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CHAPTER 8

Aleatory Creativity

The Role of Random Constraints

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Abstract

In this chapter, we discuss the use of random constraints in the creative process. Such aleatory techniques have a long history, but research on their nature and effectiveness remains scarce. Reviewing the available literature, we propose that random constraints can aid the creative process because (a) they are novel, and (b) they do not threaten autonomy. At the same time, however, working with random constraints is likely to be more cognitively demanding than some other creativity techniques.

Keywords

random constraints – aleatory techniques – aleatoricism

1 Introduction

The role of constraints in the creative process is complex. One specific kind of constraint, which has been employed by artists and scientists to stimulate their creativity, is the deliberate use of random or aleatory (chance-based) elements. For example, painter and scientist Leonardo da Vinci extolled the benefits of staring at the random 'patterns' in brickwork, composer John Cage made use of star maps to start his compositional process, and pop artist David Bowie used a computer program called the 'verbasizer' to create random word strings as a starting point for lyrical ideas. However, although such anecdotal evidence suggests that these approaches may be effective, they have not been clearly conceptualized, and remain understudied. In this chapter, we therefore aim to put forward a definition of random constraints, provide a brief overview of historical and anecdotal evidence for the use (and purported effectiveness) of some aleatory creativity techniques, and review the scarce literature on aleatory influences on the creative process. Subsequently, we will argue that random

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constraints have three core characteristics. First, because they are not meaningfully related to the task or context, they are *remote*. Second, because of their remoteness, random constraints are *cognitively demanding*. Third, because random constraints are typically *self-imposed*, they do not threaten autonomy.

2 Defining Random Constraints

In the following section, we will first develop a definition of random constraints and provide some historical examples of how they have been used in art (specifically music and literature). Subsequently, we will briefly discuss a potential typology that could be applied to random constraints.

For general constraints, we follow the definition recently proposed by Haught-Tromp (2022): constraints are "concepts or categories that reduce the search space" (p. 3). One aspect of this is that constraints *limit* the options or degrees of freedom in a creative task—in other words, the more constraints one faces, the less one is able to do. However, another important aspect is that constraints have the potential to *focus* one's creative efforts, possibly into an unexpected or unlikely direction, and as such could help one leave 'the path of least resistance' (Finke et al., 1992, 1995; Rietzschel, 2018; also see the other chapters in this volume). In the absence of constraints, people will often follow whichever strategy or associative pathway is easiest to use (e.g., most accessible), which in turn could be detrimental to creativity (since those strategies or pathways are unlikely to be highly novel).

In practice, most of the constraints people face are non-random. For example, creative or innovative projects will face a variety of constraints (e.g., financial, technical, time or legal constraints) that somehow reflect something about the desired product or the ecosystem in which the product will be expected to function. Whereas we have gained some understanding of how such non-random constraints can affect the creative process and how they can best be leveraged to achieve optimal outcomes, random constraints have remained more or less neglected. However, given that (as we shall see below) random constraints have been used in various forms throughout history, and that several scholars and practitioners in the field of creativity have extolled their (supposed) benefits, we believe that random constraints deserve more attention.

2.1 *What Is Random about Random Constraints?*

The word 'random' typically refers to probability and a lack of predictability (OED, n.d.): things are said to be 'random' if they are unpredictable or if different possibilities have an equal probability of occurring (like the throw of a die).[1] While this applies to events or occurrences, random constraints as we approach them in this chapter are different, because they are *deliberately* sought or imposed—in other words, a random constraint does not 'happen to us,' rather we decide (or agree) to use it. A better word, then, might be 'arbitrary,' which refers to things being "dependent upon will or pleasure; at the discretion or option of any one," or "discretionary, not fixed" (OED, n.d.). Random constraints in this sense are those constraints that are used or applied *not* because they are called for by the task or the context (they are "not fixed"), but because somebody decides to use them for some other reason ("will or pleasure"). In our view, this notion of random constraints as arbitrary constraints has two aspects: semantic distance and non-inferability.

