On the Role of Metaphor in Creative Cognition

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Abstract. We consider some examples of creativity in a number of diverse cognitive domains like art, science, mathematics, product development, legal reasoning, etc. to articulate an operational account of creative cognition. We present a model of cognition that explains how metaphor creates new insights into an object or a situation. The model is based on assuming that cognition invariably leads to a loss of information and that metaphor can recover some of this lost information. In this model we also contrast the role of traditional analogy (mapping based on existing conceptualization) with the role of metaphor (destroying existing conceptualizations in order to create new conceptualizations).

1 Introduction

Though there have been many approaches to characterize creativity [17] [25] [31], we start with a simple approach which sees creativity as a process of generating a new perspective on a problem or a situation. We are limiting ourselves to individual creativity here, so the information resulting from this process need only be novel to the cognitive agent, and we do not yet concern ourselves with creativity in a society. Secondly, we do not consider *usefulness* of the generated information: it is sufficient for us here that the information be novel to the agent. In fact, if the model presented here is correct, it implies that there cannot be some domain-independent principle or heuristic that would generate only (or largely) useful perspectives.

With these assumptions in place, the task we are undertaking is to propose a model that articulates the role of metaphor in the creative process and also explains why metaphor is so effective in generating new perspectives. In this model, we will also compare the role of analogy with the role of metaphor, and argue that the two play complementary roles in creative cognition.

The paper is organized as follows. In the next section we will present a few examples to illustrate how creative insights are obtained in a few diverse domains. Following this, in Section 3, we will present an account in which cognition is seen to necessarily involve loss of some information, and in which metaphor becomes one of the tools that makes it possible to recover some of this lost information. At the end of this section we will also compare the role of analogy with the role of metaphor. Finally, in Section 4, we will summarize the main points of this paper, and mention future research directions.

2 Creativity in Cognition: Some Examples

We start by considering some concrete instances where a new insight or a new perspective was generated. The examples are taken from a number of diverse domains including art, legal interpretation, mathematics, and product development. At the end of this section we will present a brief overview of the cognitive mechanisms underlying creativity that have been proposed in the past research.

2.1 Creativity in Art

In a recent study, Okada *et al* [20] consider the evolution of artistic style and creativity in the works of a Japanese artist Shinji Ogawa over several years. One interesting point in this study is how the artist hit upon an idea that led to a series of work: "[Shinji Ogawa] was a part-time teacher at a vocational-technical school of media art. When he was preparing for a class, he accidentally erased part of a picture on a computer screen by mistakenly pushing a keyboard button. At that moment, he came up with the idea that if something very important and valuable suddenly disappears, a new value may be generated and a new world could be created. With this idea, he tried to create a new movie poster for Roman Holiday by erasing the main actress, Audrey Hepburn, from the original poster. This was the beginning of the artwork series, 'Without You'." [p. 194].

Though the authors chose to interpret this example in terms of analogical modification, it resonates strongly with Piaget's account of how new schemas emerge through sensorimotor interactions with the environment. The example presented above bears a strong resemblance to Piaget's account of how a child brings a toy to her mouth in order to suck, accidentally notices the bright color of the toy and starts bringing toys near her face to look at them, eventually generalizing into a schema of 'bringing objects to the face in order to look at them' [21][22]. In Mr. Ogawa's case, he accidentally discovered the operation of 'delete figure from a picture', realized artistic potential of it, and a new style of artwork was born. That the discovery was made accidentally is not so relevant for our argument here, but what we would like to emphasize is that the discovery resulted from the *application of a familiar operation ('delete') to a familiar object but in a novel way*.

