

**MECHANISMS OF AESTHETIC EXAPTATION IN ARTEFACT DESIGN:
HOW A BEAUX-ARTS GARDEN EVOLVED INTO AN AVANT-GARDE ART PARK**

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Mechanisms of Aesthetic Exaptation in Artefact Design: How a *Beaux-arts* Garden evolved into an *Avant-garde* Art Park

Abstract

The concept of exaptation – the co-optation of a feature for its present role from some other origin- has been proposed as an important mechanism of radical innovation in technology and market evolution as well as in the design and production of artefacts. However, empirical evidence is lacking on the cognitive processes leading to exaptation events in the evolutionary dynamics of artefacts: are exaptation events only due to serendipity or are there any sorts of contingent regularities in the cognitive mechanisms producing them? Based on the findings of a longitudinal case study on the radical change of the aesthetic features of a complex artifact –e.g. the design of a public park- this paper builds a model of the cognitive processes leading to exaptation events in artefact design. The model emphasizes both calculative processes of re-combination across problem domains and adaptive processes of re-interpretation of the relationships among combined elements. Implications for the use of information-processing and distributed-cognition models of cognition in evolutionary theories of radical innovation are discussed.

Introduction

Most commercial products developed for particular markets and functions began life as something different. Microwave ovens started life as radar magnetrons, Edison's phonograph was born as a recording device for dictation; internet was a military communication exchange network. Creative re-use of artefacts' forms and functions is even more pervasive in contemporary cultural production settings -such as art, architecture and fashion- where we assist everyday to the '*aesthetics of innovation through re-use*' (Beunza 2007): warehouses transformed into offices, factories into lofts, carwash locales hosting art galleries; urinals as artistic fountains in museums (Duchamp 1917); anarchists' political symbols as icons of prominent fashion-houses' collections (Eleuthera 2008). Despite the pervasiveness of re-use in innovation and creativity, our social science theories still lack a systematic theoretical understanding of this phenomenon.

Recently, the concept of exaptation –the co-optation of a feature for its present role from some other origin- has been borrowed from evolutionary biology (Gould and Vrba 1982) to explain creative re-use phenomena in technology, markets (Mokyr 1998; Dew et al. 2004) and artefact production (Villani et al. 2007). More generally, exaptation has been advanced as a candidate mechanism to explain the changes resulting from radical innovation processes (Grandori 2007a; Kogut 2007)¹. In both biological and artificial settings, innovation-by-exaptation has been contrasted to innovation-by-adaptation, which assumes incremental evolution of structure towards better function. In contrast, exaptation has been associated with the unforeseen connection between an existing feature or tool and a new function or domain of application, for which the tool or feature was not originally designed or selected for.

The intuitive link between the definition of exaptation and serendipity, and the commonsense interpretation of the phenomenon as an unintended consequence of action, has obscured a crucial question: *are exaptation events only due to serendipity or are there any sorts of contingent regularities in the cognitive mechanisms producing them?*

¹ Processes related to the dynamics suggested by the concept of exaptation are described by the concepts of *technological pre-adaptation* (Cattani 2006) and *transposition and re-functionality* (Padgett et al. 2006).

Despite the practical relevance of the question -given the widespread diffusion of practices of re-use in the artificial world- empirical evidence is scarce on how exaptation events actually occur in real instances of artefact design and production. Recent studies have contributed novel insights into the organizational and environmental pre-conditions of exaptation (Villani et al. 2007). However, without direct empirical evidence on the underlying micro-processes leading to this creative ‘tinkering’, our understanding of the phenomenon is doomed to remain rather weak.

The above question is theoretically relevant because the concept of exaptation is likely to challenge the model of cognition underlying our established theories of evolutionary change and innovation in artificial settings. Simon (1962)’ classic claim about the hierarchical structure of human cognitive processes provided a solid micro-foundation for the mechanisms of gradual evolutionary change (e.g. Darwinian incremental differentiation by specialization of sub-systems) in artificial settings (e.g. contributing to explain phenomena such as organizational changes and product and technology innovation). However, while Simon envisioned cognitive processes as organized into a hierarchically-ordered sequence of ‘boxes’ (e.g. sub-problems composed of more elementary sub-problems), the permutation of forms, functions and contexts suggested by exaptation seems to violate this hierarchical structure, pointing to the importance of crossing the boundaries of modular domains, of making connections across “qualitatively different” domains. Despite the phenomenon of exaptation has the potential to challenge our conventional understanding of the cognitive processes underlying innovation, the cognitive micro-foundations of exaptation have remained theoretically obscure and poorly articulated.

The relative unexplored nature of the phenomenon of exaptation in artificial settings calls for an inductive exploration of its antecedents in real practices of artefact design. In the last three years, I embarked on such an exploration conducting an in-depth field study of the micro-processes leading to the exaptation events observed in the aesthetic features of a new public park recently built in Chicago. The particular type of artefact exaptation analyzed in the case study is labeled “aesthetic exaptation”, which, on the basis of the definition of exaptation provided by Gould and Verba (1982), is defined as *“the use of an aesthetic feature for a function or context different from those for which*

the feature was originally selected or designed for". The evolutionary trajectory of the aesthetics of the specific artefact considered in the case study (e.g. the design of the park) is particularly well-suited to shed new light on the phenomenon of interest. Indeed, the history of the park has been punctuated by two major exaptation events, which led to a complete revolution of the aesthetic repertoires proposed in an original prototype of the park developed by the architect of the project (see pictures in the appendix).

Through a detailed historical analysis of the co-evolution of the park design and the project organization developing the park, I first identified two crucial exaptation events in the history of this radical aesthetic change. Second, I linked the occurrence of these exaptation events to the decision-making processes of two committees in the project and to the crucial activity of several project brokers operating in-between the committees. I then analyzed the details of the meeting minutes and communication exchanges among the project brokers and committees' members, reconstructing the cognitive dynamics leading to exaptation at the artefact level.

My detailed analysis of internal communication and committee meetings' minutes has been made possible by an extraordinarily rich archival dataset built from primary (e.g. two complete archives of the project files provided by the project manager and by a key project brokers) and secondary (books, newspapers and archival material on the park) sources. This dataset is longitudinally extensive, covering the entire lifespan of the project (from early 1998 to 2004) and containing the thousands of meeting notes, communications, design maps/plans and construction documents used by the members of the project during its development. Archival sources have been integrated with extensive interviews with all the key players involved in the project.

The case study shows that exaptation events can be produced by the combination of two basic types of processes. The first is a process of making connections among different problem domains. This process gave rise to new interdependencies among formerly disconnected elements, constituting an important antecedent of exaptation. The new interdependencies provide the raw material from which exaptation events may later originate, increasing the *exaptive possibilities* inherent in the evolutionary trajectory of the artefact. The second set of processes consists in the re-interpretation of the relationships connecting the parts that had been combined together. This re-interpretation

is described as a process of changing the perspective from which the interactions among the parts are perceived and evaluated. In the specific case, this change in perception is achieved through visual manipulation and experimentation on the interfaces connecting the modules of the artefact (e.g. in my case the walking paths bounding the different areas of the park). Two types of these processes are detected and labeled: *radial association*, a process through which a focal feature is established as a central element around which the interfaces with adjacent features are re-configured; *orthogonal association*, a process through which the position of two or more non-adjacent features is used to define a perspective (e.g. in my case, a visual perspective such as an axis, a sight line, a diagonal), which serves to detect relationships of symmetry/asymmetry (or complementarities/substituabilities) between the features, on the basis of their relative position on the perspective.

While the cognitive logic underlying the former set of re-combinatory processes is found to be consistent with calculative and strategic reasoning, the latter process of boundary re-interpretation via visual experimentation emerged as an adaptive response to the new interdependencies created by the combination of different elements and it is rooted in a change in the capacity of *seeing* and *perceiving* relationships more than in an increased capacity in *calculating*. This finding places the cognitive micro-processes leading to exaptation events detected in the specific case study in a middle-way position in the continuum between random serendipity and strategic foresight.