2.1.1 Semantic Distance

Some random constraints take the form of surprising starting points or input into a creative process; for example, people can use random words or word combinations to start idea generation. Beside the arbitrariness inherent in doing so (since there is nothing about the task that calls for the use of such words), these random words (or other kinds of input) are typically *semantically distant* from the topic or task one is working on. For example, although one could 'arbitrarily' (i.e., at one's own discretion) decide to use the word 'spices' as a starting point when thinking about new curry recipes, this word is strongly related to the topic and, therefore, not likely to lead to a lot of novel ideas. We posit that this cannot reasonably be considered random input or a random constraint; when thinking about curries, spices are among the most obvious things one could think of. In contrast, words like 'stapler or 'disprove' are semantically very distant from the topic: they are not part of any recipe, nor are they typically associated with cooking or food in general. Using such semantically distant words to think about curry recipes would constitute an example of a random constraint, as there is nothing about the task that mandates, implies or even suggests the use of these words; rather the opposite. In other words, using them is fully arbitrary. Thus, the more semantically distant a stimulus is from the task or task domain, the more it qualifies as random in the sense of this chapter. Naturally, semantic distance is a matter of degree; there is no clear or hard boundary between 'close' and 'distant' concepts or stimuli (furthermore, this will partly depend on the person's knowledge and associations).

2.1.2 Non-Inferability

Tasks are typically executed according to rules, and this implies a certain regularity or pattern. Given knowledge of the goal and the (non-random) constraints one faces, we can therefore infer something about what will and what will not be done during task execution. For example, if one would like to cook an enjoyable curry meal for friends who do not enjoy very spicy food, we can infer that it would make sense to search for relatively mild curry recipes. This would be an example of a non-random constraint, which can be inferred from knowledge of the task (cooking dinner) and the context (eaters who do not like spicy food). Although not every rule or set of rules will always be followed (or in the same way) by everybody, there are some constraints that will virtually always be adopted (e.g., not using poisonous ingredients). In contrast, some 'rules' are less likely to be used, and some are extremely unlikely. For example, deliberately creating a menu where all the names of all dishes begin with a 'd' is not something that could be inferred from the fact one is having friends over for dinner. Deciding to do so would be an arbitrary choice, and would mean that one is imposing a random constraint.

Based on these considerations, we define random constraints as *concepts or categories that reduce the search space, and that are arbitrarily applied rather than mandated or implied by the task or task context*. This precludes most of the non-random constraints people typically face (financial, available materials, technology, and so on), because all of those are either mandated by, or can be inferred from, the task or context.

2.1.3 Serendipity

To a certain extent, chance and randomness have always played a role in the process of discovery, but this often takes the form of serendipity—fortunate coincidences that can lead to new insights or ideas. Serendipity is a fascinating and valuable area of study in itself (see e.g., Cannon, 1940; Copeland, 2019; Ross & Vallée-Tourangeau, 2020), but is different from the random constraints this chapter focuses on. A famous (although probably apocryphal) example of serendipity is the apple that supposedly inspired Newton's theory of gravity. Although this could certainly be seen as a form of 'randomness' influencing a creative process, we do not consider this a random constraint; rather, it was an unsolicited random occurrence that triggered certain thought processes, which, in turn, led to a particular creative output.

2.2 *Historical Examples of Random Constraints*

Although random constraints have (as we will see below) received scant attention in the psychological literature, the literature on the history of art provides quite a few examples. The deliberate use of random chance-based processes in the creative process is sometimes called *aleatoricism*. The term, which derives from *alea*, the Latin word for 'die' (as in *alea iacta est*, 'the die is cast'), was coined by the physicist Werner Meyer-Eppler (1955) in an essay on electro-acoustics. However, the use of aleatory techniques or influences goes back much further, with some early examples dating back to the 14th century. We will discuss several examples from the history of art, focusing on music and literature for the sake of brevity.

2.2.1 Aleatory Music

Most examples of aleatoricism in art are found in the history of music (see Griffiths, 1980, for an overview). Paradoxically, these are sometimes discussed in the context of *algorithmic composition* (Essl, 2017), a form of musical composition where control over (part of) the process is delegated to a rule or algorithm, rather than the composer. Although this might sound incompatible with aleatoricism (algorithms arguably being the antithesis of randomness), the algorithm could also consist of introducing a random or non-determined element in a prescribed manner. One example of this is the so-called 'Musikalisches Würfelspiel' (musical dice game), where the throw of a die would determine the way in which several pre-composed segments would be combined into a single piece. While these games were popular in the 18th and 19th centuries, aleatoricism in music was explored more deeply and systematically in the 20th century by such composers as Charles Ives, John Cage, and Pierre Boulez. Like the musical dice games, many of these experiments involved introducing a chance element into the performance of a musical piece. However, it is not always clear whether these examples concern 'true' aleatoricism, or rather a form of *indeterminacy*, where certain aspects of a work are underspecified and hence left to chance. An example of this is John Cage's work 4′33″, which consists of a musician *not* playing the piano for the prescribed period of time. The 'music' heard by the audience consists of whatever ambient noises happen to be present in that place at that particular time.

