CONSTRAINTS AND CREATIVITY

This book studies creativity in its own right in the search for a creativity science. If we assume that creativity can best be described by constraint theory, the complexity and paradoxes of creativity can be reduced by dividing it into manageable sections. The model is tested and evidenced by numerous historical cases of pioneering work within the three intellectual fields: science, art, and technology. The model guides non-specialists from the many disciplines studying creativity and demonstrates the first principles of creativity science. Going all the way back to Aristotle, the author makes the basic ideas of the original founder of creativity science accessible and up to date with current research.

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CONSTRAINTS AND CREATIVITY

In Search of Creativity Science

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Prolegomenon

Preface

This book is not meant to be merely another contribution to the 70-year-old discipline the psychology of creativity, nor does it pursue the problem of what creativity is and how it should be studied from the narrow point of view of any existing discipline or intellectual tradition that has studied some aspect of this complex and paradoxical phenomenon. The book aims at something different: to clarify the First principles of a science which studies creativity in its own right. It is a search for a creativity science from an educational psychology point of view. Like film studies, cognitive science and archeology, such a science has to be interdisciplinary in the sense that it draws upon a rich foundation of data studied by a huge number of intellectual traditions. Nevertheless, it represents a discipline of its own in the sense that creativity science has a distinct knowledge object which needs to be clarified. This basic view of science is very old. It goes back to Aristotle, the founder of the theory of First principles (the idea that methodological procedures have to be adapted to the nature of the knowledge object). But Aristotle, surprisingly, also identified the First principles of creativity science (the theory of the four causes).

Much has changed since Aristotle made his contributions. Creativity science has to be brought up to date. This is essentially what this book tries to do. For this purpose, starting by making a list of the most important unsolved problems of creativity science might be a good procedure: (1) How do we account for the complexity and paradoxes of creativity? (2) How and why are scientific forms of creativity (S-creativity) different from artistic and technological forms of creativity (A-creativity, T-creativity)? (3) How do we explain creative explosions in human history (H-creativity)? (4) Is nature creative (N-creativity) and what are the similarities and differences between problem solving in nature and culture? (5) How do we explain personal levels of creativity (P-creativity) within and across intellectual traditions? (6) Is there such a thing as geniuses, or should we instead look at levels of problem-solving capacity as learning roles (pioneers, professionals, novices)? (7) Are the motivations to engage in groundbreaking levels of creativity (pioneers, H-creativity) different from the motivations of professionals and novices? (8) Where does the problem-solving capacity of pioneers (P-creativity as H-creativity) come from in the first place and how is it to be explained? (9) What if any role does the protection of vulnerable versions or ideas play for the capacity to solve the trickiest type of problems (H-creativity), and how is the problem of protection solved in practice? (10) Is there such a thing as getting it right and does it matter if we generalize from successful or unsuccessful scientific, artistic and technological revolutions (S-, A-, T-creativity)?

A basic theoretical assumption of the book is that the best way to define and simplify the complexity and paradoxes of creativity is to foreground the role of constraints. In order to clarify the nature of these constraints, I have developed a theoretical model, consisting of five dimensions: I Types of constraints, II Levels of creativity, III Getting it right, IV Protection of vulnerable versions, V Structure of creative processes. Most of the book consists of elaborating this theoretical model or framework, referring to empirical cases I have collected over a period of 30 years, after I first became interested in the topic (Kupferberg, 1991).

The two main data sets I have drawn upon are (1) intellectual biographies of pioneers (P-creativity as H-creativity) within the three intellectual fields of science, art and technology (S-, A-, T-creativity) and (2) scientific disciplines in the making (discoveries of First principles in science, S-creativity as H-creativity). The choice of pioneers has probably been constrained by personal idiosyncrasy. The choice of disciplines has modeled itself upon the Enlightenment theory of knowledge as encyclopedic. Apart from film studies, cognitive science and archeology, I have studied or at least acquainted myself with a broad range of disciplines in the making in order to get an idea of what discovering the First principles of a science means in practice: mathematics, physics, chemistry, geology, evolutionary biology, primatology, sociobiology, molecular biology, economics, business economics, economic history, Soviet and East European studies, German studies, the psychology of creativity, neuroscience, educational psychology, pedagogy, sociology, cultural anthropology, cultural geography, architecture and design history, art history, literary theory, semiotics, psychoanalysis, medical philosophy and history, the philosophy of science, the history of science, the sociology of science, the philosophy of art (aesthetics) but also the engineering sciences, in particular materials science and computer science. Some of these studies go way back in my intellectual career, long before I became interested in creativity as an object of scientific study. Others were added as my idea that I was on to something which had not been done before deepened and made my search for a creativity science more focused.