Overall, the case study illustrates that the traditional notion of innovation as a pure re-combinatory play, commonly accepted since Schumpeter (1934) on, may need to be expanded to include more detailed micro-processes of adaptive re-interpretation in order to account for innovation-by-exaptation. Indeed, while re-combination was essential in providing the raw material from which exaptation originated in the case examined (e.g. generating new interactions among different elements combined together), the new uses envisioned for the exapted aesthetic features ultimately emerged as the result of perceiving the interactions among elements from a perspective different from the one envisioned at the moment of the generation of the combination. This process is qualitatively different from the pure integration or re-combination of elements -as usually intended- because it involves the consideration of *new relationships* between pre-

combined elements. These findings are interpreted consistently with recent decision-making research identifying new methods for the design of novel solutions (Grandori 2007b; Liedtka 2000; Sarasvathy 2001). In addition, with specific reference to the processes of visual manipulation and experimentation of prototype models, the findings can be interpreted consistently with the distributed cognition approach (Hutchins 1995), highlighting this approach as a possible complementary model of cognition underlying evolutionary accounts of radical innovation (Lorenz 2001).

The remaining of the paper is structured as following. In the first two sections, I provide an introduction to the concept of exaptation and to the theoretical challenges that this concept posits for the model of cognition underlying our evolutionary theories of change and innovation. Then I turn to an illustration of the methods and the findings of the case study, which are analyzed and used to build a process model of cognition and exaptation in artefact design. Finally, the implications of the findings to classic and emerging literatures on cognition are discussed.

Exaptation in Biology, Technology Evolution and Artefact Design

The concept of exaptation originates in the domain of biology, where it appears for the first time in Gould and Verba (1982) who referred to species evolution as the mechanism complementary to Darwinian adaptation. The following definition provided by Ceruti (1995) gives insight on the main idea of exaptation: *'the processes whereby an organ, a part, a characteristic (behavioral, morphologic, biochemical) of an organism, which was originally developed for a certain task, is employed for carrying out tasks that are completely different from the original one'*. The typical example provided by Gould (2002) is represented by a line of feathered dinosaurs, arboreal or runners who developed the capability to take advantage of feathers for flying, when originally they were intended for thermoregulation purposes. Different from adaptations, which present functions for which they are selected, exaptations generate effects that are not subject to pressures from the current selections, but potentially relevant later on.

More recently, the concept of exaptation has been used to explain the rise of new technologies. For example, Mokyr (1998) defines the phenomenon of exaptation saying that *'it refers to cases in which an entity was selected for one trait, but eventually ended*

up carrying out a related but different function'. Such a definition captures the idea that exaptations are those characteristics of a certain technology that are co-opted by another origin or utility for their current role. In this respect, exaptation has been interpreted as a key to explain the serendipity that characterizes the generation of new products, emphasizing that the functionalities for which a technology has been selected are only a subset of the consequences generated by its introduction (e.g. March 1982). A classical example of technical innovation illustrating both adaptation and exaptation is the Compact Disk (CD), originally developed for solving the problem of sound quality' deterioration of classical vinyl records and later commercialized as storage media for computer data (a function not originally intended for the CD-ROM).

The concept of exaptation has been most recently applied to explain radical innovation in the context of the design and production of artefacts by Villani et al. (2007). The authors propose a model postulating a continuous interaction between producers and users: the artefacts are transferred from the producers to the users and subsequent feedback messages are sent from the users to the producers. Exaptation events are understood as shifts in terms of the 'leading attributions' (attributions corresponding to highest reward) that the agents assign to artefacts through their categories. The results of the model show that the ambiguities present in artefacts and categories can significantly increase the probability that exaptation phenomena will occur.

Cognition and Exaptation

The concept of exaptation is likely to challenge the established model of cognition underlying our theories of evolutionary change in artificial settings. Simon (1962)' classic claim about the hierarchical structure of human cognitive processes provided a solid micro-foundation for the mechanisms of gradual evolutionary change in artificial settings, contributing to explain phenomena such as organizational changes, product and technology innovation (e.g. Nelson and Winter 1982). While Simon envisioned cognitive processes as organized into a hierarchically-ordered sequence of 'boxes' (e.g. sub-problems composed of more elementary sub-problems), the permutation of forms, functions and contexts implied by the exaptation phenomenon seems to violate this

hierarchical structure, pointing to the importance of making connections across “qualitatively different” sub-domains.

Specifically, the concept of exaptation challenges the classic Simonian claim from a number of perspectives on which there is already an intense debate in the literature on cognition and innovation. For example, while the hierarchical *structure* of the problem space has been proven to be an efficient heuristic for computationally-limited problem solvers (Newell and Simon 1972), this efficiency argument *per se* has been argued to explain, at most, the decomposition of the problem into modules, but not the fact that such modules need to be ordered into a hierarchical system (Egidi and Marengo 2003: 343). This assumption becomes even more problematic in the face of empirical evidence on the distributed structure of cognition across the members of an organization or between internal and external representation devices (Hutchins 1995). Similarly, the classic cognitive repertoires inherited from the Carnegie School tradition (e.g. local search, linear decision rules, routines, etc.) have been criticized to be too conservative and restrictive to explain the design of radically innovative solutions (Liedtka 2000; Hatchuel 2001; Savarasthy 2001; Grandori 2007b).

As the cognitive processes inspired by the bounded rationality paradigm are questioned at the micro-level, the classic mechanisms of evolutionary change -e.g. Darwinian incremental differentiation by specialization of sub-systems- are increasingly debated in social science disciplines (Padgett and McLean 2006; Villani et al. 2007; Cattani 2006). Concepts such as exaptation (Villani et al 2007; Dew et al 2004), technological pre-adaptation (Cattani 2006) and transposition and refunctionality (Padgett and McLean 2006) have been advanced to explain phenomena of radical change. Both these new cognitive and evolutionary models of radical innovation are animated by a common effort at understanding the emergence of novelty going beyond the conventional views of innovation processes. However, no systematic attempt has been made to date to link these new emerging models empirically. As a result of this disconnection in these emerging research streams, the new evolutionary models of radical innovation may remain without an adequate theoretical micro-foundation, whereas studies of micro-level processes may lose the ‘big picture’ of what the dynamic consequences of new design methods can be.

Case Study

To explore these under-investigated topics, I analyzed the complete history of a complex architectural artefact, a new public park recently built in Chicago through a \$475 millions private-public partnership. Two features of the history of this park make it an especially relevant case to investigate the phenomenon of exaptation in artifact design. First, the case constitutes an instance of radical change in the design of an artefact. Specifically, during the development of the project there has been a radical change in the aesthetic features of the park with respect an initial design master plan devised in the early stages of the project. Originally envisioned as a classic *beaux-arts* garden in continuity with Chicago architectural heritage and endowed with a modest art program, the design of the park was turned in a global outdoor art museum, combining avant-garde architecture, monumental sculpture and innovative landscape designs in a new concept of cultural park. Second, the history of the development of the park is characterized by more than one exaptation event, providing material to compare the processes underlying the emergence of this phenomenon. I'll illustrate in detail these exaptation events in the following paragraphs.

Methodology I: Data Collection and Analysis

In the analysis, I used a longitudinal case study design (Eisenhardt, 1989). I adopted a historical perspective to sharpen my understanding of the phenomenon of interest as it unfolded over time (Kieser, 1994). My primary objective was to identify the micro-cognitive and organizational processes and evolutionary forces (internal and external to the project organization) responsible for the occurrence of exaptation events identified in the evolution of the specific artefact under observation. The data collection spanned over more than two years, from the late spring of 2006 to the late 2008.

The overall research process was highly iterative (e.g. Miles and Huberman, 1984). The identification of specific exaptation events influenced the type of data collected in subsequent stages of the research process. In addition, framing the study as an empirical inquiry into the cognitive processes of exaptation led to on gathering data at the level of the decision-making processes of specific actors and organizational units in

the project organization (e.g. the design and fund-raising committees, that is, those units more involved into the exaptation events, as explained in detail below).

I started my data collection conducting extensive interviews with the key players involved in the project and assembling publicly available data on the history of the development of the park (newspapers, books and archival material). While doing that, I accessed the complete files archive of the non-profit organization that managed the development of the park. This archive is an invaluable source of data. The archive is longitudinally extensive, covering the entire lifespan of the project, from early 1998 to present. The type of files contained in the archive (including thousands of meeting notes, attendance sheets, communications and design maps and plans) provide very detailed information on the decision-making and coordination process allowing the new design to come about. Finally, the archive has never been accessed by a researcher and encompasses rare micro-level data that are typically difficult to access in social research.