In other cases, however, an aleatory element was located in the process of composition itself—for example, John Cage's work *Atlas Eclipticalis* was created by the composer superimposing blank sheet music onto star charts, thus creating sequences of notes determined by the position of the stars on the note bars. In pop music, Beatles guitarist George Harrison used the Chinese Book of I Ching as inspiration for his song 'While my guitar gently weeps,' and David Bowie reportedly made regular use of a computer program called the 'verbasizer'—the program would paste together random words into phrases or parts of phrases, and these would serve as a random starting point for the generation of musical lyrics.

2.2.2 Aleatory Literature

Although not as extensively as in music, aleatoricism has been explored by several literary authors. Probably the best-known example of this is the use of the so-called 'cut-up technique' by authors like Brion Gysin, William S. Burroughs and Alan Burns. This technique consists of either literally cutting up and recombining pieces of printed text, or combining two sheets of text by vertically folding them in half and combining the two halves into something new. A related technique is found in so-called 'vocabularyclept poetry,' which consists of rearranging the words of an existing poem. For example, poet Howard W. Bergerson took one of his own poems, arranged all of its words into alphabetical order, and (under the anagrammatic name of 'Ben Rogers') invited readers to create new poems from it by rearranging the words themselves (Rogers, 1969).

Less obviously aleatory, but still in line with our definition of random constraints, are the various forms of *constrained writing* that have been explored by multiple authors. Examples of constrained writing are those where the author is not allowed to (or is forced to) use certain letters or words (for example, Georges Perec wrote his novel *La disparition* without the letter *e*, and later wrote *Les revenentes* without other vowels than the letter *e*), or forms where a larger pattern is imposed upon the text. An example of the latter are acrostics, where the first letters of words, sentences, or stanzas make up a word or sentence (a famous example is the closing poem of Lewis Carroll's 'Through the Looking-Glass,' where the first letters of each line spell out the name of Alice Pleasance Liddell, who first inspired the 'Alice' stories). Recently, Haught-Tromp (2017) built upon a well-known example of constrained writing for her 'green eggs and ham' hypothesis: the author Theodore Geissel (Dr. Seuss) was asked by his publisher to write a children's book using no more than 50 different words, which led to the classic book *Green Eggs and Ham*.

2.3 *A Typology of Random Constraints*

Clearly, random constraints can take on many forms, and our definition aims to cover all these various forms, including the deliberate use of actual randomness and arbitrarily imposed writing constraints. In some cases, however, whether or not a constraint falls under our definition depends on the situation. For example, designing a ventilator without moving parts would *not* be a random constraint if the absence of moving parts was called for by the task—for example, if a development team is trying to design a noiseless ventilator for use in scientific laboratories. In that case, omitting moving parts is not an arbitrary decision, but part of the task description. In contrast, it *would* be considered a random constraint if, for example, the team is trying to do so simply in order to explore novel possibilities. In that case, not using moving parts is an arbitrary choice that is not dictated by anything about the task.[2]

2.3.1 A Typology of Random Constraints

Given the wide variety of random constraints, some taxonomy or typology would be helpful to understand the way(s) in which they may or may not contribute to creativity. While several taxonomies of constraints have been proposed in the creativity literature (e.g., Acar et al., 2019; Haught-Tromp, 2022; Roskes, 2015), none of them focus specifically on random constraints. However, the Integrated Constraints in Creativity (IConIC) model by Haught-Tromp (2022; also see this volume) does incorporate constraints that would fall under our definition of random constraints, which makes it relevant for this chapter. Specifically, the model distinguishes (among other things) between constraints that are *central* or *peripheral*. The more distantly a constraint is related to, or associated with, the task or task domain, the more peripheral (and less central) it is (in line with the semantic distance discussed earlier). Random constraints, then, could be seen as lying on the extreme end of this dimension.

