him or her, but not to society. Second, creativity is nondeterministic: given the same inputs, many alternative outcomes can emerge, unlike, say, doing correct mental arithmetic, where from the same starting point the result is always the same. Third, constraints are paramount to creativity: they anchor and shape the creative process.

The Role of Constraints in Creativity

Which is more likely to set creative thinking in motion? A large house or a small apartment? A blue-sky corporate project or one with budgetary and time constraints? A blank canvas or one with a green dot in the center? Of course, the easy answer is "it depends." Of course, there are countless other factors that affect the outcome of a creative process. But, by and large, I believe that the more constraints there are in place, the more creativity will be spurred.

The claim that creative thinking is not only facilitated, but in fact made possible by constraints (e.g., Boden, 1990; Stokes 2001, 2005, 2007) may seem paradoxical at first. This is because the myth of creativity (see Weisberg, 1986), which is most tightly upheld in art, rests on yet another myth: that of the starving, yet free individual – often an artist – who accepts no compromises that would potentially confine or degrade his or her creation. But freedom of choice as used in this sense does not exclude the existence of certain constraints that are described by some, including artists, as being of utmost importance, indeed indispensable, in the creative process. Stravinsky (1956, p. 64) confessed "the anguish into which an unrestricted freedom plunges [him]" and concluded that "the more art is controlled, limited, worked over, the more it is free." He expressed the common misperception of constraints and his opinion on this issue most eloquently (p. 63):

> And yet which of us has ever heard talk of art as other than a realm of freedom? This sort of heresy is uniformly widespread because it is imagined that art is outside the bounds of ordinary activity. Well, in art as in everything else, one can build only upon a resisting foundation: whatever constantly gives way to pressure, constantly renders movement impossible.

Similarly, Baudelaire (1981, p. 306) wrote the following on the constraints of a genre:

> It is evident that rhetorics and prosodies are not arbitrarily invented tyrannies, but a collection of rules demanded by the very organization of the spiritual being, and never have prosodies and rhetorics kept originality from fully manifesting itself. The contrary, that is to say, that they have aided the flowering of originality, would be infinitely more true.

More recently, the celebrated creative nonfiction writer John McPhee (2013) has expressed in vivid terms the challenge of working with a blank canvas, without any constraint, and he shared one technique for generating such self-imposed anchors that encourage creativity:

> For me, the hardest part comes first, getting something – anything – out in front of me. 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.

It is important not to fall into the trap of yet another ambiguous concept such as the one embodied by the notion of constraints. The term has been used to refer to a wide range of factors that can influence one's performance in a creative task. Constraints can be few or many, physical or psychological, self-imposed (e.g., a painter's voluntary adherence to a chosen motif and medium) or externally dictated (e.g., financial or space limitations for an architect), and so forth. In an empirical investigation, the term *constraint* usually refers to a restriction imposed by the experimental design that must be followed by all participants as they complete an assigned task.

Does Creativity Depend on Constraints?

I argue that, contrary to the "freedom to create" myth, constraints are at the heart of the creative process, guiding it and governing the generation of ideas. Indeed, creation depends on constraints. Therefore, the greater the number of constraints, within reason, the more creative individuals are likely to be.

Anecdotal and biographic evidence supports the value of constraints in creativity. For example, in business, Yahoo CEO Marissa Mayer expressed her belief that constraints are critical to creative success: "[They] shape and focus problems and provide clear challenges to overcome. Creativity thrives best when constrained" (Mayer, 2006). In literature, Theodor Seuss Geisel wrote *Green Eggs and Ham* in response to a publisher's challenge to create a fun children's book within the tight constraint of using only fifty words. The creativity involved in writing often seems guided by a variety of constraints, some self-imposed, others externally dictated. Indeed, language, with its unbounded combinatorial and recursive power, provides perhaps the most extraordinary example of creativity in action (e.g., Chomsky, 1965), and figurative language in particular epitomizes linguistic creativity (e.g., Glucksberg & Haught, 2006; Haught, 2013, 2014).

Does this anecdotal evidence stand the test of empirical scrutiny? It seems so.

Using a creative sentence production task, two experiments tested the counterintuitive hypothesis that constraints can facilitate creativity (Haught, 2015). In these studies, the participants generated creative

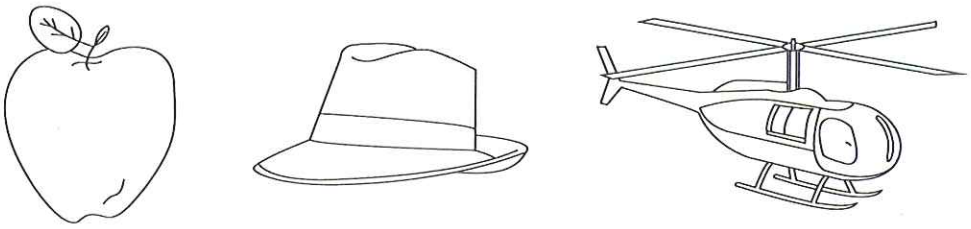

Figure 11.1. An example for the *pictures* condition.