Interestingly, similar episodes occurred later as well in Mr. Ogawa's career. Okada *et al* note: "Mr. Ogawa happened to pick up a postcard at hand with old Western scenery and drew a duplicate building next to an original one. Then he mailed it, as a postcard, to a gallery owner. When he heard from the gallery owner telling him that staff members of the gallery talked highly about his postcard, Mr. Ogawa decided to start a new artwork series, 'Perfect World', in which he duplicates a person or a thing in postcards or photographs of scenery." [p. 195]

The operations of 'delete' and 'duplicate' are quite similar. In the framework of Hofstadter [7], one could say that one operation *slipped* into a neighboring operation to lead to another creative insight. Or one could see it in terms of a Piagetian *schema* of related operations that are applied to a *different class of objects*. It is important to underscore the 'different' part here. When handling photographs of famous landmarks, people, etc., we could change the contrast, brightness level, perhaps apply red-eye reduction tool, but we do not normally delete or duplicate objects, and much less so if the object is the main theme of the photograph. In other words, we could say that the creative insights resulted from applying a set of familiar operations to a set of [also familiar] objects that are not usually associated with the operations. This is the key point that makes metaphor an invaluable tool for generating creative insights, something that we will keep reiterating in the rest of the paper.

2.2 Creativity in Legal Interpretation

Even though law is a domain that is normally not associated with creativity — for one expects a straightforward application of legal principles and many judicial scholars frown on any deviation from the literal interpretation of the legal text — in our previous research [8] [10] we have found a number of situations where a new perspective or insight was a key factor in a legal discourse. We briefly present two such examples here.

The first example is taken from [8]. In Australia and England, when a married couple divorces, the division of property was determined in large part by the old case law of 'Husband and Wife' and by various Acts. These generally provided for division according to economic value added into the marital assets. This was plainly unjust where the husband had worked, while the wife cared for children and maintained the household. In such situations, the standard decision was, until recently, that the husband would get the lion's share of the property. However in an example of productive thinking, in *Baumgartner v Baumgartner* [(1987) 164 CLR 137] the High Court of Australia introduced a principle from a completely different area of law and held that the wife's work placed into the house meant she had an equitable interest in it. The husband, though legally the owner of the house, actually held part of it in a 'constructive trust' for his wife. This decision was soon followed by a number of other similar decisions by other courts, and is now the standard approach.

This illustrates a novel application of the legal concept of *constructive trusts* to a set of situations for which it was not originally intended, which resulted in a new way of rendering judgment on them. Similarly, the decision of Lord Denning in the *High Trees case* [*Central London Property Trust Ltd v High Trees House Ltd* [1947] KB 130], which modified contract law by introducing another equitable principle, 'promissory estoppel', is another example where a legal concept from a different area was applied to deal with a problem in a domain for which it was not originally intended. (See also [27].)

The second example [10] concerns the case of a hot-dog stand operator, who claimed tax-deduction for the kitchen at home where hot-dogs were prepared [*Baie,* 74 T.C. 105 (1980)]. One argument made by B. was that her kitchen was a *manufacturing facility* of the business. The judges remarked: "We find this argument ingenious and appealing, but, unfortunately, insufficient to overcome the unambiguous mandate of the statute." [74 T.C. 110 (1980)]. The point to emphasize here is that the category 'manufacturing facility', which is not normally associated with this situation, is applied to the kitchen where hot dogs are prepared resulting in a novel perspective.

To summarize, we see that the application of a legal concept to a domain or a situation for which it was not originally intended, can sometimes result in a new way of looking at the situation thereby leading to a novel judgment.

2.3 Creativity in Mathematical Reasoning

Consider George Cantor's theory of transfinite numbers, in particular, his arguments concerning the levels of infinity [1]. Two of his key proofs, namely that 1) rational numbers have the same cardinality as natural numbers, and that 2) real numbers are more numerous than natural numbers, can now be understood by a high-school student. However, when originally proposed, they were considered very radical. Many leading mathematicians at that time refused to accept his formalization of set theory and its implications for infinite sets. Yet, Cantor's insights were derived from applying the operation of making one-to-one correspondence, which was already well known for finite sets for hundreds of years, to infinite sets. In addition, he used a

particular way of arranging infinite numbers in an array and counting them in such a way that two (or more) infinite dimensions can be mapped onto a single dimension of infinity. A somewhat different operation applied to a similarly arranged two-dimensional layout of numbers led to his famous *diagonal argument,* where he showed that certain sets cannot be put in a one-to-one correspondence with natural numbers.

