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7. FACILITATING CREATIVE THINKING IN THE 21ST CENTURY

When Constraints Help

Progress often depends on creative thinking and innovation. Be they transformative, paradigm-shifting breakthroughs, or smaller, incremental improvements that may have less of an impact on their own but still contribute to progress, creative ideas can help solve problems and lead to domain-specific innovations or broader, transdisciplinary advancements. In particular, the new, complex challenges of the 21st century often require creative solutions.

How can such creativity be facilitated, across a wide range of domains and contexts? The Green Eggs and Ham hypothesis proposes that constraints can help. They anchor the creative process, circumvent clichéd associations and encourage the exploration of previously uncharted paths to novel and useful ideas. Empirical data, along with examples from business, education, science and art, are used to illustrate the power of constraints, especially in the context of globalization, and further applications, with emphases on opportunities unique to the 21st century, are suggested.

THE EFFECTS OF GLOBALIZATION ON CREATIVITY

In our increasingly interconnected world, the 21st century brings a host of macroproblems and macro-opportunities that cannot be addressed by a single nation, or a single specialized field, or in a single, well-defined, small time frame (Ambrose, 2009; Ambrose & Sternberg, 2012). Instead, they span national borders and disciplines, and take time to solve, in the case of problems, and to bring to fruition, in the case of opportunities.

The impact of globalization on the wellbeing of individuals and societies alike has spurred a debate. On the one hand, globalization has contributed to exponential knowledge growth and cognitive diversity, two of the most important macro-opportunities available in the 21st century. On the other hand, there is the extreme view, well articulated by a character in Michael Crichton's 1995 novel *The Lost World*, that globalization, and cyberspace in particular, leads to "the end of innovation" (p. 311) and "global uniformity" (p. 312):

D. Ambrose & R. J. Sternberg (Eds.), Creative Intelligence in the 21st Century, 107–117.

> This idea that the whole world is wired together is mass death. Every biologist knows that small groups in isolation evolve fastest. You put a thousand birds on an ocean island and they'll evolve very fast. You put ten thousand on a big continent, and their evolution slows down. Now, for our own species, evolution occurs mostly through our behaviour. We innovate new behaviour to adapt. And everybody on earth knows that innovation only occurs in small groups. Put three people on a committee and they may get something done. Ten people, and it gets harder. Thirty people, and nothing happens. Thirty million, it becomes impossible. That's the effect of mass media – it keeps anything from happening. Mass media swamps diversity. It makes every place the same. Bangkok or Tokyo or London: there's a McDonald's on one corner, a Benetton on another, a Gap across the street. Regional differences vanish. All differences vanish. In a mass-media world, there's less of everything except the top ten books, records, movies, ideas. People worry about losing species diversity in the rain forest. But what about intellectual diversity – our most necessary resource? That's disappearing faster than trees. But we haven't figured that out, so now we're planning to put five billion people together in cyberspace. And it'll freeze the entire species. Everything will stop dead in its tracks. Everyone will think the same thing at the same time. Global uniformity.

Levitt (1983), a well-regarded Harvard economist, also warned about the lack of diversity that globalization ensures, decades before the 21st century even began: "Chinese food, pita bread, country and western music, pizza, and jazz are everywhere. They are market segments that exist in worldwide proportions. They don't deny or contradict global homogenization but confirm it."

Such economic and social perspectives are useful and informative, but so are the psychological ones, especially regarding creative thinking. For example, Cowen (2002) argues that while globalization may create less diversity between cultures, it also creates more diversity between individuals. Global trading allows for more cross-cultural pollinations, as does the availability of information made possible by technology. Trends that may otherwise perish end up thriving, as Cowen points out in his examples of Indian hand-weaving and music from Zaire.

But what happens to individual creativity, from a cognitive perspective? In particular, what is the impact of exponential knowledge growth and cognitive diversity? These two macro-opportunities play a significant role.

Exponential knowledge growth has allowed access to more information than ever before. With search engines at one's fingertips and technology developments that allow easy access to data from across domains, the search space becomes vaster than ever, whether looking for a solution to a problem, or aiming for a creative output where the goal is ill-defined or nonexistent. So, this macro-opportunity comes with a challenge: how does one filter through all these data in order to bring forth a breakthrough or a discovery? This is where constraints can help. Narrowing down the potentially overwhelming search space could well be one of the keys to

modern creativity. The other key could be taking full advantage of the unprecedented cognitive diversity available. Modern progress is often the result of collaborations, many of them interdisciplinary.

