

Chance Discovery as a First Step to Economic Innovation

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Abstract

This cognitive-historical study describes three cases in which business innovators created original ideas for innovation. The paper compares business creativity and Thagard's model of creativity in science and technology. By virtue of this comparison, we outline a new approach that provides an account of the importance of chance discovery and auto-noetic representation in economic innovation. During chance discovery, an innovator builds an auto-noetic mental representation of a possible future situation. The study emphasizes that a creative process in a business is dependent not only on unexpected findings or puzzling phenomena, but also on expectations regarding the future. The study regards the concepts of chance discovery and auto-noetic representation more as complementary to, rather than competing with, Thagard's model of creativity.

Introduction

How does a scientist create a novel study problem? How do engineers create a plan for a novel artifact? How does an individual create an innovative business model? These questions all relate to human creative cognitive processes in science, technology and business. The possibility to create a novelty is one of the most essential cognitive skills of the human mind. Whereas the creativity genre for most cases in cognitive-historical studies (Nersessian, 1995; Dasgupta, 2003) and the philosophy of science (Thagard & Croft, 1999; Thagard, 2003, 2005) has been science and technology, this study describes creativity in the economic business context. The study describes three seminal creative episodes (SCEs) in which business innovators created original ideas for economic innovation.

Creativity is a process whereby an individual exceeds a conventional habit. According to Mayer (1995), a creative

process brings into existence something genuinely new that is valued enough to be added to the culture. A conventional habit includes typical practical and theoretical actions and goals in a domain. Professional experts in a particular domain, including scientific experts, have learned essential skills and knowledge of this domain. Science and technology represent creative domains, as most of the work scientists and engineers carry out is a conventional habit. Thus, experts do what coheres with existing knowledge and beliefs in their domain; their work involves filling in the details on matters that are basically already understood or applying standard techniques to new specific cases (Alvarez, 1998). However, occasionally there are puzzling situations that offer an opportunity for ampliative thinking and a really major discovery or invention.

How does an individual change conventional habits for a novel route? Traditional philosophers of science prefer a logical explanation, in which novelty in science is inductively or deductively derived from previous conventional knowledge (Popper, 1959; Hempel, 1965). Then the ideal of reasoning is based on argument and logic. Sociologists prefer social explanation, in which an individual's social interests are used to explain scientific change (Downes, 1993; Latour & Woolgar, 1986). The problem with logical and sociological approaches is that they neglect the role of an individual's capability to use many different source of information in the creative process.

Thagard (1999, 2003, 2005; Thagard & Croft, 1999) describes the change from conventional habit to new discovery as a combination of puzzling phenomena, questioning and searching. Whereas creativity in science and technology was supposed to arise purely from a cognitive process, Thagard (2002) argues that emotions play a large role in creativity in science and technology.

Therefore, we refer to this account of creativity as the hot thought creativity (HTC) model.

According to the HTC model, a creative process begins when an individual encounters a puzzling and unexpected phenomenon. A phenomenon is puzzling because it is not coherent with the conventional human cognitive system and breaks the conventional habit of a scientist or inventor. Thagard (1999) emphasizes that puzzling phenomena produce emotions such as curiosity, surprise, and serendipity. In addition, practical need and frustration produce emotional curiosity and can break a conventional habit. The HTC model emphasizes that puzzling phenomena should be sufficiently interesting and baffling for an individual to want to continue the discovery process.

When an individual notices something puzzling about a phenomenon, he tries to understand it. The first step in understanding a puzzling phenomenon in science is to generate a suitable question and in technology, to generate suitable goals (Dasgupta, 1996). Then more constrained processes characterizable as a search can be used to generate answers in science and suitable means in technology (Thagard & Croft, 1999). Whereas the standard problem-solving model (Newell and Simon, 1972; Klahr, 2000) assumes that creative agents work with a problem that is presented to them, the HTC model assumes (Thagard, 1999) that the most critical phase in creativity is the generation of questions and goals. Questions and goals are produced in response to surprise, curiosity, need, and other questions; both involve emotions such as puzzlement and excitement (Thagard, 1999, 2005).