Methodology II: Defining and Identifying Aesthetic Exaptations

On the basis of the definition of exaptation provided by Gould and Vrba (1982) - the co-optation of a feature for its present role from some other origin- in the context of the case study I defined the concept of “aesthetic exaptation” as *“the use of an aesthetic feature for a function or context different from those for which the feature was originally selected or designed for”*.

According to this definition, identifying exaptation events in artefact design requires understanding not only how a feature links to its *current* role in the artefact structure, but also why and how the feature was *originally* selected or designed for the artefact in question. For this reason, I embarked in a retrospective analysis of the evolutionary trajectory of the park design, with specific reference to the dynamics involving the aesthetic features of the design.

I start analyzing the composition of the current design of the park, operationalizing the two basic concepts constituting the definition of aesthetic exaptation provided above: the concept of “aesthetic feature”; the concept of “function” (or “context”) for which the feature is used. I first identify the contexts and functions for which each aesthetic feature is used in the current design of the park. Second, I analyze

retrospectively the evolution of the design of the park to examine whether the same aesthetic feature was selected for the same or for a different context or function of the park design. Thus, an exaptation event has been recorded when the function or context in which an aesthetic feature is used in the current design of the park is different from the function or context envisioned for the same aesthetic feature in previous stages of design development.

To introduce my analysis of the current design of the park, let me first show below picture 1, depicting the design of Millennium Park as it currently stands.

Components of the Final Design of Millennium Park



The circles in the picture identify different areas of the park as envisioned by the architects and planners of the park. Indeed, the architects of the project envisioned the design of Millennium Park as composed of separated “rooms” (e.g. geographically-bounded areas), each characterized by particular technical, design and aesthetic features and each serving specific functions or uses. Empirically, I identify these areas relying on the design narratives, promotional brochures and newsletters describing the design of the

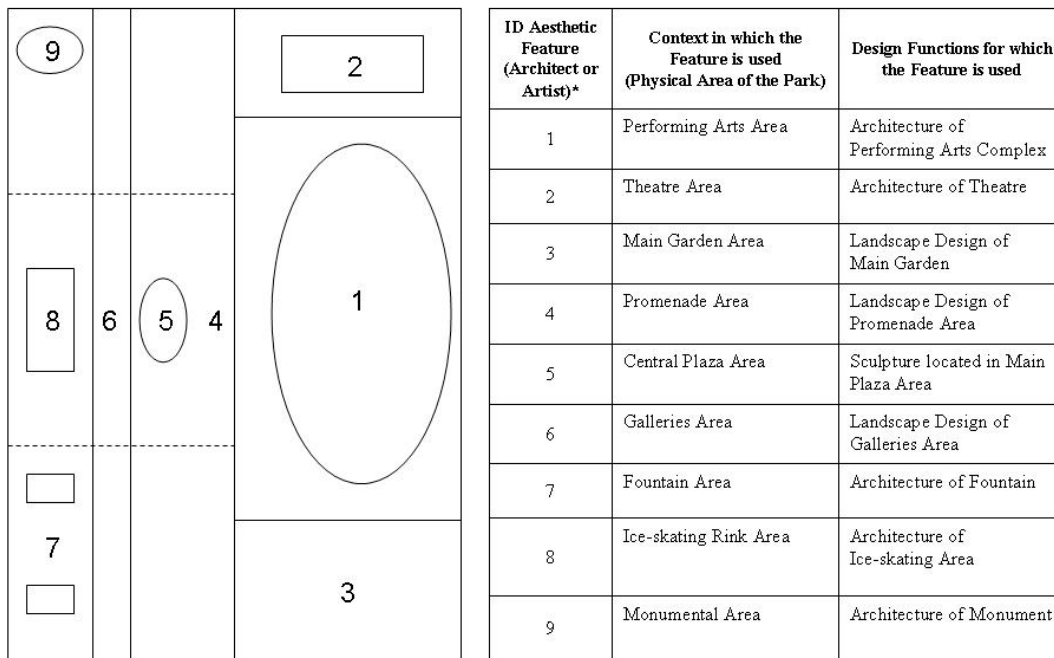
park. The areas of the design are identified by separate headings or chapters in these texts.² Thus, these headings represent the ‘cognitive classification structure’ through which architects of the park saw and categorized the design of the park, constituting a reliable source of data to identify the components of the artefact, their functions and aesthetic features.

The aesthetic features of the artefact have been identified by coding the textual description of the areas of the park. The concept of ‘aesthetic feature’ was empirically operationalized using the name of architects or artists as proxies of different aesthetic styles. When the name of an artist/architect was mentioned in the description of the park’s areas, a corresponding aesthetic feature was coded. Similarly, the concepts of “function” and “context”, from which an aesthetic feature can be exapted, have been operationalized as the design functions (“function”) or the areas of the park (“context”) characterized by the aesthetic feature in question. For example, the context of the aesthetic feature 1 (“Frank Gehry”) was the area identified as “Performing Arts Complex”, which, in turn, corresponds to a specific set of design functions.

The results of this coding work are reported in the figure below, reporting a table and a schematic diagram of the park in which the detected aesthetic features are numbered and graphically illustrated by the areas (“contexts”) and design functions (“functions”) for which they are used in the current design of the park.

² For example, Heading 1: THE GREAT LAWN: “At the heart of the park there will be a Great Lawn, an open space for family play, picnicking, etc”. Heading 2: PLAZA: “Behind the stage, there will be a new plaza marked by a pool...”

**The Current Design of the Park:
Aesthetic Features, Contexts and Functions**



* = ID number indicates the specific architect/artist designing the corresponding area

Figure 1.1 - Aesthetic Features, Contexts and Functions in the Final Design of the Park

Next, in order to identify whether any of the above aesthetic features detected in the design of the park have been exapted from different contexts and functions, I asked myself where the aesthetic features come from (e.g. how have they been selected and why? What use the features were originally thought for?), for each of the aesthetic features identified. I discovered that the aesthetic features used in the current design of the park emerged gradually from an initial master plan of the park designed by the architect of record in the early stages of the project.

By tracing back the origins of the aesthetic feature in the current design of the park, I identified two crucial exaptation events in the evolution of the design of the park. In the first event -labeled exaptation event no. 1, the aesthetic style of architect Frank Gehry (coded as ‘aesthetic feature 1’) is exapted from the function it was originally selected for (sculpture on a music band-shell) to another design function (the architecture

of the entire performing arts complex). In the second event -labeled exaptation event no. 2-, the aesthetic style of sculptor Anish Kapoor (coded as 'aesthetic feature 5') is exapted from the context (e.g. the physical area of the park) it was originally selected for (the main garden in the park) to a new context (the central plaza in the park). These exaptation events are represented graphically in the figures below:

