THE SELF-ORGANIZATION OF STUFF

Msc Thesis - TU Delft
Architecture - Studio Explorelab
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NOVEMBER 20
24h
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DECEMBER 5
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Mirach
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Alderamin
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Mizar
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PREFACE

This thesis is written as a part of my graduation project at the faculty of Architecture, Urbanism and the Built Environment at the TU Delft. The very first class of my master's studies, that took place at the University of Technology in Sydney, started by covering the somewhat unrelated skill of coding in Python. At first sight, this seemed useless. As soon as dots, lines and planes slowly and stutteringly unfolded on the screen, however, I was immediately fascinated. The computer showed that by introducing such a simple and ever-present dimension, that of time (or in coding: iteration) to the design process, basic rules could generate endlessly complex patterns, simulating natural processes much more than stupidly copying them. Time-based architecture, in combination with a love for theory, has since been the theme in my studies.

This research is the middle one of three larger projects on this topic. It is the follow-up on a theory thesis that explored the act of building in relation to duration, the idea of time as a driving force behind all form. Most importantly, it will be the basis of the final design project of this master's. The idea of creating *in* time instead of against time, is theoretically so logical and fascinating, but can also be a hurdle when designing. Where to start drawing when everything is a process?

The answer to this question is, of course, that we can only tell when we know what those processes are. This research aims to contribute to making these explicit, and to do so, starts from small beginnings.

Stella Elisabeth Groenewoud, 5-10-17

CONTENTS

SUMMARY

This research studies the phenomenon of the crystallization of stuff. The common description of the configuration of stuff in a room, one of order (tidy) and chaos (messy), fails to explain that artifacts create functional connections and concentrate around activities in a structured way. This form of organization, that is recognizable in various scale levels, emerges spontaneously in the system, without the conscious intention of ordering.

Following the growing insight in different disciplines that a theory of complexity can more adequately describe real-world phenomena than the classical causal-mechanistic model, a theory is proposed in which a third state, one of self-organization, is added to the order-chaos dichotomy. Stuff systems are considered complex systems, whose global patterns and properties unfold in time, generated through local interactions between the parts. When projecting models that describe complex system dynamics on stuff systems, much of what we observe in a house can be explained, such as the rise of order parameters structuring the parts, life cycles of accumulation, growth, restructuring and renewal, and interdependencies across scales.

The problem here, is that the constant reconfiguration of stuff can only be explained through interaction with human beings, but does not solely follow a path of top-down design. A theory is proposed that links the self-organization of stuff to action identification theory. This theory from psychology explores the cognitive construct of the action ("what one thinks one is doing") as an order parameter filtering incoming information and thus structuring behavior. This action identity is both constructing and constructed by the action, and thus follows a process of self-organization. As the arrangement of stuff is the creation of action possibility, and these action possibilities (or affordances) are also what is perceived, stuff-configuration is a phenomenon of the same kind. Action

identification and affordance creation act in parallel and can be considered a doubly complex system.

Action identification theory holds that action is in principle maintained in accordance to the prepotent identity, unless higher levels - more abstract and encompassing multiple lower levels - become accessible. This can be triggered both internally (by thoughts) and externally (by stuff in sight). Affordances are thus created through an oscillation between both searching and stumbling upon, something that can be recognized in the patterns observed in a house.

When the most characteristic scale of self-organizing stuff, the stuff cell, is dissected, the form is found to be ordered by a central working field that corresponds with the prepotent action identity. The physical form of a stuff cell thus develops in similar leveled (panarchic) steps, constantly self-organizing into more abstract and encompassing working fields.

To conclude with, three promising paths of thinking are discussed that can link the self-organization of stuff to its surroundings and therefore to design. The first suggests that the recognition of complex system dynamics across the scales of stuff, services, structure and skin, aided by explanatory models and a relevant vocabulary, gives the possibility to perform targeted interventions. The second introduces the use of patterns both as a tool of analysis and as a way to generate complex imaginary stuff configurations during the design process, in order to make explicit decisions. Lastly, stuff cells are discussed in relation to conditions, where a similarly self-reinforcing process is recognizable. Especially the parameter of publicness is one both defining and defined by the organization of stuff, and therefore can be understood as not only dynamic, but creating complex patterns over time.

INTRODUCTION

i.

INTRODUCTION

Most grown-ups, especially those who went to primary school in the 1970's, will remember having seen one of the animations inspired by the 1957 book *Cosmic View: the universe in 40 Jumps* by Kees Boeke in their classroom. The most famous amongst them is Powers of Ten, written and directed by the designer pair Charles and Ray Eames in 1977[1].

Accompanied by beautifully old electronic music we see two people installing themselves for a picnic in the park. Starting from the man, who is just about to peacefully fall asleep, we zoom out until their picnic cloth is a square in a giant field of green. We zoom out further until the lakeside park is seen between the slices of infrastructure of the city. Then 'we see the great city on the lake shore', the whole of the Chicago city grid pushed onto the Michigan Lake. The city quickly transforms into a tiny dot on the continent, the Earth into the head of a pin within the Solar System and the Solar System into an unrecognizably small point within the Milky Way.

Left - Illustration of Powers of Ten - picnic at the Chicago lakeside park. By author.

1 Earlier similar movies include 'Cosmic Zoom by the National Film Board of Canada (Verral & Koenig, 1968) and Powers of Ten, the first (black and white) sketch by Charles and Ray Eames (1968).

This dazzling movie, both fascinating and slightly frightening, illustrates the idea that the whole of nature exists of systems. The planet, Solar System and the Milky Way, and when halfway through the film the man's hand is zoomed in on, an organ, cell, nucleus and molecule; all are unified wholes, centered densities of interacting particles that to a greater or lesser extent have the ability to maintain themselves. Every system is a particle of another, which is a particle of yet another. This exponential scale succession is named a *panarchy* by the ecologist C.S. Holling - a 'hierarchy' of systems, though without any higher or lower positions, embedded in each other and interlinked in continuous adaptive cycles of growth, accumulation, restructuring and renewal (Holling, 2001; Gunderson & Holling, 2002).

When looking at a series of stills from Powers of Ten, however, it is the man-made middle part of the scale-sequence in which the existence of wholes is less obvious. The series of forms, roughly in between the shape of the coast line and the two people's bodies, is defined by lines, drawn to form arrangements (Tversky, 2016). An ellipse divided in compartments arranges sports supporters visiting a match, and logically organizes them by club and ticket grade. Jetties arrange the moored ships by size and owner, and the highway arranges the cars in lanes by speed and destination. The horizontal and vertical lines constructing these alignments, that in Chicago even appear to lie perfectly parallel and

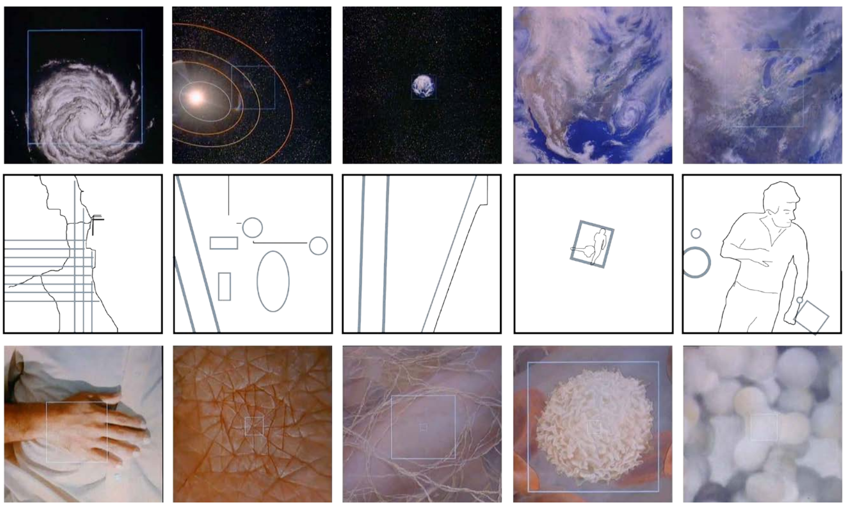


Fig i.1 - Sequence of stills from *Powers of Ten*. The man-made forms in the middle scales seem to be designed rather than emerged (based on Charles & Ray Eames, 1977, adapted by author) perpendicular to the Equator (something that mostly seems of value for the satisfaction of the mapmaker), are hardly to be found in nature. They are characteristic of the designed world and, combined in surfaces, walls, roofs and boxes, create the human biotope of buildings, building blocks and the city (Tversky, 2016).