Importantly, IConIC predicts that peripheral constraints will be more or less helpful for creative performance depending on the way in which they limit search space, and the degree to which they provide useful information or search strategies. For example, so-called *exclusionary* constraints (e.g., not using certain words, materials, or features) do not specify any alternatives, and hence provide little guidance through search space as compared to *focusing* constraints (e.g., having to use specific words, materials, or features). Another relevant aspect of the IConIC model in this regard is the distinction between anchors and channels. *Anchors* are specific starting points, such as particular words, concepts or inspirational triggers. John Cage's star maps and David Bowie's verbasizer would be examples of anchors. C*hannels* are broader categories that limit the search area, making deep exploration of that area easier or more likely. Not using a particular letter would be an example of a channel (in this case, an exclusionary one). Channels are broader than anchors, while still limiting search space and potentially pushing people into unexplored cognitive territory.

It is important to distinguish between these different kinds of constraints, because their effects will depend on the degree to which they nudge people away from common options or ideas, and different constraints will do so in different ways. For example, if an exclusionary random constraint means not using options that were unlikely to be used anyway (e.g., writing a psychology essay without the word 'leprechaun'), people will not be pushed off the path of least resistance and creativity will not be stimulated (Haught-Tromp, 2022). Similarly, a focusing constraint will not be helpful if one is forced to use or include highly common elements or strategies. Additionally, it seems plausible that random constraints will be most helpful for creativity when they are either *focusing anchors* (a random starting point to build upon, such as Bowie's verbasizer) or *exclusionary channels* (a broad category of things that are not allowed, such as not using the letter 'e'). Random focusing anchors provide people with a specific and unusual (and hence informative) starting point for the creative process, whereas random exclusionary channels preclude the use of common concepts or strategies throughout the entire creative process. Thus, using a taxonomy of random constraints is potentially useful for deriving specific and testable hypotheses regarding their effectiveness. However, as we will see in the next section, to date such systematic work is missing.

3 Randomness in Creativity Techniques

Our historical overview shows that these various forms of random constraints (exclusionary versus focusing, anchors versus channels) have been used by various creators. More recently, random constraints have also been employed in 'formal' creativity techniques as a way to stimulate novel ideation. In addition, some research has incorporated random constraints, either as a way to test the effectiveness of these specific techniques, or to test more general hypotheses regarding the creative process. In this section, we will go somewhat deeper into one specific technique that has incorporated random constraints (De Bono's lateral thinking), and then address research findings regarding the benefits of random constraints.

3.1 *Random Input in Lateral Thinking*

De Bono (1970, 1992) has proposed several influential creativity techniques, which are usually collectively described under the name 'lateral thinking.' The goal of lateral thinking is to get people to break their habitual patterns of thought, and to get them to approach problems or questions in new ways, for example by breaking through (implicit) assumptions or by not allowing for the use of routine problem-solving strategies. One of the ways in which lateral thinking can be stimulated is the 'random input' technique (also called 'random connections'). Specifically, De Bono (1992) proposes that random input is particularly useful when one feels blocked or the creative process has stagnated, when one faces a literal or metaphorical blank sheet and needs something to get started, or when some ideas are already present but one feels that a new line of thinking should be tapped into. Although De Bono argues that working effectively with random input may require some practice (since we are not used to incorporating random input into our search for ideas), the technique itself is not complicated.

De Bono (1970, 1992) has described several different variants of this technique, but their common basis is that people deliberately seek out random words (or other kinds of input) and try to use those to spur idea generation. De Bono (1970) distinguishes between *exposure* versus formal *generation* of random input—in other words, people may allow themselves to be exposed to random input or seek out opportunities for such exposure (i.e., create the opportunity for serendipity), or they may actively generate such input by, for example, using a dictionary to provide random words. Regardless of which method is used, the core is that random input is a way to deliberately seek or create new associations (e.g., between the problem at hand and the random word or concept) that would be unlikely to arise otherwise, and which could lead to restructuring of the problem or task (e.g., Seifert et al., 1995). This is in line with creativity theories proposing that creativity is largely a matter of creating or discovering new or unlikely combinations (Koestler, 1964; also see e.g., Nijstad & Stroebe, 2006)—because highly novel combinations are less likely to be made spontaneously, constraints can be helpful in doing so.