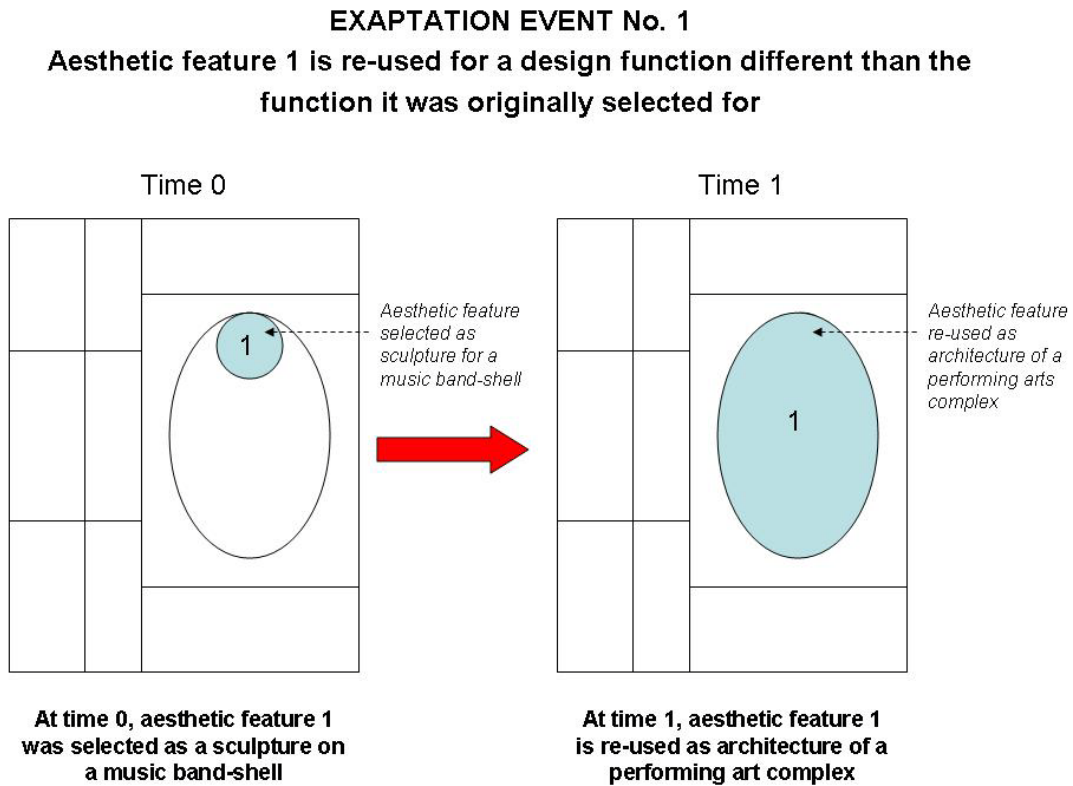


Figure 1.2 – Exaptation Event no. 1

EXAPTATION EVENT No. 2
Aesthetic feature 5 is re-used in a context different than the context
it was originally selected for

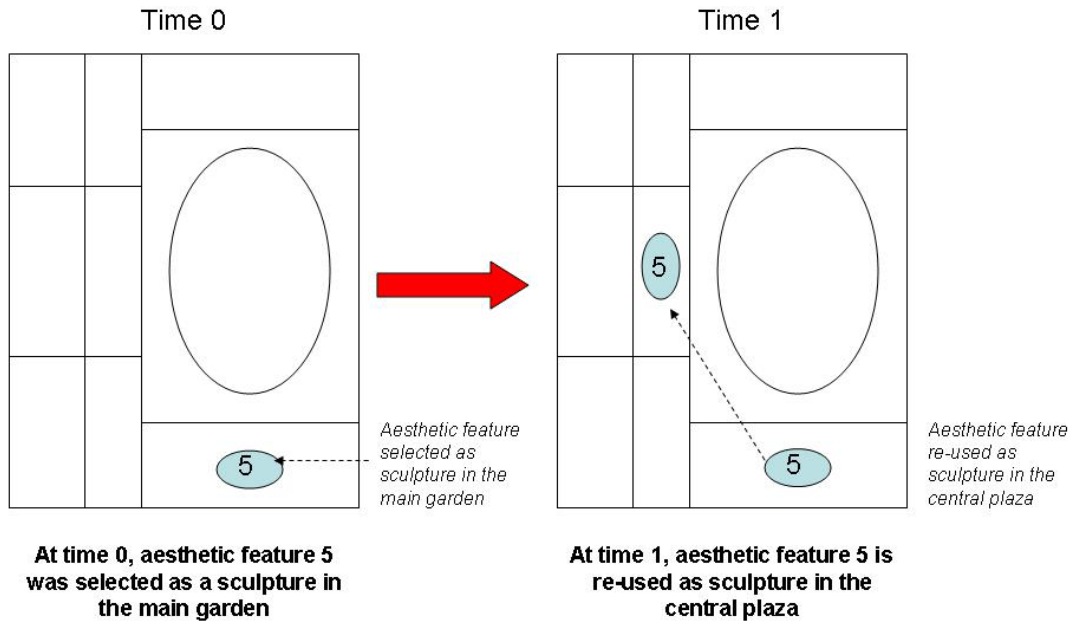


Figure 1.3 – Exaptation Event no. 2

Findings: The Processes leading to Exaptation Events

Empirically, the occurrence of the two exaptation events is connected to the decision-making processes of two committees in the project organization and to the crucial activity of several project brokers operating in-between these committees.

In the next two sections, I first provide a synthetic description of the project organization developing the park in order to contextualize the decision-making processes leading to exaptation events. I will also briefly describe the major design changes made by the committees before the occurrence of the two exaptation events. Second, I will provide a full narrative of the decision-making processes leading to the two cases of exaptation identified.

The Project Organization Developing the Park

The Millennium Park (MP) project was initiated in the fall 1997 with the idea of the Mayor of Chicago of celebrating the new millennium by extending new park land to a 24.3 acre vacant site. The formal organizational structure of the MP project was the typical one of many public construction projects: several specialized sub-contractors (such as, architectural, landscape, engineering and construction firms) reporting to a general contractor firm, which in turn reported to a specialized government agency as the client. As said, in these early stages of the project the architect of record devised a visual prototype depicting the master plan of the park. The master plan envisioned the design of the park as composed of separated “rooms” (e.g. geographically-bounded areas), each characterized by particular technical, design and aesthetic features and each serving specific functions or uses.

There was an exception to the standard organizational structure of MP project. The Mayor directly appointed two corporate CEOs to lead a private citizens’ committee in order to: 1) to select a few artistic enhancements (e.g. sculptures, landscape designs) to be located on the top of the master plan of the park; 2) to raise the private money necessary for funding the selected artistic enhancements. Given their expected role as intermediaries between private donors and the public organization of the project, I label the two CEOs appointed by the Mayor as ‘fund-raisers’ or ‘fund-raising brokers’. The fund-raisers formed the following types of committees in order to mobilize Chicago philanthropists, art experts and members of notable art and cultural institutions in the project:

1. *One Fund-raising Committee*, charged with the responsibility of identifying major naming opportunities on areas of the master plan of the park and ‘selling’ naming rights on these areas to private donors in exchange of donations;
2. *Two Design Committees*, charged with the responsibility of providing guidance and direction for the selection of sculptures (Art committee) and landscape designs (Garden committee) for the park;

Members of the design (art and garden) committees start meeting and drafting lists of artists and garden designers to be contacted for the submission of artistic proposals. The artists were selected on the basis of two criteria: international reputation and contemporary artworks. Art and garden committee members then reviewed slides and working models of the sculptors and the garden designers selected out of the original lists. Following these procedures, in less the three months of activity the art and garden committees' members identified four major sculptural and design additions to the initial master plan of the park:

- 1) a new sculpture to be located in the central plaza of the park;
- 2) a new sculpture to be located in the main garden of the park;
- 3) a new sculpture to be located on the music band-shell of the park;
- 4) a new landscape design for the main garden of the park.

As anticipated above, the two exaptation events detected in the evolutionary trajectory of the park design concern two of these design additions (specifically, the sculpture to be located on the music band-shell -*exaptation event no. 1*- and the sculpture to be located in the main garden of the park -*exaptation event no. 2*). In the next two paragraphs, I turn to a detailed case history of the processes leading to these two specific exaptation events, which are the focus of my analysis.

Narrative 1: Processes leading to Exaptation Event no.1

The origins of exaptation event no. 1 can be traced back to the fund-raising domain. Indeed, fund-raiser brokers had decided to identify a small group of donors (e.g. philanthropic families, corporations, foundations) to be contacted for a major donation in exchange of a naming opportunity on an area of the park and to be involved in the definition of the artistic enhancements. Fund-raiser brokers had their target donors well-defined in mind. On his way back from the White House –where it was celebrated the award of the 1998 Rawls Architecture Prize, recognized worldwide as the “Nobel Prize for Architecture”, the chief fund-raiser declared: “*We need to figure out some way to get Amanda Rawls* –member of the Rawls family, sponsoring the Rawls prize and

internationally renown for cultural philanthropy- *involved in the Park project*". He later approached Amanda Rawls *"to have the benefit of your views...as we consider who the outstanding sculptors and artists of our time might be, your views and expertise would be of enormous benefit to us and the City needs your help"*. In addition, fund-raiser brokers know well their 'key prospects'. For example, they were well aware of a social connection between the Rawlss and the world-renowned architect Frank Gehry, a former recipient of the Rawls architecture prize and a close personal friend of the Rawls family.

The name of Frank Gehry was in the list of potential artists to be contacted prepared by the art committee since its first meeting. Specifically, Frank Gehry was recommended as a potential candidate for doing a sculpture to be located on the music band-shell planned in the master plan of the park. Thus, when fund-raiser brokers set up a private meeting with donor Amanda Rawls, it was "a natural" to explore a donation for a naming opportunity on a Gehry-designed sculpture on the band-shell.

