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Työn nimi Rules of Emergence — Generating and Curating Creativity

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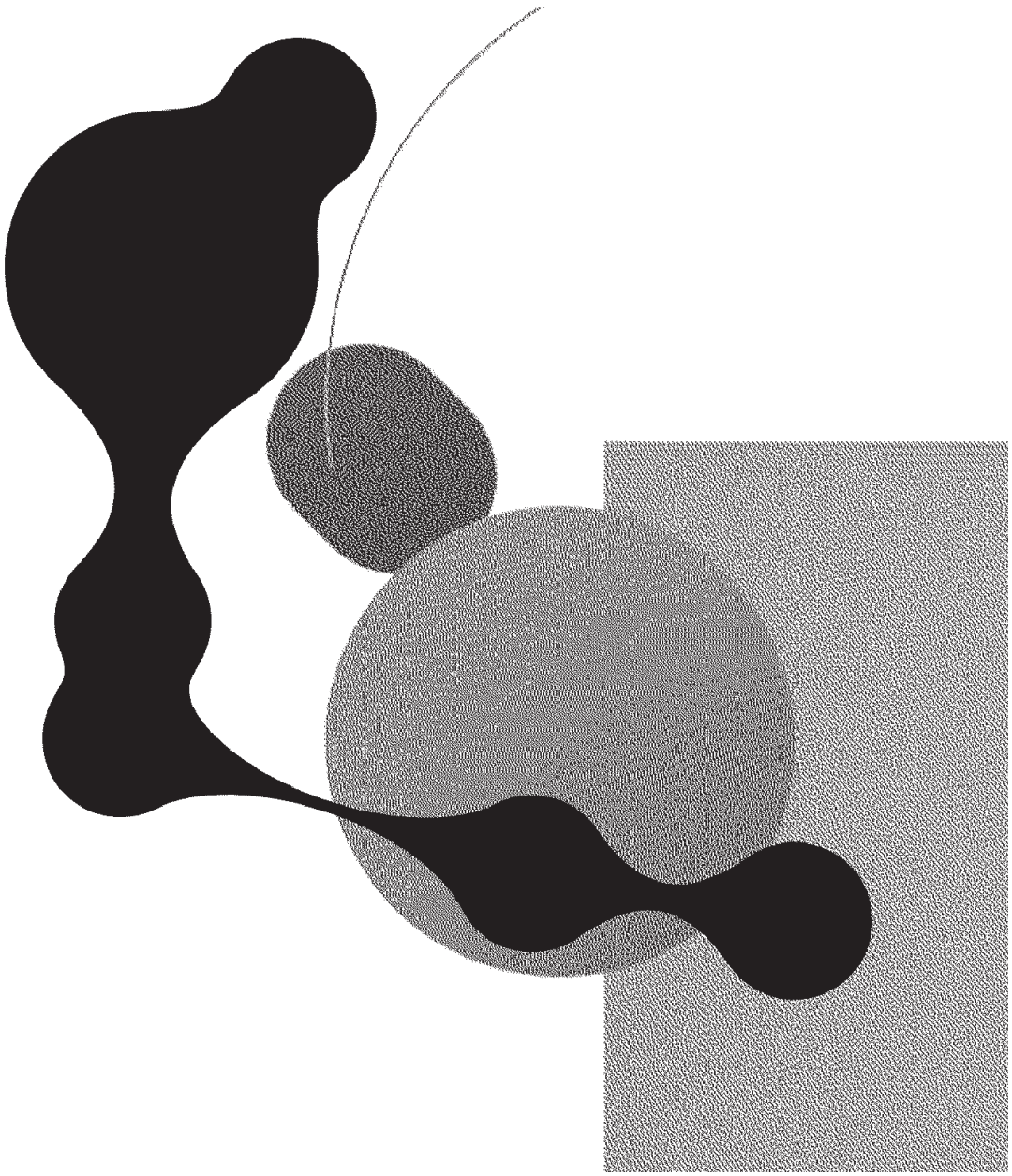
This Bachelor's thesis discusses the relationship between generating and curating in the context of artistic activity. In this context, generating refers to processes and systems used in generative art and generative design. Curating refers to the traditional profession of producing exhibitions, and to the contemporary definition of curating as a universal act of selection and evaluation. The objective of this thesis is to introduce the processes and methods used in generating and curating, and to expose the creative potential emerging from the combination of these practices.

The research analyses and compares contemporary discourses of generating and curating, and presents examples of modern generative and curatorial practices. A joint framework is proposed which illustrates the interconnection of generating and curating. Theories of creativity by Deleuze and Boden & Wiggings are accommodated in the framework to demonstrate the potential of the synthesis for emergent outcomes.

Despite the apparent discreteness of generating and curating, they in fact share many characteristics, both practical and conceptual. They both require the definition of a rule, which determines the curatorial or generative process. In generative design or art, this rule is an algorithm or some other formalisation of an action, in curating the rule is the selection criteria of the collection. Both in generating and curating, the agent creates the process instead of designing directly the product. Generating requires curating in evaluating and selecting the outcomes, as curating depends upon generating in forming the collection according to the selective rules. Deleuze's concepts of 'virtual' and 'actual' capture the emergent properties of generating and curating: the rules define the 'virtual' cloud of possible outcomes, from which the perceptible products are actualised. Thus, generating and curating both supervene on and contain each other.

Avainsanat generating, curating, creativity, generative art, generative design, algorithmic art, genetic algorithms, content curating



Rules of Emergence

GENERATING AND CURATING CREATIVITY

Bachelor's Thesis

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The treasure was far underground, beneath a network of passages, in a single room filled with black. Information at the quantum density, undamaged. Maybe five billion years had passed since the archive was lost to the nets. … They would live here a year or five, the little company from Straum, the archaeologist programmers, their families and schools. …
So now there was a tiny settlement on the surface, and they called it the High Lab. It was really just humans playing with an old library. It should be safe, using their own automation, clean and benign. This library wasn't a living creature, or even possessed of automation (which here might mean something more, far more, than human). They would look and pick and choose, and be careful not to be burned… Humans starting fires and playing with the flames.
The archive informed the automation. Data structures were built, recipes followed. A local network was built, faster than anything on Straum, but surely safe. Nodes were added, modified by other recipes. The archive was a friendly place, with hierarchies of translation keys that led them along.

> Vernor Vinge, A Fire Upon the Deep, 1991

There are notions that are exact in nature, quantitative, defined by equations, and whose very meaning lies in their exactness: a philosopher or writer can use these only metaphorically, and that's quite wrong, because they belong to exact science. But there are also essentially inexact yet completely rigorous notions that scientists cannot do without, which belong equally to scientists, philosophers, and artists. They have to be made rigorous in a way that's not directly scientific, so that when a scientist manages to do this he becomes a philosopher, an artist, too. This sort of concept's not unspecific because something's missing but because of its nature and content.

> Gilles Deleuze, Negotiations, 1990

1 Introduction

> Imagine opening any of your favourite websites or applications. Be it a social media site, such as Facebook, Twitter or Instagram; a streaming service like Netflix or Spotify; or a platform for sharing content in the manner of Tumblr or Pinterest; what you will discover is a cornucopia of images, text, audio and video, readily available and easy to reach. However, the incredible abundance of accessible material makes the need of filtering inevitable, for the user to locate what they are searching or to discover new, relevant content.

> This organising, enumerating and evaluating of the content can be carried out by in-built algorithms in the digital platform, or by the user themself. The platform might use taxonomical classifications for material, like filters for cinematic genres and sub-genres in Netflix, or it might recommend new content based on the categorisations, reviews and social connections of previously accessed items, much like Instagram suggests images and videos according the user's likes, hashtags and followed accounts. The platform might even offer user-customised collections, such as personalised playlists in Spotify. On the other hand, the user themself chooses, classifies and catalogues the content, by selecting what material they share, which hashtags they apply to it, and how they distribute it in albums, boards and threads.

> This interchangeability of classifying, framing and fabricating in modern digital media illustrates the focal point of this thesis: the connection between the acts of curating and generating. The aforementioned user emulates in their actions the traditional occupation of a curator as a person who selects, organises and tends to the items of a collection, while the platform exhibits characteristics of both curatorial and generative practices. The collections, such as playlists or catalogues of recommendations, are generated by predefined algorithms, into which the personalising variables are inserted to produce quasi-curated compilations.

> For the purpose of this thesis, generating and curating are defined as follows: generating covers the practices used in generative design and generative art (defined in detail in chapter 2.1), with the focus on algorithmic and digital generative processes. Curating is defined as the researching, appraising, contextualising, selecting, organising, presenting and managing of items, historically carried out by curators (elaborated in chapter 3.1). This thesis, however, relies on the contemporary discourse, where curating is considered as a methodology or an operational tool in a universal setting, not only as a traditional occupation in the context of museums *(Obrist 2015; O'Neill, 2012; Vishmid, 2006)*. Nevertheless, the contemporary literature states that an exhibition of visual artefacts is still the main medium of the curatorial practice *(Obrist, 2015: 38; O'Neill, 2012: 90; Filipovic, 2013)*. In this thesis the product and medium of the universal curator is generalised as 'a collection', which can consist of any kind of physical, digital or abstract elements.

> The motivation of this thesis arises from the current relevance of the concepts of curating and generating. As stated earlier, the practice of curating has undergone a major paradigm shift in the last decade: it has transcended the traditional context of museums, and even the entire art world, to incorporate a large variety of activities *(Obrist, 2015; O'Neill, 2012; Vishmid, 2006)*. One of the most influential curators of the

twenty-first century, Hans Ulrich Obrist *(2015: 34-36)*, states, that the current trend of applying the concept of 'curation' to a myriad of contexts 'records a shift in understanding from a person (a curator) to an enterprise (curating)'. According to Obrist, this repurposing stems from the same situation as was described in the opening passage: '[the] feature of modern life that is impossible to ignore: the proliferation and reproduction of ideas, raw data, processed information, images, disciplinary knowledge and material'. Obrist continues to suggest that this proliferation is shifting the emphasis from producing new content to selecting from the already existing pool of material. The expression of 'content curation' has gradually become an integral feature of marketing and media vocabulary, its applications ranging from devising a selection of an shoe store to moderating a recipe portal. Obrist *(2015: 211)* records the words of his fellow curator Steward Brand: '[Curating has] been democratised by the net, so, in one sense, everybody is curating. If you're writing a blog, it's curating. So we're becoming editors and curators, and those two are blending online.'

> Also generative design and generative art have evolved greatly during the past few decades. The availability and usability of design software, such as Processing, AutoDesk, Rhinoceros, and several other CAD (Computer Aided Design) and 3D modelling programmes, have revolutionised the field by making the means more approachable for a greater variety of designers and artist. Also the advancement of 3D-printing and other rapid manufacturing methods have made possible the easy prototyping and production of unique generative designs with the same costs and effort as identical objects *(Soddu, 2002: 8)*. In addition, initiatives such as Google's Deep Dream *(Google developers, 2016)* have popularised and advertised the possibilities of artificial intelligence and machine learning in the creative context, which has increased the public interest in generative art and design.

> Despite the easy access to generative design tools, many designers and artist still seem apprehensive

towards techniques which require even a minimum of manual computation or programming skills. Therefore one of the motivations of this thesis is to make algorithmic processes more approachable by providing tangible analogies for generative systems. This thesis also aims to offer new modes of thought for those already involved in generative design or art. According to Maeda *(1999: 10)*, many practitioners treat generative processes as kind of 'black box'[1] models that produce automatically interesting results, regardless of the input or the actual procedure. In fact, many techniques with seemingly unique outcomes, such as randomisation, are actually highly standardised and the results often homogenous. Artists and designers engaged with creative generative systems should try to escape this 'algorithmic genericism' *(McCormac et al., 2014: 139)* caused by the re-appropriation of habitual tools and simulations. This can be achieved by pursuing new ways of implementing and representing generative methods, as well as addressing the conceptual instead of the technical aspects of the process.