The breakthrough came around 2016–2017 after reading Collins (1998) a magnum opus on the history of philosophy, a discipline I had begun to study at Stockholm university in the late 1960s after having abandoned a previous biographical project (Kupferberg, 1995b) to become a chemical engineer. Collins mentions the concept of "constraints" as a possible correction to the postmodernist "everything goes" (Feyerabend, 1975) theory. The concept of constraints fits into my previous interest in neuroscience (Kupferberg, 1995) plus Searle's (1996) and Hacking's (2000) critique of the weakness of "social constructionism". Combined with the alternative (Aristotelian and Darwinian) way to conceptualize creativity as a sociocognitive phenomenon which overcomes the nature/culture divide (Kupferberg, 2011, 2012c), I became convinced that the constraint theory approach is the best, most parsimonious theoretical framework for a creativity science (Kupferberg, 2017a).

Having independently arrived at a constraint theory approach, I discovered (P-creativity) that the pioneer of constraint theory (H-creativity) is John Elster (1983, 2000, 2007). The best definition of constraints appears in Elster (1999). Although that book is about emotions, the basic idea is the same: "We can try to explain the emotions . . . by identifying the conditions under which they tend to arise. The link between the triggering situation and the emotion has been viewed as largely conceptual, as causal and deterministic, or as causal but partly indeterminate. To illustrate the last approach, which is the one I´ve been taken here: When the suspicion that one's lover is unfaithful has been raised, the reaction might be to exaggerate it or to kill it" (Elster, 1999, p. 406).

This type of half-baked determinacy (constraints) is very common not only in human affairs. It can also be found in evolutionary biology (N-creativity). Why do some species become extinct whereas others survive in the "tree of life"? Strictly predictive models of the type we can find in physics (such as the law of gravity) are hard to come by. Nevertheless, it is possible to find more or less convincing explanations why, for example, the dinosaurs disappeared some 65 million years ago or how an ape-like creature was transformed into modern *Homo sapiens* within a time span of about 6 million years. One of the follow-up questions that a constraint theory approach to creativity science might help to clarify is if and in what sense Darwin's theory of evolution (N-creativity) can help explain

Darwin's own process of discovery (P-creativity, H-creativity, S-creativity). But there are also many other spin-offs such as what creativity science can learn from studies on technology (T-creativity), why science originated so late and why in ancient Greece, why science-based technology only became possible around 1600, why modern art has abandoned not only naturalistic paintings but painting as a medium, what we actually mean with a creative milieu, what role persons play in transformations of intellectual fields, etc.

The overall goal of creativity science is to (1) account for the complexity (Andersson & Sahlin, 1997) and paradoxes of creativity (Alperson, 2003); (2) not only test but also generate theories of creative explosions in human history (Strong & Davies, 2006/2011a, 2011b); (3) more generally to study the phenomenon in an objective, methodological manner (Montuschi, 2003). The five dimensions of the theoretical model or framework presented and elaborated in this book are meant to be an intellectual tool (Kupferberg, 2012b) or guide both for those who want to orient themselves in this seemingly chaotic field and those who want to study and analyze some chosen cases of creative processes in more detail, starting with person, work, tradition and moving on to other types of constraints. The book can perhaps best be described as an introductory textbook into the field of creativity science, a kind of impersonal teacher or mediated form of learning (Säljö, 2000; Kupferberg, 2013) of the type educational psychologists working in the cultural psychological tradition pioneered by Vygotsky (Wertsch, 2007) have discovered to be an economic/elegant or parsimonious cultural tool (Säljö, 2005). It can also help us to approach the core problem of educational psychology, how to bridge the problem of ontogeny, personal learning processes and discoveries (P-creativity) with the problem of phylogeny: pioneering work, intellectual revolutions or creative explosions in science, art and technology (H-creativity).

