UNIVERSITY OF GOTHENBURG
SCHOOL OF DESIGN AND CRAFTS

# Swarming Abstractions

Sketching with a generative tool

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# Abstract

My exam is about the research, modifying and experimenting with an algorithm that shows alternative representations of a pre-defined structure. Through the algorithm we can find shapes that could have been omitted otherwise due personal experience.  My argument is that very simple models can be generated at an early stage of the design process to explore different alternatives that can be developed in parallel trough most part of the design process. I explored the possibility of producing raw representations that can shift the way we categorize information thus stimulating creative thinking and encouraging an iterative design practice.

# Introduction

If we part from the argument that creative ideas can be achieved trough the association and/or recombination of pre-existing knowledge to acquire new knowledge in a specific domain, we can deduce that the greater amount of significantly diverse concepts we can produce during the ideation phase of the design activity will give us a greater pool of ideas to break, reconfigure and refine into new ones because each new concept represents in one way or another a new form of knowledge. This means that all these new ideas will be creative or better than the former ones, but there will always be useful pieces of new information on such "mistakes".

However, experience tells us that generating a significant amount of ideas that are both valuable and substantially different could prove to be a difficult task. The reason for this is knowledge itself: prior knowledge dictates how we deal with new stimuli, it governs the way we handle new pieces of information and experience the world*(fig1).* Also, newly acquired knowledge could prevent us from contemplating other possibilities because of emotional attachment or self-imposed constraints. In some occasions, the time and effort spent on an idea makes it really difficult to let it go, to "kill our darlings". We get fixated around it. We can also fail to realize that the constraints that we deemed to be necessary at the beginning of the design process are no longer so due to a change in the paradigm. In other words, because of the evolution of a certain concept it no longer needs to be subjected to some of the initial limitations, and by leaving these, we inhibit a wider exploration of such concept.

fig1.*"Most people in time see a Dalmatian. Now, how could you ever see a dog if you didn't already have a mindset for Dalmatians? You cannot tell that there is a dog there unless you already have a template or mindset for a dog" "The interesting thing is that when I showed this same diagram to a South African person, he didn't see a Dalmatian. Instead, he saw a hyena — a different animal — looking in a different direction."*

From: " A genius within". Snyder, Allan. In "Learning and Creativity", Creativity and the Brain ed. Mario Tokoro, Ken Mogi (Singapore: World Scientific, 2007)

In every case, an issue seems to be the lack of ambiguity. We fail to see the problem from a different perspective, in a context free of associations. Our brain fights against the unknown and tries to stay within the familiar. It's easier that way. Take for example the difficulties that drawing a human face presents for most of us. It's a challenge because we don't draw what our eyes see, but instead we try to portray our pre-conceptions about what a face should look like in relation what is actually there. A known trick to bypass this is to view the face upside down, by doing so the face becomes un-familiar.

With the aid of generative algorithms we can find the unfamiliar. We can use them to find shapes, patterns and complex relationships that probably we would have not thought about other wise because of their atypical essence. We can discover new geometries based on current topologies or search for new topologies in new or pre-existing sets of points. I propose to use the algorithm as a generator of un-finished or rough ideas that will hopefully instigate something within the designer's cognition process for re-organization and development of new ideas.

My questions revolve not only on how technology in the form of generative algorithms can stimulate creative thinking, but also on how much knowledge do we need to benefit from them. Its easy to find and use algorithms designed by others, but it is true that without at least some understanding of both, limitations and affordances, instead of being liberated we can get constrained by them, as Abraham Maslow[1] said: "…*it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail"*. In this sense, If we see generative programs as creative tools, creating one requires a fair amount of mastery, but how much do we need to modify a tool so it suits are needs? With this thought I started to experiment with different available programs, from Grasshopper to Processing, within processing I found RibonKit, a Swarm Based form exploration algorithm, and it was with this program that I conducted most of my research.

[1] Abraham Maslow *"Psychology of Science - A Reconnaissance"* Chapel Hill, NC: Maurice Bassett Publishing (2002) pp15

# Creation of Ideas:
## Construction of Knowledge and Mental Sets

Creative ideas are achieved by two mental processes, one that retrieves information from memory and uses it to generate ideas, and one that evaluates if the ideas represent a valid response to the problem at hand[2]. Whilst the evaluation of an idea is subject to criteria defined not only by the nature of problem but also by personal identity[3], the generation of ideas occur by cognitive operations applied independent of context.[4] The three most common cognitive operations that allow us to combine and restructure knowledge to produce novel ideas are A*nalogy (*compare schemas)*, Combination* (combine schemas) and *Abstraction* (principles of organization, either to look for structure and organization or find the details)[5,6]. In the words of James William[7]:

> *"Instead of thoughts of concrete things patiently following one another in a beaten track of habitual suggestion, we have the most abrupt crosscuts and transitions from one idea to another, the most rarefied abstractions and discriminations, the most unheard of combinations of elements, the subtlest associations of analogy."*

Trough external representations, such as sketching, designers do more than externalizing inner imagery (commonly referred as having pictures in ones mind[8]), rather, both external representations and inner imagery collaborate to conceive new forms trough iterations of alterations and improvements[9]. Purcell and Gero[10] explain that exploratory sketches, often ambiguous and unconstrained, allow us to reinterpret them, leading to a new sketch or to access information from long-last memory, which leads to a new sketch. However, the way we access memory is not impartial: we employ cognitive bias in the form of memory shortcuts. While these shortcuts reduce cognitive effort, they also make us use generalizations for objects or whatever representation of such object first comes to mind. Because of this, subsequent

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2 Angela Ka-yee Leung and others. *"Multicultural Experience Enhances Creativity: The When and How"* American Psychologist, vol.63, no. 3 (April 2008) pp 171

3 Cora L. Dıaz de Chumaceiro "*Serendipity"* in Encyclopedia of Creativity. ed Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 2, 1999) pp .547

4 Hans Welling, *"Four Mental Operation In Creative Cognition. The Importance Of Abstraction*" Journal Of Creativity Research. (2006) pp 7

5 Michael D. Mumford "*Analogies*" in Encyclopedia of Creativity. ed Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 1 , 1999) pp .22

6 Hans Welling, *"Four Mental Operation In Creative Cognition. The Importance Of Abstraction*" Journal Of Creativity Research. (2006) pp 22

7 William James. "*Great Men, Great Thoughts and the Environment*". Lecture delivered before the Harvard Natural History Society. (Boston, Massachusetts: Atlantic Monthly Co, vol 46, Issue 276, October 1880) pp 441-459

8 John C. Houtz , Cathryn Patricola. "*Imagery*" in Encyclopedia of Creativity. ed Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 2 , 1999) pp . 8

9 Gabriela Goldschmidt, "*Design*", in Encyclopedia of Creativity. ed Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 1, 1999) pp . 534.