Fig i.2 - Still from Powers of Ten showing part of the Chicago development. The sports stadium arranges supporters, and organizes them by club and ticket grade. The jetties arrange the moored ships by size and owner, and the highway arranges the cars in lanes by speed and destination (Charles & Ray Eames, 1977).

i.1 SPONTANEOUS ORGANIZATION

It was since the second half of the previous century that phenomena in nature were first explained as an outcome of the process of self-organization. Nature is not chaotic, but creates structure over time, through the simultaneous interaction between a countless number of interdependent particles. Complexity theory explains why molecules, cells, organs, and galaxies are closely organized systems that as a whole display more properties than the sum of their separate parts. The systems we so clearly see on the macro and micro side of *Powers of Ten*, have unfolded themselves over time, without the help of any external control.

In those middle scale levels, humans do, of course, have the ability to control their environment, leading to arranged structures with notably different form properties. The buildings and cities around us are created by conscious interventions, driven by ideas that are made possible through imagining future scenarios. But the fact that this happens does not by itself exclude the fact that processes of self-organization take place also here. The development of structure through local interactions is not scale-bound, and could create configurations also in our direct surroundings. Maybe this is just more difficult to see.

When we zoom in on the smallest interactions between people and their surroundings, lying down in the grass, getting a book from a bag and passing on the salad, the decisions taken are no longer the result of predefined plans. They seem to happen quick and intuitively, but still, they generate form. Compared to the buildings in the city, this is form of a quite different kind. Does a picnic filmed from above, with plates, bowls and glasses circling around two people, not resemble a small Milky Way, a living organ or a giant white blood cell?

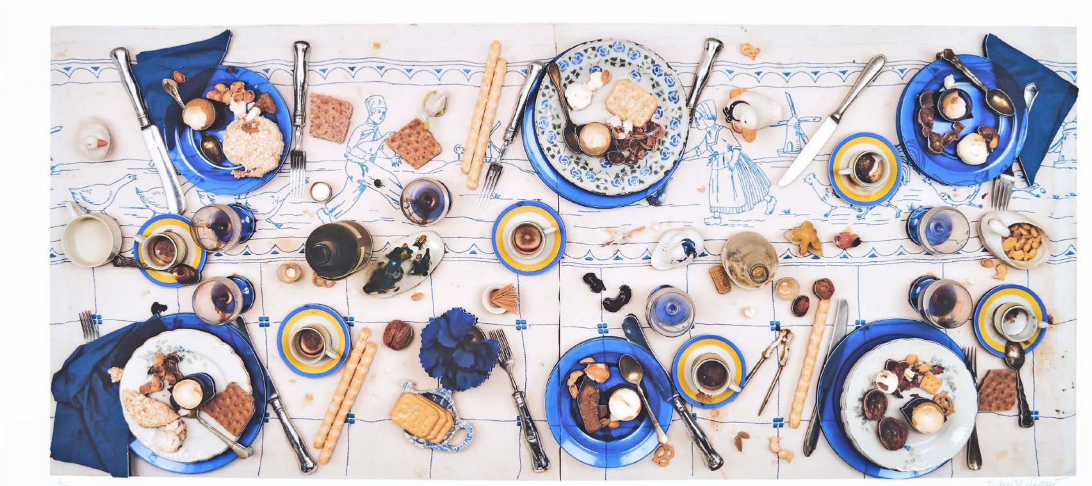
i.2 THE SELF-ORGANIZATION OF STUFF

As humans, we have the choice to arrange what is around us, but we also just live. A drawing table itself is not only a tool for designing, it is also a piece of wood, with paper, pens, pencils and an eraser, a cup of coffee and a chair. It is on the scale of stuff that our interaction with the world is so instinctive and direct, that it makes patterns spontaneously arise. On the larger scale of a house, stuff seems to live a life on its own even more. In the words of Brigitte Kaandorp: "*Things form bonds, or so, they are friends. They find each other, and preferably in the most awkward of places. Stuff appears everywhere, and it is creeping me out.*" (Kaandorp & Borst, 2008). Looking at a house by looking at the stuff inside, shows a complex ecology where we are not in control, but right inside of.

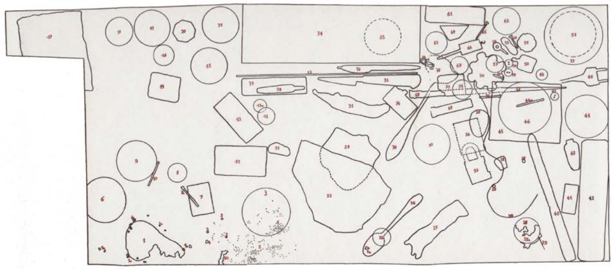
At first sight this may seem bothersome. But if stuff indeed 'forms bonds', it apparently has the ability to create structure without our conscious intervention. It forms a kind of order, but without anyone ordering. In a house, self-organization is a driving force.

The artist Daniël Spoerri experimented with these possibilities, as part of the Nouveau Réalisme in the 1960s. It was in this time that various disciplines of art experimented with aleatory elements, spontaneity and unfinishedness, not the least to criticize the suffocating sense of control operated by the government on the one hand and the elite expressionism of Modernism on the other.

Fig i.3 - Daniel Spoerri: Tableaux Piège. Date unknown (±1960).



Spoerri let the activity of having a meal decide his tableaux pièges, tablecloths with everything left glued on and vertically hung up. His autobiography from the same period, *An Anecdoted Topography of Chance*, is based on all items on his blue table on the October 17th 1961, described and traced back in the history of his life (Spoerri & Filliou, 1966). "*The Nouveau Réalistes see the world as a painting, a big fundamental of which they wish to make substantial excerpts their own*", their manifesto states (Restany, 1961, p.1). For Spoerri, these paintings of the world are tables full of stuff.



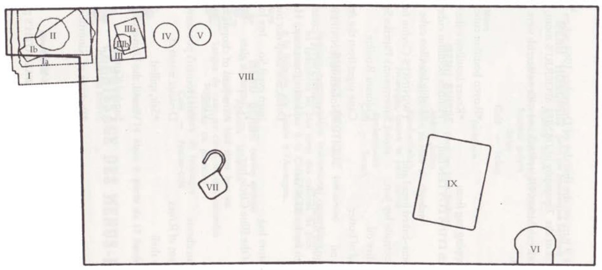


Fig i.4: Topographical map of chance,17 October 1961

Fig i.5: Topographical map of order, 21 February 1962.

Topographical maps from *An Anecdoted Topography of Chance* by Daniel Spoerri (1966). The first is the guiding drawing in the book, the second an appendix added later.

Spoerri's topography is called one of chance, and at some points indeed shows the randomness of stuff (*"a bent nail, I don't know from what"*) (1966, p. 135). However, it is not without reason that a two-dimensional map was made instead of just a list. The actual configuration of stuff is, when given second look, not so irregular at all, as it helps to trace back what has actually happened. To show his room was not always a mess, Spoerri later added a topographical map of order (1966), but this cannot communicate such a story by far. Also the tableaux pièges show no random chaos of items, but a meal. As was characteristic of Nouveau Réalisme and Fluxus, the border between performance and object faded away (Schimmel, 1998). Art became a direct outcome of action, and in this case the result of the self-organization of stuff.

i.3 RESEARCH AIM

The alternation between human-made order and inevitable chaos seems too simple to describe the configurations formed by stuff. Therefore, this research aims to find a better explanation for this phenomenon, by exploring it from a complex systems perspective. In constructing an explanatory theoretical model and vocabulary that describe the constant displacement of stuff, lies the possibility to make our observations more specific. Stuff, especially when considered over time, very directly reveals processes of interaction between people and their surroundings, which is a fundamental topic for architecture. Although this research might not directly lead to guidelines or principles on how to design, any other way of looking at this relationship is inevitably related to all design decisions concerning people and their environment.