De Bono's lateral thinking techniques are not the only ones relying on random input to spur creativity in practical settings. For example, two practitioners, Byttebier and Vullings (2002) describe a similar way of seeking out random input; they call the process of linking unrelated words or concepts to the task at hand 'resociation' (because unrelated word are 'linked back' to the domain one is working on). Moreover, in an overview of various creativity-stimulating techniques, Smith (1998) describes a technique called Catalog (Taylor, 1961, cited in Smith, 1998), which consists of taking two random words (e.g., from a dictionary) and forcing them together to create a useful idea (similarly to, for example, some of the creative writing techniques discussed earlier). As with De Bono's technique, the point here is to stimulate the process of 'bisociation' (Koestler, 1964) by which novel ideas arise through the combination of previously unrelated concepts or domains.

3.1.1 Empirical Research

Although lateral thinking is very well-known and popular in creative practice, empirical research on the effectiveness of the various lateral thinking techniques is relatively scarce (Dingli, 2009). However, some studies have tested the effectiveness of the random connection technique. Most recently, Gu et al. (2022) compared four creativity-stimulating techniques: random connections (the De Bono technique), SCAMPER (an idea-generation technique where people are encouraged to ask questions related to Substitution, Combination, Adaptation, Modification, Putting to other uses, Eliminating, or Reversing; Eberle, 1997), schema violation (exposing people to information or situations where existing expectations or assumptions are violated; cf. Gocłowska et al., 2013), and simple ideation (the act of generating ideas). Having trained participants in one of these four techniques, Gu and colleagues found that the random connections technique led to a (slight) increase in fluency and idea diversity as compared to a pretest; moreover, the diversity effect was stronger than that of simple ideation. In another study, Malycha and Maier (2017) compared the effectiveness of random input with that of mind-mapping (a technique where ideas are visually laid out and hierarchically organized, for example in a tree-like structure) in a full factorial design. They found that random input stimulated the originality of participants' idea generation, and marginally stimulated productivity (but not idea diversity)—however, mind maps also contributed to creative performance, and the highest performance was observed when the two techniques were combined.

In contrast, Svensson et al. (2002) found that random input *decreased* creative output. They used a before-and-after design comparing three conditions: a random input condition, a 'provocation' condition (another lateral thinking technique, where idea generation is spurred by provocative questions that put the issues in a different light), and a control condition. Participants in both experimental conditions produced fewer, rather than more, ideas after exposure to the manipulation (whereas no such difference was found for the control condition). Regarding the unexpected decrease in fluency, the authors speculated that presentation of the random words and provocation question may have detracted attention away from the problem itself, and that people may have needed more time to learn how to work with these techniques. This would be in line with De Bono's (1990) suggestion that random stimulation requires some time and confidence to work with; indeed, both Gu et al. (2022) and Malycha and Maier (2017) used longer training sessions to allow participants to get used to working with the technique than Svensson et al. (2002) did.

3.1.2 Other Forms of Random Constraints

As a focusing anchor, the random input technique captures only a limited set of random constraints—other forms are certainly possible, and some research has looked at their effects. For example, Finke, Ward, and Smith (1992) asked participants to design products, either providing them with randomly chosen parts (such as spheres, half-spheres, tubes, cubes, cylinders, etc.) and/or categories (furniture, transportation, appliances etc.) to use, or allowing them to choose these for themselves. Results showed that the participants who received randomly chosen parts and categories (and thus were most randomly constrained) generated the most creative designs.

Another example of random constraints in creativity techniques are Goldenberg et al.'s (1999a, 1999b) 'inventive templates' (specific combinations of operations or transformations used to come up with novel product ideas or to identify interesting avenues for future exploration). In terms of IConIC, these could be considered channels (broad constraints) with both exclusionary and focusing components (some templates revolve around removing parts or functions from a product, some revolve around forcing new connections). Some research suggests that, like random input, these templates can indeed stimulate creative performance (Goldenberg, 1999a). Goldenberg et al. (1999b) further tested the effectiveness of these templates against that of lateral thinking techniques such as random stimulation, and found that participants trained in the use of templates created ideas of higher originality and usefulness. More recently, Sagiv et al. (2009, Study 2) also found that participants instructed to use creativity templates performed more creatively (came up with more creative advertisements) than participants without templates. Importantly, however, this effect only occurred for participants with a systematic (as opposed to intuitive) thinking style, suggesting that the effect of such constraints may depend on the fit with personal traits related to people's preference for structure (cf. Rietzschel et al., 2014; Wronska et al., 2019).

All in all, while the effectiveness of random constraints has not been studied very extensively, the available evidence strongly suggests that they can help. However, results like those of Svensson et al. (2002) and Sagiv et al. (2009) highlight that this will not always be the case, and that personal (e.g., thinking style) or contextual (e.g., opportunities for practice) factors could be important moderators.