10 A. T. Purcell and J. S. Gero , "*Drawings and the design process"* Design Studies, Vol 19 ,No 4, (October 1998 ) pp 392

access to memory is limited[11]. Snyder[12] refers to these shortcuts as mind-sets: *"collections of sensory details that characterise familiar objects".* According to him, they can be understood as knowledge templates built on experience that let us navigate quickly in familiar environments, while these templates have many benefits for us in every day life, Snyder warns; "*they also blind us to novelty. We see what we know; we see only the whole, not the parts". (fig2)*

Another bias often experienced by designers is fixations. A fixation occurs when one adheres to examples or solutions that where use in the past[13]. We can also get fixated due to concept iteration, as Dow [14] explains; iterating around one idea can prevent us from finding -or even consider- alternative solutions. This happens because after spending time and effort with one idea we can become "*emotionally attached or mentally fixated to* it". Also, It has been proven that the way a problem is presented is enough to bias the solver, suggesting that even the presence of pictorial examples (such as browsing images to use as a collection of precedents, a common practice amongst designer[15]) can cause fixation in the search for effective solutions[16]. Complications arise when the examples sought don't represent a good solution for the problem[17], because we can get fixated to bad examples, not only good ones. Furthermore, we can become fixated to the typical function of an object and fail to use such object in alternative contexts, in this specifics

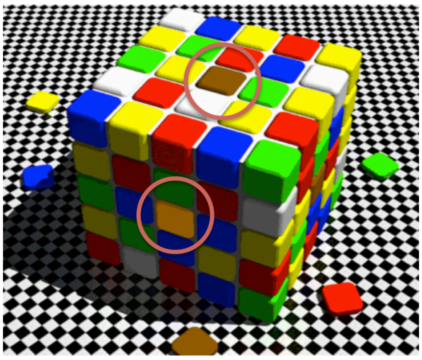
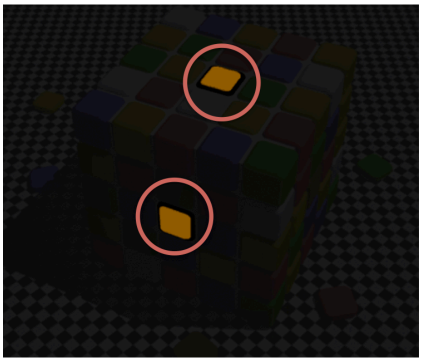


Fig2 *"The information in the image strongly suggests that the dark brown tile on the top means a poorly reflective surface under bright light, whereas the bright orange one at the side means a highly reflective surface in shadow. So you see them differently because your brain thinks they have a different meaning - given the rest of the information in the scene".*

From: R Beau Lotto. "The science of optical illusions". 18 october, 2010. http://www.bbc.co.uk/news/magazine-11553099



[11] Martin Hilbert. "*Towards a Synthesis of Cognitive Biases: Noisy Information Processing Can Bias Human Decision Making*". Psychological Bulletin, vol 138-2, (Mar 2012) 211-237

[12] Allan Snyder, "*Learning and Creativity"*, in Creativity and the Brain ed. Mario Tokoro, Ken Mogi (Singapore: World Scientific, 2007) pp. 6-10

[13] Evangelia G. and others. "*Following the Wrong Footsteps: Fixation Effects of Pictorial Examples in a Design Problem-Solving Task"* Journal of Experimental Psychology: Learning, Memory, and Cognition, Vol 31(5), (Sep 2005) pp1134-1148.

[14] Steve Dow, *"How Prototyping Practices Affect Design Results"* Iteration Magazine. (May-June 2011) pp54

[15] Céline Mougenot and others, "*Visual materials and designers' cognitive activity: Towards in-depth investigations of design cognition*". (2009)

[16] Evangelia G. and others. "*Following the Wrong Footsteps: Fixation Effects of Pictorial Examples in a Design Problem-Solving Task"* Journal of Experimental Psychology: Learning, Memory, and Cognition, Vol 31(5), (Sep 2005) pp1134-1148.

[17] Michael C. Frank, Michael Ramscar , *"How do Presentation and Context Influence Representation for Functional Fixedness Tasks"* Cognitive Science Society. (2003) Web: http://csjarchive.cogsci.rpi.edu/Proceedings/2003/mac/prof277.html (accessed march 2012) pp1

case, the bias is known as *"functional fixation",* which is correlated to the inability for divergent thinking.[18] (fig 3)

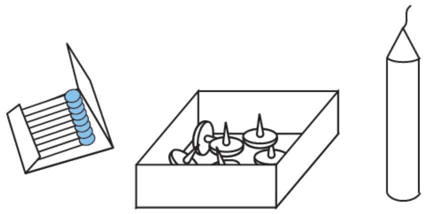
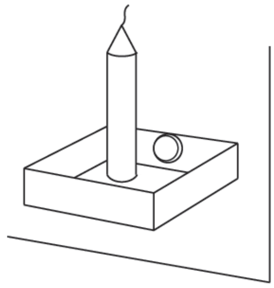
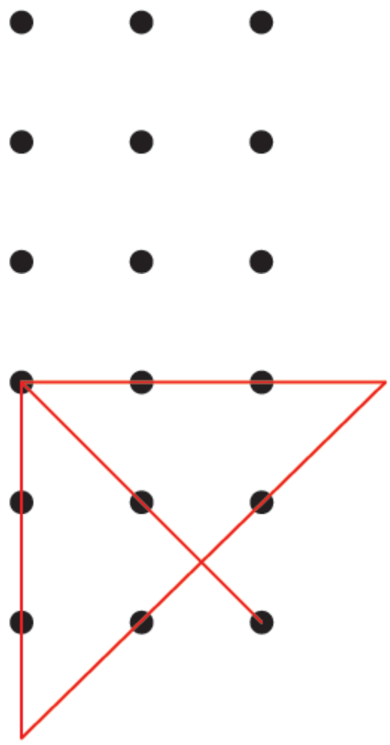


Fig3 A classic example of functional fixation; given the item shown above, how can you fix the candle to a wall and prevent it from dripping wax once is lit?



One last cognition bias that is worth to mention are implicit constrains. Constrains refer to the boundaries that define the search space for a solution. Explicit constraints are stated in the problems definition; implicit constraints, however, are self-imposed strategies, mental rules or assumptions of what should or should not be done despite such limitations aren't mentioned. The more we use implicit constrains the harder it is to supress them, until they become the *"only way"* to perform a task. Implicit constrains can be the result of prior experience, rigid interpretation of explicit rules or inductive logical reasoning. (fig4)

Fig4 Thinking outside the box; how can you connect all dots with only 4 straight lines without lifting your pencil?