> In conclusion, this thesis aspires to fulfil the previous objectives by analysing and comparing the discourses of generating and curating. These practices are introduced in chapters 2 and 3 respectively, with a review of existing literature and some demonstrative examples. Regarding curation, the emphasis is on contemporary literature, in which the changing role of curatorial practice transcending the museum context is acknowledged. However, little academic research has been conducted on the more speculative implementations of curatorial practice, so the available material is mostly anecdotal and still partially confined in the traditional context of the art world. In regard of generating, the focus is on academic literature since the 1990s, where the concepts of generative art and

1 Latour *(1999: 304)* describes black boxing as 'the way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity'.

generative design have been established. Chapter 4 suggests a joint framework for generating and curating, which aims to demonstrate the correspondence between the practices. The chapter also addresses the immense creative potential arising from the synthesis, along with the introduction of Deleuze's concept of 'the virtual' *(Brassett and Marenko, 2015)* and the Creative System by Boden *(1990, 1994)* and Wiggins *(2001, 2003)*. Finally, chapter 5 discusses the social and cultural implications of generating and curating by raising some questions of agency and power.

2 Generating

> In the present context there is no need to address the concepts of generative art and generative design separately, since the variations of their processes and products can be greater within the disciplines than between them. In addition, some writers, like Soddu *(1994, 2002, 2006)*, do not make distinctions between generative art and design. Thus in the following chapters the terms will be used interchangeably, and chapter 2.2. will briefly discuss the most fundamental differences between generative art and generative design.

2.1 META-PROJECTS AND IDEA-PRODUCTS

> 'To generate' essentially means 'to create' or 'to produce', so what makes generative art and generative design different from the usual creative or manufactural endeavours? The mathematical definition of the word offers a useful insight, by stating that generating entails performing a set of logical operations as the method of production. Correspondingly, many writers have outlined that the utilisation of some kind of logical rule is inherent to generative techniques. *(Soddu, 2006; Singh and Gu, 2011; Maeda, 1999)*. Soddu *(2006: np)* provides the following definition: 'Generative Design is a logical synthesis of a creative process using transformation rules

(algorithms).' As algorithms often refer to problem-solving procedures carried out by computers, it is easy to make the common assumption that generative art/design is exclusively digital and computational. Consequently, in their definition of generative design, Singh and Gu *(2011:185)* emphasise the benefits of harnessing the computational capabilities of the computer for exploring design solutions. However, Dorin et al *(2012:240)* astutely point out that 'Generative art is neither technological, nor specifically digital, despite the recent popularity of works that are both'. Galanter *(2003:4)* succeeds in providing an all-encompassing definition which allows a greater variety of methods for generation:

> Generative art refers to any art practice where the artist creates a process, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is then set into motion with some degree of autonomy contributing to or resulting in a completed work of art.

> Thus according to Galanter, the nature of the generative process is almost completely free for interpretation: it can be physical or digital, natural or artificial, straight-forward and computational or complex and random. Despite the variation of methods, all definitions of generative art/design seem to highlight the procedural nature of the discipline: the primary intention of the artist/designer is not to create a finished product/artwork, but to to create the *process* which gives birth to the product/artwork. Soddu *(2006:np)* describes this idea of 'designing design' as follows: 'Generative Design could be represented like a morphogenetic meta-project, an organized idea of "how to run" a design process.' So the actual product of the generative artwork / design schema is the process itself as an 'idea-product', and the finished outcome of the generative process is one of the possible temporal manifestations of the 'idea-product' *(Soddu, 2002:291)*.

> Dorin et al *(2012)* deliver perhaps the most comprehensive definition for generative art. In

addition to emphasising the process as the most essential part of the discipline, they describe altogether five characteristics of generative artworks, which they identify as *entities*, *processes*, *environmental interaction*, and *sensory outcomes*.

> *Entities* describes the physical or simulated subjects the generative process acts upon. They can consist of a population of homogenous elements or an ecosystem of dissimilar classes of agents. The entities must have formally defined attributes (spatial, temporal or formal properties) which the process can affect and alter.

> *Processes* are the operations which change the states of the entities. The events can be hierarchical, so that micro processes form macro processes; causal, or interacted with by a feedback system; autonomous, or initiated by an active agent; and continuous, or temporally set with a terminating condition.

> *Environmental interaction* is the flux of information between the process and the environment. Manipulating and adjusting the generative process, either with continuous user-interface and feedback-loop or with discreet events of alteration, the environmental interaction subsequently modifies the outcomes. The 'environment' in this case refers to any entity outside the process itself, including the artist/designer.

> *Sensory outcomes* are the experienced products of the generative process. They can be artefacts, such as the end result of the terminated process, or records of its different stages. The unfolding of the generative process itself can also be the outcome as a performative gesture. If the entities and results of the process are not apparent, they must be rendered perceivable by some sort of mapping. It can be simply a visual representation created by a computer software, or an arbitrary creative choice. If there is no inherent relationship between the entities and the process, the physical manifestations of the generative system are open for creative interpretation.

2.2 GENERATIVE ART AND GENERATIVE DESIGN: MEANS OR ENDS?

> Despite the fact that creating the process is the main pursuit in both generative design and generative art, the disciplines treat this process slightly differently. In the context of design (especially industrial design and architecture), generating often has an utilitarian value as a tool, while in the art context the characteristics of the generative process itself posses some intrinsic value. For example, Singh and Gu *(2011: 185)* emphasise the practical benefits of automating parts of the design process: generative methods can be used for solving various optimisation problems, which can reduce the costs and increase the efficiency of the design instance. Generative simulations also decrease the need for trials and testing, and computer-regulated processes can help gaining a higher level of accuracy and consistency in the finished products. Also Maeda *(1999: 10)* accentuates the usefulness of the generative design process to the finished product: 'Modern design objects display in their function and form the process that generated them. Such objects are determined not by the process but rather by the use that is made of it.'

> In generative art, however, the process itself can be the main focus as an artistic performance and be exhibited along the product *(Dorin et al., 2012: 256)*. The autonomous nature of generative processes is often accentuated in the art context: by reducing the intentionality of the artist, the process can lead to emergent, unpredictable outcomes *(Dorin et al., 2012: 256; McCormac et al)*. The concept of emergence refers here to the characteristic 'coming-into-existence' which takes place in generative processes: the outcomes arise from complex causes and exceed the sum of their effects.

> However, the juxtaposition of intrinsic and extrinsic values of generative processes in art and design can also be reversed: in the art context algorithms and mathematical operations can be used as a tool for eliminating manual repetition and need of human motor skills, for example in creating intricate, geometric patterns *(Maeda, 1999)*. Correspondingly, in the design

context complex generative systems can be used as a starting point for exploring the creative space *(Soddu, 2002: 7; Singh & Gu, 2012: 185)*. Eventually, the fundamental differences between generative design and generative art are derivative of the contrasting objectives of art and design: design in its traditional sense aims to find solutions to problems[2], while art necessarily does not.

2.3 DETERMINATION AND CHAOS: REVIEW OF GENERATIVE PROCESSES

> If the defining characteristic of generative art is the use of operational rules as a method of production, then generative art can be said to be as old as art itself. From Palaeolithic ornaments to Islamic mosaics and Buddhist mandalas, humans have always used arithmetic and geometric rules for aesthetic expression *(Dorin et al., 2012: 240)*. With the proliferation of digital computers towards the end of the 20th century, the encoding and execution of such deterministic computational processes has become increasingly easy and attainable. Since the use of the computer as an executional tool has become routine for designer and artist, the contemporary discipline tends to lean towards complex, non-deterministic generative processes which exhibit emergence and variance.
> This chapter will briefly introduce some common generative techniques and their implementations. These examples focus on demonstrating the aspects of order, determinism, agency and subjectivity in generative processes, which will later be used to illustrate the connections between generating and curating.
> Many generative methods, such as *cellular automata* and *L-systems*, pursue complexity by borrowing their operational rules from nature. Singh and Gu *(2011)*

2 This generalisation has understandably met a great deal of opposition in the past, and many writers have argued agains the narrow role of a designer as a service provider and problem solver. For further reference, see for example Potter (1968), van Toorn (2004), Bailey (2007) and Poynor (2008).

describe these two methods as follows: Cellular automata are discrete models consisting of regular grids of cells with a finite number of defined states (for example 'on' and 'off'). When the cellular automation is set into motion, the cells change their state according to the states of their neighbouring cells, defined by a set of rules (an algorithm). Depending on the rule used, the cellular automation system can exhibit diverse behaviour, fluctuating between mathematical order and apparent, life-like randomness. Figure 2.1. depicts a knitted tea cosy with a static pattern of a cellular automation process.

> L-systems or Lindenmayer systems, are mathematical algorithms that mimic the biological process of growth by generating recursive, self-similar forms *(Singh and Gu, 2011)*. This kind of fractal sequences can be found in numerous natural formations, one example being the branching growth pattern of tree limbs, mimicked with L-systems in figure 2.2.

> Despite the apparent organic nature of generative methods such as cellular automata and L-systems, they are still fairly deterministic: using the same rule for the same entities, the generated results are always identical. If one of the main incentives for using generative processes is to reach emergent results, then the artist/designer has to increase the system's autonomy by some means. This can be achieved by introducing some form of randomisation to the process.

FIGURE 2.1.
Tea cosy with cellular automata pattern *(Fox, n.d.)*.

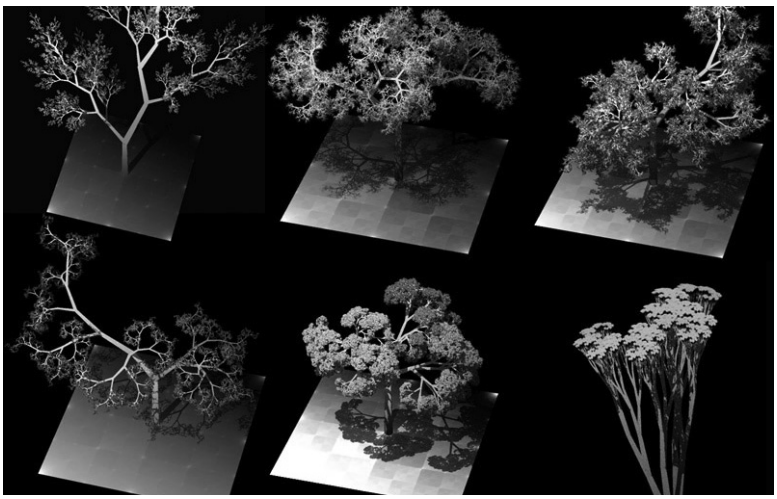


FIGURE 2.2
Computer-generated fractal trees created with Lindenmayer systems *(Solkoll, 2005)*.

> McCormac et al *(2014:138)* point out that chance events are widely used in generative art to make the underlying deterministic process seem more varied and 'humane'. It is true, that randomisation removes some of the intentionality of the artist, thus providing an relatively easy source of apparent emergence. However, Maeda *(1999:247)* objects the use of randomisation as an all-cure remedy for unimaginative, rigid processes: 'Randomness is a form of profanity you should avoid, or at least know where it comes from.' McCormac et al *(2014:138)* accurately remind us that not all randomness is equally random:

> We can distinguish different sources of randomness in generative art. The first is "pure" randomness, obtained by a physical process such as rolling dice, tossing coins or dividing piles of yarrow sticks, as used in generating hexagrams for the I Ching. With the use of computers, pseudo-randomness, where the numbers are obtained by a deterministic function, but pass statistical tests for randomness, has largely replaced pure randomness.