To emphasize, we see again that the application of familiar operations to a different sets of objects resulted in a novel perspective. For indeed, the theorems and proofs discovered by Cantor revealed a whole new aspect of numbers and opened a fresh chapter in mathematical research.

2.4 Creativity in Product Development

Consider a case study described in Schön [24] where a product development team was faced with the problem of figuring out why synthetic-fiber paintbrushes were not performing as well as natural-fiber paintbrushes, and to improve their performance. The members of the team tried many ideas — for instance, they noticed that the natural fibers had frayed ends, and they tried to have synthetic fibers with frayed ends too — but without success. The breakthrough came when one member of the team suggested that the paintbrush might work as a pump. This idea was initially considered quite shocking, for a paintbrush and a pump were thought to be very dissimilar. Yet, in trying to make sense of the analogy, a new ontology and structure for the paintbrush was created. In this new representation, the paint was sucked in the space between the fibers through capillary action, and when the fibers were pressed against the surface to be painted, the curvature of the fibers caused a difference in pressure that pumped out the paint from the space between the fibers onto the surface to be painted. From this new ontology, when the synthetic-fiber and natural-fiber paintbrushes were compared, it was found that the synthetic fibers bent at a sharp angle against the surface, whereas the natural fibers formed a gradual curve. Thus, juxtaposition with pumping caused a new perspective to be created on the process of painting and paintbrush.

There are many other such examples [Gordon 1961] where seeing one familiar object as another familiar object, but one that is not normally associated with the first object, led to a new perspective and eventually to solving a difficult problem.

2.5 Cognitive Mechanisms of Creativity

So far we have seen a number of examples where a set of operations or concepts are applied to an object or a situation with which they are not normally associated, resulting in a novel perspective. Perhaps not surprisingly, such mechanisms have been noted and studied in the past by various researchers, and they have been known under different labels. Here we summarize a few major veins of this research.

Making the Familiar Strange: Gordon and his colleagues [6] studied creative problem solving in real-life situations for many years, and found that one way to get a new perspective on the target problem is to look at in a *strange* way. The mechanism is they proposed is to juxtapose the target problem or object with a completely unrelated object or situation.

Displacement of Concepts: Schön [24] emphasized that in order to get a new insight about a concept, it needs to be *displaced,* that is, put in the context of other unrelated concepts. He emphasized that the most important step in problem solving is *problem*

setting, that is how the problem is stated and viewed, and metaphors play a key role in this step.

Bisociation: Koestler [18] coined this term to emphasize that the pattern underlying a creative act is the perception of a situation or an idea in two self-consistent but habitually incompatible frames of reference.

Lateral Thinking: Edward de Bono [4] contrasted vertical thinking with lateral thinking. In the former, one starts with some assumptions and explores their implications deeper and deeper. But in lateral thinking, the goal is to look at the problem in different ways so that the familiar assumptions one makes about it can be questioned and perhaps a new set of assumptions can be brought in.

Estrangement. Rodari [23] focused on creativity in inventing stories, and proposed many practical methods that stimulate imagination and creativity in children (and in adults). Many of his methods rely on random juxtaposition of concepts. One mechanism he emphasizes as the first step in creating riddles is *estrangement,* where you are asked to see the object as if for the first time. In other words, instead of seeing the object in terms of the familiar categories it naturally evokes, you are asked to consciously block this evocation and try to view the object as if it is a strange object you are seeing for the first time.

Conceptual Blending. Fauconnier and Turner [5] analyzed how people combine perceptual, experiential and conceptual aspects of different concepts subconsciously to generate new insights.

Though each of these approaches has its own peculiarities, they all emphasize that in order to get a new insight about an object or situation, we need to get away from, or break, its existing conceptualization. In this task, viewing the object in terms of (or juxtaposing it with) another unrelated object can be a key step.

3 An Account of Creativity in Cognition

We saw numerous examples in the last section that show that to get a new perspective on an object or a situation, an approach that often works is to apply operations that are not normally associated with that object, or to see that object as another unrelated object. Here we will propose a model to explain why this process works as it does.