Take, for example, modern seismology. Massive amounts of data are constantly gathered all around the world, from tens of thousands seismometers. Such data, which used to be stored by the individual country or institution that owns the machines, would often collect dust. Now, thanks to the right computational tools and open source software, they are increasingly available to most researchers. These individuals, endowed with access to such rich, detailed information from different parts of the world, can put their individual and collective creativity to work and generate better-informed theoretical models that are also tested more easily. They almost always need a starting point, a constraint of sorts, which often means limiting the data to a smaller subset. Once the constraint is in place and the model is derived, the remaining data are incorporated and the model is finessed in the process. Thanks to such models, we now have a better understanding of what the earth looks like beneath its surface.

Knowledge growth and the availability of such knowledge contribute to such scientific progress and discoveries. So does cognitive diversity. Teams often include specialists from different disciplines. For seismology, they may include mathematicians, physicists, geologists, and computer scientists, each bringing their unique perspective and tools to the table. These different, interdisciplinary perspectives act as additional constraints. For example, Ambrose (2009) took seventy-two theories and research findings from twenty-nine academic disciplines and professional fields and then cross-referenced them to see how ideas from one discipline or field could make one think creatively about an idea from another discipline/field, through the process of creative association. What would grouping together the rational actor model from economics with discoveries about empathy in animals from primatology yield, Ambrose wondered? This sort of wide-ranging interdisciplinary exploration imposes constraints by forcing one to make connections between clearly specified, domain-specific constructs. Might constraints facilitate creative thinking?

CONSTRAINTS AS CREATIVITY ANCHORS

The term *constraint* is used in a wide range of domains, with context-specific meanings. In mathematics, constraint optimization refers to a condition of a problem that must be satisfied by the solution. In business management, the Theory of Constraints rests on the assumption that the performance of a system is determined by the performance of its biggest constraint, and that constraints represent obstacles that must be removed in order to achieve a goal. In classical mechanics, a constraint limits the freedom of movement of a system of particles. In artificial intelligence, constraint satisfaction refers to the assignment of a value to each variable in the set, such that the solution meets the specified constraints. In engineering, the Theory

of Inventive Problem Solving (also known as TRIZ) puts forth a toolkit based on constraints, which helps with the development of new products, making new discoveries and solving problems. In literature, constrained writing requires the writer to follow a certain pattern or to embrace some limitations. Palindromes, alliteratives, and lipograms are examples of the sort of outputs that emerge. In Bayesian inference, a "prior" probability density function is combined with a "likelihood" function to produce a "posterior" probability density function. The prior expresses a constraint on permissible values of the model parameters, whereas the likelihood expresses the probability of a model given the constraints of the data.

In creativity research, two main conceptual pillars have framed the role of constraints: "freedom to create" and "thinking outside the box." According to the "freedom to create" myth, no limits on the opportunities to be explored allows access to an infinite number of options from which to choose, which in turn leads to a vast array of creative outcomes. The proponents of the "thinking outside the box" framework also endorse the lack of limitations and suggest that the exploration of the immense field of options that lie elsewhere, outside the proverbial box, facilitates creativity and its ensuing outputs.

I argue that both premises are flawed. Limitations, or constraints, should be sought out and embraced, rather than avoided and removed. In theory, an infinite field of possibilities may sound appealing, but in practice, the prospect is daunting: where to begin the exploration, and how?

De Brabandere and Iny (2013) propose an interesting alternative: instead of aiming to "think outside the box", and therefore viewing the proverbial box in a negative light, they suggest thinking "in new boxes." What they mean is experimenting with new frameworks or mental models. This approach is especially useful in a business setting. In line with the cognitive diversity opportunity (Ambrose, 2009) discussed in the focus chapter near the beginning of this book, one suggestion for increasing the sort of interdisciplinary thinking that stimulates creativity, is to bring in experts from different domains, e.g., ask a nurse to evaluate an accounting firm's performance. The new "nurse box" is used to guide the generation of novel and useful ideas. Indeed, team member diversity has been shown to yield more creative team decision-making (Jackson, 1996).

One could go a few steps further. First, instead of representing a way of thinking, a "box" could simply be a constraint, be it formal or semantic, chosen arbitrarily or thoughtfully, self-imposed or externally generated. Second, several such "boxes" could be used simultaneously. Imagine a container filled with different boxes, akin to a computer folder that holds different files from which data are extracted. The goal remains the same: to generate novel and useful solutions to a problem. The path to such solutions is guided by the various independent constraints and/or the interplay among them.