> A copybook example of pure randomness is Knowles's *Tree drawings* series *(2005-2012, figure 2.3.)*, where the artist attached drawing implements to tree branches, which then created paintings while moving in the wind *(Knowles, nd)*. This artwork also exemplifies the

'environmental interaction' introduced in chapter 2.1: the wind acts as an indeterministic outside force that acts upon the entities of the generative process. On the other hand, Rosebush's *Letter Field (1975, figure 2.4.)* illustrates the use of pseudo-randomness in generative art. Rosebush utilised random number generators to determine the size, colour and position of the letterforms in the composition. The in-built random number generators in programming languages might serve their purpose in providing seemingly un-repeatable results, but what is the actual value and purpose of this randomness? McCormac et al *(2014: 138)* suggest,

FIGURE 2.3
Knowles's *Dragon Spruce* from the *Tree drawings* series uses chaotic natural randomness *(Knowles, 2012)*.

that in generative art the allegorical associations of chance might be more important than its origins. This brings us back to the 'algorithmic genericism' discussed in the introduction: truly emergent results can hardly be reached with arbitrary randomisation of a limited number of variables, but with more conceptual, complex, and comprehensive generative systems.

> There are, however, indeterministic generative methods that can be used to escape the arbitrariness of randomisation. These methods, such as *genetic algorithms* and *swarm intelligence*, posses a greater degree of 'intelligent' autonomy, thus resulting in generated products that

are still highly explorative but less erratic. Genetic algorithms, like the previously introduced L-systems and cellular automata, borrow their methods from nature. Holland *(1975, cited in Ushakov, 2014: 97)* describes the process as follows:

> A Genetic Algorithm is a method of problem analysis based on Darwin's theory of natural selection. It starts with an initial population of individual nodes, each with randomly generated characteristics. Each is evaluated by some method to see which ones are more successful. These successful ones are then merged into one 'child' that has a combination of traits of the parents' characteristics.

> So genetic algorithms use basic randomisation in the initiation phase, but the fitness of the individual solutions increases systematically with every new generation. Consequently, genetic algorithms are often used in optimisation problems, where the optimal functionality of the product can be quantitatively evaluated *(Ushakov, 2014: 97-99)*. Such an example are the evolutionary antenna designs by NASA, where a genetic algorithm was used to produce and evaluate millions of options to define the shape of an effective space antenna *(Bluck, 2004, Figure 2.5)*.

> A genetic algorithm requires the definition of two basic components: First, a genetic representation (the 'genotype') of the resulting individuals (which

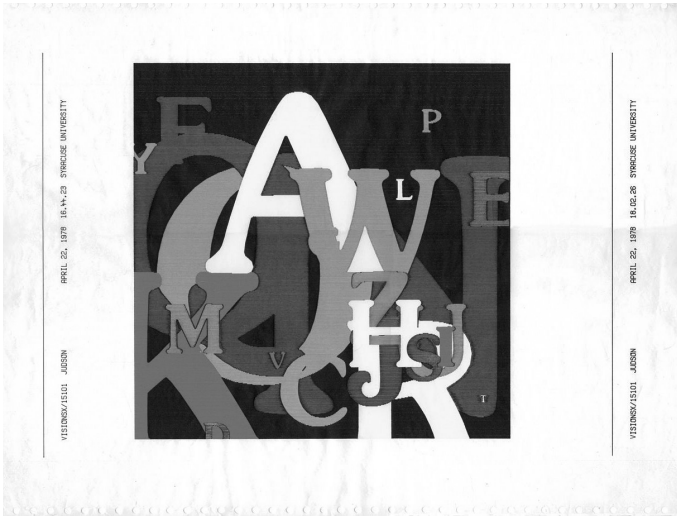


FIGURE 2.4
Rosebush's *Letter Field* uses a random number generator to assign values to variables. *(Rosebush, 1975)*

FIGURE 2.5
NASA's evolutionary antenna designs utilised genetic algorithms for defining the most efficient curvature. *(Black, 2004)*.

express their genetic makeup in their physical form, or the 'phenotype'), and secondly, a fitness function to evaluate the solutions *(Ushakov, 2014: 98)*. This formalisation of the design concept to the logical language of the genetic code and the fitness function can be seen as an primary example of all generative processes: the genetic algorithm is the 'idea-product', and the resulted designs its possible manifestations. Accordingly, Soddu *(2002: 291)* uses the evolutionary metaphor of 'artificial DNA' to describe all generative art and design:

> In the field of generative art and design, design concepts are represented as code. This generative code functions as DNA does in nature. It uses artificial life to generate a multiplicity of possible artworks, artificial events, architectures and virtual environments. … It represents an artificial species able to generate an endless sequence of individual events, each one different, unique and unrepeatable but belonging to the same identifiable design Idea.'

> In addition to the functional use of genetic algorithms in optimisation problems, they can be also utilised for more creative design exploration. Because of the highly automated and multi-staged process, genetic algorithms can yield complex and emergent results. Soddu's *Argenia* project demonstrates

FIGURE 2.6
Unique lamp designs generated with Soddu's *Argenia* software *(Soddu, 2002)*.

the use of genetic algorithms in a more expressive and experimental context: *Argenia* is a generative software which can produce various kinds of industrial objects, each unique, but representing the characteristics that are required for the said class of objects *(Soddu, 2002)*. Figure 2.6. depicts a population of lamps generated with *Argenia*. Soddu describes how the generative method does not simply combine predefined parts, such as the lampshade and the stand, but creates completely independent forms within the guidelines and limitations defined in the artificial DNA and the fitness function. Soddu *(1998: np)* also recognises the issue of the designer's subjectivity that arises with these definitions:

> The genetic algorithms are used to perform the selection. But the selection, in design approach, is not only the selection between choices with different functional or quantified qualities. … When the alternatives are between different possibilities with the same functional level of quality, the selection is only the exploding of the designer identity.

> So, if the designer deviates from the straightforward praxis of design-as-problem-solving, the generated results can not be quantitatively optimised. This means that the evaluation of the fitness is a subjective act of selection; a form of *curating*. The next chapter will introduce some main points of the contemporary curatorial discourse, and chapter 4 will further elaborate the relationship between generating and curating.

3 Curating

3.1 FROM OBSCURITIES TO OBRIST

> With the free circulation of content via modern communications networks, it is easy to forget how new the concept of a publicly accessible collection actually is. The idea of the public museum came into being as late as the end of the 18th century, as a consequence of large private collections being inherited by democratic states *(Obrist, 2015: 57)*. These private collections were often in the form of a Wunderkammer, a chamber of curiosities: a motley, unorganised accumulation of artworks, instruments and natural objects; oddities and artefacts from far away places and foreign cultures; archived by natural scientist, monks, artists and wealthy dilettantes alike *(Obrist, 2015: 54-55)*. These vast, public archives naturally needed organising, cataloguing and maintaining, and thus the traditional role of the curator as the professional caretaker and trained expert of the collection was established.

> Of course one can argue that curatorial practices are an inseparable part of the circulation and presentation of art: 15th century aristocrats served as patrons and private collectors *(Morgan, 2013)*, ordering artworks and displaying them in private venues, or presenting them as gifts for public viewing in churches or other institutions. This aspect of the curator as the connoisseur and gatekeeper of taste

and history is one that can not be undermined. By selecting what is shown, maintained and thus valued, the curator has the capability to educate and restore, but also the power to re-contextualise and manipulate *(O'Neill, 2012: 90)*. Obrist *(2015: 54)* sums successfully the opportunities and responsibilities of the curator:

> To make a collection is to find, acquire, organize and store items, it is also, inevitably, a way of thinking about the world – the connections and principles that produce a collection contain assumptions, juxtapositions, findings, experimental possibilities and associations.

> Therefore, the collection can be described as the physical manifestation of the curator's interior world and intentions, and thus the curator can be seen as an original author and artist. The concept of the 'artist-curator' or 'curator-as-author' has been well-established in the contemporary curatorial discourse *(Obrist, 2015, Hoffman, 2013; Filipovic 2013; Vishmid 2006)*, all of which denotes a paradigm shift in the traditional role of the curator.

3.2 THE UBIQUITOUS CURATOR

> Since the emergence of disruptive conceptual art towards the end of the last century, the role of the artist has become to resemble that of the curator. The practice of art has shifted from the mere craft-like producing of art objects towards the manipulating of readymades, assembling of installations, managing of systems and mediating information *(Vishmid, 2006: 44-45; Obrist, 2015: 46-47)*. Because these methods adopted by contemporary artists overlap with the curatorial practice, the contemporary curator has had to become an independent maker of meaning.

> While the traditional 'salon style' of the early exhibitions accentuated taxonomic schools of painting and commonalities of motifs *(Obrist, 2015: 40)*, the role of the modern curator transcends the apparent methods of classification and arrangement. As Filipovic *(2013: 75)* states, "Exhibition is not just the sum of its

artworks, but also the relationship created between them, the dramaturgy around them, and the discourse that frames them." So the curator-as-author has assumed the role of motivator of events and convener of disciplines in addition to the traditional taste-making one *(Vishmid, 2006: 45)*. Also after the proliferation of the contemporary *(but once-disruptive)* consensus of art as act of naming—that anything which is called art is art—the only inhibitors of the complete dissipation of the art world have been the capitalist market powers and institutional authority. Therefore the curator, working in a commercial gallery or a public museum, has gained influence as the central interpreter of art, a position once reserved mainly for the critic or the collector. *(Vishmid, 2006: 44-45)*

> Gertrude Stein, an avid art collector herself, claimed that museums are the cemeteries of culture, and therefore can never be modern *(Obrist, 2015: 132)*. Whether or not one agrees with the statement, it is apparent that ubiquitous digital media has diminished the role of the museum and the gallery as the exclusive sources of artistic stimuli. What is then the domain of the contemporary curator, if museums and galleries have become redundant and outdated? The curator could commandeer new, unexpected venues for staging the modern-day theatre of the exhibition, like Obrist *(2015)*, who boasts arranging exhibitions in restaurants, airplanes, domestic kitchens and even in the sewage system. The curator could also invent and implement new practices for reactivating and re-contextualising the existing collections *(Obrist, 2015: 132)*, exemplified by John Cage's exhibition Rolywholyover in chapter 3.3. and Paolozzi in chapter 4.2.4. Maybe most in line with the concept of curator-as-author is the generative approach to curating, where the curator acts as an instigator of a process giving birth to the exhibition, illustrated by Obrist's *do it* exhibition in chapter 3.3.

> An even more far-reaching approach to curation would be to abandon the context of the art world altogether, and treat curation not as an occupation, but as an independent methodology or operational tool in

FIGURE 3.1
Installation view of *Rolywholyover: A Circus for Museum by John Cage* displays the mobile arranging which was altered daily *(Hirose, 1994)*.

a universal setting *(Hoffman, 2013)*. As mentioned in the introduction, the new relevance of curatorial control and concepts such as content curation have emerged, because of the abundance of stimuli and material provided by digitalisation have made filtering indispensable. In addition, curatorial practices can be adapted to the digital realm very naturally, since programmatic online spaces inherently support classification and categorisation, which are quintessential to curating. In the endless, immaterial networks of data, the ubiquitous curator faces opportunities not provided by the traditional practice of displaying artefacts in a physical venue: the collection is no more limited by location, space, budget, or availability, and the curator is free to create chains of context and hierarchy by linking, collaborating, and re-appropriating. *(Paul, 2006: 87-99)*

3.3 DEMONSTRATING THE DEMATERIALISED

> The practice of curating has naturally evolved simultaneously with the practice of art. Especially the approaches exercised in early conceptual art can be seen as a major influence for the concurrent experiments in curation. Lillemose *(2006: 118-124)*

describes, how artists in 1960s and 1970s, such as the Fluxus group, strived to dematerialise the art object by shifting the attention from the physical dimensions of the artwork to the conceptual and procedural. Lillemose reminds, however, that this post-formalist approach doesn't necessarily render the physical artwork superfluous or require concrete immateriality. It simply uses the tangible as a media for concentrating on the contexts, contingencies, systems and the 'flux … of postmodern culture' *(Lillemose 2006: 124)*, much like contemporary curating.