Fig i.6: Visiting N. John Habraken in his house (full of self-organized stuff), 26th of January, 2017

This exploration follows the architect and theorist N. John Habraken in the idea that the built environment resembles more of an organism than an artifact. This idea in itself changes architectural decisions; intervening in a living body does not ask for artistic expression, nor for building to resist time (Habraken, 1998). Instead, this perspective implies a responsibility for the architect to make thoughtful choices, based on a substantiated understanding of what will happen over time. Habraken pleas for a systematic build-up of a body of knowledge that describes the behavior of the built environment (1998), an aim this thesis will try to contribute to.

Projecting complexity theory on stuff is possible with the inspiration of various other disciplines, that have proven that many natural phenomena can be more adequately explained by self-organization than by classical causal-mechanistic thinking. One field of study that already makes a link to the man-made environment is that of complexity theory of cities, that applies various theories of complexity to the study of cities (Portugali, 2011), through which it is able to describe global phenomena such as city growth and the pattern of urban fabric as an outcome of local interactions. The fact that this discipline is already being developed gives a solid starting point for the translation to a smaller scale.

There is another opportunity for design in this outcome. Self-organization is a driving force, a spontaneous creation of structure and something Spoerri could even 'paint' with. With more knowledge about these processes, we may not only be able to design for the self-organization of stuff, but also with it. Maybe this energy, when extrapolated, could even create architectural form.

i.4 RESEARCH QUESTIONS, METHODOLOGY & STRUCTURE

This research is centered around a topography of stuff, not of a table, but of a room in the course of a year: that of my own. Since I moved in, exactly a year ago, it has been the arena for all sorts of stuff configurations: tidy, messy, but mostly consisting of all sorts of smaller systems around all sorts of activities. All dynamics of this room have been recorded, and its pictures are the main source of information, examples and illustrations in this thesis.

The method used is that of abductive reasoning, as proposed by Haig (2005). Different from hypothetico-deductive reasoning, it does not depart from a hypothesis, but from phenomena, empirical regularities obtained by data analysis. Once detected, plausible theories (or 'educated guesses') are constructed to explain the mechanisms behind them (Haig & Evers, 2016). This happens amongst others by the sub-methodology of analogical abduction, in which models from other disciplines are projected on the phenomenon in order to develop a specified theoretical model. This methodology proved of much value for the topic, due to the fact it affects behavioral science, in which the method is particularly relevant (Haig, 2005).

This method is used to answer the research question: **How can the spontaneous organization of stuff be explained from a complex systems perspective?**

The structure of the abductive theory of method and its sub-methodologies are applied in three main parts:

i.4.1 Phenomenon detection (Chapter I)

The phenomena detection departs from two data sets. The first is the longitudinal study consisting of the photographs taken in my room in the course of a year. The second is more cross-sectional in nature, as it depicts stuff cells around different activities; although the data are not retrieved on one given point in time, there are no regards to differences in time. Both are analyzed in relation to the current dominant statements describing the dynamics of stuff, revealing that some forms and processes cannot be explained with these means.

i.4.2 Theory generation (Chapter II)

The first generation of theory is inductive, conducted by the sub-methodology of existential abduction, in which the existence of a previously unknown or unaccepted feature is introduced to explain the phenomenon. In this case a third organizational state is added to the existing paradigm, thus inducing additional transitional processes that are further explored.

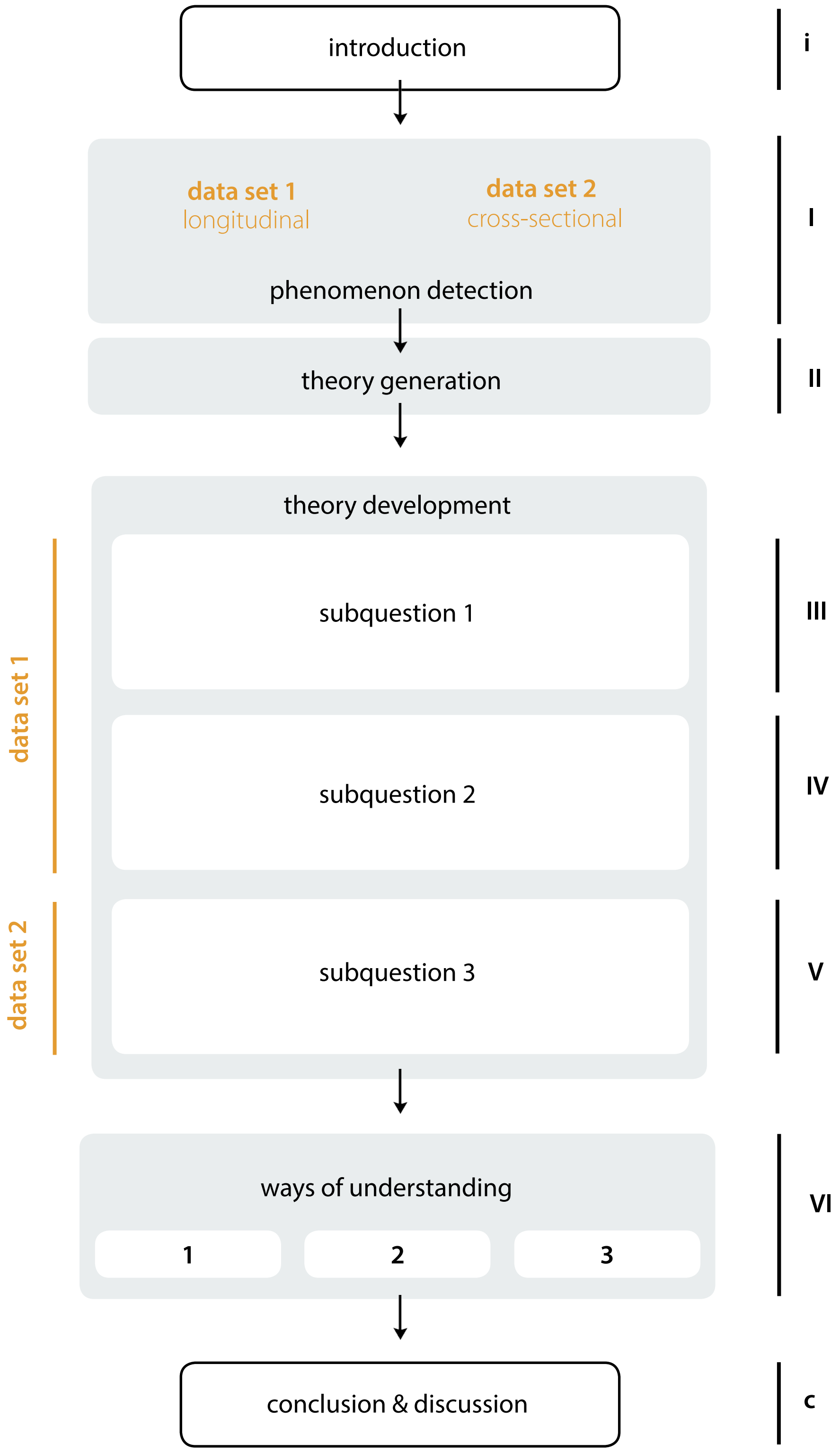
i.4.3 Theory development (Chapter III, IV, V)

The main section of the research uses the sub-methodology of analogical modeling to develop a theory, meaning that various models are projected on the subject and through constant testing developed to give explanations as simple and accurately as possible (Haig, 2005). This is done in three parts, consecutively on complex system dynamics, processes of interaction and as a synthesis and test of the theory developed, the description of physical forms.

subquestion I - complex system dynamics: How do theoretical models of self-organizing processes describe the dynamics of stuff?
subquestion II - processes of interaction: How do interactions between people and their surroundings relate to the self-organizing abilities of stuff?
subquestion III - dissecting the stuff cell: How can self-organization explain the physical forms of stuff cells throughout time?