In short, mental sets refer to the way we interpret problems, fixations to the way we get attached to solutions and constrains on how we delimit the search space; all of them reinforced by repetitive behaviour.

Research offers a number of options to overcome the for-mentioned cognitive biases and stimulate creativity. Some are aimed at the design process itself, such an iterative practice, the cross fertilization of ideas, deferment of critical judgment[19] or taking brakes from work. This last suggestion, known as *"incubation period"* not only may allow fixed ideas dissipate[20], but also prevents frustration and the feeling of "*being stuck*", known as impasse, which could lead to conformity or giving up on finding the solution. One last suggestion, the one that I find the most interesting, is to make the familiar strange[21].

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[18] Pro Bonson, Ashley Merryman. "*The Creative Crisis*". Newsweek (July 10, 2010) pp

[19] Richards J. Heuer, Jr. *"Psychology of Intelligence Analysis* " History Staff, Center for the Study of Intelligence, CIA, (1999) https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/art9.html (accessed march 2012)

[20] Rebecca A. Dodds, Steven M. Smith. "*Fixation*", in Encyclopedia of Creativity. ed by Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 1, 1999) pp . 727

[21] Gary A. Davis, *"Barriers to Creativity and Creative Barriers"* in Encyclopedia of Creativity. ed by Mark A Runco, Steven R Pritzker (San Diego, California : Academic Press, vol 1, 1999) pp 169

# Exploration for ideas:
## Generative Design

Hitherto we have explained two main ideas: First, that creativity can be achieved from the combination, comparison and abstraction of ideas; and that our capacity to generate ideas is conditioned and impaired by previous knowledge. We have also mentioned known "tricks" used by artists to overcome misconceptions and suggested that trough generative design we can do the same. But what that does generative design mean?

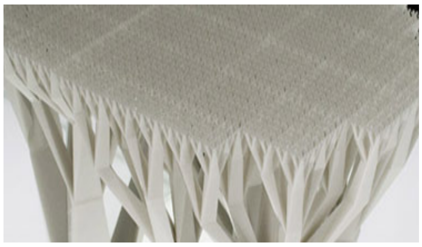

Fig5 Platform Wertel-Oberfell/ Matthias Bär´s "fractal table[1]" is produced trough 3D printing in epoxy resin from a singled pieced stereolithography, where tree-like stems grow into smaller branches until they get very dense at the top. An other example is CKR´s "snowflake table [1] " for Swedish furniture company Offect. The table top its designed by a recursive grammar to emulate snowflake patterns. Each pattern is unique and 2D cut with a CNC router. What is interesting in this table is that only one element of the table is unique, allowing for the standardization of parts, thus reducing costs and rendering it a feasible commercial product

Generative design **(GD)** refers to the use of generative algorithms in a design context. *"Its not about designing an object; it's about designing the system that designs the object"* says Hesselgren[22]." This means that the output is generated by a set of rules in the form of a parametric model or an algorithm that can produce a set of results. Hence making it a fast way to explore design solutions. One important aspect of generative design is that not all the results are useful or finished ideas, one has to produce a lot of output, assimilate it and select the best results, and most of the times, even do some post production work[23]. In this sense, the useful material is referred as signal, the useless, monotonous or incomprehensible material is referred as noise. In order to receive greater amounts of signal, one has to set constrains to the space that is to be sought since this space is infinite. However, an overly constrained space can lead to boring, monotonous results[24].

Fig6. An iconic example of evolutionary systems used in furniture design is the "bone chair" by Boris Laarman. With the help from Opel International, the automobile maker company, the bone chair uses Opel´s software- which they use to refine car parts to increase strength and efficient use of material- to mimic bone growth and how the body is able to add tissue where is needed and remove it when is redundant. The result is a chair with a peculiar personality where the minimum material was used to make it as light as possible.

Some of the most common generative algorithms found in design through which we can explore emergent behaviours and were relevant to my research are: shape

[22] Lars Hesselgren, *"Changing the face of Architecture*". BeCurrent magazine. (Vol 6, issue 3, sept-oct 2009) pp21
[23] Palle Dahlstedt, Mats G. Nordahl *"Living Melodies: Coevolution of Sonic Communication"* Leonardo Vol. 34, No. 3 (2001) pp243–248
[24] Robert Pepperell "*The Posthuman Condition: Consciousness Beyond the Brain*" (Bristoll, UK: Intellect Books, 1995) pp118.

grammars, self-organization, lsystems, and evolutionary algorithms.

A **Shape grammar** is a set of rules that apply in a step-by-step way to generate a collection, or language, of designs. of designs they are called "shape" grammars because their elements are points, planes, lines or volumes.[25] .

*Fig7. An example of reaction diffusion principles applied in product design is found on nervous-system´s "seed lamp", where coral growth is mimicked. The lamp can only be produced trough adaptive manufacturing, also known as 3d printing. This means that the product is not suitable for mass productions, but allows to each lamp to be different; sharing the same traits but not being quite the same, just as it happens in nature.*

**L-systems** are set of terminal and non-terminal symbols and some rules that define how non-terminal symbols generate strings of new symbols. They are useful to simulate some natural growing processes, like fungi, plants, or inorganic forms like crystals, or natural patterns. Since L-Systems are recursive processes, they are good examples of self-similarity, and are often considered a kind of fractals[26]. (fig5)

**Evolutionary Algorithms** (EAs) mimic the processes of natural selection and random mutation by "breeding", selecting and re-breeding possible designs to produce the fittest ones. The success depends on the specification of a parameterized model that is general enough to allow a wide variety of possible outcomes of interest to the designer.[27] Although many outputs will be discarded, after thousands of generations or more, useful features accumulate in the same design, and get combined in ways that likely would not have occurred to a human designer[28]. (fig6)

**Self-organization** systems consist of large numbers of simple, autonomous components that combine to construct large-scale artefacts or may interact with one another to solve problems collectively.[29] Examples of self organization, reaction diffusion models and flocks. (*fig7*)

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[25] Terry Knight *"Shape Grammars in Education and Practice: History and Prospects"* Massachusetts Institute of Technology, (1999 ) http://www.mit.edu/~tknight/IJDC/ (accessed april 2012)

[26] Umberto Roncoroni "*LSystems Tutorial For Artists*" (august 2008)

[27] Jon McCormack, Alan Dorin, Troy Innocent "*Generative design: a paradigm for design research"*. Monash University, Centre for Electronic Media Art (2004) http://www.csse.monash.edu.au/~jonmc/research/Papers/genDesignFG04.pdf (accessed april 2012) pp5

[28] Paul Marks. *"Evolutionary algorithms now surpass human designers*" NewScientist Magazine (28 July 2007) pp.26-27

[29] Jon McCormack, Alan Dorin, Troy Innocent "*Generative design: a paradigm for design research"*. Monash University, Centre for Electronic Media Art (2004) ) http://www.csse.monash.edu.au/~jonmc/research/Papers/genDesignFG04.pdf (accessed april 2012) pp8

# On Both

Iteration refers to the exploration of one concept, while parallel prototyping encourages the simultaneous exploration of many concepts.[30] A key benefit of parallel prototyping is that multiple ideas allow cross-fertilization. But how can we arrive at multiple creative ideas?