> Many examples of curatorial practice with similar conceptual tendencies emerged already in the 1960s *(Filipovic 2013)*. This chapter will examine two cases

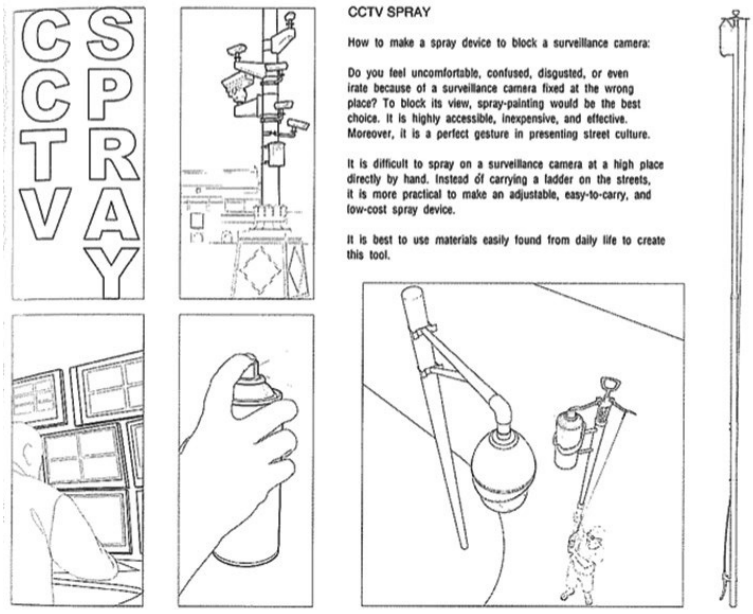


FIGURE 3.2
Artist Ai Weiwei's instructions for making a spray device for blocking CCTV cameras in Obrist's *do it* book. *(Obrist, 2013)*.

of contemporary curation in light of the new role of the 'ubiquitous curator' presented earlier: John Cage's exhibition *Rolywholyover: A Circus for Museum by John Cage*, and *do it* by Hans Ulrich Obrist. These instances demonstrate similar issues of order, determinism, agency and subjectivity as the generative examples in chapter 2.3. Accordingly, they will be later examined to accentuate the relationship of generating and curating.

> John Cage's[3] curatorial exhibition, *Rolywholyover: A Circus for Museum by John Cage* in 1994 (figure 3.1) was composed of four smaller, independent exhibitions. Two of these, *Museumcircle* and *Circus* illustrated Cage's infatuation with randomly generated content: In *Museumcircle* Cage invited museums in the vicinity of the gallery to submit a listing of ten objects which could be borrowed for the exhibition. The displayed artefacts were then chosen by selecting one item from each list by chance operations[4]. The method for selection in *Circus* followed a more traditional curatorial practice, being based on Cage's professional opinion and subjective taste. However, if the original piece could not be obtained, Cage exhibited replicas produced with the permission and instructions of the artist. Also the approach for the presentation of the exhibition was exceptional: the artefacts were rearranged daily according another chance operation. This resulted in a constant alteration of context and a multitude of possible readings, since the traditional linear narrative of the exhibition arrangement was disrupted.

> Another insightful example of contemporary curatorial practice is the *do it* project initiated by Hans Ulrich Obrist in 1993. Obrist invited artists to write instructions for the production of artworks as a kind of a 'score' for the exhibition. These instructions were printed as a book and distributed to various galleries and museums in several countries, where they were interpreted and enacted anew in succeeding iterations. *(O'Neill, 2012: 103)* Obrist *(2015: 30-31)* explains the guidelines of the *do it* exhibitions as follows:

> Realizing the artworks, in the sense of actually executing the instructions, was left to the public or museum staff. The artists who originated the instructions were not allowed to be involved: there

3 As a composer and artist, Cage (1912—1992) is known for his groundbreaking work in the field of generative music.

4 The nature of the specific chance operations used by Cage in this instance is unclear. However, Cage often utilised I Ching, the ancient Chinese method of divination, which provides apparently random numbers. *(Marshall, nd)*

> would be no artist-produced 'original' that might be considered the 'correct' version, and no traditional artist's signature. … Also, the components from which the works were made were, at the end of the exhibition, had to be returned to their original context, making *do it* completely reversible … At the end of each *do it* exhibition, the institution presenting the show was thus obliged to dismantle or otherwise destroy not only the artworks but also the instructions by which they were created, which also removed the possibility of the artworks becoming part of a permanent collection. *do it* appeared, but only in order to disappear. … *do it* was unconcerned with the notion of the 'signed original', and its opposite, the reproduction or copy – the idea was to focus on the different interpretations. … Every realization of *do it* was temporary: an arrangement in space and an activity in time.

> Both of these examples illustrate the dematerialised quality of modern curating: the physical artwork is surpassed by the concept and the process. Consequently, the role of the artist as the author and owner of the artwork is diminished, either by removing the agency of the artist altogether, like in *do it* and *Circus*, or undermining the artist's intention and sovereignty by randomising the context and participation, as in *Museumcircle*. The post-object perspective is also evident in the ways these exhibitions treat originality and material limitations: in *Circus*, unobtainable artworks were replaced by replicas, and in *do it*, the artworks were treated as mere temporary materialisations of the idea. Despite not being digital or immaterial, they truly are both examples of the 'flux of postmodern culture': complex, dynamic systems of changing contexts and contents.

4 Generating and curating: The framework & the wanderer

4.1 VIRTUALITIES TRANSFORMED

> Chapters 2 and 3 discussed the main aspects of generating and curating discourses. This chapter aims to create a synthesis of the aforementioned theories by suggesting a joint framework for generating and curating (figure 4.2). Each of the four stages of the framework proposes a chronological step of the combined process, and illustrates the correspondence between the two discourses. First, this chapter will introduce two theories for creativity, which will be accommodated in the framework to demonstrate the creative potential arising from the combination of generating and curating.

> The elusive nature of creativity has inspired countless attempts for scientific and subjective definitions. The more in-depth analysis of the discourse is outside the scope of this thesis, so this chapter will focus on Deleuze's concept of virtuality *(Deleuze, 1991; Brassett and Marenko, 2015)*, and the Creative System by Boden *(1990, 1994)* and Wiggins *(2001, 2003)*, which both provide particular insight to the characteristics of generative and curatorial processes.

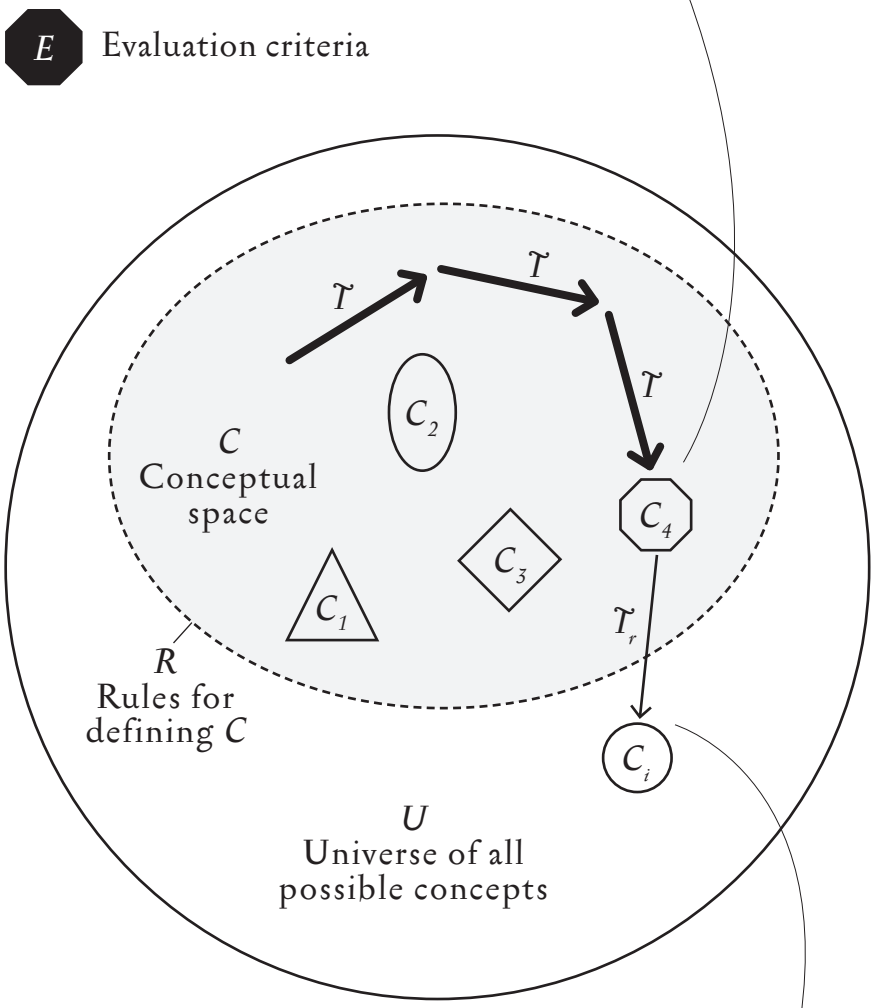
> Deleuze *(1991)* states, that creativity is always about virtualities being actualised. 'The virtual' here denotes the vast, immaterial cloud of possibilities surrounding each process of production. Actualisation

contracts the virtual to actual, pinning down a possibility to the present material reality. Brassett and Marenko *(2015: 17-18)* paraphrase Deleuze by stating that actualisation is the process which 'engenders the emergence of new forms' from the 'container of manifold tendencies' of the virtual. Brassett and Marenko *(2015: 17-18)* also remind, that the transformation from virtual to actual is 'problematic and problematising', since it allows only a limited number of possibilities to be realised. It is, however, creative precisely because of this persistence of proposing questions: actualisation functions as a filter between 'what is and what could be' *(Brassett and Marenko, 2015: 18)*.

> The *Creative System* introduced by Boden *(1990, 1994)*, elaborated by Wiggins *(2001, 2003)*, and discussed here after the example of McLean *(2011)*, demonstrates the characteristics of a creative process with logical operators *(Figure 4.1)*. U denotes the universe of all possible concepts, that is the imaginary group of every conceivable solution to all possible creative problems. R is the set of rules which define the appropriate concepts for the particular problem at hand. C defines the 'conceptual space', which is the group of concepts that are relevant to the subject matter by rule R. The conceptual space thus contains all the possible solutions for the current creative problem. T is the set of rules which define the behaviour of a creative agent as it traverses the conceptual space. T therefore describes the method that is used to find suitable solutions from C. E, on the other hand, is the set of rules by which the creative agent evaluates the concepts found in C. Thus E describes the qualitative or quantitative conditions that the artist/designer poses for the optimal solution. The act of creation according to the Creative System then functions as follows: the creative agent (that is, the artist/designer/curator) explores C with the search strategy defined in T and then evaluates the findings with E to define the best creation. This typical implementation of the creative process is called *exploratory creativity* by Boden and Wiggins.

1 EXPLORATORY CREATIVITY

The creative agent traverses the conceptual space C with the method defined in T. Among the appropriate concepts *(here denoted with C_1— C_4)* the creative agent discovers the optimal concept *(C_4)* which fits the conditions in E.



2 TRANSFORMATIONAL CREATIVITY

The rules in *T* are revised, so that the new search method T_r takes the creative agent *outside* the conceptual space. The creative agent discovers an invalid concept C_i, which however fits the conditions in *E*.

FIGURE 4.1

The Creative System introduced by Boden *(1990, 1994)* and elaborated by Wiggins *(2001, 2003)* describes two types of creativity: *(1) exploratory creativity* and *(2) transformational creativity*.

However, the Creative System recognises also another form of the creative process, called *transformational creativity*: The creative agent traverses outside C and finds an invalid concept C_i, which is not defined by R. Wiggins *(2001, 2003)* calls this inapplicable concept *aberration*. The aberration is, however, valued by the rules in E, which means that C should be enlarged to include C_i. Therefore the discovery of the valuable but invalid concept C_i *transforms* the entire creative space, which makes the results of transformative creativity more unexpected (and thus creative) than those of exploratory creativity.