The construction of this theory has been a very dynamic course, since the search for underlying principles was a continuous strategy of observation and comparative analysis in the data and in real life. Theory here is a process, and the 'final' models not a finished product, but still an ever-developing entity (Glaser & Strauss, 1967). As the topic of the research, activity and stuff, is so ever-present, not only in daily life, but also in the minds of all introduced to this fascination - everyone intuitively knows about mess, organization, productivity and creativity - this is even more the case.

Finally, the last chapter demonstrates three ways in which the findings can be understood in the practice of architecture, by giving methods for the observation, analysis and simulation of the self-organization of stuff.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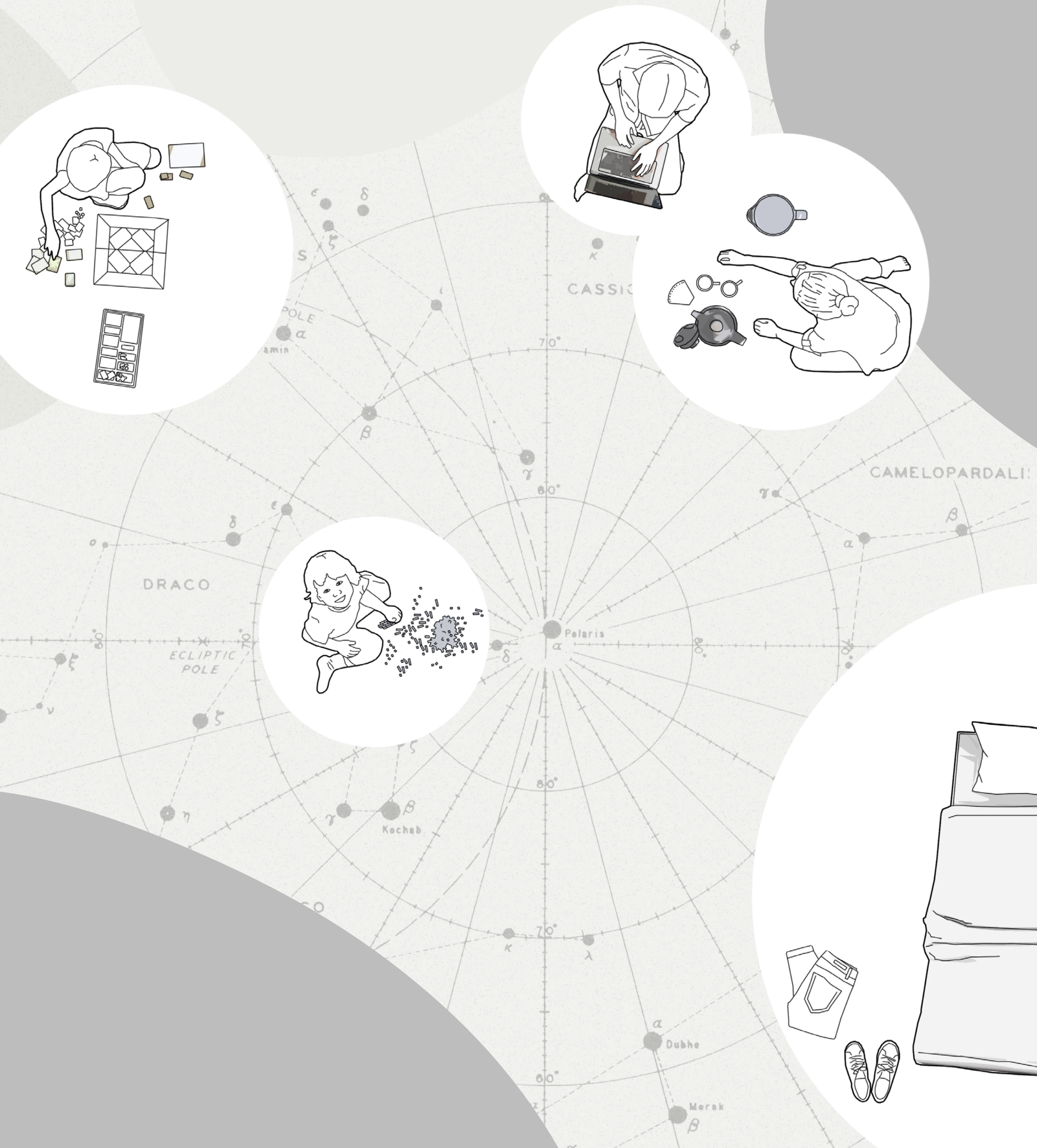
I. PHENOMENON DETECTION

SPONTANEOUS LIFE



I.

INTRODUCTION

This research is not about stuff itself. Instead, it explores its constant reconfiguration as a collection of connected parts through a multiplicity of processes; something like *stuff system dynamics*. A *stuff system* consists of all stuff surrounding us, and is essentially endless. It entails what we use, what we touch, what we see in the distance or, even what we know is available, a cognitive presence. More than a collection with a defined boundary it is the consolidation of artifacts around us, conjugating with an increasing interdependency between them, that form the system. For this reason this research does not analyse separate parts of the whole, but aims to capture the dynamics of the lively and ever-changing structures through time and in the midst of action.

The following chapter describes a phenomenon within these dynamics that the common narrative of order (tidy, neat, orderly) and chaos (messy, cluttered, disordered) fails to explain. Both system states and the transitions between them are indeed recognizable in a house, but are unsuccessful in describing the organization of stuff that is actually being *used*.

Left - Illustration of stuff crystallizing around activities. By author.

1.1 STUFF SYSTEM DYNAMICS IN DATA

Below a small selection of the two data sets used for this research can be found, both published complete in Appendix I and II. The first is a longitudinal study, in which the same room (in this case, my own) is photographed on repetitive occasions throughout a year. The room, being a student accommodation, serves many different purposes - from working and studying to sleeping, to hosting dinners and meetings and even serving as a model studio

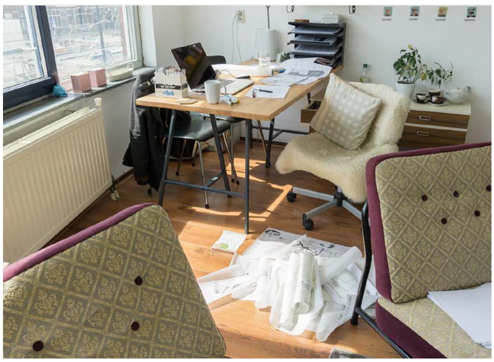

26th of October '16 - sorting out papers


21st of April '17 - Study group


13th of May '17 - designing

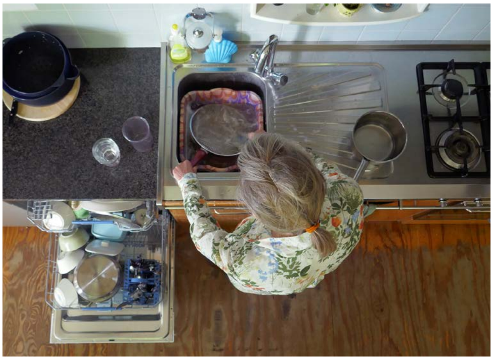

6th of May '17 - party


3rd of November '16 - Woodstaining the table


20th of May '17 - failed designs

Above: a selection of data set 1

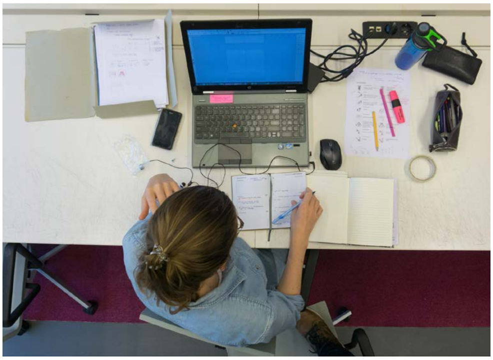
or dance floor. The other set of data is more cross-sectional in nature and pictures people engaged in activities of all sorts in all different places from above, showing the collection of stuff that has gathered itself around them. Whereas the pictures of the room are variably zoomed in and out - although within the maximum measurements of the 30m2 between the walls - the pictures of the second set are all taken on the same level of scale in order to be easily compared.