Stokes (2014) cleverly proposes "thinking inside the tool box." Since expertise in a domain leads to vast knowledge acquisition, these tools inevitably accumulate in a "box" that frames the way experts think about a problem. When it comes to creative

thinking, such expertise can become a liability: it's easy to fall back on the numerous past tried-and-true solutions to a problem. This is where imposing constraints can help (see Boden, 1991; Johnson-Laird, 1987, 1993, 2002; Haught-Tromp, 2015, in press; Haught-Tromp & Stokes, in press; Stokes, 2005).

One additional note about these proverbial "boxes": specialized silos, or boxes, be they internal frameworks or organizational structures, lead to thinking that is myopic. The parable of the blind men and the elephant illustrates this problem. What happens when a group of blind people (or people in the dark) aim to find out what some object or creature, such as an elephant, looks like, and each person proceeds to touch a different part of the elephant and limits himself to that one part, be it the tail or a tusk? Not surprisingly, after such individual data collection, no agreement emerges from the group on what the elephant is. The tail, studied in isolation, could be a rope. The tusk could be a spear. But the Gestalt, "seeing" of the full elephant, only emerges after taking into account the other fellow blind men's perspectives. Once again, this is an example of taking full advantage of the cognitive diversity available. These additional constraints anchor the hypotheses about what the creature is, and they are instrumental in forming a full understanding.

The term *anchor* may describe the concept more aptly than *constraint*, which conjures up negative imagery about lack of freedom and lack of opportunities. The etymology of the word explains its modern negative connotations. From the Latin *constrictus,* through the Old French *constreinte*, meaning "binding, compulsion", the term has firmly rooted its representation of "coercion" and "tied up", "inhibited."

THE *GREEN EGGS AND HAM* HYPOTHESIS: CONSTRAINTS IN CREATIVITY

What makes a search difficult, be it for a job candidate, a romantic partner, a thank-you gift, a solution to a technical problem, or a 21st century macroproblem (Ambrose, 2009; Ambrose & Sternberg, 2012)? The process is often challenging because the search space is vast. This is particularly true for problems that do not have a single specified, correct solution, i.e., those that typically require "creativity." Constraints help narrow down the search, limiting the area of exploration to a more manageable section. Within it, a deeper divergent search is more likely to avoid existing, well-trod, clichéd paths and instead yield a creative solution.

Working with constraints, even unexpected, Kafkaesque, or Dr. Seuss ones, may help spur creativity. This is the Green Eggs and Ham hypothesis (Haught-Tromp, in press). Theodore Geisel's ("Dr. Seuss") best-selling children's book emerged in response to a challenge from his publisher to work with a very tight constraint: the story cannot use more than fifty different words. Creativity was not inhibited. It flourished. The trick is to be open to new experiences and willing to experiment with constraints. Once you do, even though at first the process may seem challenging and you may be tempted not to like the constraints, "try them, try them and you may."

The following section presents support for this hypothesis, in the form of anecdotal and empirical data. Much work remains to be done to test and refine this hypothesis, but the premise that constraints facilitate creativity is worth further exploration.

CONSTRAINTS IN CREATIVITY: APPLICATIONS TO 21ST-CENTURY CHALLENGES AND OPPORTUNITIES

Empirical research on the role of constraints in creativity is sparse. Nonetheless, findings from existing studies lend support to the Green Eggs and Ham hypothesis. In a series of experiments, Finke (1990) asked participants to come up with practical inventions by combining certain parts, such as a hook, wheels, a cone, etc., to create a new object within a category, such as furniture or appliances. Finke (1990) manipulated whether the category and the parts were externally imposed or selected by the participant. The number of creative inventions was greatest in the constrained condition, when both the parts and the object categories were specified.

Haught (2015) showed that sentences generated in response to pictures are more creative than those in response to words. Pictorial representations are more constraining than the corresponding words and pictures turned out to be a better source of creativity. Haught-Tromp (in press) continued testing the role of constraints in language production. In two experiments, I asked participants to generate two-line rhymes to convey a special message, such as *Happy Birthday*, *Thank You*, or *I Love You*. Two constraints were tested. In the first experiment, the messages had to include a given word. In the second experiment, the messages had to include a word that the participants had previously generated. Interestingly, not only were the rhymes more creative in the constrained condition, but both experiments showed a carry-over effect: in the non-constrained condition, the participants were more creative after having first worked with constraints. Mere practice with constraints seems to help facilitate creativity in a subsequent identical task. It remains to be seen whether this carryover effect holds for different types of tasks and whether it extends to dissimilar tasks.