4.2 FRAMEWORK FOR GENERATING AND CURATING

4.2.1 Formalising & delineating

> Instigating either a generative or a curatorial process requires the formalisation of a decisive rule. In generative processes this rule reconstructs the design problem or artistic idea to a language which can be acted upon by the process. This could mean writing an algorithm, like in Rosebush's *Letter Field*, or devising a physical system, like Knowles's *Tree drawings*. Likewise in curating, the rule defines the operators or the selection criteria which guide the formation of the collection, such as the instructions for artworks and guidelines for the exhibition in Obrist's *do it*. The selection criteria can be unambiguous and quantitative, such as a certain historical period, or vague, qualitative, and based on a subjective opinion. The generative or curatorial rule can be described by R in the Creative System, which limits the appropriate concepts C from the universe of all possible solutions. The conceptual space C can be seen as consisting of the 'entities' of the process, defined by Dorin et al. The rule describes the entities by their attributes or altering states, thus evoking the 'species' of the outcome. This makes the decisive rule very similar to the concept of the 'genome' in genetic algorithms, such as the 'artificial DNA' of a lamp in Soddu's *Argenia*.

> In curatorial context, the entities in the conceptual space can be an imaginary group of all items outlined by the selection criteria or operators: artworks with a specific theme, digital items with a certain hashtag, or a more distinct group qualified by the rule, such as the list of 10 possible objects from each museum in Cage's *Museumcircle*. The formalisation of the curatorial or generative rule can thus be considered as 'metadesign' for the forthcoming process itself. This delineating of conceivable solutions in the form of a rule also represents Deleuze's 'virtual': the pool of possible actualities not yet realised.

4.2.2 Processing & implementing

> The generative or curatorial process is the implementation of the rules defined in the previous step, and functions as the actualisation of Deleuze's 'virtual'. According to Dorin et al., the process is the operation which changes the states of the entities, such as the cellular automation which creates the 'on-off' pattern in Fox's tea cosies, or applying the randomly generated values to the variable-entities in Rosebush's *Letter Field*. Similarly the actual process of curation applies the predefined operational rules to the available body of content (the creative space of entities), consequently generating the collection. This can be exemplified by the chance operations used by Cage in *Museumcircle* and *Circus* or the act of creating the artworks in Obrist's *do it*. In general, any implementation of the curatorial selection criteria in the form of filtering, sorting or organising is the enactment of the process. This procedure of reaching the generative or curatorial outcome can be illustrated by Υ in the Creative System: it describes the method of pursuing solutions in the creative space and thus, actualising the possible.

> Many generative and curatorial processes are, however, able to develop and improve independently, or can be adjusted by the creative agent: genetic systems, content curation algorithms, randomised processes

and procedural curatorial methods employed by Cage and Obrist, exhibit either autonomy or interaction, or both. As the generative or curatorial process is modified, the rules in $\mathcal{T}$ are altered accordingly. Consequently, the revised $\mathcal{T}_r$ allows the creative agent to traverse outside the initial area of C, and thus find the unexpected, aberrational solution C_i. This is how self-directing or interactive processes exhibit *transformational creativity*.

> Deleuze's concept of 'the event' illustrates the characteristically dynamic and indeterministic nature of generative and curatorial processes: 'Objects come to exist not out of a predetermination, as a compound of matter and form, but as the outcome of the continuity and variation of matter captured as a specific type of individuation: the event.' *(Marenko, 2015: 117)* The product of the process is not necessarily set and stable, but a 'temporal expression of an event-affect continuum' *(Marenko, 2015: 112)*, the actualisation of the virtual, constantly interacted, evaluated and evolved.

4.2.3 Interacting & evaluating

> The immediate results of the generative process can, at least in theory, number to infinite. Therefore some kind of method for assessing and filtering the outcomes is necessary. It could be an in-built system of evaluation, like the 'fitness function' in genetic algorithms, or an interactive procedure carried out by the artist/designer. The evaluation method depends on the ambiguity of the design problem at hand: if an 'optimal' solution can be defined, the quantitative valuation of the outcomes is a mechanical task of computation, such as defining the final shape of NASA's evolutionary antenna. However, if the ideal product can not be incontrovertibly[5] described, which often is the case especially in the context of art, assessment is an exercise of personal taste, values, or intuition, that is, a form of curating. As an example, we can

5 In regard of algorithms, this usually means numerically.

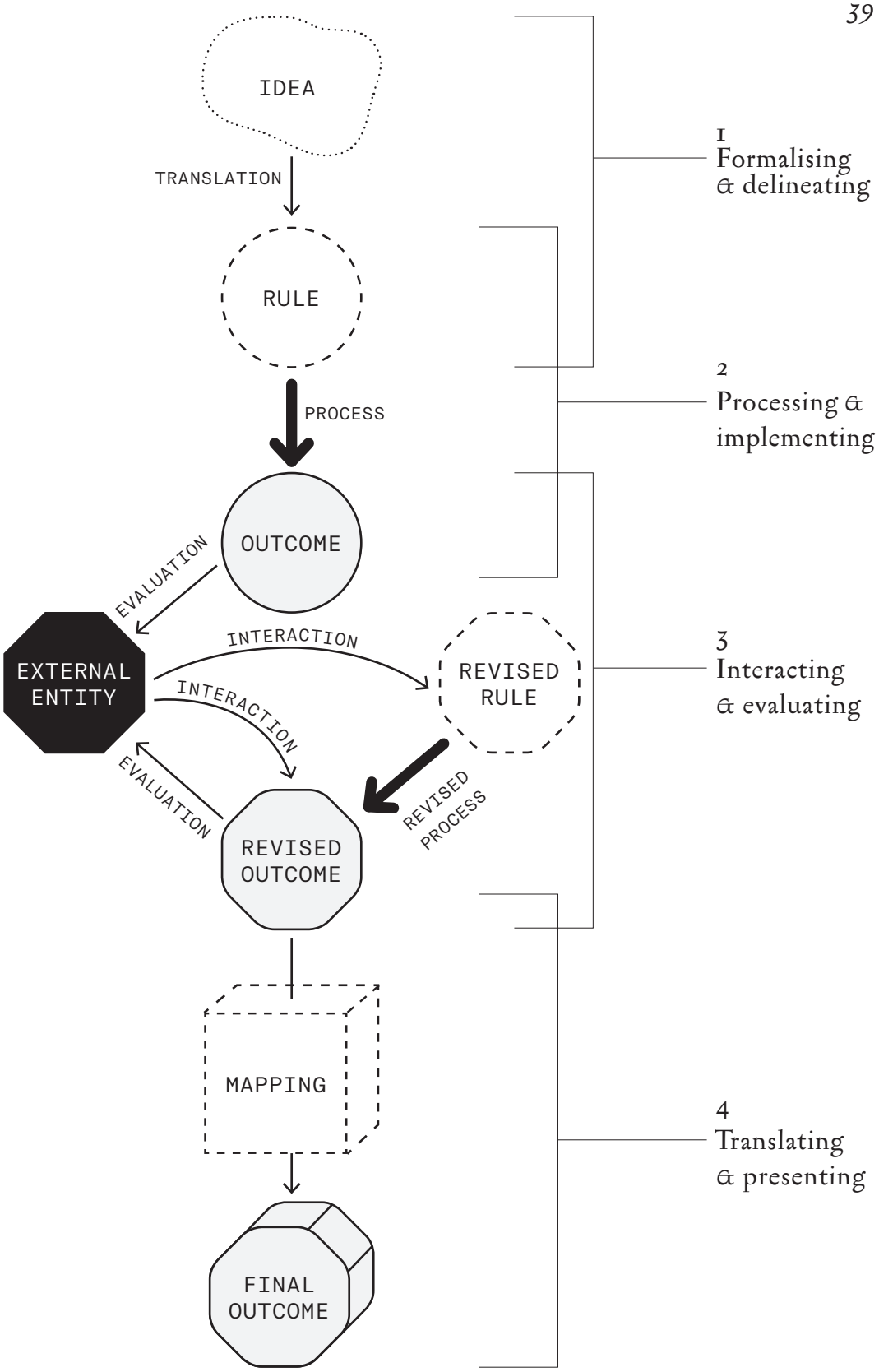


FIGURE 4.2
The proposed framework for generating and curating.

surmise that the version of Rosebush's *Letter Field* in figure 2.4. is one of the many iterations produced by the randomised algorithm, subsequently hand-picked for display by the artist. This method of evaluation, which is the essence of curating and indispensable to generating, can be described by E in the Creative System. The evaluation criteria established in E defines the final product of the curatorial or generative process among the possible items in C. By selecting the ultimate product, the creative agent thus interacts with the outcomes of the process.

> Interaction can also happen directly with the process itself. This manipulation of the system is illustrated by the 'environmental interaction' defined by Dorin et al. The interaction can be continuous, indeterministic and intertwined with the process, like the effect of wind on the tree branches in Knowles's *Tree drawings*, or it can happen as discrete events, such as the evaluation of the subsequent generations in genetic algorithms. In this case, evaluation is used to tweak the process, and indirectly, the products, towards a more desirable outcome. This feedback loop of repeatedly evaluating the results and revising the process, and thus increasing the fitness of every subsequent generation, is typical to a variety of generative processes, not only genetic algorithms.

> Also in the curatorial context, 'environmental interaction' can be an integral part of the process, like the daily rearranging of objects in Cage's *Circus*, or artworks produced interactively with the museum visitors in Obrist's *do it*. In general, any alterations made to the curated collection, such as addition or removal of the items, is an act of evaluation and interaction. In curation as well, evaluation of items can lead to tweaking of the process in the manner of a feedback loop. This, again, takes the form of *transformational creativity*: if the creative agent finds a valuable concept outside the conceptual space, the rules of the process (an thus, the limits of the conceptual space) have to be revised. Accordingly, if a curator includes an 'aberrational' item to the collection, the formative rules of the collection are

reconstructed, which increases the number of possible additions. As an example, in digital content curation the input and interaction of the user-curator alters the results of the quasi-curatorial algorithms: liking a video on YouTube changes the generated collection of suggested videos, which leads to successive discoveries.

> It is notable here, that the acts of evaluation and interaction always require an entity outside the process itself: it could be an indeterministic external force, such as the wind, or an intentional subject, like our creative agent, but nevertheless, the generative or curatorial process can not function completely independently. Even in autonomous systems, such as genetic algorithms, where the evaluation and tweaking of the process is outsourced to the system itself, the creative agent has to devise the evaluation criteria. In addition, the instigating of the process and presenting of the outcomes require some form of outside interaction.

> In effect, the requirement of agency is what gives rise to creativity. Deleuze *(1991: 15)* recognises the creative value of evaluating and interacting, even if (or because) an absolute, optimal solution can not be reached: 'True freedom lies in a power to decide, to constitute problems themselves … it is a question of finding the problem and consequently of positing it, even more than solving it'. It is the process, the 'event', the flux of information and matter, which breeds creation: 'Deleuze compares the force of inventing concepts to a feedback loop, to an echo chamber, where in order to get moving an idea has to traverses [sic] different filters, different fields.' *(Brassett and Marenko, 2015: 15)*. This well-established idea of the journey eclipsing the destination emphasises the importance of the process in generative and curatorial practices.

4.2.4 Translating & presenting

> Despite the dematerialised, event-based and 'virtual' nature of generative and curatorial practices, the perceivable outcomes of the process are still perhaps

the most evident constituent of any act of generation or curation. The experienced products, or 'sensory outcomes' defined by Dorin et al., can be the final results of a terminated process, where the 'optimal' (or subjectively most highly valued) creation has been reached by some method of evaluation, or the process has been been otherwise brought to conclusion. Again, the termination point of the process might be inherent to the system, like when a generative algorithm has been successfully completed by the computer, or it can be an arbitrary artistic choice, such as the instance when the artworks in Knowles's *Tree drawings* were deemed 'finished'. The outcome of the generative process can also be a snapshot-like record of some stage of the process, in the manner of the fixed cellular automation pattern in Fox's tea cosies. Because of the tendency of generative processes to produce slightly varied, unique outcomes, multiple results are often exhibited side by side in the manner of a curated collection, exemplified by the presentation of Soddu's generated lamp designs.