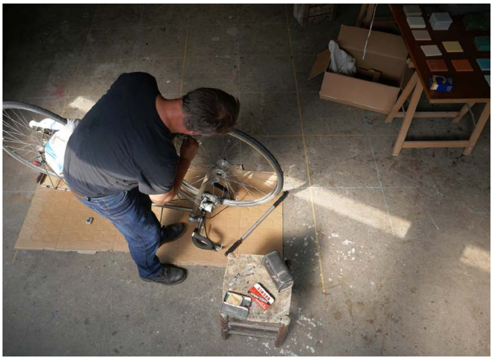
Doing the dishes

Lying at the beach

Filling a vegetable tart



Studying



Replacing a tire

Serving pasta

Above: a selection of data set 2

1.2 DESCRIBING THE DYNAMICS OF STUFF

Describing the state of a space full of stuff is generally done by two simple opposites: that of order and chaos. A house, room or a desk is regarded as either tidy and neat or a chaotic mess that needs reordering. Often, tidiness is the preferred state; a clear organization is believed to boost productivity and work flow, which is the reason why many companies hold a *clean desk policy* (Bjerrum & Bødker, 2003). On the other side of the spectrum some state that a certain amount of chaos can help creativity and increases the chance of unintentional inventions (e.g. Tim Harford in *Messy, how to be resilient and creative in a tidy-minded world*) (Harford, 2016). Apparently there is a dichotomy that can be clearly pronounced.

Chaos, or disorder, is, according to the second law of thermodynamics, the equilibrium where all closed systems would spontaneously fall into when no ordering would take place. This high-level entropy state of a system is completely smoothed from irregularities; all parts can move individually, without any restraint from the system. What is called 'order' here is the opposite state in which the parts are sorted by their properties.

It is not hard to recognize those principles in a house. In a room that has just been tidied up, all stuff is where it belongs; the books are in the bookshelf, not only sorted by their property 'book', but even more precisely on topic or alphabet. Clothes are sorted as being clean or not, and further on type and season. Order has some great advantages in our houses. It is possible to find a specific part we know the properties of efficiently, it saves space as we can optimize the stacking and stowing away and it gives us a satisfying overview of what is available so that in a glance we know what we have access to. At the end of a busy week, however, stuff can be all around, moving randomly around the room. Piles of non-related papers move from the bed to the desk and back to the bed, clothes are draped over chairs and the computer desktop is clotted with arbitrary screenshots.

Four processes between the two states of order and chaos can be identified, as to be found in the scheme on the right. These transitions are similarly easy to recognize in stuff systems. They represent the act of tidying up and the process of cluttering.

1.2.1 A deterministic viewpoint

But is this description complete? Since two of those processes, the ordered state falling into chaos (1) and the random movement

Fig 1.2 (right): Four processes as indicated by fig. 1.1 explained and projected on stuff systems in a house.

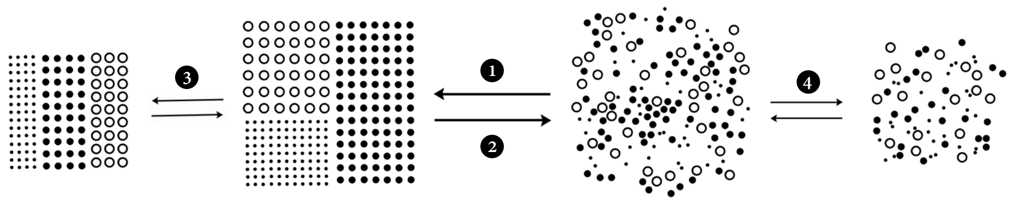


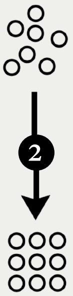
Fig 1.1 (top) : The identification of four processes between the states of order and chaos.

ORDER TO CHAOS

The second law of thermodynamics: all matter tends towards equilibrium. The diffusion or 'falling apart' of systems, decay over time.

spontaneous

Clothes that first hung in the wardrobe are now all over the place. Pencils originally sorted on color now lie all around.



CHAOS TO ORDER

Tidying up; sorting things that are scattered around by their properties and organize them in a way that gives a logical overview.

conscious

Sorting out mail on date and topic and organizing it in piles. Putting magazines that lie everywhere back in a rack sorted per month.

ORDER TO OTHER ORDER

Changing an ordered system to another ordered system, in which the parts are sorted by another property.

conscious

Reordering a bookshelf in which the books were first sorted on alphabet now on color.

CHAOS TO CHAOS

Not an actual process of transformation as chaos is no other than 'other chaos'; the parts have ultimate freedom and move around.

spontaneous

A pile of stuff moves from the desk to the bed and back to the desk.

of 'loose' parts (4) happen without conscious human intervention, spontaneously, any stuff system is doomed to fall into an undesirable state of disorder when no-one intervenes. This increase in 'mixedupness', seems inevitable, and could theoretically be calculated (Gibbs, 1876), influenced by the time since the last measurement and the amount of activeness and entrepreneurship of the inhabitant. Also it implies a dichotomy between man and nature, a struggle between what we as humans prefer the world to look like and a certain 'natural state' we will always be fighting against.

Both aspects of this conclusion that classical thermodynamics would give, do not only seem pessimistic or at least uninspiring, they also simply do not seem to be right. Only when we distance ourselves from the spaces we live in, and observe them in a detached, objective and laboratory-like way, we see a constant increase in disorder, until someone consciously intervenes. However, human habitats that are actually used, like the ones from the two sets of photographs in the beginning of this chapter, are comprised of other forms than these two forces can create. They are alive.

1.3 THE THIRD STATE

It is in the midst of action that another state appears, in which the parts are neither sorted nor completely loose. Around activities in which artifacts are being utilized a crystallization appears of particles that maintain a lower degree of freedom spontaneously. The particles dense in a cloud-like figure, that is dynamic yet preserving its structure through time.