The HTC model describes searching in science as finding suitable answers for questions generated on the basis of puzzling phenomena. Scientific questions are abductively answered by generating hypotheses that explain the puzzling phenomena that generated the question (Thagard & Croft, 1999). In technology, searching involves identifying a desirable goal and trying to produce it (Thagard & Croft, 1999). We refer this process in technology as practical abduction. The form of practical abduction is roughly as follows. There is a target B that needs to be reached. With Y it is potentially possible to carry out B. So Y is plausible and acceptable, because it is coherent with the inventor's goals and beliefs. Thus, Y is satisfactory enough to carry out B and so Y is feasible.

Target B is not necessarily clear. In a business context, it is usual to have many potential, different goals. So, the goal space could be a set of many different possibilities B1 to Bn. In the same way, the means are a set of different possibilities Y1 to Yn. In evaluating different possibilities, a person judges the situation, individual competences and the competence of their network (Taata, 2004).

The finding of a novel goal B and a novel mean Y to achieve it is based on goal generation and searching prompted by the innovator. According to HTC, it would be psychologically unrealistic to assume that Y and B must be sentences or propositions. In contrast, practical abduction can be fully multimodal, in that both puzzling target and the

mean to achieve the target can have the full range of verbal, visual, sensory and other types of representations (Thagard, 2005). A narrowly verbal account of practical abduction, such as that favored by logicians, would clearly not fully reflect the multimodal character of practical abductive inference.

From this point of view, an innovation is a psychological process that fits something to be created into pattern established by mental representations (Thagard, 2003). The HTC model argues that the most essential part of human mental representations is based on semantic and procedural knowledge in an individual's memory system (Sahdra & Thagard, 2003).

In conclusion, the HTC model contains four phases: recognition of puzzling phenomena; goal generation; searching; and discovery. Thus, creativity is not only matter of logic, but requires mental representations such as concepts, images, and pattern matching that go beyond the types of structures and inferences allowed in the logical framework (Thagard, 2000). The HTC model captures much of what is central in ampliative reasoning in science and technology. Now we are ready to concentrate on our own research material and to consider whether the HTC model also applies to start-up economic innovation.

Creativity in an Economic Context

Economic innovation consists of the generation of a new idea and its implementation as a new product, process, or service, leading to the dynamic growth of the enterprise and profit creation (Taata, Suomala, Siltala & Keskinen, in press; Urabe, 1988). Economic innovation can involve a new product, the further development of an existing product, a new service, or a new marketing system. The term economic innovation is used in this paper to indicate interest in finding novelty products and services that create economically viable innovations, instead of just any novelties, that may lack a positive financial outcome. Thus, our approach to economic innovation is similar to that of creative studies to creativity in general, i.e. that creativity is the production of useful, new products and ideas (Csikszentmihalyi, 1996; Mumford, Baughman & Sager, 2003).

This study is a part of the wider research program "Business co-evolution – innovation mechanisms in the network economy" (Keskinen 2004). Other sections of the study have been described elsewhere (Taata et al., in press).

To increase understanding of the creative processes in economic innovation, we consider three start-up cases who were interviewed using theme interview methods in Santa Barbara County, California. The first innovation is a surgical robot called an automated endoscopic system for optimal positioning (AESOP). The second innovation is a revolutionary oxygen device for patients suffering from chronic obstructive pulmonary disease (COPD) called INOGEN ONE. The third innovation is a photocopy service called KINKO's. For each case, one innovator—nominated by business experts from the Chamber of Commerce in Santa Barbara and from the University of California at Santa Barbara (UCSB)—who invented the idea participated in an

interview. The interview events were audiotaped and transcribed. The interviews were carried out between December 2004 and January 2005, and each lasted between 43 and 70 min. This paper concentrates on idea generation in the innovation process. The research questions are: How do innovators get an idea for a business economy innovation? Is the process similar to the HTC model described? In interviews, the first author of the paper asked innovators to describe the situation in which she or he became aware of the idea. All interviewees clearly remembered the situations. They have given permission for the authors to use their own and their company names in our research reports.

AESOP

AESOP was the first commercial surgical robot in the world when the company Computer Motion, Inc., brought it onto the market in 1994. In 2003, Computer Motion merged to Intuitive Surgical company and Yulun Wang founded a new company called InTouch Health®. The idea of AESOP was born in 1991 after discussions between the founder of the company, Yulun Wang, and medical doctor and surgeon, Ron Lattimer, in Santa Barbara. Then the development process began and AESOP became a profitable product in 1997.