However, the donor was perplexed about the overall aesthetics of the park and about the idea of juxtaposing contradictory aesthetic styles: *"we would put a piece of sculpture on this side and another sculpture on that side so that we could be artsy, I immediately thought that was a really dumb idea"*. As reported by the fund-raiser brokers, the donor *"wanted to be sure that Gehry "will have full latitude" in the project, what she told us was: "If you guys are serious to get such an internationally acclaimed artist like Gehry involved in this project, let's not get him just to decorate this side or that side of the proscenium, let's get him to really do something here, to do both decoration and proscenium...if you really want an artistic statement for the pavilion, why not ask Gehry himself to design it? If you get somebody like him, the music pavilion itself will be the art and you don't need all of this stuff....and if you are serious about that, my family and I will pay for that"*.

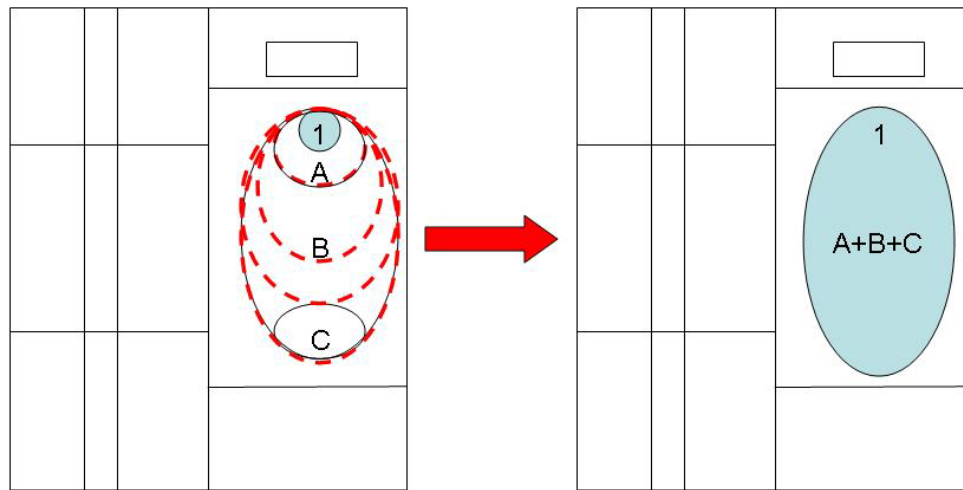
However, meeting the donor' requests required re-thinking the original use and function planned for the aesthetic style of Frank Gehry: from a sculptural piece to an architectural piece. This, in turn, required thinking about the design scope to be eventually assigned to Frank Gehry and to revise the existing naming opportunity offered to the donor. The fund-raisers attempted to meet the requests of the donor by enlarging

the area to be designed by Frank Gehry to the entire music band-shell instead than commissioning simply a sculptural ornament on the existing band-shell.

Specifically, they sat down with the project manager of the project and mayor representative in order to define the exact design scope to be proposed to Gehry *“It was important to ensure the architectural integrity of the Performing Arts Complex, avoiding to give the impression that two conflicting design styles –the classic beaux arts framework of the master plan and the post-modern design of Gehry- had been juxtaposed by mistake. For this reason, we thought to enlarge the area to be re-designed by Gehry by including both the music band-shell and the entire oval defined by the great lawn, the sound system and the amphitheatre”*. In this context, fund-raisers and the city project manager started debating about the radiation waves of the sound system. The circular image of the sound waves shaped the visual perspective from which the relations among the areas of the park were to be interpreted. They re-interpreted the boundaries between the three separated areas of the plan –the great lawn, the music band-shell and the amphitheatre- visually, circling on the map of the plan the radiation of circular waves produced by the music sound system, thereby progressively including all the elements included in the oval, formerly envisioned as composed of three functionally separated elements.

The circles made on the master plan by the project manager and the fund-raisers are illustrated in the figure below, together with the final proposed scope for the aesthetic style of Gehry:

PROCESS LEADING TO EXAPTATION EVENT no. 1



Red Dotted Lines = Radial Perspectives Drawn by Fund-raisers and City Manager

1 = Aesthetic Feature 1 (Style of Frank Gehry)

A, B, C = Areas of the Park → A = Music Bandshell, B = Great Lawn, C = Amphitheatre

Figure 1.4 – Process Leading to Exaptation Event no. 1

Narrative 2: The Processes leading to Exaptation Event no. 2

The garden committee had commissioned a elliptical stainless-steel sculpture by sculptor Anish Kapoor to be located in the main garden. His work was selected for the ‘visual excitement’ created by his gigantic stain-less-steel mirror-like elliptical sculptures. We thought these almost object-less objects could beautifully reflect their surroundings, so they were a perfect fit for the main garden in the park, since they could have reflected the surrounding flowers and landscape, creating a great color-full effect”, declared an architect member of the art committee.

Committee members were then called to evaluate the scale, size and concrete details of the artists’ submissions. The working model of the sculpture by Kapoor -to be located in the main garden- was reviewed together with the schematic design of the new garden design. In looking at pictures and models of the sculpture in the context of the

new garden design, committee members determined that the massive elliptical sculpture was just too large for the design of the garden: *“we felt that putting that gigantic piece of sculpture in that setting does not do justice to the piece, which needs a larger setting. Additionally, it dominated the flower garden. It just didn’t work. The question was: can the sculptor design something of dramatically smaller scale? Otherwise, it will have to be located somewhere else”*.

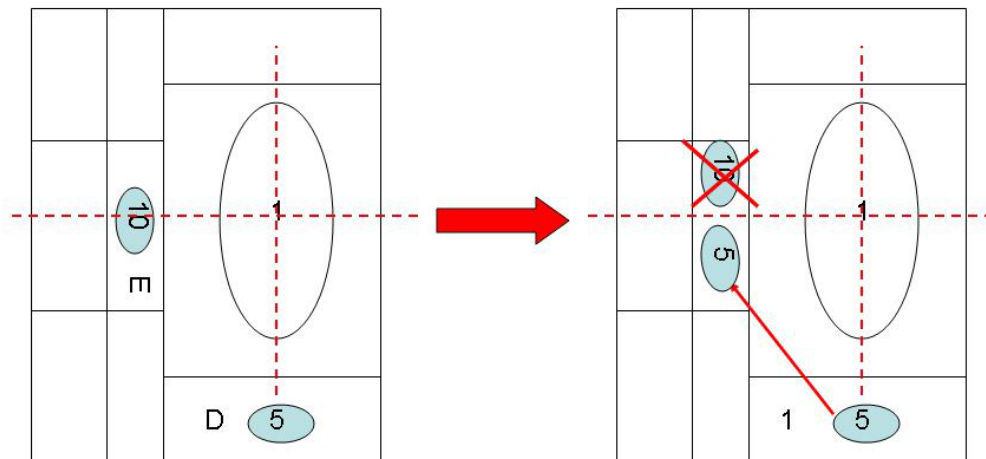
Subsequently, a special meeting for reviewing garden and sculpture issues was called to examine alternative options to solve this problem. The options considered were: 1) to decide against the sculpture in the garden; 2) to let the sculptor to do a gallery-size piece dramatically reducing the size of the piece (this option was suggested by the landscape architect Deborah Evans). In case of 1), a new problem would emerge of where to locate the sculpture by Kapoor in the park. It was advanced the idea of locating the sculpture in the central terrace, where another piece of sculpture was planned and almost finalized. In this case, should both pieces of sculpture be maintained?

The first to talk was Peter Rood, the president of the Art Museum. His remarks, as reconstructed from a recollection of various transcribed meeting notes: *“We may have already too much sculpture in the park. Gehry work is phenomenal, but it would probably be a gigantic piece of sculpture by itself. One other unique piece of sculpture is fine. Sometime “Less is more”...also, we got to consider these visual axes crossing the park (INDICATING IN THE MAP)...if we move the Kapoor’ sculpture to the main terrace we would have a clear sculpture-axis crossing the park from west to east vs a clear north-south music-garden axis....now, the first axis can be thought as in the direction of the flow of people entering in...it could actually guide the flow of people entering from Michigan Avenue...they will be attracted by this gigantic stainless-steel kidney bean, which will draw them all into the park, we all already know that, the bean is stunning and fascinating to everyone...and then, they will be looking at this other gigantic piece of sculpture, being slightly moved towards the central room of the park, almost by a visual force made of subtle mirror-like resemblances”*. The stunning opening comment of Peter Rood anchored most of the subsequent discussion around this visual perspective argument, emphasizing the importance of the axes to take a decision. Thus, the architect of the master plan followed: *“any sculpture located on the music-garden axis does*

inevitably compete with Frank Gehry...the quality of Kapoor should be refined and revised to see how Kapoor can compete with Frank...”. Mike Rasch, director of the public art for the City of Chicago, “Kapoor and Gehry are a superb combo...it depends from which perspective the combination of the two is more interesting... we may loose a clear sight line connecting the elements of the park”.