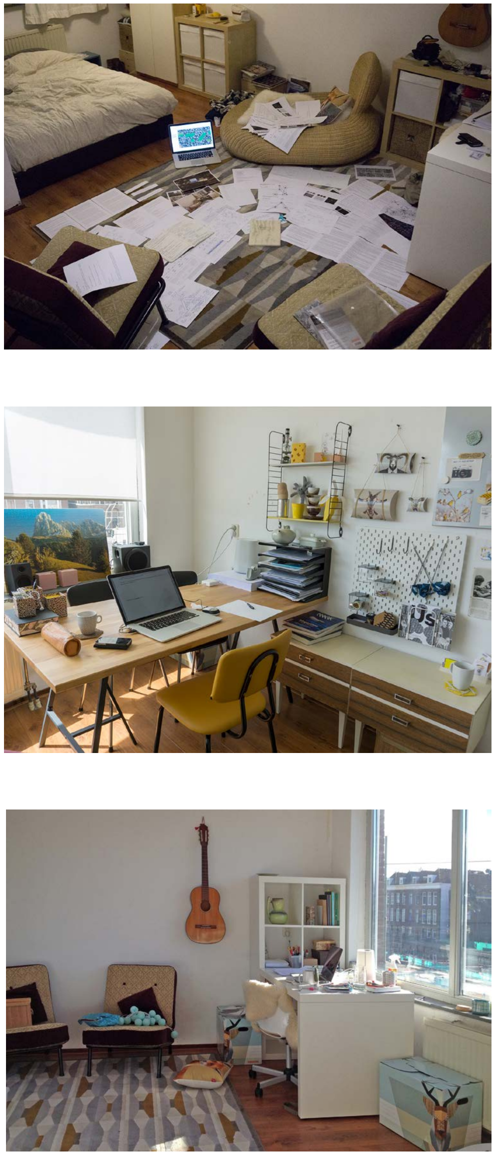
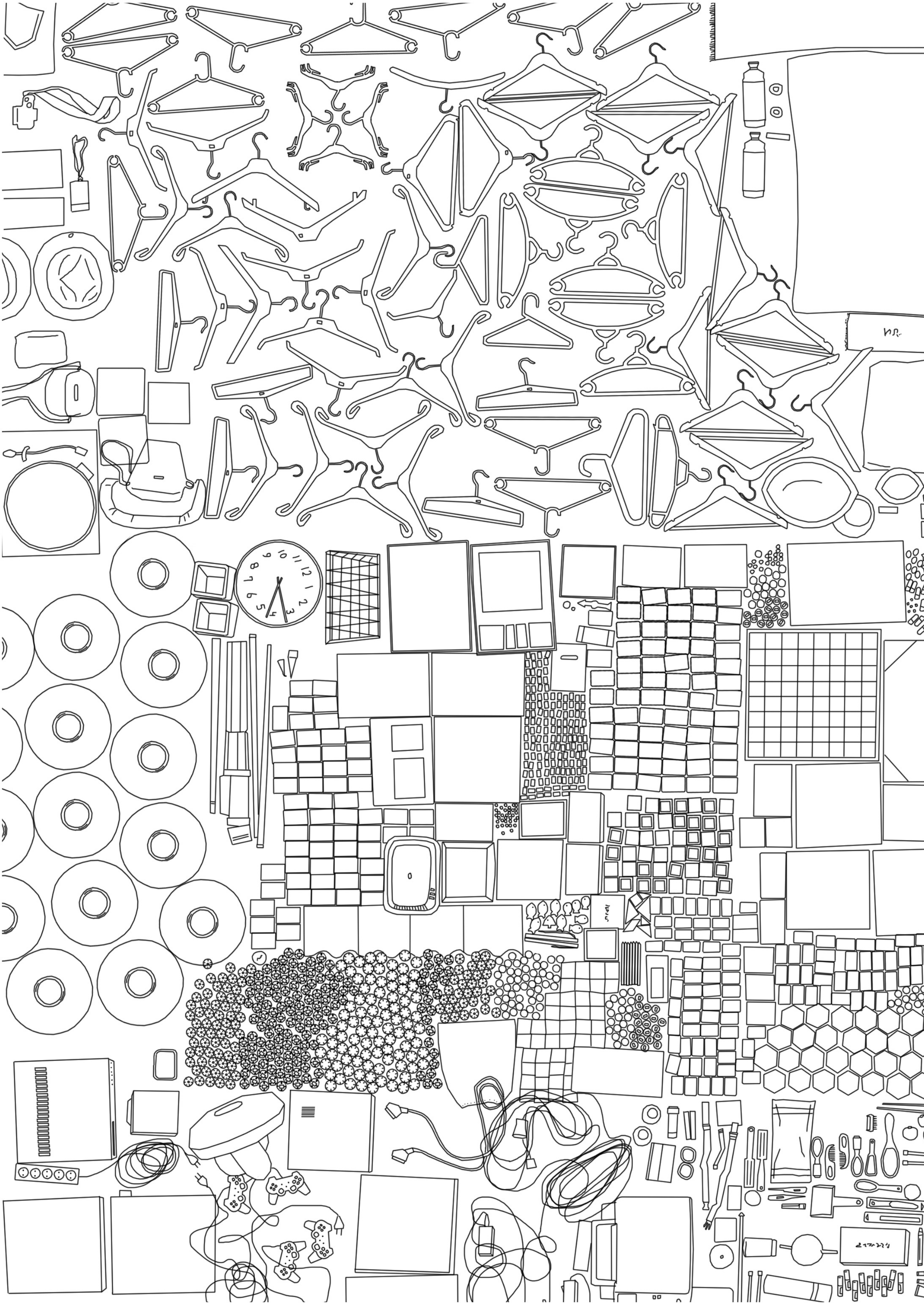


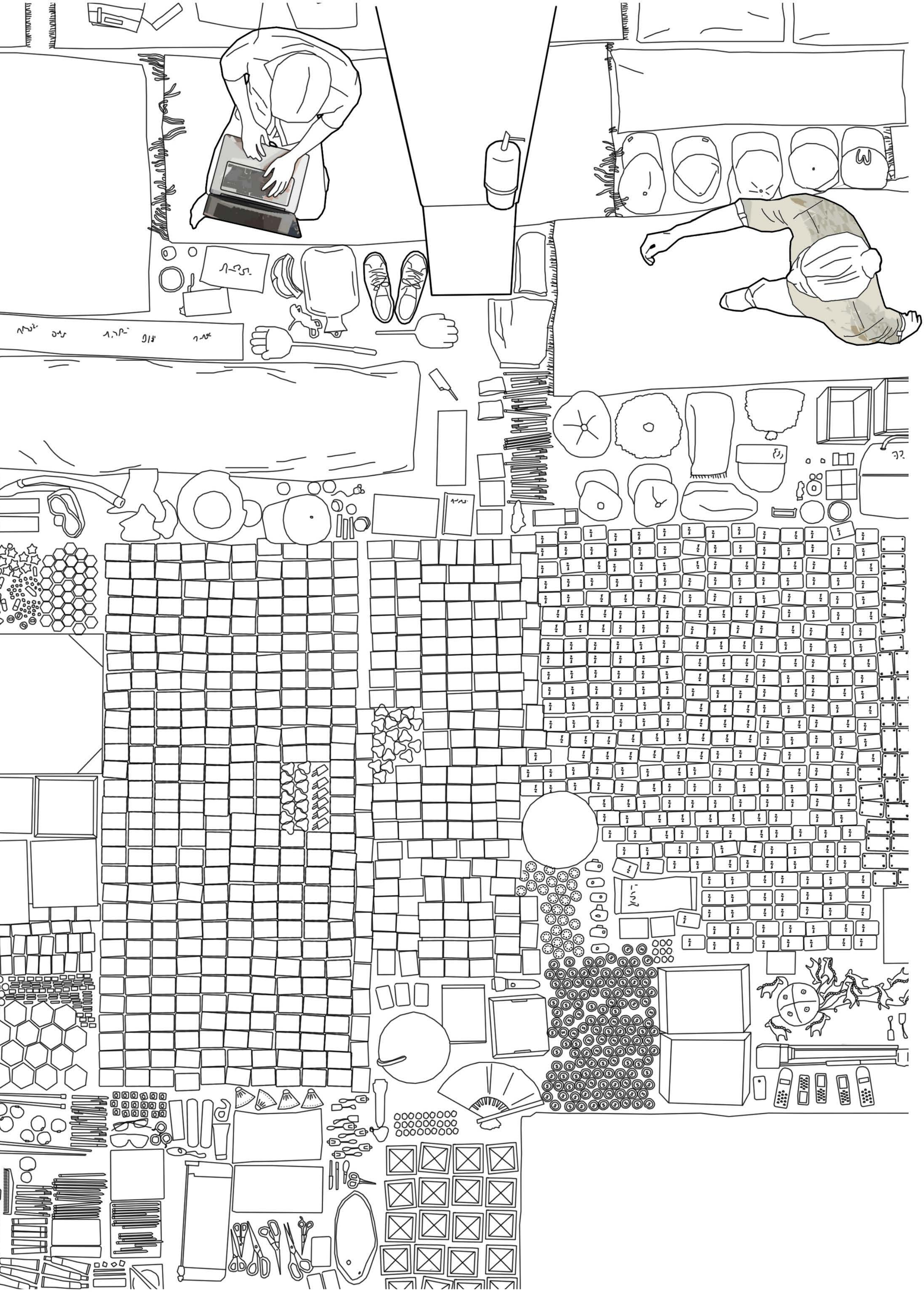
Fig 1.3: Examples of stuff 'crystallization'.