The logical structure of the book and what type of theory it seeks to falsify and why now follows. In order to become a scientific discipline, creativity science must identify the First principles of the discipline. But given that each discipline has its own First principles, the search for a creativity science might be enriched from how other disciplines managed to clarify their First principles (see Chapter 1). Such a comparison is helpful to identify a number of empirical patterns which creativity science can start its search from. One important discovery when comparing disciplines in the making is that what counts as valid data, method of interpretation or proof for one discipline does not necessarily count as valid data or proof for other disciplines (see Chapter 8). Valid data in practice tend to be adapted to the nature of the knowledge object. But the knowledge object might also sometimes have to be clarified. It cannot always be taken as given (see Chapter 7).

These methodological and conceptual concerns are at the heart of creativity science. Take the discipline of history. What is it that historians study and how? Professionally trained historians study literate societies and this legitimates the preferred method of historians (Thorstendahl, 1966), the critical comparison of contemporary texts found in archives. Contemporary texts are the type of data novices entering the discipline are trained to appreciate and regard as reliable and valid. But this type of data is of little value for archeology, the discipline that studies preliterate societies which at some point turned into literate societies. Until such transformations begin (as in ancient Egypt or Mesopotamia), such societies leave no texts to be compared. Hence, as a general rule (First principle), if we find texts, they must have been written long after the event. This is the reason why archeology, in order to become a scientific discipline, had to redefine its primary data from texts to artifacts (Trigger, 2003) and replace hermeneutics with stylistic analysis as its primary method of interpretation (Renfrew & Bahn, 2008).

Studying how archeology became a scientific discipline is interesting as it tells us how the unsolved “demarcation problem” (what makes science as science) can be solved in practice. Contemporary philosophy of science has given up on this problem. It has been declared to be unsolvable in principle (Laudan, 1996). But how do we know this to be an indisputable fact unless we have tested it in practice? Perhaps philosophers of science have arrived at this conclusion by using the wrong data and methods (see Laudan & Leplin, 1991/2007)? To get it right in science (Dimension III, Chapter 4) is not always possible for historical, professional or personal reasons, and this is where constraint theory is of help. Why did Aristotle believe that eels are reproduced by “spontaneous generation” (Rhill, 1999)? Why did he fail to discover the laws of fall (Renn, 2001) or solve the problem of the origins of species although he was very close to doing so, according to Darwin (Jones, 2001)? And how can we explain that Aristotle nevertheless, in spite of his many mistakes, did solve the “demarcation problem” at least in principle (the theory of First principles)?

As we know the discipline of archeology originated in Denmark between 1800 and 1830. But why precisely there and why around 1800? And why was it Christian Jürgensen Thomsen a successful businessman and amateur coin collector? Could the fact, noted by Charles Lyell, one of the two founders of geology (the other was the mining engineer James Hutton), in *The Ancestry of Man*, that Denmark for geological reasons had a rich source of data both to generate and test archeological theories, be part of the explanation? For this purpose, foregrounding the role of physical constraints (Dimension I, Chapter 2) and material cause (Dimension V, Chapter 6) might be helpful. But data have to be accessed and interpretations protected from premature death. This takes us to the problem of opportunity (Dimension I, Chapter 2) and helpers (Dimension IV, Chapter 5). Here Thomsen's successful career as a businessman which provided him with personal contacts in high circles with access to the Danish court might help us a little bit along the road. But this still does not exhaust the issue. How did Thomsen know precisely that stylistic analysis was the correct methodology, helping him to get it right (Dimension III, Chapter 4)? Here Thomsen's novice type of knowledge of numismatics (he happened to be an amateur coin collector), might provide the critical edge which explains why Thomsen could take the step from professional businessman to pioneering scholar (Dimension II, Chapter 3) in precisely this intellectual tradition.

In this case, the two data sets of intellectual biographies and disciplines in the making intersect. But this is not always the case: creativity science is also here to explain pioneering work in other fields such as art and technology. This raises a number of difficult and challenging questions for creativity science. Why is technological creativity (T-creativity) the type of creativity that is closest to nature (N-creativity) and why does science (S-creativity) appear so late in human records? For this purpose, we need to clarify the different rules of science, art and technology (Dimension I, Chapter 2).