In 1988, Wang completed his Ph.D. in robotics at the Department of Electrical and Computer Engineering at UCSB. He developed a new computer architecture for robot control. With this technology it was possible to apply robotics that need extreme precision. During his Ph.D., Wang learned many underlying technical tools and had the chance to work at the Center of Robotic Systems and Microelectronics at UCSB.

Because he wanted to be an entrepreneur since his childhood, Wang founded the Computer Motion company in 1989. In his interview he recalled: "I think I've always thought about being an entrepreneur. I don't know why, I had the choice of going into academics or going into industry and I always felt that I wanted to build and design innovative new products." Although he founded the company in 1989, he did not know then what his business should involve. At the beginning, as the inventor of a new computer architecture for robot control, Wang got consulting jobs with Hughes Aircraft, General Motors, Toyota, and the US Navy. In addition, he obtained government grants from NASA, NSF and NIH, but he did not know the domain.

In his interview he said: "I think at that point of time I was looking at many ideas simultaneously, and then you keep pushing them all forward and see which ones fall down and which ones keep moving". The conventional intellectual habit of the robotics experts involved the defense sector and the automobile industry. Because these traditional robotics fields were both in a downturn at that time, Wang was actively looking for suitable new applications for robotics. Because the traditional areas were not promising and the medical domain was, he tried to look for possibilities in medicine. He started talking to his friends who had trained as physicians, which led to meeting with a medical doctor and surgeon, Ron Lattimer. In his interview, Wang

described the appointment with Ron Lattimer as follows: "... that was a significant moment ... very first time the concept of AESOP came into being was when Ron Lattimer said 'why don't you hold my scope for me ... why can't you hold the camera for me?' Lattimer continued: 'if I can have direct control of that camera that would be very helpful for me'. And that's how the whole idea of how AESOP came."

The background to Lattimer's question was that there was a huge change in minimally invasive surgery, called laparoscopic surgery. Doctors were carrying out these procedures through little holes and viewing them with a camera. When a surgeon holds surgical instruments with both hands, somebody else has to hold the camera. Wang described the situation: "And when someone else holds that camera, it's like if you and I were in a dark room, but I had to hold the flashlight and you had to tell me where to put it, it's not very accurate. You say, 'look to the right', I don't know how far right you're talking about." So what Lattimer told Wang was that if doctors could have direct control of the camera, that would be very helpful. A clear goal for an innovative product and business was born.

INOGEN ONE

INOGEN ONE is a revolutionary oxygen device for patients suffering from COPD. The INOGEN ONE company brought it onto the market in 2004 and today the company is profitable. The idea was born at the end of 2000, when UCSB student Alison Perry was at home on Christmas vacation.

During fall 2000, students Alison Perry, Byron Myers and Brenton Taylor wanted to enter the business plan competition at UCSB. They entered the competition because they wanted to learn business and because it was possible to win \$10 000 as the first prize. Thus, they needed to identify a product or service they could develop into a business. The idea was born during the winter break in December, 2000, when Alison Perry went home to Santa Rosa in California for the holidays. Her grandmother joined the family for Christmas. She suffered from COPD and needed to use oxygen therapy. She had a traditional oxygen device that tethers patients to an oxygen tank and she could venture only as far as her lifeline would allow. In her interview, Alison Perry described the situation as follows: "And this innovation was derived mainly because my grandmother was using the oxygen equipment and I realized how her quality of life just diminished, the second that she got put on the oxygen, and so as a result we saw a huge need of people wanting to be more free and mobile and being able to live on their own schedules and that's where the company idea came out, was why can't we make something more miniature that would help a lot of these people out and that's what we set out to do and that's what we've done". Actually, she said it haphazardly, "wouldn't it be great if there was something smaller, why can't there be? I just started mulling it over and it sounded like a good idea and I kind of watched her and looked at the device."

The idea for an innovative patient-friendly medical device was born. With this idea, Perry came back to UCSB and told Taylor and Myers about her idea. First they hesitated, but accepted the idea very soon. They participated in the

business competition with this idea and won the first prize of \$10 000 in May 2001. Later the same year they founded the company INOGEN. The company's first product INOGEN ONE was on the market in October 2004.