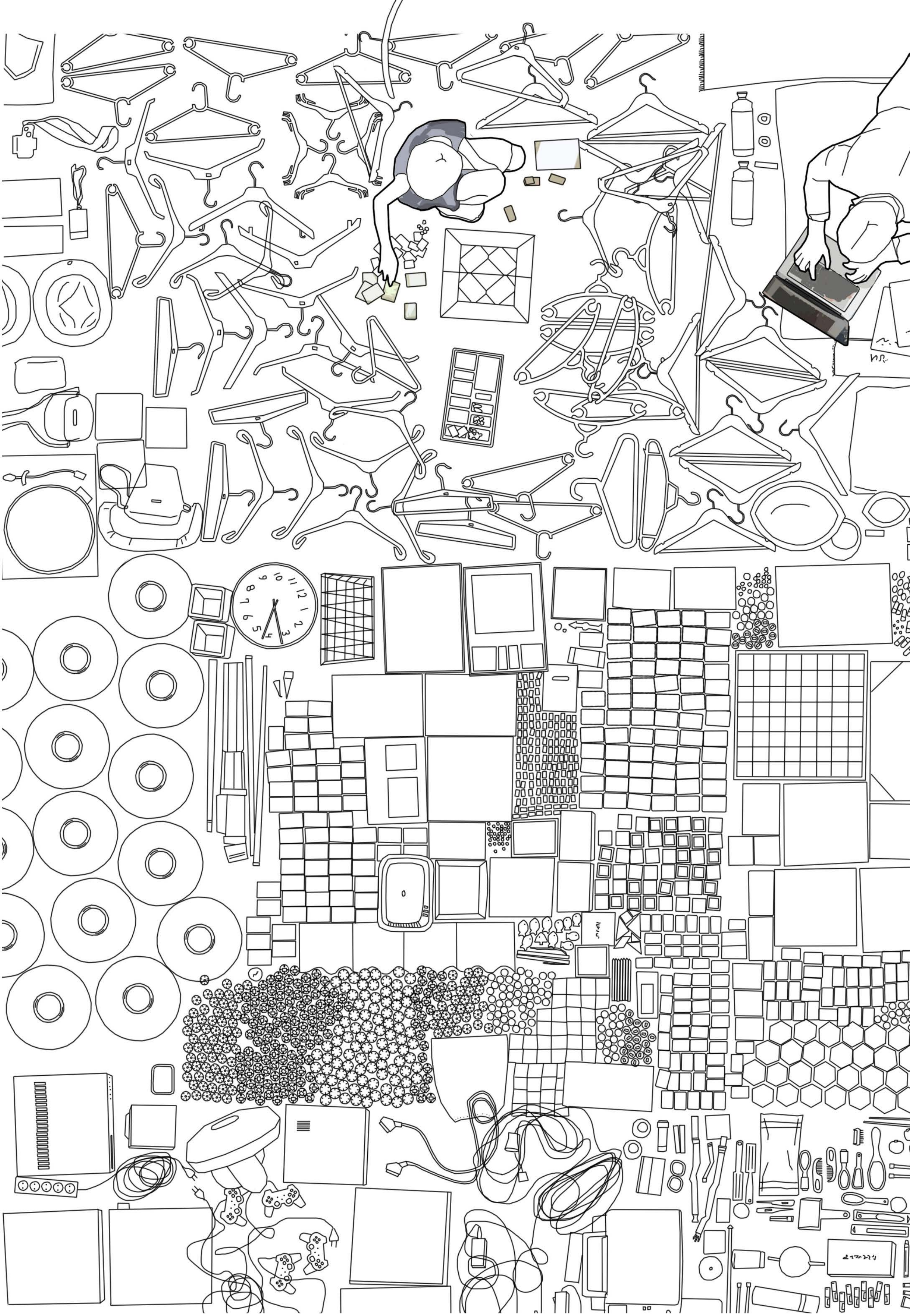
A thought experiment in which the amount of particles is increased can illustrate this phenomenon in a clear way. In the documentary Overal Spullen (*"Stuff Everywhere"*), Dutch filmmaker Judith de Leeuw is filming herself within a months-long process of counting every item she owns (2011). One of the final shots is the overview of a giant hall filled with blocks of piles and assortments and a spreadsheet on her computer showing the final addition: 15,734 pieces. The image of all this stuff is impressive, not only by its vastness. After counting randomly and loosing track multiple times, De Leeuw realizes that the only way to do the job is by working extremely systematically. Every single object is categorized, labeled with a number and put into an enormous grid that is set up as logically as possible. When the family walks in between their perfectly ordered belongings, the place is all but a house. Every item is artificially separated from all its associated items and the collection has become an alienated landscape of objects.

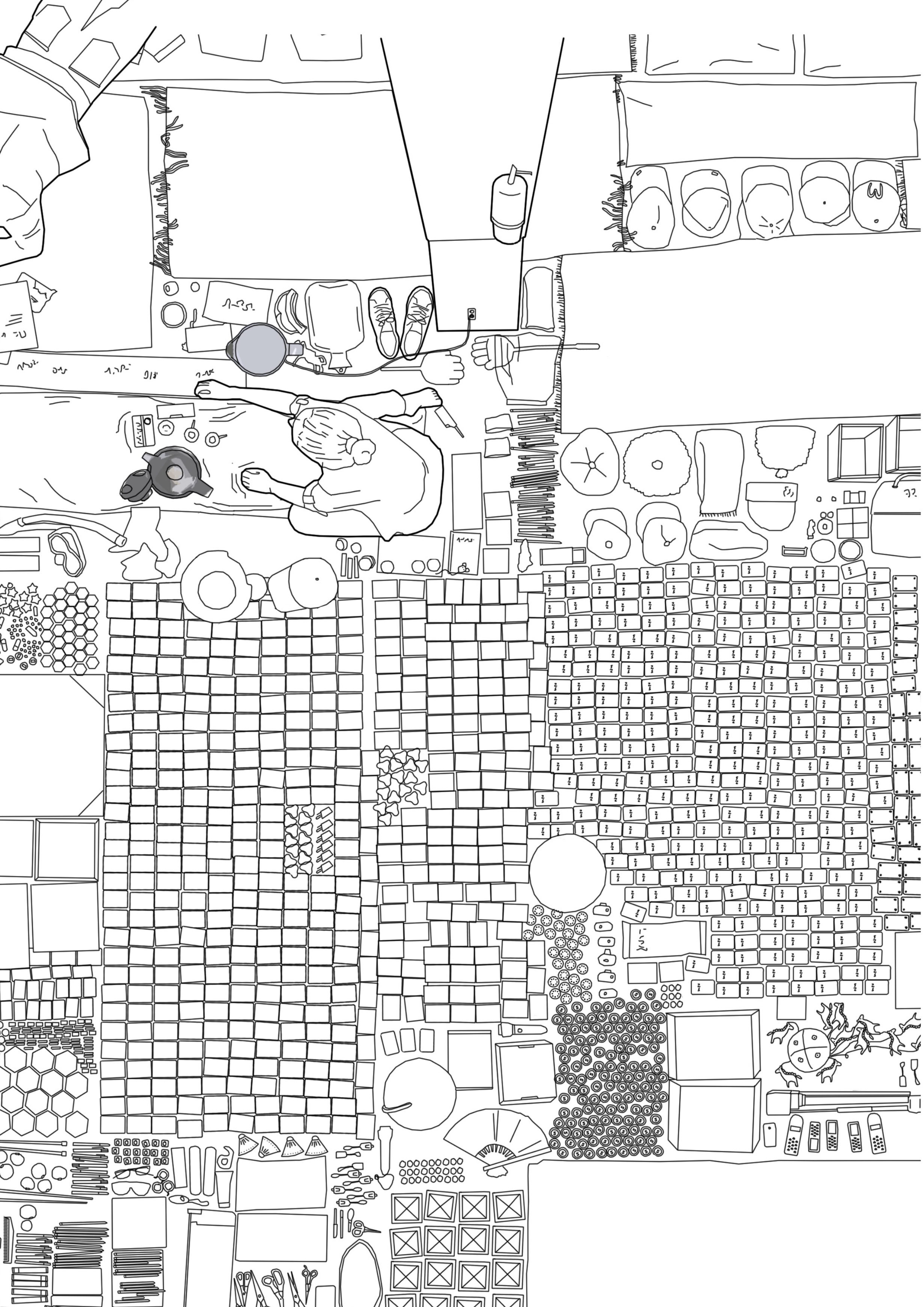
Now what would happen, if just when they are about to go to their home (in which they installed mattresses, sleeping bags, and some essential camping facilities borrowed from friends), one of them realizes they forgot the key? The three of them, mother, father and their six-year-old son, are forced to spend the upcoming evening and night here in the hall, luckily surrounded by everything they could possibly need. What would happen? Or in other words, how will the particle arrangement of this stuff system change?