Trough visual stimulation is possible not only reinterpret the physical structure of a concept, but its telos as well. However, such images need to be close enough to our mental representations of what is possible so a relationship can be established, and far enough so a conceptual change can occur[31]. With the use of Generative Algorithms one can find unexpected results within a specified context, the only problem is that most of these results represent finished solutions, despite the considerable amount of clean up that sometimes is needed, which means that they leave no room for reinterpretation. This happens not because GAs only work that way, but because for the most part they are designed that way. What can be expressed through the use of GAs is deriving into a new aesthetic style, one that Schumacher calls "*Parametricism*"[32]. I, however, will try not to constrain the algorithm to a desired style or language, like those in favour for shape grammars do, nor embrace this new style. What I want to do is to take the results given by the algorithm and reinterpret them within my own idiosyncrasy as the design process advances.

[30] Steve Dow, *"How Prototyping Practices Affect Design Results"* Iteration Magazine. (May-June 2011) pp58
[31] Luigi Anolli and others *"Accessing source information in analogical problem-solving"* The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 54:1, (2001) pp237
[32] Patric Schumacher. *"Parametricism as Style- Parametricst Manifesto".* Paper presented and discussed at the Dark Side Club, 11th Architecture Biennale, Venice 2008

# Goals

I believe that very simple models can be generated  early in the design process as a mean to explore different alternatives where work can be done in parallel with the selected alternatives until the very end. I want to explore the possibility of producing raw representations that encourage an iterative design practice.

For the most part, the strength of Generative Design resides in the capacity to produce formal structures for products in ways that are not only difficult to conceive, but also to reproduce. Its convenience becomes evident with the up-raise of adaptive layering technologies and CNC manufacturing that allow for intricate shapes to be created, mass customization be exploited or "individualization" or "uniqueness" marketing to be employed.

However, I want to find a method for working with generative design where the outputs do not necessarily depend on expensive manufacturing machines. While rapid prototyping allow for seemingly impossible shapes to become real, and CNC opens the door for mass customization, they are both either constrained by the scale of the work or the cost of fabrication.

Also, if I spend so much time working with computers, isn't it relevant to explore the way of creating my own tools thus waning the dependency on the ones available? Just as furniture designers make jigs for cuts that are either impossible or unsafe within the default settings of a machine, a designer who uses the computer as his main tool would not benefit by the ability of producing its own virtual jigs for the same reasons?

# The Work

Driven by the concept of emergence, the first attempts of form exploration with generative algorithms started with grasshopper. Grasshopper, a plugin for Rhino3d, is *"a graphical algorithm editor."*[33] It can be understood as programming, but instead of writing strings of code, you drag, drop and interconnect components in the form of geometries (e.g. points, lines and solids) actions (e.g. arithmetic operations, functions, Booleans) or visual aids (e.g. data lists). This graphical interface makes it rather intuitive for someone used to 3D modeling and totally alien to programming. Once I got the basics of the program and experimented with modularity I realized the limitations of the program *(fig8).* For instance, recursion and looping – common operations in generative algorithms- is limited. It's not possible to do it natively, but you can either write your own scripts or use someone else's. Since I was still learning the basics of rhinoScript I opted to experiment with "Rabbit" -a bundle of scripts written by Morphocode[34] that facilitates cellular automata and L-systems.

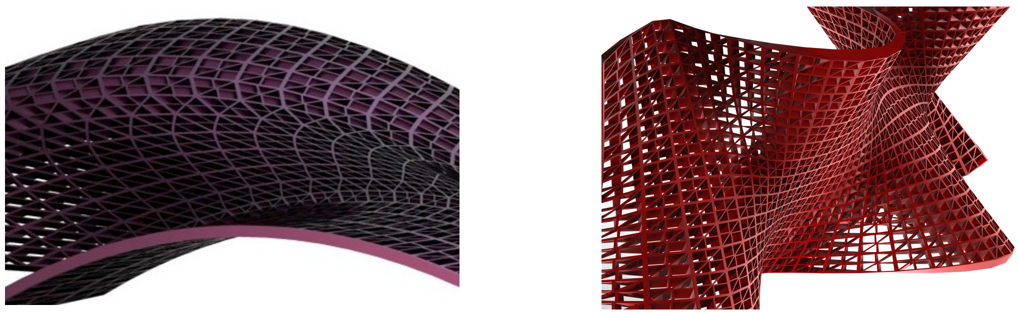


*Fig8.* An example of an early modularity exercise with grasshopper. The module is place over a divided lofted surface. If the surface changes it gets updated with the same module. If the module changes, the surface gets updated with the new module. Different modules can be placed at controlled intervals

Soon thereafter I encountered a new problem. After a couple of iterations data starts to accumulate and the architecture of Grasshopper can't handle the complexity of the operations or the floating information. Because of this I decided to use a second program that can interact with rhino trough grasshopper: Processing.

Processing is an open source programming language for artists and designers with the purpose of teaching the basics of computer programming in a visual context. One of the stated aims of Processing is to act as a tool to get non-programmers started with programming, through the instant gratification of visual feedback.[35] Once I started to learn processing I discovered a thriving community of users willing to spread their knowledge in the form of finished sketches

[33]Grasshopper: gnerative modeling for rhino. http://www.grasshopper3d.com/ (accessed april 2012)
[34]MorphCode http://morphocode.com/work/rabbit/download/ (accessed april 2012)
[35] Ira Greenberg, "*Processing: Creative Coding And Computational Art*" Berkeley CA: Apress (2007) pp.8

(the name for the programs written in processing) or answer questions in online forums. It was trough this forums that stumbled upon RibonKit, a sketch written by Architect Yiannis Chatzikonstantinou.[36] About the sketch, Yiannis describes:

> *"RibonKit can be thought of as an experiment that attempts an interpretation of abstract networks of relationships and swarm behaviour, to potentially corresponding materials organizations.*

It works as a swarm of insects. Each insect has a predefined life span and purpose in life, to reach the next node in the chain whilst still having interaction with the other insects based on flocking rules. The chain is form by a set of 3D points connected to each other by a Minimum Spanning Tree (MST), which refers to the shortest way to interconnect all points. As the insects travel to their destination, their path gets traced and this influences the behaviour of other insects. *(fig9)*

With RibonKit I found exactly what my goal was: A way to explore a wide range of possibilities within constrains that can be promptly re-defined. However, Ribonkit, as Yannis originally wrote it, needed some refinement to work in the context of furniture design. Adding points and moving through de 3D space, is quite difficult, this makes it almost impossible to have any degree of control over the position of the nodes and the structure that is formed. The structure is relevant because this is what dictates the objectives of the agents.