Marguc, Forster, and Van Kleef (2011) showed that obstacles can enhance creative thought. In one experiment, participants were asked to play one of two versions of a computer maze game: an easier one, with fewer obstacles, and a more difficult one, where more obstacles increased the difficulty of escaping. The participants' creativity was then assessed, using the Remote Associates Test (Mednick, 1962). Forty percent more of the problems were successfully solved following the constrained condition, with more obstacles to overcome. This effect was attributed to a "global processing" mode triggered by the obstacle condition, which led participants to focus on the "big picture." In a similar vein, Marguc, Van Kleef and Forster (2015) found that obstacles lead to the generation of broader solution categories and more original means of achieving a goal.

Stokes (2005, 2009, 2014) illustrates the facilitative role of constraints with case studies from art, which support the paired constraints model (see also Haught-Tromp &

Stokes, in press): one constraint limits the search for a solution, precluding clichéd responses, while the other directs the search, promoting novel associations. She also applies the constraints model to teaching place-value in American kindergartens (Stokes, 2014). A more effective math curriculum emerged, in which children are taught explicit base-10 count and they use one rather than many different manipulatives.

Other applications to education can be envisioned. For example, let's contrast for a moment the following two scenarios. First, imagine a child is surrounded by dozens and dozens of toys, and is free to play with any of them for 30 minutes. What is she likely to do? She'll probably choose a favorite set, and after a while get bored. Now, imagine a child is given fewer toys – one dozen, instead of, say, ten dozen – along with the freedom to play with any and all of them for 30 minutes. What is *she* likely to do? Spend more time exploring each toy, and postpone boredom, or get bored even faster? Imagine further that the child is given a task, for example, to engage in as many different pretend-play scenarios as she can with the given toys. When will she be more creative: when fewer or more toys are available? The Green Eggs and Ham hypothesis predicts the counterintuitive answer: creativity will be spurred when the starting points are constrained and the process is anchored. Granted, the child's imagination will also be more taxed in the process (Exactly how many different uses can one think of for a wooden spoon, for example? It's not easy.), but that's exactly the point. The task may be more challenging, but it may also yield more creative responses.

Empirical studies should test such predictions. If they are supported, then perhaps curricula would place more emphasis on teaching children how to become more creative. Specific strategies on how to seek out and use constraints to bring a creative task to fruition could be incorporated.

Anecdotal data from different domains, such as art, business, science, medicine, and day-to-day lives, complements empirical research on constraints. In the domain of art, celebrated composer Igor Stravinsky (1956) acknowledged the importance of constraints: "The more constraints one imposes, the more one frees one's self […], and the arbitrariness of the constraint serves only to obtain precision of execution." Nonfiction writer John McPhee (2013) also relies on constraints to overcome writer's block: "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."

Architect Frank Gehry (cited in Sims, 2011) refers to constraints as "guard rails" which he uses to his advantage. Such constraints can range from deadlines to budget restrictions to materials to the building site specifics. The growing "tiny house" movement, is another, extreme example of space constraints. This minimalist, "conscious living" approach forces one to think creatively about ways to maximize the use of a mere few hundred square feet of available living space, while keeping both functional and aesthetic considerations in mind. Many New York City or Tokyo apartment dwellers are familiar with such constraints.

In business, so-called "blue-sky" projects are not as successful as one may think. Without guiding constraints, the solutions that emerge are not as creative or they lack the practical implementation element. Marissa Mayer, formerly of Google and now the CEO of Yahoo, wrote about the key role that constraints play in arriving at a creative solution: "Constraints shape and focus problems, and provide clear challenges to overcome as well as inspiration. Creativity loves constraints" (Mayer, 2006).

In science, illustrations of creative, interdisciplinary thinking based on constraints abound. For example, tomography, initially used only as a medical technology, is now a key method in a number of fields, including seismology. More generally, when tackling a large-scale scientific problem, constraints can help. For example, computer modeling, a widely used technique in many disciplines, unfolds by the judicious use of constraints. Typically, an overwhelming amount of collected data is available that cannot be tackled all at once. So, the initial challenge lies in the selection of the variables to input, and the attribution of weights and other specifications. Once some boundary conditions are specified, these constraints frame the model, and the problem becomes more manageable and easier to solve.