KINKO's

University of Southern California (USC) student, Paul Orfalea, founded an innovative photocopy service company named KINKO's close to UCSB in fall 1970. This type of service for college students was very novel at that time. KINKO's has grown into a international photocopy company and at the beginning of 2004 it was sold to FedEx for \$2.4 billion.

Since Orfalea's childhood it was self-evident that he would like to found his own business. All his relatives had their own businesses. Before the photocopy idea born, Orfalea had work experience in his father's clothing company. He also tried to sell vegetables and fruit in the market. However, he was not successful in these domains and he actively looked for a new opportunity for his own business.

In spring 1970, Paul Orfalea participated in a study project with his college friend at USC. Because he could not read well, he could not help much in the way of either research or writing. Instead, he became the gofer for his college friend. Therefore, one of his jobs was to make copies for his friend. One day he went to the university's copy center. When he was in line to use the photocopy machine, he noticed something very interesting, the copy center itself. In his interview he recalled: "I saw people in line and I figured, well if they're in line there, why wouldn't there be a line in Santa Barbara." In his autobiography he writes: "I went to the university's copy center, paper in hand, on the day it was due. Right off, I saw something far more interesting: the copy center itself. This was spring of 1970 and people were scurrying around making voluminous copies of legal paperwork for the trial of accused serial killer Charles Manson. I came running back to class, nearly out of breath." (Orfalea & Marsh, 2005, 6-7). In class he said for his friend: "Danny, I've got this great idea!" (Orfalea & Marsh, 2005, 7). He realized he could start a copy shop at Isla Vista, close to UCSB. The place was familiar to Orfalea, because his girlfriend was a student there.

The novelty of Orfalea's business was the supply of a full service. In the morning, on their way to the campus, students ordered copies from Kinko's and picked them up in the evening. This benefited both customers and Kinko's. The company was profitable after 4 months.

Results and Discussion

There are three similarities between the different SCEs. First, the business innovators had goals to create their own business models. Orfalea and Wang had the goal of starting their own companies since childhood. Perry's goal of starting her own company was tied to a business competition plan at UCSB. Second, the reason for beginning the innovation process was a practical need and the goal

came from commercial motivation. Although commercial motivation and practical need were at the origin of the process, we should not neglect the intrinsic pleasure and curiosity of business innovators in building an innovative business idea. Third, the basic business innovations created in the SCEs were the same until the company was profitable. We are aware that a good innovation does not end with idea generation in the SCEs described here; rather, it ends with implementation and profitable marketing. However, from a cognitive point of view, innovation-based goal generation is the most difficult part of innovation process. After the goal is generated, a focused and constrained search for idea implementation is possible.

The first difference between the HTC model and start-up innovations is the different starting situations. According to the HTC model, the discovery and invention process begins when an individual encounters a puzzling and unexpected phenomenon. In start-up economic innovation, the process begins when a business innovator decides to found a business. When the business innovators created more specific business models in the SCEs, this involved finding an expected rather than an unexpected goal. The process was not as unexpected or puzzling as in the HTC model, because they had actively sought a business possibility before the SCE. During the SCE, the goal came clearer and more arguable. However, the SCE is undoubtedly emotionally a high impact episode.

Before innovations were created in the SCEs, the business innovators had a fuzzy idea of a profitable business. Their chain of reasoning may be described in the following way.

- (1) I would like to set up my own business (B).
- (2) With innovation (Y), can I get my own business?
- (3) I need to create something (Y) in order to achieve B.

When an individual has a general goal to create his own business B, he is looking for the possibility to carry out Y. We refer to this type of discovery as chance discovery and define this more specifically as follows. Chance discovery involves discovering Y when the individual has a general and fuzzy goal B. Y should be coherent with the innovator's original goal and his previous experience and mental representations. In addition, the individual judges Y, based on their belief as it relates to individual competencies and their network competencies (Taatala, 2004).

To say a chance discovery involves discovering innovation Y when the individual has a general goal to set up their own business B is not to say that every innovation process follows the same order from phase (1) to phase (3). Many innovations have arose in a academic context without the intention of developing a business. In addition, many innovations have been developed in companies without any direct idea to going to market immediately. In these cases, phase (2) came before phase (1). However, the assumption behind this study is that a creative process is dependent not only on unexpected findings or puzzling phenomena, but also on the expectations we have regarding our future.