On the basis of these considerations, committee members decided to move the Kapoor bean sculpture in the main terrace –the location planned for the another sculpture, which was eventually rejected- and start over again with the design of the garden. The process is illustrated in the figure below:

PROCESS LEADING TO EXAPTATION EVENT no. 2



Red Dotted Line = Visual Axes Perspective Drawn by Committee Members
1, 5, 10 = Aesthetic Features
D, E = Areas of the Park

Figure 1.5 – Process Leading to Exaptation Event no. 2

Analysis: Building a Process Model of Cognition and Exaptation

In this section I'll elaborate from the case history illustrated above to identify, in more abstract terms, the processes that may lead to exaptation events in artefact design.

Both exaptation events originated from some sort of tension between design elements. In exaptation event no.1, the tension concerns the scope of the aesthetic style of Frank Gehry and the interactions among the areas of the park adjacent to the music band-shell, where the feature was originally planned. In exaptation event no. 2, the design tension concerns the interaction between the size of the Kapoor sculpture and the design of the main garden, for which the aesthetic feature was originally selected.

These tensions in the design domain came from different sources. In the case of the Gehry-designed sculpture, the design tension originated from the involvement of a new 'stakeholder' in aesthetic choices, that is, the donor contacted by the fund-raiser brokers to fund the Gehry' sculpture. What was initially planned as a fund-raising strategy –e.g. getting donors involved- had the (unexpected?) consequence of changing the way the use of Gehry' aesthetic style was evaluated in the design domain. The way in which the aesthetic style of Gehry was evaluated in the context of committee' discussions was different from the way the same style was considered in the context of the private interactions between the donor and the fund-raisers. For example, the donor believed inappropriate using Gehry' style only for a sculpture (e.g. *juxtaposition of two contradictory design styles was a very dumb idea*). Thus, in exaptation event no.1, the design tension emerged as a by-product of the connection between fund-raising and design domains made by the fund-raiser brokers.

Differently, in the case of the Kapoor-designed sculpture, the design tension emerged from an interaction between two design elements (e.g. the garden and the sculpture) which was actually envisioned ahead by committee' members. However, while committee members thought the aesthetic features of the two elements as complementary (e.g. *flower garden and the mirror-like surface of the sculpture would have reciprocally reinforced their visual power*), the schematic design of the garden and the working model of the sculpture revealed a design conflict between these two elements (e.g. compared to the size of the garden, the scale of the sculpture would dominate the garden, visually obscuring the flowers).

Despite their differences, these design tensions emerged as a result of a similar process of re-combination across sub-problem domains. To illustrate this point, we must start by analyzing the initial decomposition of the overall task assigned to the fund-raisers (e.g. developing a fund-raising campaign and selecting artistic enhancements of the park). By forming three separated organizational sub-systems (e.g. the fund-raising, art, and garden, committees), the fund-raisers decomposed the initial problem into three separated sub-problems, which can be labeled as: SUB-1: find money; SUB-2: find sculpture; SUB-3: find garden design. The organization of fund-raising and design activities into specialized committees represents a modular de-composition of the problem into separate sub-problems. In addition, for each sub-problem, an initial list of alternatives (e.g. names of sculptors, garden designers, donors to be contacted) was generated using simple selection heuristics, such as, baseline criteria and repertoires of previous experiences. Thus, the resulting structure of the problem can be represented as in Figure 1.6 below:

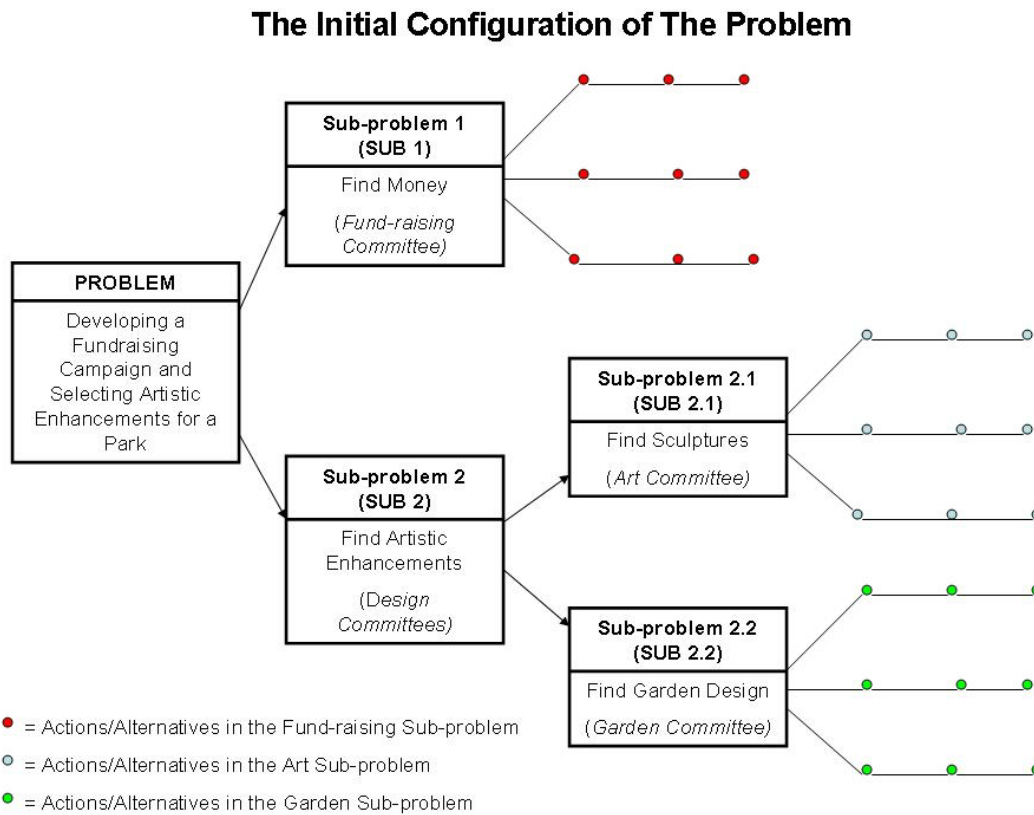


Figure 1.6 – The Initial Configuration of the Problem

Despite the structure of the problem was envisioned as a hierarchical nesting of modular sub-problems, the case histories describe how the individuals brokering between the fund-raising and design domains –e.g. the fund-raiser brokers- envisioned new interdependencies across these separate sub-problems. Specifically, while committee members were searching and evaluating the set of alternatives generated, the brokers started making connections between alternatives generated in different sub-problem domains. For example, as we saw, they connected the name of Frank Gehry –identified as potential sculptor in the art sub-problem- with the name of a donor identified in the ‘fund-raising sub-problem’. They followed the same procedure for the garden sub-problem, connecting the name of a sculptor identified in the art committee (Anish Kapoor) with the landscape architect identified in the garden committee. The making of connections across sub-problems is represented in Figure 1.7 below:

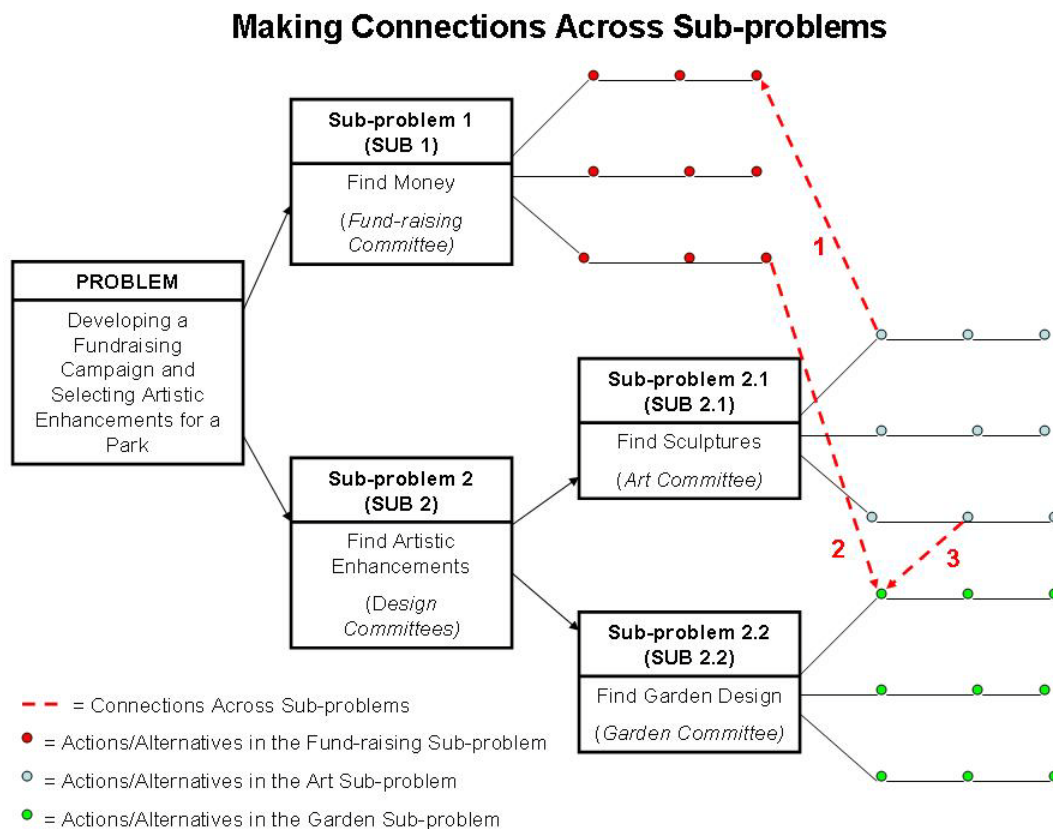


Figure 1.7 – The Process of Making Connections across Sub-problems

In sum, the design tensions surrounding the exapted aesthetic features emerged out of a process of making connections among different problem domains (e.g. combining alternatives generated in the domain of fund-raising with alternatives generated in the domain of design). This process gave rise to new interdependencies among formerly disconnected elements, constituting an important antecedent of exaptation events by providing the raw material (e.g. the new interdependencies and tensions) from which exaptation events will later originate.

In a later stage, the emergence of these design tensions prompted a re-consideration of the relationships between the aesthetic style selected, the function it was selected for, and the other design elements of the park.

In the case of the Gehry-sculpture, the fund-raisers went back to the map of the master plan of the park, visually manipulating the boundaries of the areas, attempting various schemes to accommodate the aesthetic style of Gehry into new functions and areas as provided in the plan. Through visually experimenting various decomposition patterns in the visual model (e.g. representing the representation of the overall problem at the artefact level), fund-raisers, with the help of the city project manager, discovered and understood new relationships between the elements of the park that were not envisioned in the first master plan. Specifically, as illustrated above, fund-raisers and the city project manager started debating about the radiation waves of the sound system and on various sound issues into the debate on how to define the design scope (e.g. the new function) for the aesthetic style of Frank Gehry. The circular image of the sound waves shaped the visual perspective from which the relations among the areas of the park were to be interpreted. They re-interpreted the boundaries between the three separated areas of the plan –the great lawn, the music band-shell and the amphitheatre- visually, circling on the map of the plan the radiation of circular waves produced by the music sound system, thereby progressively including all the elements included in the oval, formerly envisioned as composed of three functionally separated elements.

This process can be labeled as a process of *radial association*, a process through which a focal feature is established as a central element around which the interfaces with adjacent features are re-configured; In the specific case analyzed, this process led the

design elements adjacent to the focal feature (e.g. the music Bandshell irradiating the sound waves) to be progressively subsumed by the focal feature, generating an exaptation of the aesthetic style feature into the functions of the adjacent design elements. Via visual experimentation and this adaptation process unfolding within a (visual) perspective, fundraisers were able to re-define a new space and function for the aesthetic style of Gehry, which was formerly selected for another, more limited, function.

The process leading to the exaptation event no. 2 –the change of space for the sculpture originally selected for the garden- was similar in many respects. Confronted with a problem of increasing interdependence in the design domain (e.g. the size of the sculpture was too large for the space defined by the garden), the committee members started using the map of the master plan in order to examine various options (see case history above) to resolve this design conflict.

Again, the map of the plan was used as cognitive device to change the visual perspective from which the relationships between the components of the park had been re-interpreted. In this instance, committee members draw two visual axes that had never considered before in the design of the master plan. Using these axes, committee members evaluated the ‘aesthetic value’ of the location of the sculpture in the garden, discovering similarities and contrasts between elements of the park, previously considered un-connected. Precisely, the sculpture was envisioned as an aesthetic element competing with the sculptural shape of the architecture of the Performing Arts Complex *if* located in the garden; whereas the same sculpture was evaluated as a complementary element to the Performing Arts Complex *if* located in the main terrace. Thus, the position *on the axes* became the discriminating variable to ascertain the aesthetic value of the sculpture.

This process can be labeled as *orthogonal association*, a process through which the position of two or more non-adjacent features is used to define a perspective (e.g. in my case, a visual perspective such as an axis, a sight line, a diagonal), which serves to detect relationships of symmetry/asymmetry (or complementarities/substituabilities) between the features, on the basis of their relative position on the perspective.

In sum, the case study shows that exaptation events can be produced by the combination of two basic types of processes. The first is a process of making connections

among different problem domains. In the case analyzed, this process gave rise to new interdependencies among elements formerly disconnected in the design domain. These processes constitute an important antecedent of exaptation because, as we saw, the new interdependencies constitute the raw material from which exaptation events originated in the first place. Thus, by creating new interdependencies between elements previously disconnected, this process increases the *exaptive possibilities*. The second set of processes consists in processes of re-interpretation and change of perspective (in my case visual perspective) from which the interactions among the elements of the new problem are evaluated. This process emerges as an adaptive response to the new interactions among elements generated from the first set of processes.

This two-step model of the cognitive processes leading to exaptation emerging from the case study is graphically represented in Figure 1.8 below:

A Model of the Cognitive Processes Leading to Exaptation

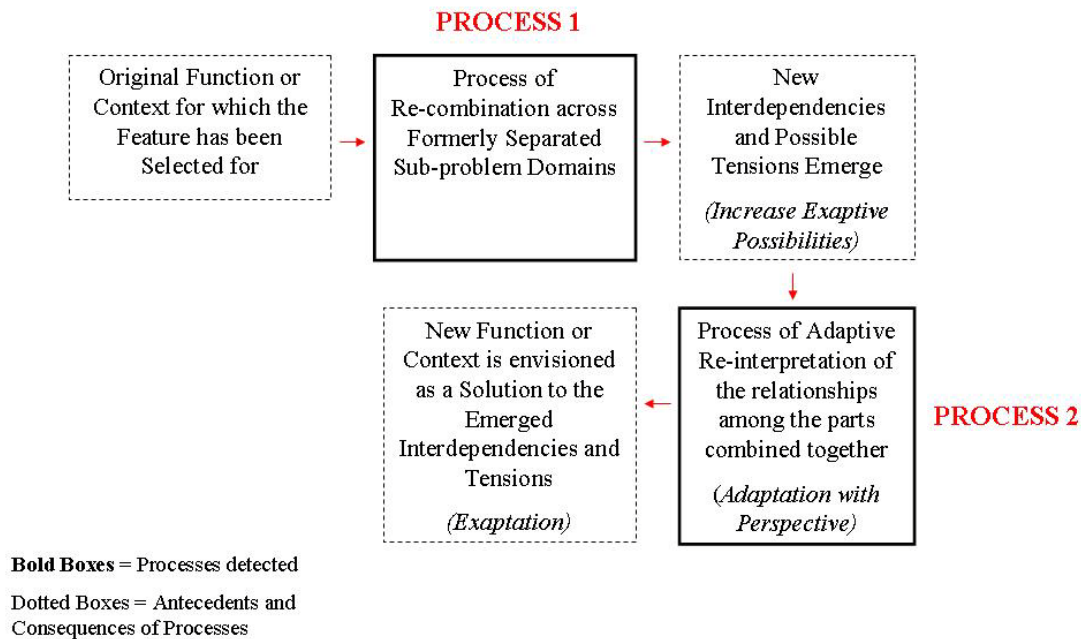


Figure 1.8 – A Model of the Cognitive Processes Leading to Exaptation

Discussion

The first set of combinatory processes underlying the exaptation events detected in the case study can be interpreted consistently with recent models of cognition expanding and developing the information-processing approach pioneered by the Carnegie school (March and Simon 1958; Newell and Simon 1972;).