APPLE HAT HELICOPTER

Figure 11.2. An example for the *words* condition.

sentences that incorporate a given set of concepts. I manipulated the constraints on the task by presenting the concepts as either pictures (see Figure 11.1) or words (see Figure 11.2). The words were concrete, unambiguous, nonpolysemous nouns, and their corresponding pictures consisted of line drawings selected from a set of normed representations of concepts (Snodgrass & Vanderwart, 1980).

Pictures show a particular entity, while words are general. Therefore, line drawings are more constrained representations than their corresponding nouns. As the saying goes, "One picture is worth a thousand words." Because any concrete concept maps onto an indefinite number of visual representations, any particular visual representation, such as a line drawing, conveys much more information than the corresponding word. I therefore predicted that people would produce more informative, hence creative, sentences in response to sets of line drawings than in response to words.

To assess creativity, two methods were used. The first, Shannon and Weaver's (1949) information-theoretic measure, capitalizes on the novelty criterion that is often used in the evaluation of a creative product. This measure of information was initially proposed as a useful tool for engineers, who could, using Shannon's unit, called a bit, specify the channel capacity of a communicative set-up in terms of bits per second. It relies on the plausible assumption that the less probable and predictable a response is, the more information it conveys. I adapted Shannon and Weaver's measure to assesses novelty via statistical rarity: the more diverse the responses, the more informative and less predictable, hence more creative, they are deemed to be. The sentences produced were sorted into categories based on the meaning expressed in each sentence. For example, for the set

of items *LION STRAWBERRY HARP*, sentences such as "*After the lion finished playing the harp, he ate some strawberry*" and "*The lion was playing the harp while eating the strawberry*" were placed in the same category because the propositions conveyed are highly similar, whereas "*The harp had a strawberry-colored lion carved in its post*" was judged to belong to a different category. The information-theoretic measure was applied to the sentences sorted by content as described, and it was used to compute the relative improbability of the scenario expressed by each sentence, yielding the first measure of creativity. The second, more standard and more often used assessment of creativity, which has its own share of imperfections, consisted of ratings. Two independent judges who were hypothesis- and condition-blind rated each sentence on a creativity scale.

Pictures are a more constraining representation than words. Were the sentences in response to pictures more creative than those in response to words? Yes. Results from both the information-theoretic measure and the judge's ratings supported this prediction: the participants yielded more creative sentences when they had to refer to the more constraining representation, pictures, than to words.

Constraint has enhanced creativity in this particular task. When the participants see a visual representation of an item, they are more anchored into a clear, concrete image of that concept, which may lead to the activation of fewer mental models. A narrower starting field of exploration is likely to facilitate a more in-depth successful search for a creative scenario. Pictures appear to yield more creative outputs than words. In particular, concrete concepts, the only type of concept used in the experiments reported, may facilitate creativity. George Orwell (1968, p. 264) expressed this intuition well:

> When you think of a concrete object, you think wordlessly, and then, if you want to describe the thing you have been visualizing, you probably hunt about till you find the exact words that seem to fit it. When you think of something abstract you are more inclined to use words from the start, and unless you make a conscious effort to prevent it, the existing dialect will come rushing in and do the job for you, at the expense of blurring or even changing your meaning. Probably it is better to put off using words as long as possible and get one's meaning as clear as one can through pictures or sensations.

How Constraints Work

> Interviewers have asked me how I get ideas for pictures and to this day I am not able to answer satisfactorily. [...] I would say, pick a subject that would

> stimulate you, elaborate on it and involve it, then, if you can't develop it further, discard it and pick another. *Elimination from accumulation* is the process of finding what you want. (Chaplin, 1964, p. 209)

Charlie Chaplin may have been on to something.

How exactly do we complete a task that requires creativity? For example, how do we generate a creative linguistic message, such as a note for someone's birthday or anniversary?

At a macro level, the task is accomplished using the following steps, some of which are analogous to those involved in any problem solving. First, a goal is established, for example, write a creative birthday greeting. Next, several appropriate alternatives are generated or, in Chaplin's terms, "accumulated." Third, the alternatives are evaluated to make sure they meet the criteria. Fourth, following the evaluation, one of the possible alternatives is selected, while the rest are discarded, or "eliminated." Lastly, the chosen alternative may be evaluated again and, if not deemed satisfactory, a new iteration begins. Constraints can be imposed at any stage in the process, to help reach the goal.