3.1 Cognition and Loss of Information

Here we argue that every act of conceptualization (or cognition) invariably involves some loss of information. When we choose to label an object as a 'chair' numerous specific details of the object, like its color, the material it is made of, shape, etc. are all lost. Of course, we could make our conceptualization of the object more specific — it is a red chair, made of teak, with a high back, and so on — but no matter how detailed the conceptual representation is made, there is always some aspects of the object that are excluded, and it is these excluded aspects that constitute the *information lost in the conceptualization*. (This precisely is the theme of a short story *Del Rigor en la Ciencia (On Exactitude in Science)*, by Jorge Luis Borges and Adolfo Casares.)

Whenever this lost information becomes crucial to solving the problem, then the existing representation becomes hopelessly inadequate. In the paintbrush example presented above, the information about the spaces between the brush fibers etc. was discarded in the then existing model of painting, so no matter how much and how hard the product development team tried, the problem could not be solved. It was necessary to *change* the representation or the conceptualization of the object.

3.2 Interaction with the Environment Through Actions and Gestalt Projection

If the hypothesis presented above is correct, namely that some information is invariably lost in conceptualization, the next question is how can we recover, at least partially, this information. Here we assume that we do not have the God's eye view of the world, meaning that we do not have another way to access the object except through the cognitive agent. This may seem a technicality, but it is a very crucial point, so let us elaborate a bit. In a computer simulation or a model, one can posit a very rich and detailed representation of the object, and then show how a conceptualization picks out some aspects of this rich representation, while ignoring others. For example, the rich representation of a chair may include its material, shape, color, weight, and so on, but the conceptualization can only include legs, seat and back. However, for us here, the rich representation is not available, for if it were, it would be just another conceptualization, and there will still be some lost information. In other words, that our conceptual representation of an object does not include *all* the information about the object is like an existence proof: we can argue about its existence but we cannot say what it is. So the key question is how can we become aware of this lost information, and how can we recover at least some of it.

Piaget's action-oriented approach provides a possible way to addressing this question. Piaget argued that an object is relevant or meaningful to a cognitive agent in only as far as how the agent may act on it. Thus, a ball is something that a baby might roll, kick, squeeze, and so on. In this approach, novel aspects of an object may be revealed when the agent carries out new actions on it. Moreover, the actions can be *internalized* actions, which are called *operations* in Piaget's framework. In our earlier work [13], we have used the term *gestalt projection* to emphasize that it is not just individual operations, but a network of operations, namely a schema or a gestalt, that are projected onto the internalized object or situation. In other words, a cognitive agent can get more information about an object or a situation by projecting a different gestalt, or a different set of operations onto it.

3.3 Metaphor: A Tool for Generating New Information about the Environment

So far we have argued that all conceptualization involves some loss of information, and that some of this lost information may be recovered by projecting a different gestalt or a different set of operations onto it. But this is essentially what a metaphor does! By inviting us to see one object as another, we are forced to project the conceptual organization of the second object (usually referred to as the *source*) onto the experiences, images etc. of the first object (usually referred to as the *target*). Thus, metaphor can be a useful and powerful tool to get new information about the environment.

This is essentially the crux of the arguments made by Turbayne [28]. He argued that though we can understand the world only through some metaphor or other, we enrich our understanding by viewing the world through two different metaphors. What a metaphor does is essentially give us an alternate conceptualization of the target. While this alternative conceptualization also loses some information (as all

conceptualizations do), the point is that this loses a *different kind of information* than what was lost in the original conceptualization, and taking them together we recover some of the lost information. (See also [14] and [24].) In this way, metaphor becomes a potent cognitive tool for generating creative insights.

An interesting consequence of this view is that there cannot be any a priori criterion for determining which metaphors will be useful for a particular problem or to achieve a particular goal. If it is the missing information that is the key to solving the problem, then the existing conceptualization is hopelessly inadequate in pointing the way to recovering this information. The metaphor approach presented here is essentially a trial-and-error method that makes no promise to deliver even in a probabilistic sense. We elaborate on this further below.