*Fig9.* Ribonkit's control panel.

Therefore I started to modify Ribonkit and renamed it *"Ribonkit_VG"* or RVG for short. My first objective was to use RVG with Grasshopper, where information between them could be exchanged. In this sense Grasshopper would send a list of points to RibonKit, then RibonKit will take this list, read the items as as nodes and send the agents to their respective goals. Once an interesting structure was found I would export this structure as curves back to rhino, so it could be reinterpreted and based on the results of such analysis, evolve the initial point list to repeat the whole operation. Because the nodes are connected by a MST, continuous deformation from a sphere seems possible once the geometry is parsed into Grasshopper, however I was never successful.
However, I realized that the interesting aspect of the emerging structures was not only in their formal aspect, in terms of spatial

[36]Yiannis Chatzikonstantinou, "RibonKit" http://www.volatileprototypes.com/projects/ribonkit/ (accessed on april 13th, 2012)

relationship; but there was also something really appealing in the visual aesthetics of swarm. It was almost like a sketch! *(fig10)*

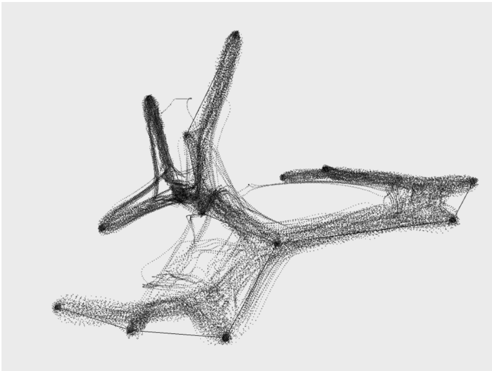


Fig10. This is a screen shot of RibonKit. The "sketchy" style of the program is evident, something unusual to find amongst different 3D programs. The panel on the left presents the different options to interact with the

With RVG the quick search of possible solutions could be explored in the shape of un-finished sketches or scribbles. Sometimes, the scribbles would be really ambiguous, allowing for a great deal of reinterpretation and re-structuring, other times the sketches would be well defined and proportioned, restricting re-interpretation but serving as inspiration and allowing direct analogy. Whatever the case, if a behaviour was found interesting each variable could be controlled to achieve refined results. AS Goldschmidt[37] points out:

> *"A sketch's 'backtalk' provides more information than was invested in its making, as random relationships on a sheet of paper (or on a computer screen) suggest new possibilities that the designer is invited to discover and make use of using imagery, subjects combined given shapes into practical objects"*

Even though of chaotic and orderly behaviour can be perceived between one configuration to the next by (drastically) changing just one variable thus allow to search in several directions, in RVG is necessary to have a goal in mind, since the program depends on an initial sets of points and those correspond to a representation of such problem. In other words, If we are looking for a table, at least 8 points (such a those that form the vertices of a cube) should be drawn, but from there, the scribbles can be vague descriptions of something rather diverse In RibonKit the search space is defined both by a set of nodes placed in the 3D world and a graph from this set which defines the goals for the agents. Changing the position of a node just a small amount can drastically change the whole global behaviour. However, whilst removing nodes is rather easy since, adding them with precision is not.(fig11) To have greater control of the program and the possibility of achieving more interesting results I performed several changes to the source-code of the program.

[37] Gabriela Goldschmidt "*Design*",, in Encyclopedia of Creativity. ed by Mark A Runco, Steven R Pritzker (San Diego, California: Academic Press, vol 1, 1999) pp534

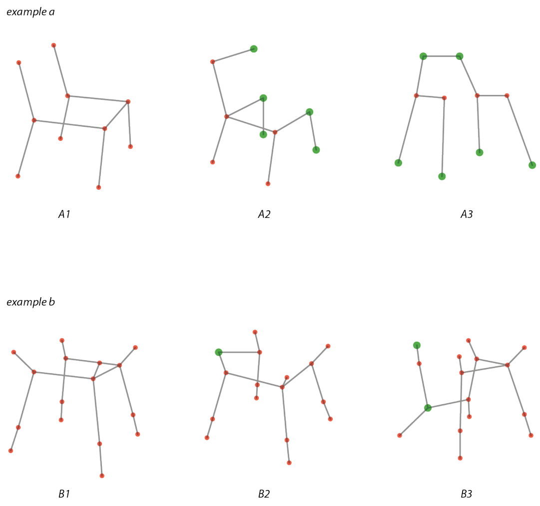



Fig11. Two examples of initial set of points defined in Grasshopper. They are connected to each other trough a MST. Modifying the position of one point can change the spanning tree. It might be a small change as in example A or a drastic change as in graph B. This becomes useful for the emergence of novel structures. It's important to notice, that the way the vertices are interconnected deeply affects the system, since the agents goals in RKG is define by the node they are born from and their connected neighbours.

My first objective was to establish a connection between Grasshopper and Processing so accurately drawn points could be parsed. The result was partially successful. Even though the program could be initialized, once I tried to move a node in Grasshopper and have a live update in RibonKit, the later would crash. Due to time constrains, I had to conform to export the coordinates of an array of nodes as a text file. Once I had this, the second step was to add a "randomizer", a command to arbitrarily change all the possible variables (there are 9 of them, fig9). With this, the control is taken from the user, thus avoiding manipulation towards a favoured aesthetic configuration and enabling a broader search.

The third change was the background, from grey to white, and the paths drawn by the agents, from a set of points to lines, this was done to reinforce the feeling of a "sketch". Then I added a ground plane. However, this change was dismissed since I realize that getting "lost", (not knowing from which angle you are looking at the sketch or what is up or down) is better for exploration purposes. On the same line of though, I disabled the rendering of the edges constructed by the MSP. Afterwards I introduced a command so screen captures of the swarm could be saved in a folder. From there I introduced the possibility to bring extra geometry from grasshopper and the ability of the agents to detect such obstacles was introduced. The behaviour is still in the code, even though tests showed that is of little use. The goal is to have obstacle avoidance, not only detection. The last change that implemented was the possibility to switch the graph from MSP to a complete graph, where all the nodes are connected to each other.