The production of a sentence that describes a situation is in itself a complex and perhaps creative task (e.g., Levelt, 1989). For the particular task of generating creative sentences – and possibly any sentences – with concepts presented as words or line drawings, the following cognitive processes may be involved. The sets of words or pictures activate another set of concepts, namely, those properties that characterize the given items and that are most salient to the individual. Salience in this case can be based on a variety of factors, including prototypicality of the object, personal experience, knowledge base, and availability. Some of the properties activated (especially when line drawings are presented) are *descriptive* specifications of the subconcepts that form the foundation of perceptual models – for example, a pear's shape, a leaf's color, or the texture of a lobster's exoskeleton. The inclusion of the given concept into its immediately superordinate lexical level, that is, its hypernym – for example, a hat is a clothing item, a trumpet is a musical instrument – activates another type of properties. These features will probably specify the *function* of the given concepts and are most useful in a sentence production task because they can easily be expressed by verbs. It is likely that more descriptive properties are produced in response to line drawings than in response to words, whereas the presentation of words triggers a greater activation of the function features. It is also important to note that when the concepts are presented in a set, the process of feature activation for each item will not take

place independently of the other items. Thus, the fact that two concepts appear together may also influence the kinds of properties activated and may make one of the items' features more salient than the others. For example, given the concepts *onion* and *bottle*, the function of the bottle as a container is likely to be activated faster than the fact that an onion is a vegetable, so a mental model that represents the onion inside the bottle is quickly generated. Similarly, as indicated by several studies of sentence production that involved recall or picture description tasks (see Bock, Loebell, & Morey, 1992), when one of the given concepts is an animate object, it will often be assigned the role of agent in the sentence. Because of an increased level of predicability, that is, the range of properties or predicates that can be used to describe a concept (Keil, 1987), and possibly because of the centrality of animacy within knowledge networks, animate words are conceptually more accessible, so they are assigned higher level grammatical roles (McDonald, Bock, & Kelly, 1993). These points explain the frequent tendency toward anthropomorphism observed in the creative sentence generation experiment.

When all the concepts are entities, as is the case in the Haught (2015) experiment, a set of relations must be established for any usable scenario to be produced. Presumably the participants bear in mind their objective, that is, to create a sentence using the given concept, which may bias the type of features that are activated. Namely, it is more pragmatic to encourage the activation of function properties, which can often be expressed through verbs, that is, the needed linguistic structure to link the concepts, and to exclude some of the other features, which are more easily conveyed through adjectives, such as the fact that a leaf may be green or a lobster's exoskeleton is tough. Indeed, for the *words* condition, the data on latencies support the prediction that function properties were activated more often and more easily than descriptive ones; hence response times were faster. At the same time, if one also bears in mind that the sentences must be creative, one would try to avoid the cliché associations that are bound to occur if the focus is on the main, often prototypical, function of an object. Thus, the sentences produced in response to line drawings may have been more creative because more descriptive features were activated, which forced the participants to incorporate them in an original way, sometimes as expressions of the relations among concepts.

After the automatic activation of several properties, the search for an appropriate mental model begins. Some of the features already activated are sufficient for generating at least one set of relations that can

successfully link the given concepts[1]. Therefore, if the task calls for participants to produce the first sentence that comes to mind and that incorporates the given items, at least one viable mental model would be quickly constructed, and, if more models are available, one would be chosen arbitrarily. However, when the goal is to produce a *creative* sentence, more cognitive work ensues. Depending on factors such as one's level of motivation, understanding of creativity or degree of perfectionism in completing the task, either (1) a mental model is selected from those already available or (2) if none of the features automatically activated can be used to generate a scenario deemed creative by the participant, that person will engage in a deliberate search for more properties and relations that are relevant for the task at hand, which will eventually lead to the production of a satisfactory model.