More specifically, the findings are consistent with an emerging body of research studying new processes for the design of novel solutions, suggesting an extension of the traditional limited-problem-solving heuristics (Grandori 2007b; Liedtka 2000; Sarasvathy 2001). In general terms, these studies suggest that in conditions of Knightian uncertainty search processes may be described as processes of *design, experimentation* and *scientific hypothesis testing* on alternatives having multiple consequences and a multiplicity of cause-effect relations (Grandori 2007b)³. For example, Grandori (2007b) emphasizes how variation in knowledge processes may be guided by the generation of multiple hypotheses, by modifying problems and cause-effect relations on elements of existing problem models and that “*problem shifts and new hypotheses are generated in the directions that are guided by experimentation (real or mental), by the very process of solving them*” (Grandori 2007b: 154) This strategy of “opportunistic multi-purposedness” can be detected also in Campbell (1960: 394) which describe the thought processes of scientists: “*in the pure science to which they were accustomed, if they were unable to solve problem A they could turn to problem B, and while studying this with perhaps small prospect of success they might suddenly come across a clue to the solution of problem C*”.

In the case study, exaptation events emerge out from processes consistent with these accounts of discovery. For example, in both events decision-makers re-envisioned the relationships among the existing elements of the master plan opportunistically, on the basis of the emerging uses and consequences of the aesthetic feature (e.g. the Gehry-designed sculpture; the Kapoor sculpture) initially selected for another use. Similarly, in the case of the elliptical sculpture originally commissioned to be located in the garden in

³ More specifically, a number of new heuristics and processes have been advanced in these studies. For example, the concept of bricolage (Ciborra 1996) and effectuation (Sarasvathy 2000) in studies of entrepreneurship; circular experimentation and design rules in studies of architectural design (Liedtka 2000); hypothesis testing procedures in models inspired by the scientific method (Grandori 2007b).

order to reflect the flowers in the garden, the consequences of this alternative have been opportunistically evaluated, so that a new use (reflecting skyscrapers vs reflecting flowers) seemed to be more appropriate. A central heuristic used in this phase was that of re-usability: *“Now I got this, what else can I do with this? Is this re-usable in some other context? Is this necessary or redundant if seen in the context of the other solutions?”* This heuristic reverses the typical design process followed by professional architects and moving from functional requirements (e.g. what element could we think of for serving a transportation/mobility function?) to aesthetics/design. In contrast, committee members followed a process going from the aesthetic feature available at hand (e.g. the style of Gehry) to function (e.g. we do have the possibility of hiring Frank Gehry, what can we do with him?). This evidence is consistent with an idea of innovation as stemming more from *“resources and artefacts in search of use and consequences rather than from a use in search for a resource or artefact that satisfies it”* (Grandori 2007a: 155).

Central to these processes is the fact that the problem solver may look for “robust alternatives”⁴, alternatives that may be solutions in multiple sub-problems at once, following a heuristic that could be labeled *“kill two birds with one stone”* (e.g. get two solutions with one action). For example, the selection of Gehry and Deborah Evans out of, respectively, the lists of sculptors and landscape artists identified in the committees, followed this path: both Gehry and Evans were solutions to two different sub-problems at once (e.g. solutions to both the fund-raising and to the design sub-problem). When a robust alternative was identified by making connections across sub-problems, the brokers stopped searching the alternatives included in the set within the sub-problem.

The logic followed by brokers in carrying out this process was calculative: they planned ahead to connect the domains of fund-raising and design. Fund-raiser brokers targeted certain types of donors, spent time and effort in developing naming opportunities and strategically planned the right timing for approaching the targets at a specific moment in time. In sum, the cross-connection of fund-raising and design domains was a purposeful, calculative, strategy devised by the fund-raiser brokers.

⁴ The notion of robustness originates in biology and in the science of complex systems (see Jen 2005 for a review). It has been extensively developed in engineering and design methods by Genichi Taguchi. Grandori (2007b) explicitly uses the notion of ‘robustness’ to develop a theory of rational decision-making under Knightian uncertainty, defining ‘robust alternatives’ as *“having multiple functions and therefore entailing positive consequences independently from the state of the world”* (ibidem: 18).

Thus, while the findings of the case study are consistent with the basic understanding of cognitive processes defined by the classic information-processing view, they also contribute new insights into the dynamics of problem re-framing, identifying new calculative heuristics (e.g. the heuristic of robustness) as the cognitive engine behind processes of re-combination across formerly separate sub-problems. These insights are consistent with emerging streams of research aimed at extending the classic insights pioneered by the Carnegie school tradition.

The processes through which the boundaries of the map of the master plan have been manipulated in order to resolve the design conflicts can be interpreted consistently with the distributed cognition approach pioneered by Ed Hutchins (1995). Differently than in the information-processing view, in the distributed cognition approach the environmental and material world surrounding the problem-solver take on a central role, acting not only as external support to internal memory, but also as computational medium, thus becoming an integral part of the cognitive system under observation. In this respect, in the distributed cognition approach the central phenomenon under observation is *“the complex ways in which external environments interact with internal ones, involving coordination between internal resources –memory, attention, executive function- and external objects –the objects, artifacts, and at-hand materials constantly surrounding us (e.g. work materials become elements of the cognitive system itself rather than just stimuli for a disembodied cognitive system)”* (Hollan et al 2000: 174-175).

Consistently with these assumptions, in the exaptation events studied architectural design skills and park design concepts (e.g. envisioning visual axes and people flows; studying the patterns of diffusion of the sound waves) have been coordinated with the manipulation of objects in order to establish a particular state of coordination between the boundaries of the areas and the aesthetic object (or style) considered in order to find a solution to the particular design conflict emerged. Here, the contribution of the study is identifying the two specific processes illustrated above –radial association and orthogonal association- that can achieve this coordination between the material world and internal cognitive processes. Consistently with the distributed cognition approach, both processes

point to the value of visual tools for changing the perspective from which relationships of complementarities and substitutabilities among elements are evaluated.

Finally, consistently with this approach (e.g, Hutchins 1995; Hollan et al 2000), these processes have been *adaptive* in nature, following a non-calculative cognitive logic entrenched into a perceptual change of the relationships among the components of the park occurred through a change of the visual perspective from which these relationships were formerly seen. Thus, both processes point to a change in the capacity of *seeing* relationships among pre-existing objects and features, more than a difference in the capacity of *calculating*.

Conclusion

Starting from Schumpeter (1934), a long tradition in the innovation literature has viewed innovation as the combination of parts that did not previously go together. Consistently with this research stream, the case study illustrates how recombination and brokerage are important notions to explain how exaptation events –as instances of innovations- occur. Indeed, this process of cross-connecting different domains generates the raw material from which the core exaptation events originated.

However, the case study illustrates how processes of re-combination needs to be substantially expanded and further elaborated to include more detailed micro-processes for exaptation events to be explained. Innovation-by-exaptation can not be explained only drawing on the mechanisms of pure recombination. There is something more to those mechanisms in the exaptation phenomenon. Key to the exaptation events detected there is also a process of re-interpretation of the parts that are re-combined together. In the case study, this process of re-interpretation is described as an adaptive response to the emergence of the new interdependencies created by the combination of elements of different type. Specifically, in the case study, re-combination changes the context for evaluating alternatives, prompting to re-think the use for which the feature was originally selected.

From a substantive standpoint, this re-interpretation process is described as changing the perspective from which the interactions among design elements are evaluated. The new use/function (e.g. the new location for the bean, the new envisioned

design scope for the aesthetic style of Gehry) emerges as a process of evaluating the interactions among elements based on a perspective (e.g. what interactions are relevant) different than that considered before. This process is substantially different than pure integration or re-combination because involves the consideration of *new relationships* (new operators) between pre-existing elements.

APPENDIX



Picture 1 – The Initial Prototype of the Park Design (Visual Model, July 1998)



Picture 2 – The Final Design of the Park (July 2004)

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