> The collection, which is the outcome of a curatorial process, embodies its selection criteria and formative operations. In the context of the art world, this group of items often takes the form of a temporary exhibition, such as Obrist's *do it* and Cage's *Rolywholyover*, or more traditionally, the permanent collection of a museum. In content curation, this collection can be any kind of compilation of items—material, digital, or conceptual—a playlist, a catalogue of blog articles or a listing of film recommendations. Similarly to generating, the outcome of the curatorial process is not necessarily stable and set, but can be continuously or discretely altered by an evaluating feedback loop or some form of interaction, described in the previous step.

> The question of *how* the outcomes are presented is, however, even more urgent than the question of *which* outcomes are presented. In some generative processes, such as Knowles's *Tree drawings*, the form of the perceptible outcomes is inherent to the generative system, and the process is 'designed to match the

ontology of the intended outcome' *(Dorin et al., 2012: 249)*. There are, of course, artistic choices, such as the selection of the drawing method, but the 'data' of the process (the movement of the branches by the wind) is nevertheless translated directly to a visible output (the markings of the drawing utensil on the surface).

> If the generative process does not have an inherent, experienced outcome, which often is the case with digital methods, the results have to be 'mapped', in other words, rendered perceivable, by some means. McCormac et al. *(2014: 137)* write about the necessity of mapping in virtual processes: 'Unless software design is conceptualized directly at the level of individual bits, it is impossible to write a computer program without recourse to some form of representation.' They continue by stating, that generative art often mimics scientific mapping methods, because of their adeptness in simulating real-life processes. Dorin et al *(2012: 249)* point out, that the protocols of modern computation rely heavily on screen-based presentations as the most 'natural' way of representing the imperceptible machine states of bits. Nevertheless, if the artist/designer decides to deviate from this customary method of simulative presentation towards an arbitrary physical mapping, the options are practically unlimited. For example, Fox's tea cosies adopt the unrelated materiality of knitting to represent the binary states of the cellular automation. This translation from abstract to tangible is thus perhaps the most creative choice in the generative process.

> The creative potential of a curated collection similarly emerges from the presentation of the collection: it is not only the items itself, but the *relationships* created between the items, that gives birth to the reading of the whole. The curator can manipulate these relationships by juxtaposing, contextualising and contrasting the items, demonstrated by the randomised, daily changing arrangement of the collection in Cage's *Circus*. Filipovic *(2006: 77)* describes, how the presentation can completely alter the way the collection is

experienced: 'Exhibition is the form of its arguments, but its very premises (classificatory systems, logic and structure) can be unhinged by the artwork that defies the context.' An demonstrative example of the power of presentation and context would be Eduardo Paolozzi's exhibition *Lost Magic Kingdoms and Six Paper Moons from Nahuatl (1986)* at the Museum of Mankind in London. Paolozzi, an artist focused on collages and pop art, selected anonymous ethnographic items from the archives of the anthropological museum, and combined them into imaginative assemblages *(Napier, 1992: 71, figure 4.3)*. In the permanent collection of the museum, the exact same objects would be representatives of their cultural origins, but in Paolozzi's exhibition they were now transformed into a medium of the artist's creative expression. The connotations projected by the items, as religious artefacts, practical tools or emblems of power, were eclipsed by their physical characteristics in the visual narratives fabricated by the artist/curator.

> As in Fox's tea cosies, where the choice of mapping (knitted household objects) provides an unexpected and distinctive visual and conceptual experience of the immaterial process (cellular automata), similarly in curation the 'mapping', consisting of the order, arrangement and exhibiting of the items, creates the aesthetic and thematic entity. In the art world example of an exhibition, the presentation of the curated collection could involve the exhibition venue itself; the way the artworks are spatially and temporally located; the method of their mounting and display; the signage, labelling and other extraneous material; and finally, the naming, conceptual framing and public communicating of the exhibition. In this case, the presentation of the results of a generative process could also be considered as a two-tiered operation. First, establishing the actual 'mapping' of the system; the technique of representing the data in a perceptible form, and secondly, deciding on the method and style of exhibiting the mapped results. As an example, Soddu used 3D computer graphics for rendering ('mapping') his generated lamp designs, and

then exhibited the various results compiled in a grid (figure 2.5.). Knowles's *Tree drawings*, on the other hand, used a method of mapping which was already prescribed by the process: the pen markings on the paper. (figure 2.3.) The various generated (and subsequently curated) results were, again, exhibited side by side and along with photographed records of the process (figure 4.4).

> In effect, the concept of 'mapping' provides an interesting analogue in the curatorial context: O'Neill *(2012)* compares the practice of curating to map drawing: discovering connections between concepts and translating them to the spatial and material dimensions of the collection. Therefore the curated collection can be considered as a 'simulation of

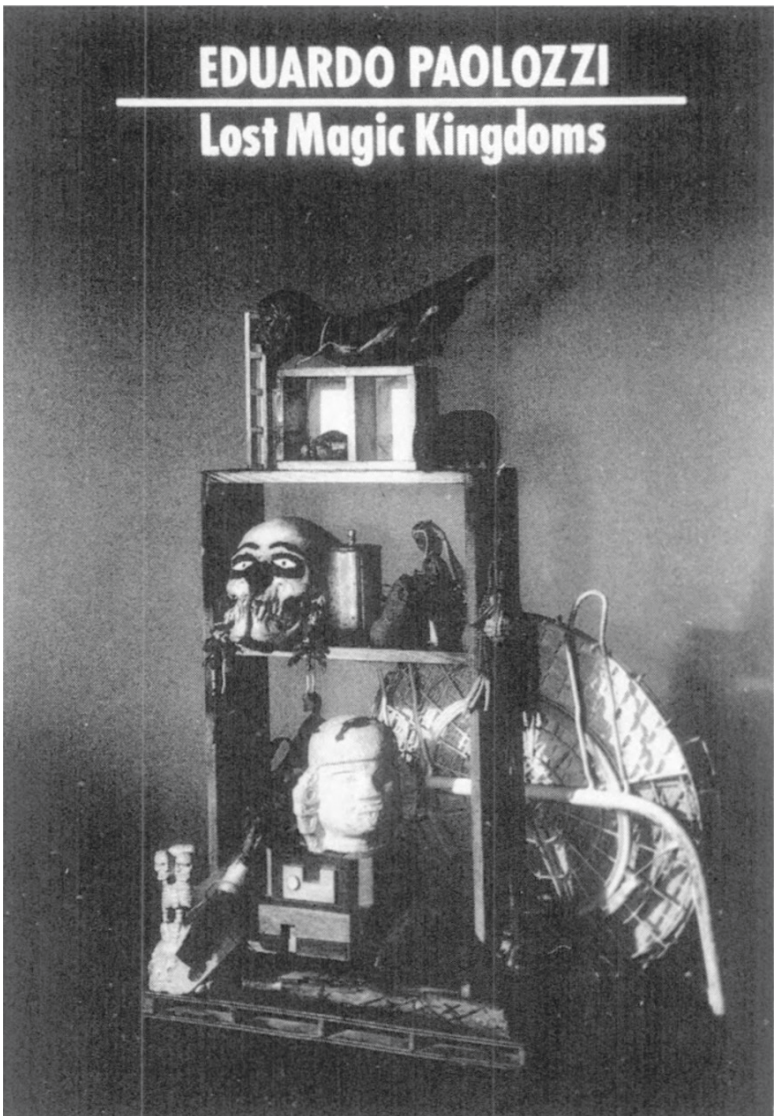


FIGURE 4.3
Catalog cover for the exhibition Eduardo Paolozzi: *Lost Magic Kingdoms and Six Paper Moons from Nahuatl* at the Museum of Mankind in London. Paolozzi appropriated ethnographic artefacts for his own artistic expression.

real-life interrelations', much like the mapping of a generative process. The notion of mapping as concept-connecting is even more prevalent in modern content curation. As discussed in chapter 3.2., the hypertextual nature of online spaces encourages linking and cross-referencing, thus leading to conceptual map-networks that transcend all physical dimensions.

> In conclusion, the exhibited form of the generated or curated product is an exercise of subjective creativity. If the method of presentation can completely alter the experienced outcome, what

FIGURE 4.4
Two levels of presentation of Knowles's *Dragon Spruce* from the *Tree drawings* series: the mapping of the data and the exhibiting of the mapping. *(Knowles, 2012)*

responsibilities and opportunities does that inflict on the creative agent? If the curator is able to re-appropriate items by manipulating their contexts, do they cease to be a curator and become an author? Or, as McCormac et al. *(2014: 137)* point out, 'If generative art uses real-world data, what are the ethical and political implications of the artist's chosen representations?' In general, curating and generating raise several urgent question about agency, intention and power, which will be discussed in the next chapter.

5 Author or Mediator?

5.1 EQUILIBRIUM OF INTENTION

> The topics of agency and authorship in generating and curating have been touched upon several times in the previous chapters. In chapter 2.2 it was stated that in generative art the artist often strives to reduce their intention by using autonomous, indeterministic processes. Chapter 2.3 elaborated on this idea by explaining how different types of randomisation, environmental interaction or self-evolving processes can be used as a means for reaching emergent and unpredictable outcomes. Accordingly, chapter 3.3 described examples from contemporary curating, where the curator has disrupted the traditional role of the curator, first by reducing the autonomy and authorship of the artist, and secondly, by introducing randomisation and interaction to the process as a means for eliminating their *own* intention. However, chapter 4 illustrated how the agency of the creative agent can never be completely erased: formulating the rules of the system, evaluating the results, and devising a method for exhibiting the outcomes require the creative agent's intention, even if the process itself might be autonomous. Soddu *(2006: np)* describes this unavoidable subjectivity in regard to genetic algorithms, but the same applies for curating: 'As all creative processes it involves subjectivity in the definition of how the process runs and how the

transforming rules are created and organized into a system.'

> Even with the growing acknowledgement of the curator's authorship and agency *(discussed in chapter 3.2)*, the role of the curator is still essentially that of a mediator. An artist can also act as a curator, exemplified by Cage's and Paolozzi's curatorial exhibitions, but in that capacity they do not craft or produce as such, but convey and translate by using someone else's work as their medium. In the making of the collection and the arrangement, the curator proposes a reading for the artworks *(Filipovic, 2013: 77)*, and thus they have the ability to insert their own message in the collection. Obrist *(2015: 46, original emphasis)* describes how, since the rise of thematic exhibitions in the 1980s, the curator has been seen as 'an overriding figure or *auteur* who uses artwork to illustrate his or her own theory'. As an opposition to the dubious notion of curator-as-appropriator, Obrist's mentor, curator Kasper König has stated that 'it is not the job of a curator to impose their own signature but to be a mediator between artist and public' *(Obrist, 2015: 132)*.

> In generative art and design, questions of agency and intention have been widely discussed, especially in regard to computer-generation. We can expand this discussion to include also curating, if we regard curating as an analogy to programming[6] along the lines of the framework introduced in chapter 4: the curator translates their idea into a rule, a sort of 'intuitive algorithm', which is then communicated through the collection. Similarly, a programmer expresses their idea in a programming language, which is then compiled to execute the algorithm. Cox *(2006: 75)* describes how 'programmed art is action that is conceived in advance of it's execution'. This can also be applied to curating: the rules of the process precede the actualised collection. The issues of intention and agency in curating verge on those

6 Interestingly enough, 'programming' is used as a curatorial term, in the purpose of devising a programme for a museum. *(Hernández, 2013)*

in generating even more closely, if we consider the contemporary modes of content curating which take place online through programmed algorithms.