4 Characterizing Random Constraints

Like other constraints, random constraints have the potential to stimulate creativity, for example by forcing us to consider alternatives that would normally not have come to mind. The scarce research that we were able to uncover suggests that random constraints *can*, but do not always stimulate creativity. This is probably partly explained by the fact that constraints more generally have the potential to either stimulate or hinder creativity, depending on the nature of the constraints, the task at hand, and the persons involved (see Haught-Tromp, 2022; Rietzschel, 2018; Roskes, 2015, for overviews). However, although random constraints can in principle be conceptualized like other constraints (and the line between random and non-random constraints is not fixed, as previously argued), we propose that random constraints have several crucial characteristics that make them both more challenging and potentially more useful than most non-random constraints. Specifically, we argue that random constraints differ from non-random constraints in three ways: semantic remoteness, cognitive demands, and motivation/autonomy.

4.1 *Random Constraints Are Remote*

Because random constraints are not inherently related to the task or context, they are more semantically remote, novel, and/or surprising than other kinds of constraints. Non-random constraints may be annoying or difficult to work with, but they will typically be non-surprising, especially to somebody with extensive experience or domain knowledge. For example, researchers facing a word limit for short research reports have come to expect such limits and will have built up certain routines for dealing with them. In contrast, people will not normally have built up expertise for dealing with specific random constraints—in fact, such expertise would make random constraints useless, because they would no longer stimulate novelty. People may, of course, build up expertise in dealing with the presence of random constraints in a general sense. For example, one may have become accustomed to using random input as a creativity-stimulating tool—in fact, this may well be necessary in order to reap the benefits of random constraints (cf. De Bono, 1990; Svensson et al., 2002). However, such expertise will not have been built up for the specific random words themselves.

4.1.1 Random Constraints as Remote Search Cues

One way to think about random constraints and their remoteness is in terms of *search cues*. According to SIAM (Search for Ideas in Associative Memory), Nijstad and Stroebe's (2006) cognitive model of the idea generation process, idea generation is a two-stage process where (1) a search cue is generated and used to activate available knowledge in an associatively organized long-term memory, and (2) the activated knowledge is used to create and/or find ideas in a process of spreading activation and combination of knowledge. Because the activation level of this knowledge dissipates over time and is subject to interference, people will need to construct new search cues—but doing so is cognitively demanding. An alternative is that people are *provided* with search cues—for example by their (social or physical) environment. This forms the basis of cognitive stimulation effects in group brainstorming (e.g., Dugosh et al., 2000): the ideas generated by other group members can function as a search cue and activate a new 'train of thought' (although cognitive interference and production blocking are more likely; see Nijstad & Stroebe, 2006, for a detailed discussion).

Following the definition given earlier, a search cue is a constraint (specifically, in terms of IConIC it would be a focusing anchor), in the sense that it (temporarily) reduces the search space: The content of the search cue determines which knowledge in LTM gets activated, which, in turn, determines the 'raw materials' that can get used for the construction of new ideas. Like other constraints, most search cues people use will not be random; rather, they will be task- or context-related. For example, when generating ideas about how to attract more customers to their restaurant, a restaurateur will most likely kick-start their search for ideas by accessing relevant examples, which will result in the generation of many unoriginal ideas. In contrast, although search cues completely unrelated to the problem or setting are much less likely to be used spontaneously, they are also less likely to lead to the generation of 'obvious' ideas. For example, our restaurateur could use an online random word generator and be presented (as we were while writing this chapter) with the random word combination 'classical shop.' This may activate domain knowledge about music stores and classical music, which could be combined with the restaurant owner's own knowledge of restaurants. This might lead them to the idea of selling CDs burned on demand with the classical music that happened to be played during people's visit.