In medicine, the so-called "tumor paint," currently in the stage of human clinical trials, uses chlorotoxin, a protein derived from scorpion venom, to help surgeons distinguish between cancerous areas and healthy tissue, which are notoriously difficult to tell apart during surgery. This was pediatric oncologist Jim Olson's discovery: the substance lights up the malignant tissue, so that it can be removed completely, even when it is hidden behind healthy tissue, and precisely, i.e., without removing unaffected areas. This is especially critical for brain surgery. An equally remarkable point about this breakthrough is how it came about and how. When an idea as outlandish as using scorpion venom to highlight cancer did not garner the needed agency funding, Dr. Olson was not dissuaded. Once again, he displayed ingenuity and started actively fundraising, and these efforts paid off: "Through bake sales and golf tournaments and chili cook-offs, they raised 8 million dollars and that funded the early discovery work that allowed Tumor Paint to get FDA approval for human trials," Olson said (Mohney & Olson, 2014).

In our day-to-day lives, we are surrounded by constraints. Some of them are a matter of choice. Virtually all sports and games are rule-bound, and it is precisely these constraints that make a tennis match or a Pictionary game so much fun: they trigger creativity. Others, such as budget restrictions, deadlines, or the weather on vacation, are outside of our control. Even for this latter category, remembering that creativity thrives when constrained may help refocus efforts towards generating creative solutions.

A growing body of psychological research is dedicated to the study of happiness and wellbeing, under the umbrella of positive psychology. This subfield focuses on the study of the "good life" and what factors contribute to the experience of a happy, meaningful and fulfilled existence. Day-to-day lives could be improved by an understanding of the variables that affect wellbeing, and creativity plays a key role. There is a particular feeling of self-satisfaction that we all experience after we made

a good joke, or thought of a creative experiment, or figured out a creative solution to a problem. If constraints can help trigger such positive experiences that enhance our wellbeing, then why not seek them out?

If you have only 5 minutes to make a pitch, use that limit to express your message more concisely. Seize the opportunity to crisp up the pitch, rather than complain how hard it is to do it and how much you have to leave out. If you only have a few ingredients in the fridge that constrain what you can fix for dinner, do not be discouraged. Let the limitations guide your creativity.

Twitter is a prime example of the successful use of an extreme constraint: just how much can one convey in a 140-character message? A lot, it turns out. Even recipes, which, within the Twitter constraint, become "awesome acts of compression. Ingredients, actions, quantities, times and temperatures—both Fahrenheit and Celsius—boiled down to utmost richness, density and clarity. A dish, a meal, a trip to deliciousness magically packed into the tiniest carry-on bag" (Downes, 2009).

Similarly, six-word memoirs have attracted a cult following. This powerful, creative story telling method is fueled by a very tight constraint. How would you tell a story in six words? Ernest Hemingway is said to have embraced the challenge. He wrote: *For sale: baby shoes, never worn.* The Hemingway legend inspired the online Smith Magazine to jumpstart an ongoing project, aptly called Six-Word Memoirs, which captures what are probably the world's most concise autobiographies. How would *you* encapsulate your life in six words? Daunting as it may seem, the extreme constraint forces one to focus on the content that matters most and to engage in creative thinking. One such brilliant 6-word autobiography, cited by Seelig (2012): *I'm the careless man's careful daughter.*

An equally powerful example of a creative program that serves a dual function is the concept of intergenerational day care, which is gaining traction. By providing day care for elderly adults and children and integrating the two age groups, such programs propose a creative solution to two separate, constraining challenges, and it's a win-win proposition: each group benefits from the company of the other's, and everyone's overall daily experience is enriched.

CONCLUSION

Many of the issues with which we are confronted in the 21st century are bounded by constraints. Often, these constraints are perceived as insurmountable or as obstacles that must be eliminated before a successful solution can emerge. What if, instead, challenges were reframed as opportunities, and constraints were viewed as anchors that aid rather than hinder? The problem solving or creative discovery process might proceed differently.

The Green Eggs and Ham hypothesis (Haught-Tromp, in press) proposes that creative thought is grounded in constraints, and preliminary evidence supports this postulate. In this spirit, whether tackling daily problems or global issues, one should work *with* constraints, not against them.

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