3.4 To Analogize or Not To Analogize

If we follow the arguments presented above, analogies, in their traditional sense at least, turn out to be an anathema to creativity. The reason is that analogies are based on mapping the structure or attributes of the source, to the structure and attributes of the target. So an analogy, which is based on the existing conceptualization of the source, will retrieve sources that are similar to the structure, thereby further strengthening the existing conceptualization of the target. But if the problem could not be solved because of the missing information, then an analogy-based approach will not be very useful.

Yet, analogy has also been recognized as a key mechanism of creativity [2] [6] [7] [18] [19] [20]. One must distinguish between two modes of analogy here though. On one hand, analogy refers to "seeing one thing as another", which is essentially the same as how we have characterized metaphor above. The other use of the term analogy refers to the process whereby the structure and the attributes of the source are mapped to the target. It is this latter mechanism that seems contrary to creativity according to the view presented here, and so it needs some further elaboration.

The cognitive structures (categories and conceptualizations) that naturally evolve through a cognitive agent's interaction with the environment reflect the priorities of the agent. The information that is retained in the conventional conceptualization is the one that has been useful to the agent (or to its ancestors) in the past, and the lost information may not be very relevant. So as long as one stays in the familiar domain (in which the conventional conceptualizations are very useful), and the problem does not require the lost information, reasoning from conventional operations and conceptualizations may be very efficient. Indeed, many of the case studies that show effectiveness of analogy in creative problem solving either stay within the same domain, or they use a source that is already similar to the target in a way that leads to a successful solution to the problem. However, as soon as the problem becomes different requiring new information, analogy becomes a hindrance, and the metaphor approach is called for. (See also [6] and [9].)

To put this in another way, metaphor in the *making-the-familiar-strange* mode is a cognitively expensive operation, with *no a priori guarantee* if it will succeed, or when it will succeed. Therefore, this is used sparingly, and only when other avenues (like reasoning from analogy) have been tried out and were not successful.

3.5 Implications for Computational Modeling

The account of creativity and cognition articulated here has a number of implications for computational modeling, and we will briefly highlight a few major ones. First of all, traditional approaches based on mapping existing symbolic representations clearly

have limitations [3] as far as creativity is concerned. They do capture a certain aspect of creativity in noticing new connections between existing knowledge, and in importing novel hypotheses from the source to the target, but they do not produce a paradigm shift of Kuhnian kind. In this regard, models based on corpus-based analyses and distributed representations seem more promising [26] [29] [30], but so far they are limited to linguistic metaphors.

Another approach is to model the representation building process itself so that new representations can emerge through an interaction of concept networks and low-level object details that are available through sensory system or through imagination [7] [13]. This comes closest in spirit to the cognitive mechanisms underlying metaphor that we mentioned above in Sec. 2.5, for the creative insights emerge from applying a concept to an object (or a low-level representation of it) that is not habitually associated with it. In our earlier work, we have formalized this process [9] [12], and have applied it to model creativity in legal reasoning [10], but clearly much more work remains to be done. Moreover, in real-life, a number of different cognitive processes may act in consort to generate a creative insight, modeling of which may require hybrid architectures [19].

4 Conclusions and Future Research

We have articulated an account of cognition here in which cognition necessarily involves loss of some information. Creativity essentially lies in recovering some of this lost information, and metaphor play a fundamental role in this process. This, however, is a cognitively expensive operation. In many situations, such a novel perspective is not needed, so other problem-solving methods, including analogy, may be more efficient.

Following the ideas outlined in our earlier research [11], it is possible to build a number of computer-based creativity-support systems to reduce the cognitive load on the agent in generating novel ideas and perspectives, or to stimulate their imagination in coming up with more creative ideas. We have demonstrated this point in a story-telling system that was designed and implemented earlier [16]. Currently we are working on designing and implementing another system to retrieve and display pairs of pictures that are based on perceptual similarities but are conceptually very different, in order to stimulate the user's creativity [15].

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