Some research provides indirect empirical support for the notion that random search cues can be helpful. For instance, exposure to other people's ideas or other stimuli can increase people's creative output (i.e., cognitive stimulation effects; e.g., Dugosh et al., 2000; Nijstad et al., 2002) and several studies have found that highly novel examples can lead to stronger stimulation effects (e.g., Kohn et al., 2011; Berg, 2014; Agogué et al., 2013; Perttula & Sipilä, 2007). Using stimulation materials that were not merely original but actually unrelated to the task at hand, Hender et al. (2002) found that creativity support systems that provided participants with such random stimuli led to the generation of more original (but fewer in total) ideas. Moreover, Chen et al. (2021) recently found that participants generated more, and more original, ideas when provided with task-unrelated stimulus words than with task-related words, especially when presentation of these words happened at the discretion of the participants themselves, rather than at pre-programmed moments. In line with the findings on lateral thinking discussed above, it seems that random search cues can push people into more novel cognitive territory during idea generation. However, as with lateral thinking, results are not entirely consistent (for example, with regard to productivity), which suggests that things may be more complex than merely stimulating novelty.

4.2 *Random Constraints Are Cognitively Demanding*

The remoteness of random constraints is an important part of their potential effectiveness. However, for the same reason, working with them is more difficult. Indeed, research on cognitive stimulation effects has also sometimes found that presenting participants with novel stimuli *decreases* ideational output (e.g., Connolly et al., 2003; Dugosh & Paulus, 2005; Fink et al., 2010; Kohn & Smith, 2011). As mentioned earlier, Svensson et al. (2002) found that De Bono's random input technique negatively affected idea generation, and Hender et al. (2002) found that random input stimulated participants' originality, but decreased their productivity. Moreover, in line with Sagiv et al.'s (2009) findings, De Jonge et al. (2018) found that cognitive needs (e.g., need for structure) moderated people's responses to novel and non-novel input, arguing that highly novel ideas are more cognitively demanding and potentially confusing, because they are so dissimilar from the ideas one would ordinarily think of. In other words, being pushed off the path of least resistance by random constraints may come with a cost, especially for some people.

Writing a novel without the letter 'e' will arguably require more effort than, for example, writing a novel in the second person ('you'). Both will require authors to do things differently than they are used to, but since most of us are at least somewhat acquainted with texts in the second person (such as personal communication), that gives us some basic repertoire to work with. In contrast, not using any 'e' will annoy, obstruct, and possibly put out most aspiring authors, who might adapt, but not without hard work for (probably) suboptimal products (as this particular construction shows!). In other words, working with highly remote constraints will not only require the domain knowledge and expertise (e.g., a large vocabulary) to adapt to the constraint, but also the willingness to invest extra effort.

4.2.1 Flexibility and Persistence

The role of cognitive effort in the creative process is illustrated by the Dual Pathway to Creativity Model (De Dreu et al., 2008; Nijstad et al., 2010). According to this model, creative performance can be attained through cognitive *flexibility* (approaching a problem from multiple directions and generating ideas in many semantic categories) or cognitive *persistence* (taking a more systematic and focused approach and generating more ideas within a limited number of semantic categories). The flexibility pathway is more spontaneous and less effortful; however, some people are more likely to use it than others (see Nijstad et al., 2021, for a recent review). In contrast, persistence is a potentially effective, yet highly effortful and cognitively depleting pathway towards creative performance. It requires sustained effort and cognitive control. While the flexibility pathway relies on reduced lateral inhibition (that is, it allows for a wider range of associations), persistence is associated with lower distractibility and more focused attention. When cognitive resources are depleted (e.g., under high working memory load), using the persistence pathway becomes too demanding (Roskes et al., 2012).

What may make (some) random constraints particularly difficult to work with, is that they appear to require both cognitive flexibility and persistence. On the one hand, the remoteness of random constraints requires cognitive flexibility and low lateral inhibition: people need to be able to bring to bear, or to connect, a wide range of potentially relevant knowledge or ideas. As such they will need to be able to broaden their criteria of what is 'potentially relevant,' because random constraints may not seem relevant at all (cf. De Jonge et al., 2018). On the other hand, random constraints also require the ability to inhibit or override dominant responses or associations (cf. Schmeichel, 2007). In fact, random constraints (such as not being allowed to use certain letters or characters) have also been used as a manipulation to test the effects of cognitive control on creativity (e.g., Chiu, 2014; Taylor, 2019): not being allowed to use highly common letters requires active inhibition of dominant responses, which, in turn, will require high executive control and subsequently lead to cognitive depletion. This is especially important since random constraints are, by their nature, arbitrary—thus, people will need to exert cognitive control in order to keep using them even when the going gets tough. Research suggests that constraints in creative tasks may be particularly attractive and helpful to people who are more likely to depend on cognitive persistence, such as high Personal Need for Structure (Rietzschel et al., 2014), a systematic thinking style (Sagiv et al., 2009), or avoidance motivation (Roskes et al., 2012).