> Several writers claim that all algorithmic designs are extensions of the programmer's intention, since a computer program essentially is a codification of intent *(Cox, 2006: 75; Maeda, 1999: 217; Soddu, 2006: np)*. Maeda *(1999: 217)* points out, along the lines of chapter 4, that human intention is at least required to initiate an otherwise autonomous process:

> Computation is a means for defining systems of change. … Even when you are designing computational forms that transform in ways beyond your control, never forget that it is you, not the computer, who is affecting the change. Left alone, a computer would never initiate change because it does not have intent.

> However, this claim for programmer's intention raises further questions: what if the creative agent does not personally author the program? As discussed in the introduction, many artists and designers are disinclined to devise their own generative systems, but result to customary, widely-used algorithms and simulations, such as L-systems and cellular automata. Or alternatively, the creative agent themself might devise the functionalities of the system, but then require the assistance of a programmer for translating the rules to a logical language. Is it then essential to understand the inner workings of an algorithm for claiming the authorship of its results? On that account, McCormac et al. *(2014: 136)* remind that it is almost impossible for the programmer to completely comprehend and predict the behaviour of complex software—this is why programs have 'bugs'. McCormac et al. continue with a statement which objects Maeda's view of computers as passive executors of commands:

> Computers have already demonstrated the ability to originate something: to exceed their programmers' anticipations or knowledge. Indeed, this potential for

> "emergence" is the basis for many an artist's decision to use the computer. As computers have developed, we have seen our relationship with them change and the computer's role shift from that of a "tool" under the direct control of the artist to that of a collaborator or creative partner and, potentially, an autonomously creative entity.

> If computerised processes might be considered autonomous entities according to McCormac et al., is the creative agent then stripped of all agency in the end? One could argue not. If it is the *intention* of the creative agent to shift the agency to the autonomous system, is not the role of the system then reduced to that of a tool? Marshall *(nd, np)* notes, amusingly but accurately, how Cage's reliance in chance operations in music composing became so compulsive, that nothing was left to chance. If randomness becomes this kind of an artistic trademark, is it not then the very manifestation of agency and intent?

> One could also insist that as a subjective act of evaluating, curating must require human agency. However, curating can be—and on some level already is—highly automated and computerised: quasi-curatorial algorithms that filter and organise content online can recognise and classify material through hashtags, contexts, or other metadata. These autonomous curator-generators can roam the virtual realm with speed and accuracy impossible to human agents. Nevertheless, this argument boils down to the (present) inability of computers to spontaneously initiate anything. A computer could recognise an image of cat through modern-technology computer vision, it could teach itself to identify increasingly varied pictures of cats, it could start a collection of cat images, and it could even rate the images with the help of peer-reviews, but someone would have to tell the computer to do so. Also any other multifaceted or more abstract topics or complex conceptual ideas, which seem to be prevalent in modern collections, would be beyond the abilities of present softwares.

> In conclusion, curating and generating both perform on the vague borderline of intention and indeterminism. They require subjectivity and human agency in some phases, but in others the autonomous process might take over and provide indeterministic results. The unintentionality of the results might be 'intentional'—designed and delineated by the creator—or caused by the complexity of the process that exceeds the creators understanding: a 'bug' or other unpredictable event. These unintentional solutions are the 'aberrations' described in the Creative System: unexpected and technically invalid solutions, which exhibit transformational creativity. So the creative agent has to devise a curatorial or generative system which balances intention—the desired characteristics of the outcome—and indeterminism—an emergent and unpredictable outcome. Thus, one could say that creativity is about creating a system that helps imagine unimaginable outcomes.

5.2 WHO CURATES THE CURATORS, WHAT GENERATES THE GENERATORS?

> The discussion of agency and intention in generating and curating naturally raises questions of moral nature, in regard to power and authority. As was alluded in the previous chapter, the act of curating is never completely neutral, because it requires subjectivity and thus reflects subjective values and opinions. Filipovic *(2013: 74)* describes the curated exhibition as 'a scrim on which ideology is projected, a machine for the manufacture of meaning, a theatre of bourgeois culture, a site for the disciplining of citizen-subjects, or a mise-en-scène of unquestioned values'. As gatekeepers of taste and value, curators curate culture and history: they decide what is saved, maintained and appraised, and how it is framed and presented. Fortunately, the proliferation of virtual material and online tools has heterogenised and enriched the participants of cultural curation from predominantly western academics to anyone with internet access. Contemporary art and curation are

both characterised by this immaterial production of value and 'processing, circulation and development of soft materials such as communication and data' *(Lillemose, 2006: 120)*. This aspect of curating and generating is also described by Borriaud's *(2002: 113)* concept of 'relational aesthetics': 'a set of artistic practices which take as their theoretical and practical point of departure the whole of human relations and their social context, rather than an independent and private space.' Similarly, Vishmid *(2006: 42)* reminds us that because of being information-based, generated internet art is not traceable to a single authoring subjectivity. The same applies to curating: independently curated online collections function outside institutions and are run by individuals *(Paul, 2006: 93)*, in a way that communalises the curatorial power from the ideological establishment to anonymous masses.

> Despite the apparent communalising and emancipating force of immateriality, Goriunova and Shulgin *(2006: 238)* accurately point out that software is never a culturally, socially or aesthetically neutral layer between human and computer. For example, the persistent gender imbalance in the field of computer science shapes the syntax and the tools we use, thus affecting the experience of our existence in the digital realm. One could also state that the false conviction that quantitatively optimal, computer-generated outcomes are intrinsically and universally virtuous overlooks the exclusiveness of such solutions. Soddu *(2006: np)* describes how a design approach focused on optimisation assumes that 'all people are equal, all people need the same equal product'. Slater *(2006: 141)* expresses a similar frustration towards the assumed virtuousness of the virtual:

> Informatic globalisation is ceaselessly paradoxical; affording glimmers of freedom, connection and empowerment whilst simultaneously collapsing such mass intellectuality into the grid of appropriation and control.

> Even well-meaning instances of curatorial and algorithmic control can turn into totalitarian nightmares: Feuz *(2011: np)* has studied how user-customised search result in search engines can be a threat to the free circulation of information, since they filter the available material with possibly suspect principles. As immateriality displaces value from object to process *(Vishmid, 2006: 40)* and while interaction, appropriation and collaboration destabilise the concepts of authority and ownership in online curating and generating, new economies and systems of control are bound to be created. However, it is very unlikely that copyright laws, watermarks, or subscription fees can stop the 'generalised creativity' of curating and generating taking place in online galleries, meme sites and social media. Slater *(2006: 144)* calls this commodifying and hybridising of aesthetic experiences an 'unassignable leakage':

> disorientation produced by the proliferation of nodes of (immaterial) production and mediation (weblogs, free software communities, community WIFI networks, peer-2-peer file sharing, community media projects, street TV, auto-labs, etc.) which is unleashing a generalised creativity unconcerned with the categorical definitions of art. Somewhere, out there, everywhere and anywhere, art within immaterial production is mingling with all these creative efforts, swapping its DNA, in ways that are simply uncuratable because they have been incorporated into other economies of, one hopes transformative, desiring-production. This is not relational aesthetics or even Net Art, but something else which defies categorisation because it is multitudinous and mutant; an 'unassignable leakage'.

6 Conclusions

6.1 RULES OF EMERGENCE

> Despite the apparent discreteness of generating and curating, they in fact share many characteristics, both practical and conceptual. A defining similarity between the practices is the establishing of the *rule*: a formula which translates the intuitive or ideal to the language of logic. The creative agent devises the *rules* of the process instead of designing the *outcome*, a method that bestows autonomy and emergence on the process. This aspect of advocating 'metadesign' over design dematerialises the disciplines: generating and curating become fluctuating systems and complex processes, 'events' described by Deleuze, not just manifestations of design products, artworks or collections. Marenko *(2015: 111-112, emphasis added)* paraphrases Deleuze:

> > The object, writes Deleuze, has a new status. No longer confined within the mould that has created it, it has become an *event* continually modulated in time. … The object ceases being the fixed representation of a relation between matter and form to become instead the temporal expression of an event-affect-continuum, that is, the active and affective dynamism that permeates matter.

> Deleuze describes how events propagate from chaos through a 'great screen' or 'universal sieve'. This

sieve-membrane filters the incoming chaos of data into an operational event *(Marenko, 2015: 120-121)*, much like the act of curating determines relevant material among the possible concepts. Deleuze's dichotomy of 'the virtual' and 'the actual' describes this realisation of potentials well: in generating and curating, perceptible entities, such as design products, artworks and collections, are actualisations of the virtuality of the rules. The creative agent devises the 'species' of the outcome, and lets the process give birth to the individuals.

> In face of the emergent and indeterministic autonomy of the process, the creative agent still has to claim their agency. The establishing of the formative rules, the evaluating of the items, the subsequent interaction with the system, and the exhibiting of the results all require human intention and creativity. Generative and curatorial processes often entail a feedback loop, where the input and interaction of the creative agent tweaks the process, and indirectly the products, towards a more desirable outcome. This revising of the process requires evaluation of the products, that is, a form of curating. Adapting the rules of the process alters the possible outcomes—thus the process exhibits transformational creativity described by Boden and Wiggins. In effect, the true creative potential of generative art and design arises from the stages where curatorial control is present, not from the algorithmic process itself. Likewise, curation can not exist only as a set of selective rules, but requires the generative implementation of the rules; the other half of the feedback loop. Thus, curating and generating both supervene on and contain each other like an ever-enfolding fractal pattern.

> Because of the required human agency, even autonomous curatorial and generative processes display characteristics of both intention and indeterminism: the decision to use techniques with emergent properties, such as randomisation, is of course intentional, while the way the technique is implemented and how the results are presented,

requires another kind of intention. For reaching creative emergence, the curatorial or generative process has to balance intention—the desired characteristics of the results—and indeterminism—unpredictable and destabilising forces. Thus, creativity is about creating a system that helps imagine unimaginable outcomes: writing the rules of emergence.

6.2 FURTHER QUESTIONS

> Questions of agency and power in generating and curating provide a fruitful ground for further research. Especially the globalisation of information and valorisation of immaterial objects and immaterial processes affect both practices drastically. Hannah Arendt's[7] ideas of action, labour and power, arising from the plurality of human relationships would offer interesting theoretical frames for addressing these questions.

> One could criticise this thesis by arguing that the research should have discussed some exemplifying, existing initiatives that combine curating and generating, such as the Kurator8 application. Kurator lets users to discover, identify and purchase artworks through the mobile applications image recognition software *(Kurator, nd)*. These kinds of technology-driven tools for generative curatorial practices are sure to proliferate in the future, and possess great potential for novel implementations of curating and generating. However, the aim of this thesis is to find abstract connections between the acts of generating and curating and introduce new modes of thought for designers, artist, and curators, not necessarily to find direct, concrete applications. Because creating is, in Deleuze's terms, about inventing new languages for proposing

7 See for example d'Entreves *(2006)*.
8 See http://wekurate.xyz/

questions, not about finding solutions *(Brasset and Marenko, 2015: 19)*:

> Positing a problem has therefore to do with invention, rather than uncovering solutions that already exist; it is about creating the space, the milieu in which problems may become, along with the solutions that go with them. It is about creating the terms by which a problem will be stated. Problems have no given solution; they must generate solutions by a process whereby what did not exist, what might never have happened, is invented.