Take Galileo and Picasso. If we are to believe Feyerabend (1975), the scientist Galileo essentially worked like the artist Picasso, breaking all the rules. But Galileo did not break the basic rule of science (to falsify theories by separating fact from fiction, Dimension V, Chapter 6). Nor did Picasso break the basic rules of art (evoking emotions by transforming facts into fiction). What Galileo did was that he collected the relevant data, interpreted them with valid concepts and adapted methodological procedures (problem-solving strategy) to the nature of the knowledge object (Dimension V, Chapter 6). This explains why knowledge constraints are critical for how scientific creativity works in practice (Dimension I, Chapter 2).

In contrast, the core problem-solving strategy of Picasso was the choice of techniques (Dimension V, Chapter 6). But in order to get it right, Picasso had to consider the historical problem situation of French painting at the start of the twentieth century with the rise of American cinema as a threatening competitor (Dimension III, Chapter 4). A close analysis shows that what characterized these two art forms (one premodern, the other late modern) was ultimately the nature of physical constraints (Dimension I, Chapter 2). Feyerabend therefore managed to get nothing right.

Galileo managed to rectify Aristotle's basic methodological mistake (Dimension V, Chapter 6) projecting the laws of biology upon physics. But if this is indeed the case, how could Aristotelian physics be categorized as a science, as Feyerabend's colleague Kuhn claims? How could Aristotle be the pioneer of this discipline (according to Kuhn, Aristotle even anticipated Einstein)? Is Kuhn's simple sociological criterion, that politics, the predominance of one paradigm, is the only thing which defines what should be categorized as science, correct? Is scientific creativity not ultimately a type of problem solving? But in order to solve problems in a scientific manner we need to get the methodology (First principles) right. Kuhn's sociological theory of science is not more convincing than Feyerabend's.

But whereas Feyearbend's mistake was the belief that pioneers in science and art follow no rules, Kuhn's basic mistake was to project the peculiar logic of artistic revolutions upon scientific revolutions. Scientific revolutions evolve gradually, by overcoming one knowledge constraint after another (Kupferberg, 2017a; Dimension I, Chapter 2), artistic revolutions move both forwards and backwards just as planets do when seen from the Earth (Dimension V, Chapter 6). Naturalistic techniques evolve gradually over time but are once in a while abandoned and replaced by symbolic techniques, until naturalistic techniques are once again rediscovered, etc., a logic very similar to religion, see Max Weber's (1922/1964) sociology of religion.

Kuhn's basic mistake, that scientific revolutions follow the same pattern as artistic revolutions, has become the core principle of postmodernist theory (Lyotard, 1984; Schusterman, 2003). From a creativity science point of view though we also need to ask how and why Kuhn arrived at this misguided and misguiding theory of science. But for this purpose, we must be able to separate theories on or in science that manage to get it right and those that fail to do so. This is the very opposite of the "symmetry principle" recommended by David Bloor in *Knowledge and Imagery*. What Bloor fails to realize is that his methodological principle takes it for granted that Kuhn got it right when he claimed that scientific revolutions are not cognitive but exclusively sociological events. But this, as John Searle notes in *The Construction of Social Reality,* is itself a cognitive claim and has to be dealt with in a cognitive manner.

From this it does not follow that getting it right in science, art and technology does not entail sociological issues, but to understand what is social and what is cognitive and how the two are entangled, we must make a distinction between successful and unsuccessful scientific revolutions. A closer investigation of the intellectual origins of Kuhn's sociological theory of scientific revolutions, reveals that Kuhn for some reason chose to generalize his theories from an unsuccessful revolution. Copernicus' theoretical model in fact did not manage to get it right (Dimension III, Chapter 4). Hence the "symmetry principle" ultimately derives from a prototype which happens to use the wrong prototype (Dimension I, Chapter 2).

Falsifying incorrect First principles (S-creativity) is what pioneers in science engaged in the problem of "disciplines in the making" in practice do (Dimension V, Chapter 6). Pioneers in art (A-creativity) and technology (T-creativity) also do pioneering work (H-creativity), but nevertheless they have different aims and use different types of problem-solving strategies. The best way to understand how this works is constraint theory. Constraint theory also helps us to reconstruct how and why Kuhn arrived at his false theory of S-creativity. But for this purpose we need to collect the relevant types of data (material cause, Dimension V, Chapter 6), (1) intellectual biographies and (2) intellectual traditions, in particular disciplines in the making (see Chapter 1).