Johnson-Laird (1987a, 1987b) proposed that the generation of a sentence may be based on one of three processses: a neo-Darwinian algorithm, where alternative mental models are generated at random; a neo-Lamarkian process, whereby the mental models constructed are constrained by criteria and the only arbitrary aspect of the process consists of the selection among the available models that seem to meet all the requirements of the task; or a multistage process, the most likely of the three candidate algorithms. In a multistage process, some constraints intrinsic to the task are in place from the very start. For example, in addition to the instruction that certain concepts must be incorporated into a creative sentence, the mere fact that the output must be expressed via a linguistic structure is constraining in itself. Words are not like pizza toppings that can be placed in any combination and order in the dough of a sentence. Instead, linguistic productions are bound to strict grammar rules that limit the number of possible combinations among lexemes, albeit minimally: even if one were constrained so that there are on average only four possible words that can occur next in a sentence, the numbers become so vast so soon that the constraints may hardly impinge on the speaker. These initial constraints yield a vast array of possible outputs, on which additional constraints are imposed to filter out products that are not adequate, and an arbitrary choice is made among the remaining viable products.

[1] In the rare cases in which no relation whatsoever is apparent, an easy solution is to simply incorporate the items into a mental model that asserts their existence, often via enumeration – for example, "I saw X, Y, and Z..."

Could a computer program be built to carry out the operations that are needed to generate a creative sentence that incorporates given concepts? The task is relatively straightforward: the input is a set of concrete nouns and the expected output for each of these sets is a sentence that can be judged as creative. The main task of the program will likely consist of generating, as the participants did, the relations that link the given concepts, often through verbs, the key lexical structures needed to achieve this goal. The key challenge remains defining an implementable algorithm that would ensure that the sentences produced are creative. The groundwork for developing such a program is already in place. For example, machines such as BRUTUS (Bringsjord & Ferrucci, 2000) can go beyond generating mere sentences and can construct stories based on given themes, although Brigsjord himself argues that computers cannot be creative.

The main difficulty is that, indeed, computers do not have a built-in sense of which scenarios would qualify as creative. Even if the novelty and appropriateness criteria were used to operationalize creativity, the program might still be severely limited. Given the adequate inputs, it may construct more alternatives than a human mind would, but how would the most creative one be selected? The right detailed instructions for choosing the sentence subject, the verb, and any adjectives and adverbs should guide a computer program to generate, in response to given words, such as *cow* and *bicycle*, creative sentences of the sort that a human participant would, for example, "*The cow rode the bike to get milk from the grocery store.*"

An algorithm that could yield creative sentences is undoubtedly complex. It would have to simulate the links between concepts and the corresponding mental representations that they activate. The robustness of the algorithm would also rest on a careful and comprehensive analysis of the linguistic structures and the relations among concepts that contribute to the creativity of a sentence. The development of a computational model of the creative language task that rests on this sort of encompassing analysis is yet to be fully fleshed out. When such a program is designed, the emerging benefits would be tremendous. It would allow the testing of hypotheses concerning constraints, and it would fill many of the lacunae in our understanding of creativity.

Creativity and Constraints: A Look Ahead

Much anecdotal and some empirical evidence exists regarding creativity. Yet, the mechanisms that underlie creative processing remain largely a

mystery. Future research should aim to develop a comprehensive theory that explains how individuals produce creative responses, not only within language production, but across other domains. It should also further test the counterintuitive hypothesis that constraints can enhance creativity.

Although current research on this topic is only in its infancy, preliminary indications suggest that constraints could play a key role. But the broader important question remains: What exactly are the constraints that could facilitate creative language production, and creativity in general? This is one of the key empirical issues that remains to be addressed, and to be incorporated into any developing theory of creativity.

Another important question concerns the optimal number of constraints. For low-familiarity tasks, this number should be correlated with how much information one can hold in working memory. However, the type of constraints, their familiarity to the users, and the domain expertise of the users are important factors to take into account.

Although the manifestations of creativity may be task specific, some general trends might emerge. For example, I would expect time constraints to diminish creativity in novices, but enhance it in experts, who are have internalized and experimented with constraints in their area of expertise. Similarly, the mere practice of working with constraints should facilitate creativity. Thus, when constraints are first imposed on a creative task, and then removed, people would likely be more creative than when no constraints are ever introduced.

Finally, we know that creativity is essential to cognitive development. Might constraints help further encourage creative thinking in children? Imagine that instead of asking students in a classroom to write a poem, the teacher would instead ask them to create a poem that incorporates a set of given constraints, be they semantic (you must incorporate a certain word) or formal (you must not use the letter "e"). Such techniques that constrain a challenging task could be taught and then internalized in an effort to promote creative thinking. The steps are simple: first narrow down your field of possibilities, anchor your search for a creative output, and then explore the newly narrowed set of options in more depth.

Further insights into the role of constraints in creativity could have wide-ranging applications, both in fields as diverse as education, business, art, and science, and in everyday life. We may innovate more easily, create better meals, deliver better business pitches or wedding toasts, write more persuasive messages, and render more expressive musical performances. Constraints in creativity may turn out to be liberating.

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