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The image on the cover was created with the enclosed algorithm. First, the algorithm was used to generate thirty candidates, from which the fifteen images displayed on the back cover were curated. For each of the three printed copies of this thesis, one of the images was selected for the cover.

```
<!DOCTYPE html>
<html>
<head>
<title>Rules of Emergence</title>
<meta charset="utf-8">
<meta name="viewport" content="width=device-width, user-
scalable=no, minimum-scale=1.0, maximum-scale=1.0">
<script src="https://ajax.googleapis.com/ajax/libs/
jquery/3.2.0/jquery.min.js"></script>
<script src="jquery.halftone.js"></script>
<script type="text/javascript" src="paperjs/dist/paper-
full.js"></script>
<style>
html, body {
  width:  100%;
  height: 100%;
  margin: 0;
}

canvas {
position: absolute;
top: 0;
left: 0;
}

</style>
</head>
<body>
<canvas id="c">
</canvas>
<canvas id="c2">
</canvas>
<script>

var h = window.innerHeight;
var w = h;

function random(min,max) //random number generator
{
    return Math.floor(Math.random()*(max-min+1)+min);
}

function rcolor() //random color
{
    var r = random(0, 255);
    var g = random(0, 255);
    var b = random(0, 255);
    color='rgb('+r+','+g+','+b+')';
    return color;
}

function rd() //random point
{
    var d = random(0, 360);
    return d;
}

function rp() //random point
{
    var p = random(w, h);
    return p;
}

function rx() //random x-coordinate
{
    var x = random(100,w-100);
    return x;
}

function ry() //random x-coordinate
{
    var y = random(100,h-100);
    return y;
}

function rwh() //random width/height
{
    var wh = random((h*0.1),(h*0.7));
    return wh;
}

function rsw() //random stroke width
{
var w = random(1, 150);
return w;
}

function rsw2() //random stroke width
{
var w = random(1, 10);
return w;
}

function ri() //random integer
{
    var i = random(1,50);
    return i;
}

function ri2() //random integer
{
    var i = random(1,10);
    return i;
}
function ri3() //random integer
{
    var i = random(1,10);
    return i;
}
function ri4() //random integer
{
    var i = random(1,10);
    return i;
}
function ri5() //random integer
{
    var i = Math.random()*random(0,10);
    return i;
}
function ri6() //random integer
{
    var i = Math.random()*random(1,5);
    return i;
}
function ri7() //random integer
{
    var i = Math.random()*random(2,10);
    return i;
}
function ri8() //random integer
{
    var i = Math.random()*random(60,300);
    return i;
}

function ra() //random angle radians
{
    var a = random(1,6);
    return a;
}

var canvas = document.getElementById("c");
var ctx = canvas.getContext("2d");
ctx.canvas.width  = w;
ctx.canvas.height = h;
//ctx.fillStyle="#ffffff";
```

```
function drawrec(ctx){ //draw rectangle
    var x1 = rx();
    var y1 = ry();
    var h1 = rwh();
    var w1 = rwh();
    var grd=ctx.createLinearGradient(x1,y1,x1+300,y1);
    grd.addColorStop(1,rcolor());
    grd.addColorStop(0,rcolor());
    ctx.fillStyle=grd;
    ctx.fillRect(x1,y1,500,500);
}

function drawcurve(ctx){ //draw curve
    var x = rx();
    var y = ry();
    var h = rwh();
    var a = ra();
    var a2 = ra();
    var grd=ctx.createLinearGradient(x,y,x+h,y);
    grd.addColorStop(1,rcolor());
    grd.addColorStop(0,rcolor());
    ctx.strokeStyle=grd;
    ctx.lineWidth=rsw();
    ctx.lineCap="round";
    ctx.lineJoin="round";
    var path = new Path2D();
    path.arc(x,y,h,a,a2);
    ctx.stroke(path);
}

function drawbez(ctx) { //draw bezier curve
    var x=rx();
    var y=ry();
    ctx.bezierCurveTo(x,y,x+50,y+50,x,y);
}

function drawblob(ctx) {
    var x = rx();
    var y = ry();
    var h = ri6()*40;
    var d = ri5()*h*0.7;
    var grd=ctx.createRadialGradient(x,y,h,x*2,y*2,2*h);
    grd.addColorStop(1,rcolor());
    grd.addColorStop(0,rcolor());
    ctx.fillStyle=grd;
    var path = new Path2D();
    path.arc(x,y,h,0,10);
    ctx.fill(path);
    ctx.translate(0,d);
    ctx.fill(path);
    ctx.translate(0,d);
    ctx.fill(path);
    ctx.translate(0,d);
}

function drawshape(ctx) { //draw custom shape
    var grd=ctx.createLinearGradient(0,0,w,h);
    grd.addColorStop(1,rcolor());
    grd.addColorStop(0,rcolor());
    ctx.lineCap="round";
    ctx.lineJoin="round";
    ctx.strokeStyle=grd;
    ctx.lineWidth=rsw();
    ctx.beginPath();
    for (i = 0; i < ri7(); i++) {
    drawbez(ctx);
    }
    ctx.closePath();
    ctx.stroke();
}

    drawshape(ctx);
    drawrec(ctx);
    drawcurve(ctx);
    drawblob(ctx);

    </script>

<script type="text/paperscript" canvas="c2">

project.currentStyle = {
          fillColor: 'black'
};

var ballPositions = [[rx(), ry()], [rx(), ry()], [rx(),
ry()], [rx(), ry()], [rx(), ry()]];

var handle_len_rate = 2.4;
var circlePaths = [];
var radius = 50;
for (var i = 0, l = ballPositions.length; i < l; i++) {
          var circlePath = new Path.Circle({
                    center: ballPositions[i],
                    radius: 50
          });
          circlePaths.push(circlePath);
}

var largeCircle = new Path.Circle({
          center: [rx(), ry()],
          radius: 100
});
circlePaths.push(largeCircle);

largeCircle.position = [rx(), ry()];

var connections = new Group();
function generateConnections(paths) {
          // Remove the last connection paths:

          for (var i = 0, l = paths.length; i < l; i++) {
                    for (var j = i - 1; j >= 0; j--) {
                              var path =
metaball(paths[i], paths[j], 0.5, handle_len_rate, 300);
                              if (path) {
                                        connections.
appendTop(path);
                              }
                    }
          }
}

generateConnections(circlePaths);

// -----------------------------------------------
function metaball(ball1, ball2, v, handle_len_rate,
maxDistance) {
          var center1 = ball1.position;
          var center2 = ball2.position;
          var radius1 = ball1.bounds.width / 2;
          var radius2 = ball2.bounds.width / 2;
          var pi2 = Math.PI / 2;
          var d = center1.getDistance(center2);
          var u1, u2;

          if (radius1 == 0 || radius2 == 0)
                    return;

          if (d > maxDistance || d <= Math.abs(radius1 -
radius2)) {
                    return;
          } else if (d < radius1 + radius2) { // case
circles are overlapping
                    u1 = Math.acos((radius1 * radius1 +
d * d - radius2 * radius2) /
                                        (2 * radius1 *
d));
                    u2 = Math.acos((radius2 * radius2 +
d * d - radius1 * radius1) /
                                        (2 * radius2 *
d));
          } else {
                    u1 = 0;
                    u2 = 0;
          }

          var angle1 = (center2 - center1).
getAngleInRadians();
          var angle2 = Math.acos((radius1 - radius2) /
d);
          var angle1a = angle1 + u1 + (angle2 - u1) * v;
          var angle1b = angle1 - u1 - (angle2 - u1) * v;
          var angle2a = angle1 + Math.PI - u2 - (Math.PI
- u2 - angle2) * v;
          var angle2b = angle1 - Math.PI + u2 + (Math.PI
- u2 - angle2) * v;
          var p1a = center1 + getVector(angle1a,
```

```
radius1);
          var p1b = center1 + getVector(angle1b,
radius1);
          var p2a = center2 + getVector(angle2a,
radius2);
          var p2b = center2 + getVector(angle2b,
radius2);

          // define handle length by the distance between
          // both ends of the curve to draw
          var totalRadius = (radius1 + radius2);
          var d2 = Math.min(v * handle_len_rate, (p1a -
p2a).length / totalRadius);

          // case circles are overlapping:
          d2 *= Math.min(1, d * 2 / (radius1 + radius2));

          radius1 *= d2;
          radius2 *= d2;

          var path = new Path({
                    segments: [p1a, p2a, p2b, p1b],
                    style: ball1.style,
                    closed: true
          });
          var segments = path.segments;
          segments[0].handleOut = getVector(angle1a -
pi2, radius1);
          segments[1].handleIn = getVector(angle2a + pi2,
radius2);
          segments[2].handleOut = getVector(angle2b -
pi2, radius2);
          segments[3].handleIn = getVector(angle1b + pi2,
radius1);
          return path;
}

// ------------------------------------------------
function getVector(radians, length) {
          return new Point({
                    // Convert radians to degrees:
                    angle: radians * 180 / Math.PI,
                    length: length
          });
}


</script>

<script>

 var bayerThresholdMap = [
  [  15, 135,  45, 165 ],
  [ 195,  75, 225, 105 ],
  [  60, 180,  30, 150 ],
  [ 240, 120, 210,  90 ]
];

var lumR = [];
var lumG = [];
var lumB = [];
for (var i=0; i<256; i++) {
  lumR[i] = i*0.299;
  lumG[i] = i*0.587;
  lumB[i] = i*0.114;
}

function monochrome(imageData, threshold, type){

  var imageDataLength = imageData.data.length;

  // Greyscale luminance (sets r pixels to luminance of
rgb)
  for (var i = 0; i <= imageDataLength; i += 4) {
    imageData.data[i] = Math.floor(lumR[imageData.data[i]]
+ lumG[imageData.data[i+1]] + lumB[imageData.data[i+2]]);
  }

  var w = imageData.width;
  var newPixel, err;

  for (var currentPixel = 0; currentPixel <=
imageDataLength; currentPixel+=4) {

    if (type === "none") {
      // No dithering
      imageData.data[currentPixel] = imageData.
data[currentPixel] < threshold ? 0 : 255;
    } else if (type === "bayer") {
      // 4x4 Bayer ordered dithering algorithm
      var x = currentPixel/4 % w;
      var y = Math.floor(currentPixel/4 / w);
      var map = Math.floor( (imageData.data[currentPixel]
+ bayerThresholdMap[x%4][y%4]) / 2 );
      imageData.data[currentPixel] = (map < threshold) ?
0 : 255;
    } else if (type === "floydsteinberg") {
      // Floyd-Steinberg dithering algorithm
      newPixel = imageData.data[currentPixel] < 129 ? 0
: 255;
      err = Math.floor((imageData.data[currentPixel] -
newPixel) / 16);
      imageData.data[currentPixel] = newPixel;

      imageData.data[currentPixel       + 4 ] += err*7;
      imageData.data[currentPixel + 4*w - 4 ] += err*3;
      imageData.data[currentPixel + 4*w     ] += err*5;
      imageData.data[currentPixel + 4*w + 4 ] += err*1;
    } else {
      // Bill Atkinson's dithering algorithm
      newPixel = imageData.data[currentPixel] < 129 ? 0
: 255;
      err = Math.floor((imageData.data[currentPixel] -
newPixel) / 8);
      imageData.data[currentPixel] = newPixel;

      imageData.data[currentPixel       + 4 ] += err;
      imageData.data[currentPixel       + 8 ] += err;
      imageData.data[currentPixel + 4*w - 4 ] += err;
      imageData.data[currentPixel + 4*w     ] += err;
      imageData.data[currentPixel + 4*w + 4 ] += err;
      imageData.data[currentPixel + 8*w     ] += err;
    }

    // Set g and b pixels equal to r
    imageData.data[currentPixel + 1] = imageData.
data[currentPixel + 2] = imageData.data[currentPixel];
  }

  return imageData;
}
    var canvas = document.getElementById("c2");

    var ctx = canvas.getContext("2d");
    ctx.canvas.width  = w;
    ctx.canvas.height = h;

    var imageData  = ctx.getImageData( 0, 0, w, h);

    var dither = monochrome(imageData, 10,
"floydsteinberg")

    ctx.putImageData( imageData, 0, 0);

    var canvas = document.getElementById("c");

    var ctx = canvas.getContext("2d");

    var imageData  = ctx.getImageData( 0, 0, w, h);

    var dither = monochrome(imageData, 10,
"floydsteinberg")

    ctx.putImageData( imageData, 0, 0);

</script>

    </body>
    </html>
```