Interestingly Kuhn's own method forbids the use of biographical data (called "anecdotic evidence") and the same applies to postmodernist theories of scientific and artistic creativity in general ("death of the author"). But as Carroll (1992/2008) noted, the idea of the death of the author is not a new methodology. It originated in literary criticism and aesthetics (the philosophy of art) where the methodological assumption of the "fallacy of intentions" (Wimsatt & Beardsley, 1954/1992) has been a governing doctrine (First principle) for a long time (cf. Beardsley, 1958; Gombrich, 1996; Dickie, 1997).

Studying archeology as prototype for a creativity science, might also help us to rethink the problem of creative explosions in human history (H-creativity). Paleolithic hunter-gatherer societies lived very close to nature (Cornwall, 1966). This could explain why technological creativity and the creativity of nature seem to be very similar, a recent discovery made both by scholars of engineering and evolutionary biologists (French, 1994; Dawkins, 1986/2006). It might also explain why technological artifacts happen to be the earliest form of creativity in the human record (Mithen, 1998; Gable & Poor, 2005). Art appears much later with the oldest art works being about 30,000 years old (Pfeiffer, 1982; Jensen, 2013). Science only appears very late, in ancient Greece 2,600–2,300 years ago. All these empirical patterns confirm that creativity is not contingent but constrained. The question is how these constraints work. For this purpose, the theoretical model presented in this book might be helpful. But the model can also help us to identify wrong ways to go about studying and explaining creativity. Falsification is the ultimate goal of all science and creativity science is no exception to this rule.

But science is also about clarification of concepts (Dimension V, Chapter 6, Hanson, 1956). Today we tend to take science-based forms of creativity ("modernity") for granted, but this is far from the case. Moreover, what is called "modernity" can be many things. Greek society for some reasons lacked science-based technology but was rich in science-based art (classical architecture, naturalistic painting and sculpture, and it also invented a new art form, drama). This raises the question why science-based technology (engineering science) was delayed for about 2,000 years. Without science-based engineering, there would have been no Industrial Revolution (science-based engineering functioned as a constraint of industrial development, an important creative explosion in modernity). How is this long delay to be explained? What delayed (constrained) it? And why was the pioneer of science-based technology/engineering science an Italian and why precisely Galileo? These are the types of questions creativity science is here to answer.

A new science originates when the time is ready for it and I believe the time has come for creativity science to be born. The psychology of creativity, which in contrast to postmodernism has not abandoned the scientific method, began in the late 1950s (Cropley, 2001) at about the same time as the birth of the computer (Isaacson, 2014/2015), cognitive science (Gardner, 1987), Crick and Watson's discovery of the structure of DNA (Ridley, 2006), but also the rise of primatology (van Lawick-Goodall, 1971) and sociobiology (Wilson, 1975/2000) as new and exciting disciplines. From a historical point of view, it seems as if the present time is a case of what Pfeiffer (1982) called a "creative explosion" (H-creativity).

Although psychological creativity research has done a lot to clarify the nature of creativity, the conditions of creativity, how to explain it (Sawyer, 2006) are still very much up for grabs. There might be many explanations why the psychology of creativity has not been up to the task. Psychology as a discipline is very good at studying cognitive phenomena or problem solving, the core of the content of creativity, but it lacks the competence necessary to analyze the sociological (historical and cultural) conditions of creativity. A constraint theory approach should be able to theorize the entanglements between context and content of complex and paradoxical problem solving. This is the ultimate reason (Mayr, 1998) why we need to move from the psychology of creativity to creativity science. The time is ripe for it. We live in an era of creative explosions, but we lack a theory which can explain both the present and the past (Strong & Davies 2006/2011a; 2006/2011b) from a creativity science/educational psychology point of view. Such an endeavor could not be more timely.