Tawfik (2004) describes chance as a high impact event, situation or change. These situations are rare, but their effects are so significant that it is advantageous to utilize them as early as possible. Tawfik (2004) explains the concept of the chance discovery as a process of discovering

such situations. In addition, the chance discovery predicts future outcomes.

Our definition of chance discovery differs from Tawfik's definition in one essential way. All situations of SCEs in this study are ordinary, not rare. However, the innovators transformed an ordinary situation, where there is no problem to be solved, into a situation where an idea ready for implementation exists. In an ordinary situation, the mind worked in a creative way. Despite that difference in definitions, both views of chance discovery predict future outcomes.

The second difference between the start-up cases and Thagard's cases are different positions in relation to the domain. The HTC model is based on creative individuals in science and technology who are experts in their domain. In contrast, the start-up innovators in this study are at the beginning of their careers. How do mental representations and the interpretation of seminal creative situations differ between creative experts and novices? We argue that experts interpret unexpected findings based on their expertise. They construct mental representations based on their knowledge, skills and past experiences, which an expert has in his/her working memory and long-term memory. In contrast, the start-up innovators had a general goal to found a business. They had to keep track of what was going on in their potential domain. This process does not involve a search through predefined representations, but rather the identification of a goal for a business by virtue of new representations forged from many resources. The construction of their potential chance is sensitive to the domain facing the start-up innovators. Whereas experts build multimodal representations based on previous learned knowledge and skills, start-up innovators build multimodal representations based on active goals. In this case, goals are representational structures that guide the innovators in their pursuit of a reference state (Markman & Brendl, 2000). During the chance discovery process, situations are evaluated relative to active goals. Because the goal to found a business can be long-standing, sometimes for many years, this goal is chronically active (Markman & Brendl, 2000). This does not mean that an individual is aware of the goal all of the time, but it is likely that chronic goals affect the individual's perception and evaluation of different events. Goals have an important effect on how an individual organizes and categorizes the world, and help to organize the long-term representation of our knowledge (Dunbar, 2002). How can an individual build goal-based multimodal representations from future events?

We use Geary's (2005) description of a human auto-noetic mental model. This concept is a fusion of Tulving's (2002) auto-noetic awareness and Johnson-Laird's (1983) mental models. In essence, an individual can create a self-centered mental simulation of the "perfect world" in the future using an auto-noetic mental model. A perfect world is one in which the individual is able to organize and control his own life in ways that will enhance his expected standard of living. According to Geary (2005), auto-noetic awareness can be integrated with the motivation to control. The motivation to control is facilitated by the ability to mentally simulate potential future scenarios and changes in situations.

Auto-noetic awareness is not simply self-awareness, but also involves the ability to mentally relive past experiences and to project oneself into the future (Geary, 2005).

When start-up innovators pursue a goal to found their own business, they build an auto-noetic mental representation relating to future situations. In the SCEs, the innovators evaluated a chance based on this future scenario. As in the HTC model, the SCE interpretation is multimodal. The concept of auto-noetic representation is an addition to this multimodality. The idea of innovation becomes a target for implementation when it is sufficiently interesting and baffling. The innovators believed that they had enough cognitive, social and material resources to implement their ideas for products or services.

Conclusion

This study presents three cases in which an original idea was created for economic innovation. Before the SCE, all cases had a long-standing goal to pursue their own business. Thus, the finding of a business idea in the SCEs was expected, in contrast to the HTC model. In the HTC model, experts begin the creative process when they encounter an unexpected finding or puzzling phenomenon. Because of this difference, we call the SCE a chance discovery.

The reasoning process during any SCE is based on multimodal representations. An essential part of this multimodal representation is auto-noetic mental representation, whereby an individual can mentally simulate future situations. We regard the concepts of chance discovery and auto-noetic representation as complementary to, rather than competing with, Thagard's HTC model. This study highlights that a creative process is dependent not only on unexpected findings or puzzling phenomena, but also on the expectations we have regarding our future. Otherwise, our account of the creative process is similar to Thagard's HTC model. Three cases of economic innovation are hardly sufficient to conclusively generalize an explanation as to why an individual creates novelty in certain situations. However, the AESOP, INOGEN ONE, and KINKO's cases are rich examples of the creative mind at work in the business world.

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