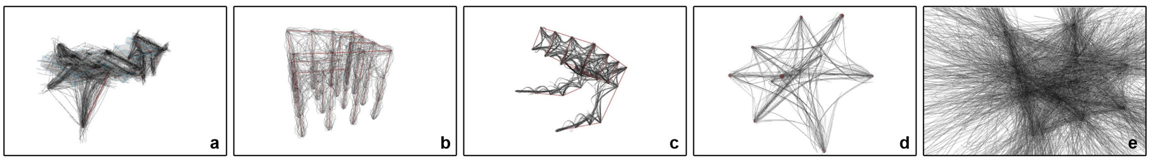
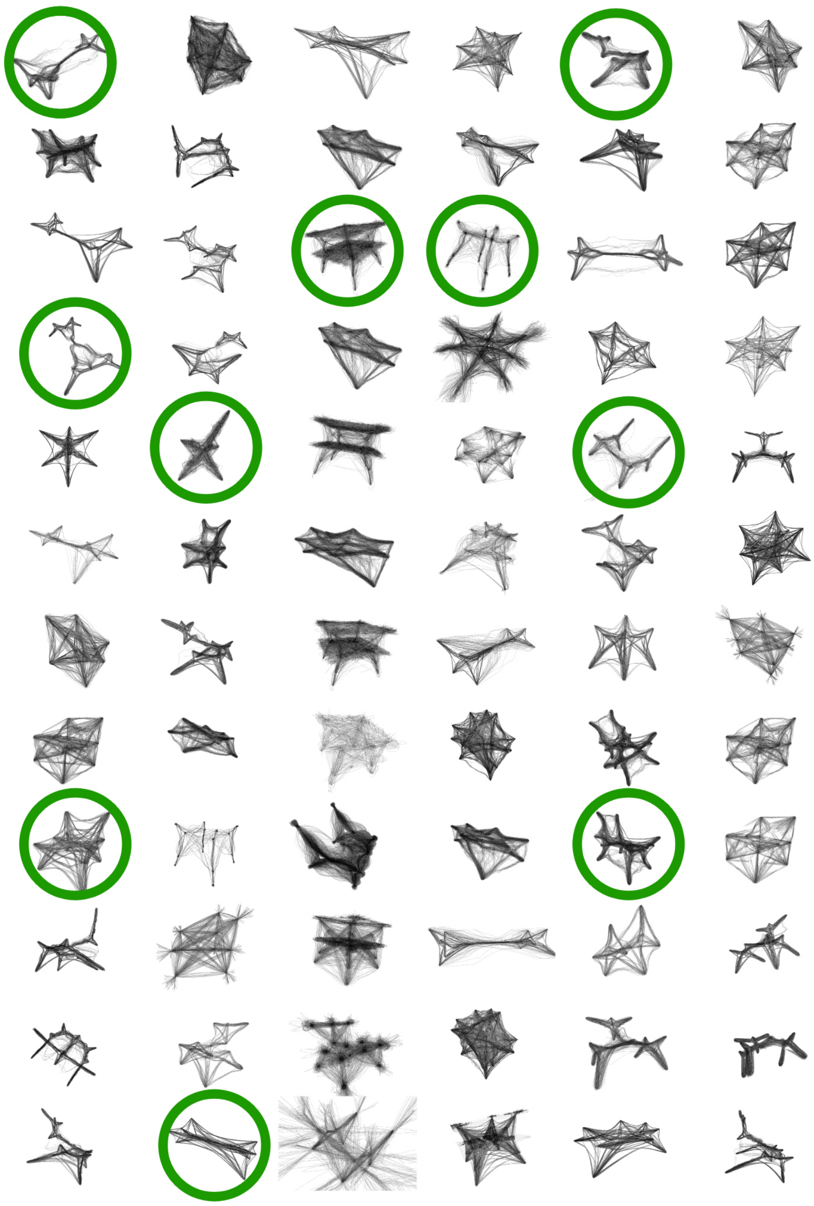



Fig12 These are my first results with RKG. In (1.a) I imported boxes from grasshopper. In this case, the agents don't acknowledge their presence and run right trough. I eventually dismissed this feature because I never got to control the way the swarm interacts with the rest of the environment. I found that to work with to many points would barely ever result in interesting behaviours, this is shown in (1.b) and (1.c). In the later, however, I reduced the points at the bottom and kept the ones on top. The image shows how the MSP algorithm would build edges in unexpected ways, sometimes that would be good, sometimes frustrating. Frame (1.d) demonstrates that for the most times, working with the least amount of nodes gives the most interesting results. Frame (1.e) is an example of "noisy" chaotic material, material.

Once all this changes where implemented or discarded, I let the program run. After a couple of hours I had over a 1000 different sketches. As was expected most of thme where noise, both in the form of monotonous and incomprehensible material. *(fig13)* From all the results, I selected 10 that served as templates for further concept development. Some of the selected sketches where substantially different, some are frames from the same genome, only taken from a different angle. In all cases I saw some particularity that set them apart while still being interesting, and from these, references to different materials, scales, processes and objects were called upon from a repertoire of memories. From there I started to sketch and experiment towards a piece of furniture.

Fig13 These are some of the results got from the program. The selection process is quick since most of the noise was redundant material. Circled are the sketches that were developed further.



For a couple of days I sketched aimlessly, just inspired by the images taken from RKG. Tables, chairs, low chairs, sofas, and benches where the result of this time of exploration. However, it was thanks to a short tutorial meeting with Swedish product designer Peter Andersson that a clear idea sprung. He thought that the aspect of the sketches reminded him of wire and suggested to work with it. I follow his advice and tried to “sketch” with wire in 3D, but soon it became evident that a great amount of technic was need to shape the wire towards a desired intention. But there was an interesting look to the results. So instead of dismissing the wire idea y tried to find a way to control it by filling up the hollow parts. I wrapped the wire around a turned piece of wood. The complexity of the shape did not translate well trough the wire, so simpler shapes where needed. At this point I believed that I was into something, so I stopped testing with wire and went back to the drawing board, but this time with a clear goal.