Format of the Book

Regarding the format of the book and its expected audiences, most books on creativity are research monographs seeking to advance knowledge (Caves, 2000) of some special discipline other than creativity science and, if only for this reason, cannot function as a general introduction which, using the textbook format, seeks to outline the basic structure of the discipline, its knowledge object and guiding concepts, type of data it leans upon and methodology or First principles taking into account the overall aim of science, falsification. My two role models have been Lyell's *Principles of Geology* for the former purpose and Darwin's *On the Origin of Species* for the latter.

An introductory text needs to have a very clear and logical structure. This is best done if the structure can be described by a theoretical model which strikes a balance between simplicity and complexity. Novels are typically complex because casual chains (characters in action and interaction) are embedded in detailed narratives. Mathematical formulas are highly abstract and simple because so much information is crammed into a few symbols. Theoretical models (Wartofsky, 1968) lie somewhere in between. They combine detailed descriptions (stories) with simplifying concepts (formulas or schemes, see Gombrich, 1996). The way this works is exemplified in an abridged version of the theoretical model following immediately after this Preface and as an appendix to the introduction

Although aspects of the five dimensions that constitute the theoretical model I present can be found dispersed in the literature across a number of disciplines, they have never been gathered together in this economic and logical manner before, around the concept of constraints. The foregrounding of the constraint theory approach (Elster, 2000) is what makes this book different. But a theoretical model is basically here to serve as an intellectual tool. The idea is that the book should be of help to both students and researchers studying some selected historical case of creativity.

The book is meant to be read from beginning to end, but knowing how students often read books or how I myself have assigned chapters from books for reading, I have written the different chapters as self-contained, episodic "short stories" (compare the writing techniques of Selma Lagerlöf, who started her writing career after having trained and worked as a schoolteacher, see Edström, 2002). Moreover, the model can be used in many different ways. In principle a teacher, student or researcher can choose merely to focus on one dimension and ignore the other dimension or only focus on one aspect of a dimension and ignore the other aspects, although I would not recommend that. A better approach is probably to start with some aspect of one of the five dimensions, and work from there, by discovering other aspects either within the same dimension or another dimension. In this case, the richness of real cases and the complexity but also paradoxes of creativity as a conceptual phenomenon will be better balanced. The ideal approach is probably to start from the empirical end, select one biographical case, a pioneer in whatever personal, professional or historical problem situation and investigate that case in depth, using the theoretical model as an intellectual tool for interpretation of data.

My own interest in creativity originated in the mid-1980s, during a very stimulating year as an exchange professor at University of Wisconsin–Green Bay where I rediscovered art and literature. My first book on the topic was my Ph.D. thesis presented at Aalborg University in the mid-1990s. The book took on the problem of creativity in teaching and learning. My second book on creativity, published in 2006, explored the concept of "creativity regimes" which I had presented in an article for the Danish national journal of sociology (Kupferberg, 2003a). The idea for that book arose out of two projects, one on entrepreneurship studies and the other from a growing interest in film studies after a year as a guest researcher at Berkeley. My interest in the interesting similarities between N-creativity and T-creativity/C-creativity arose during the six years I functioned as editor of the *National Journal of Educational Research* in Sweden. My interest in artistic creativity has many sources but took off professionally during my 10 years in the department of Culture, Language and Media at Malmö University and then at the department of Artistic Crafts and design at Gothenburg University.

The Theoretical Model

Dimension I: Types of Constraints

1 Physical constraints
2 Prototypes or developmental constraints
3 Knowledge constraints
4 Rules of the game
5 Motivational constraints
  a pressure
  b pleasure
  c opportunity

Dimension II: Levels of Creativity

1 Are children romantic geniuses?
2 Novices: participation as pleasure
3 Professionals: competitive pressure and transmutation of craft and judgment
4 Pioneers: opportunity as the regulative gene and the complexity of creative explosions
5 Is there such a thing as genius?

Dimension III: Getting It Right

1 The principle of parsimony
2 Independent (re) discovery and convergent evolution
3 Co-evolution and the complexity of creativity
4 Problem situations and problem solvers

Dimension IV: Protection of Vulnerable Ideas

1 Geographical isolation
2 Intellectual migration and teamwork
3 Skunk works
4 Confidants and working alone
5 Patrons, mentors and agents

Dimension V: The Structure of Creative Processes

1 Material causes
2 Formal causes
3 Effective causes
4 Final causes