It is possible that these two conflicting demands (flexibility and control) make random constraints difficult to work with. Alternatively, it is possible that different constraints pose different demands: focusing random constraints (such as random input) may primarily rely on flexibility (the ability to work with highly divergent and seemingly irrelevant materials), whereas exclusionary random constraints (such as not being allowed to use certain letters) may rely more strongly on control (the ability to suppress dominant responses). This, in turn, would suggest that different constraints will be differentially effective or useful depending on traits or states that are associated with flexibility versus persistence.

4.3 *Random Constraints Do Not Threaten Motivation*

Finally, although random constraints are arguably more cognitively demanding to work with than most other constraints, their arbitrariness also means that they are less of a threat to (intrinsic) motivation than non-random constraints. In the context of creativity, there is an inherent tension in any kind of constraining situation. Whereas limiting the degrees of freedom can nudge people in the direction of greater novelty, doing so can make them feel externally controlled and hence destroy intrinsic motivation and the associated tendency to explore creative options (see Rietzschel, 2018, for an overview). Autonomy is usually seen as an important precondition for creativity, and indeed highly creative people tend to be characterized by high levels of autonomy, self-determination, and individualism (e.g., Feist, 1998). Any kind of constraint thus carries the risk of creating a sense of external control.

We propose that random constraints, although they may be difficult or even frustrating to work with, are not as likely to be perceived as controlling. This is not so much due to the nature of these constraints themselves, but rather to the context in which they are used or encountered. Our anecdotal review of random constraints in practice strongly suggests that they are typically self-imposed. People will usually seek out random constraints deliberately, as a challenge they want to overcome or in order to stimulate the creative process. But even if random constraints are Imposed on them by others, this is likely to happen in a context where exploration and playfulness are highly saliant goals, such as when using Goldenberg et al.'s (1999a) inventive templates or De Bono's (1992) lateral thinking techniques.

Hermann, Goldschmidt, and Miron-Spektor (2018) argue that externally imposed constraints are less conducive to creativity than self-imposed constraints, and the work by Chen et al. (2021) discussed above demonstrated that random input was most effective when the input was presented at the discretion of participants. This is in line with other research on constraints and motivation; for example, Burgess et al. (2004) found that self-imposed deadlines (as compared to externally imposed deadlines) led to more time spent on target tasks. Beside the self-imposed nature of random constraints, the remoteness of random constraints may also affect the way they are perceived. Random constraints may be more likely to be presented or appraised as useful tools than as instructions or externally imposed limitations (Rietzschel, 2018). Precisely because random constraints are so arbitrary and remote, they may fit better with people's implicit theories of creativity (Baas et al., 2015; Ritter & Rietzschel, 2017), whereas non-random constraints may be more likely to be perceived as a threat to creativity. In line with this, Haught-Tromp and Sternberg (2022) also recently pointed out that constraints may be appraised either as *challenges* or as *hindrances* (Cavanaugh et al., 2000). Thus, a valuable area for future research seems to be the appraisal of random (and non-random) constraints and the factors that affect these appraisals.

5 Conclusion

In this chapter, we have attempted to provide a first overview and integration of the literature on random constraints and creativity. Based on our review, two conclusions seem possible. First, although empirical evidence is limited and mixed, random constraints appear to have real potential. Several studies have found that random constraints (such as random input) can stimulate creative performance, and work on creative cognition and the process of idea generation provides us with some preliminary ideas as to why this might be the case. Second, random constraints clearly need to be studied more extensively and systematically. As we have seen, there are good reasons to expect different constraints (e.g., exclusionary versus focusing) to have different effects (and for different people). Moreover, the semantic distance, cognitive demands, and self-imposed nature of random constraints suggest that research and theory on general (non-random) constraints may be of limited use in predicting or explaining the effects of random constraints. Random constraints form a class in themselves and deserve to be studied as such. We hope that the present chapter forms a useful starting point for this new line of research.

Notes

1 This begs the question of whether these events are truly random or whether they are determined at some deeper, unobservable level (and hence not fully random in principle); for the purposes of randomness in practice, what matters is that we are *unable to predict* an event.

2 One could argue that this constraint is dictated by, or at least inferable from, the motivation to explore novel possibilities; however, even in that case there is nothing about this motive that predicts the use of *this particular* constraint.

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