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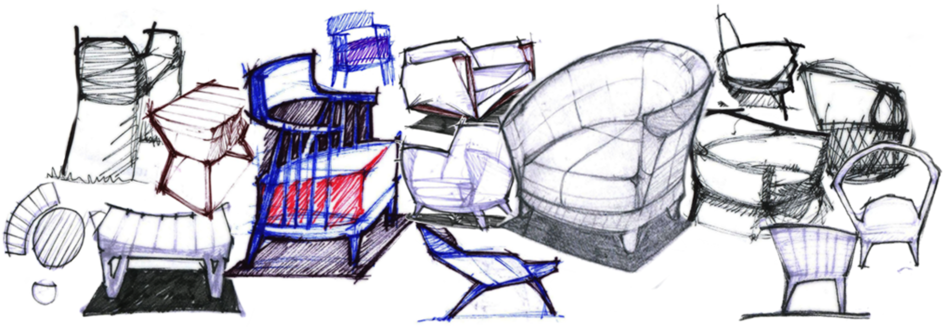


Fig14 First exploratory sketches based on the results that interested me the most from RVG

It was time to make a decision: what kind of furniture to make? Because of time constraints I decided it should be something that wouldn’t require much testing and where ergonomics wouldn’t become an issue. For me it came to 3 possibilities: a bench, a stool and a table. I sketched around all three options fro a couple of days, but in the end opted for a bench since I believed that it would have the better scale for exhibition, would only need one, as opposed to a stool and would allow more artistic freedom as opposed to the bench

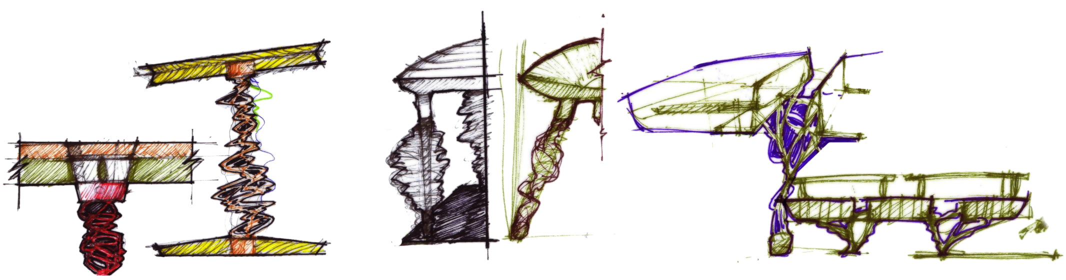
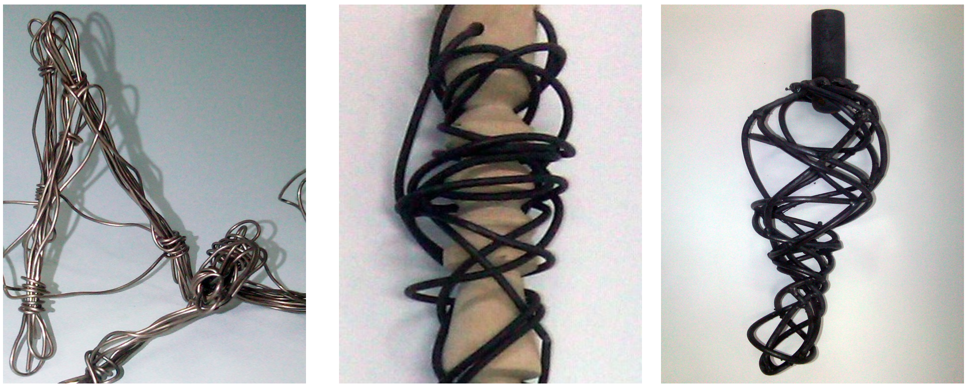


Fig15 Examples of table, stool and bench sketches

The first thing was to define the legs of the bench, since it could be said that they were the most interesting aspect of the project and could drive the rest of the design. I decided to use cabriole legs. Felt that simpler legs could pass unnoticed, plus the movement of the shape and the randomness of the bar could give interesting results (fig16). For the wooden top I sketched extensively different profiles and made two mock-ups, both to test proportions and aesthetics. In the end I decided to go for a simple looking top with no upholstery and a nice detail where the metal and legs meet.



(Fig16) The idea started with a suggestion of working with wire. After some experimentation it became evident that due to my lack of expertise, working just with my hands would be extremely difficult, so first I tried a lathed piece where wire could be wrapped around and ended up with an abstraction of cabriole legs.

The end result is a wood bench in maple with the legs made from 6mm thick metal rod, sand blasted and treated with Chinese oil to get some nice movement and reflections. The dimensions are 140 in width, 45 in depth and 45 in height.

# Conclusions

Generative algorithms provide more than fiddling around with given variables to explore the pre-defined space. It fosters a deeper understanding of the target's teleology since this is needed to define the boundaries of the possible in an acceptable way. Again, acceptable in the sense that the limits are specific enough to produce understandable results but broad enough to allow ambiguity and reinterpretation. The relationship between definition an ambiguity has been stress throughout the present document because that is in fact a key aspect of creativity, as Gero[38] points out, creative design is about disturbing schemas to produce new results that can be understood in current or new contexts.

Recurrent was the question regarding the use of generative algorithms for creative work, of whether computers can be creative or not and whether the designer is being creative or not. For the former question the answer is not yet. Sims[39] explains that anthropocentrism might be the reason why most people doubt the possibility of machines capable of producing creative work. With the same disbelieving spirit Norman considers that computers can't have the abrupt and erratic processes of thought in which creativity relies to emerge, and argues that while able to bring terrific incremental innovation, they will never be capable of brake trough innovation[40]. While failing to give a concrete answer or taking a position but leaning towards a possible affirmation, Reperrell[41] timidly says:

> *"One could anticipate that an effectively creative machine would require several properties, including sufficient complexity to produce emergent global behaviour, access to rich data, and the capacity for adaptation, learning and mutation."*

Computers can create, but can they evaluate? When generative algorithms are employed in sciences the evaluation parameters are well defined, thus allowing the computer to select the best results. In artistic work, the evaluation is left to the artist; computers are capable of generating unexpected, odd and sometimes interesting material, but it's our capacity to evaluate, (confronting schemas) what makes the work creative. Design, however, is not exclusive to arts or science, since it's generally considered a convergence of both. For me to answer how and to what extent can generative algorithms evaluate the appropriateness of a solution in design will require a deeper understanding of the design process and the algorithms themselves. Non the less, its important to mention that sometimes optimization can lead to its own aesthetic expression, as in the case of the *"bone chair*". *(fig6)*

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[38] Dow, Steve. *How Prototyping Practices Affect Design Results*. Iteration Magazine. (May-June 2011). pp54
[39] Karl Sims, *"Genetic Images"* (1993) http://www.karlsims.com/genetic-images.html (accessed april 2012)
[40] Don Norman. "Desing without desingers" (7 oct 2010) http://www.core77.com/blog/columns/design_without_designers_17587.asp (accessed april 2012)
[41] Robert Pepperell "*The Posthuman Condition: Consciousness Beyond the Brain*" (Bristoll, UK: Intellect Books, 1995) pp130

Is the designer being creative or not? That depends on the roll of the designer and the algorithm itself. If the roll of the designer was to write and implement the algorithm, then yes, providing that the results are both novel and relevant. If the designer is using a given algorithm, it will be most likely that no, since two users with the same algorithm will certainly achieve similar results[42]. In the case that creative work is in fact achieved, then both designers, the user and the programmer, should be considered co-authors of the creative work.

Am I being creative with RibonKit? Yes, even though the algorithm is not from my authorship and that anyone else using the algorithm can certainly obtain similar results, what I do with the results is what could develop into creative material. The outputs given by RibonKit are not finished results, they are just contextualized and original sources of inspiration that can be taken literally or can be reconfigured into something new. In other words: the outputs from RibonKit are not the culmination of the creative process, but just part of it.

However, had I not learned at least the basics of programming in processing, I doubt the program would have been of any use to me. But how much knowledge do I need? Mastery is said to take up to 10 years, this would mean devoting a good part of your professional life to the mastery of one tool when designers also need to develop many others. Whilst a good understanding on the principles behind programming is necessary, that is all one needs to get started. With a good understanding a designer can grab other free source codes and modify them, take ideas from other designers and implement them, or develop a sound understating of what it is that he needs and whether its possible to do it and then, seek out for help by asking concrete and well structured questions. With this I am not undermining the value mastery and its importance becomes more than evident with the shortcomings of the changes I tried to do to RibonKit, but saying that is indispensable could be discouraging to inexperienced designers. In my case, by the experiences with RibonKit V2, there are a number of implementations that I tried but failed, such as bringing and modifying nodes from grasshopper, having several graphs at the same time, having several swarms at the same time, different weights on nodes, different graphing methods, the possibility to freeze a graph so points can be moved while maintaining the same structure, clustering of nodes, changing behaviour from agents depending on the proximity to specific nodes and implementing obstacle avoidance. All these changes to the program will greatly decrease the chances of getting predictable results, but will increase both the complexity in defining a stretched search space and the amount of noise derived from this. Finding the right balance between complexity and predictability requires a heuristic approach. As the program is now, the results can become predictable, but with such changes, the program could be used to generate concepts and to iterate them with more control and possibly even focus on peculiarities or details.

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[42] Peter J Bentley "*Evolutionary Desing by Computers*" (San Fransisco CA: Morgan Kaufmann Publishers, 1999) p276

# Addendum

Before sending the report to the opponents I tried to write as little as possible about the piece that was to be presented at the examination. The reason for this is simple: I didn't want the opponents to focus too much on that piece, which is just an example of a bigger, more complex and, to a degree, flawed idea. What I wanted from them was to reflect and critique such idea and unfortunately they barely did. By the time I sent the report I kept working on three different fronts. 1) The theory behind my exam. 2) The Program. 3) The object. The difficult part was to find the right balance of the time spent between working with the program – making changes to it as I saw fit while actually using it- and working on a final and tangible piece, one to which not only the opponents, but pretty much everyone else at Steneby could relate to.

Its important to mention that the theory was not to support my ideas, but to shape them and steer them. Still today there is a lot of reading material in my *to do list*, and the more I read, the more I realize that my exam is years away from competition, that the results are wrong, but that the base could have some potential. For me, my exam can only be properly evaluated by considering all of the forth mentioned fronts.

If we are to judge my exam by the program I have certainly failed. The program is not bad, but is not mine, and the changes I made to it are minimal, important yes, but small non-the less. In a way, they represent not more than a couple weeks worth of work for a student in, lets say, C+Arts at Valand.

Is my exam about the finial piece? Certainly not. There is a lot that can be criticized about the bench as a design project. Not only on the way it looks, but also on how is made and how is supposed to be used. The truth is that I did not spend much time working on this part of my exam, and as a design process is lacking so many things. There was not a design process behind it, no initial constrains, no research, no nothing at all and just the amount of resources it takes to make the legs is outrageous, thus rendering the bench an art/craft piece *(a really poorly made one)* and not a design one.

And as a research paper…well, as I said before, I have more sources on my hard drive that I didn't read than those that I did. But once we put research, program and object together, they strength each other, they make sense of each other. Based on the premise that sketches do more than show information, but also lets us handle, categorize and retrieve information, my argument is that a generative algorithm that makes sketches can help to speed or enhance the creative process. But does it? As it is now, just a little. The time necessary to write it (even if you are really good at it) does not justify the quality of the solutions given, because after a couple of iterations the results become predictable and un-predictability is the aim. And to design a new algorithm for each project is more expensive than just sit still and wait for the *"aha debris"*.

And interesting debate between Palle Dahlstet and Per (**add last name)** sprung in the middle of my exam regarding this issue, with Pear arguing what I just said, and Palle taking the opposite side, and by doing so, seemingly trying to defend my exam but in reality defending his own profession. I don't agree with neither and yet concur with both. Per had a point when he said that "in the real world" designers don't have time to spend in writing a program, but failed to see that my attempt was to design a system that could be used over and over.

He also argued that with the system, I was trying to bring more stimuli into the design process, and that I should strive for less. In this sense I perhaps failed to make clear in the report the importance of finding the right balance between noise and output, that is, useless and useful material, and to what extent too much useful material becomes useless. But I am absolutely positive that new stimuli will help us most of the times. Finally, there was some discussion about the way the actual look of the bench, and I agree with Per that something is a bit off with the top, but I am yet to find what, I don't think that painting it black, as suggested, is the answer though. I sketched a lot around the top of the bench, and made 3 different mockups to test them. My first intention was to go for a burlesque, but it just was not working. Still today I think that that is the way to go, but further iterations are necessary. One excellent comment from Per was to always think about the context, or the space, when working with furniture, and advice that I´ll try to always take. Sadly, I did not get any useful comments or questions from the rest of the opponents, one of the actually admitting that did not read the paper because she could not understand the title.

Today, I don't really see my exam relevant to my immediate future, but I do see some possibilities for the future. Now all that is left is to keep studying. There is a lot of reading to do about knowledge, sketching, creativity and design process that I will have to do on my free time combined with tutorials in processing, all this just to be ready for the time when I need this knowledge.

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Fig 1 - "A genius within". Snyder, Allan. In "Learning and Creativity", Creativity and the Brain ed. Mario Tokoro, Ken Mogi (Singapore: World Scientific, 2007)

Fig 2 - From: R Beau Lotto. "The science of optical illusions". 18 october, 2010. http://www.bbc.co.uk/news/magazine-11553099

Fig 5 - Fractal Table by Platform Wertel Oberfell. http://www.dezeen.com/2008/06/13/fractal-table-by-platform-wertel-oberfell/

Fig 6 – Bone Chair by Joris Laarman. http://www.jorislaarman.com

Fig 7 – Seed Lamp by Nervous Systems. http://n-e-r-v-o-u-s.com/

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