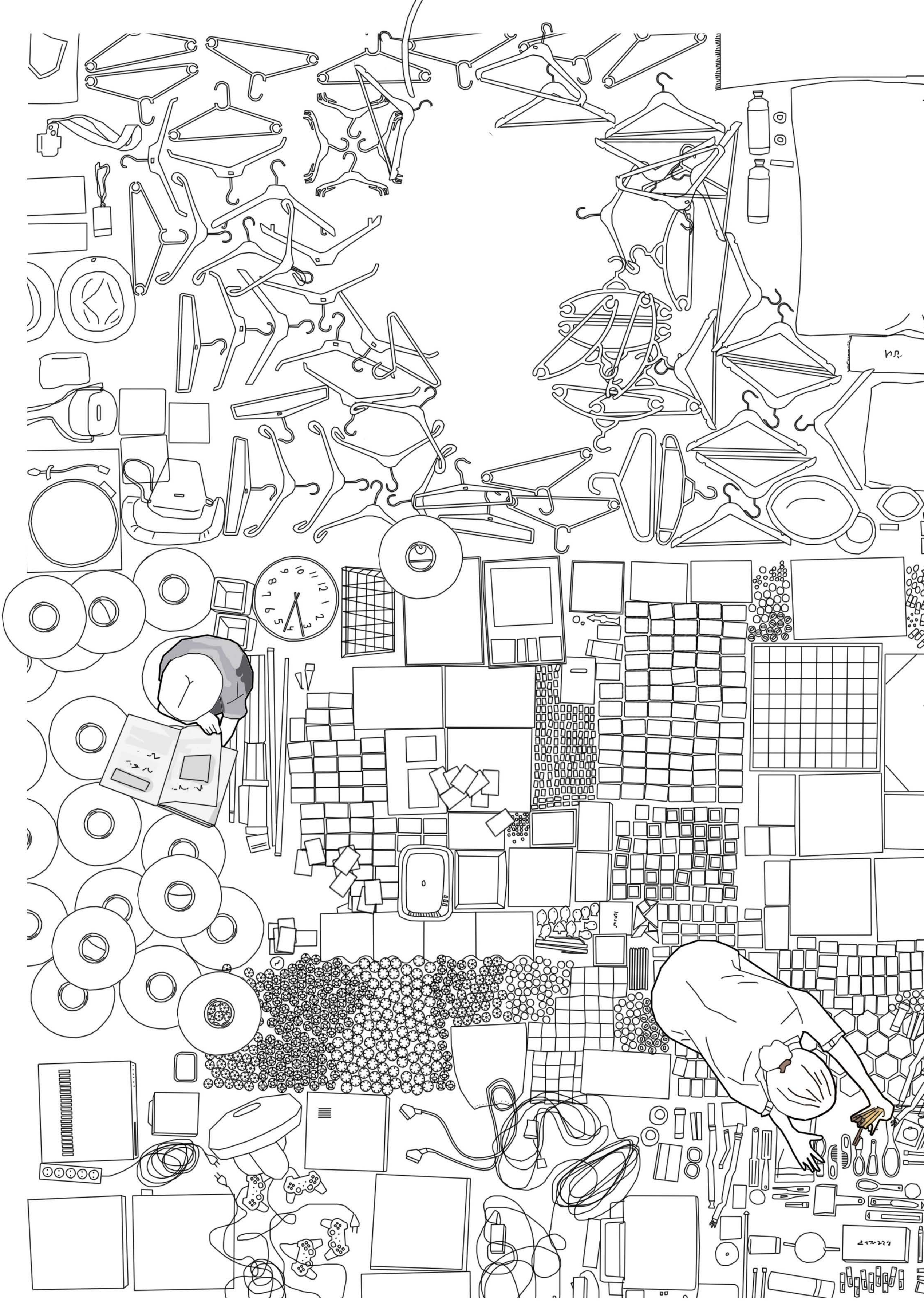
After some grumbling and sighing, the father grabs his laptop to try to contact someone who might have a spare key (which fails), while the mother looks around if she can find the most essential things they need, at least some pillows to sit on and a bottle of wine. Then she gets the water boiler that she plugs in the closest power outlet, cups and tea bags to brew some tea, and finds a glass and carton of fruit juice for their son. In the meantime the six-year old wants to play and pushed away the clothes hangers to make room for a board game he found, and the father is finishing some work. After the game is over, the son installs himself between his parents' LP records to read a book, while they together make a bed from a mattress, sheets and pillows, and collects clothes, toothbrushes and toothpaste to make the family ready for the night.









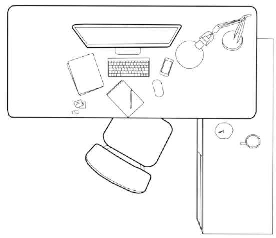


1.4 STUFF THROUGHOUT SCALES

In this crystallization systems of artifacts are formed that showcase emergent properties, abilities of the whole that the individual parts lack. These possibilities (such as the ability to perform an activity as a whole) appear on three nested scale levels between that of an individual artifact and the house as a whole.

The first are stuff configurations, compositions that are typically still smaller than the human body and support a simple activity, or a part of a more complex activity. Examples are items lying in the corner of a desk, like pens, pencils, paper and a pair of reading glasses; everything needed to read and write. Or a 'coffee corner' existing of a machine, coffee, filters and sugar lumps, standing on the kitchen counter top.

Second are the most recognizable self-organizing systems; stuff cells. These fully support an activity and are mostly grown around a place for a human being to stand or sit. A stuff cell around computer work exists of a desk, chair and all stuff that is either used or useful as a back-up or background; one around the activity of sleep consists of the bed, pillow and duvet as well as the side needs on the edge, like a bed stand with a glass of water and an alarm.



The third scale level is that of stuff cell configurations, which is a combination of stuff cells that strengthen each others functionality. In a kitchen, while cooking a meal, a collection of highly interdependent stuff cells arise where the user continually alternates between. The chopping board, where the vegetables are cut, directly complements the sink, where they are washed, and the stove, where they are tossed in a pan. Also in a bedroom a series of stuff cells reminds one of all sub consecutive rituals we go through when getting up; a space in front of the wardrobe, a mirror and a chair to sit on while putting put on shoes.

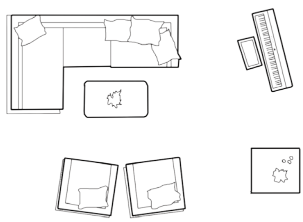


Fig 1.4 (right): An overview of three stuff system scales in between that of an individual artifact and a house.

STUFF

composition of materials with emergent properties

A vase; a laptop; a bag; a box of cereals; a book; a plate; a table; a chair

STUFF CONFIGURATION

1

composition of stuff because of its interdependency, with emergent properties

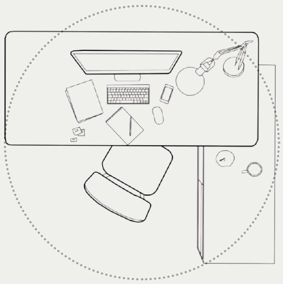
The coffee machine with coffee, filters, a spoon and cups standing next to it

STUFF CELL

2

composition of stuff (0) and stuff configurations (1) with emergent properties

An easel with a stool, a table with brushes, paint trials and a cup of tea

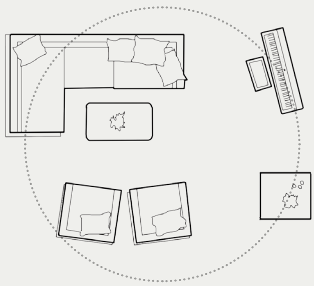


STUFF CELL CONFIGURATION

3

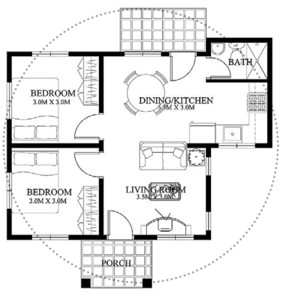
composition of stuff configurations (1) and stuff cells (2) with emergent properties

A living room with a couch 'cell', a piano cell and a reading/bookshelf cell



STUFF SYSTEM

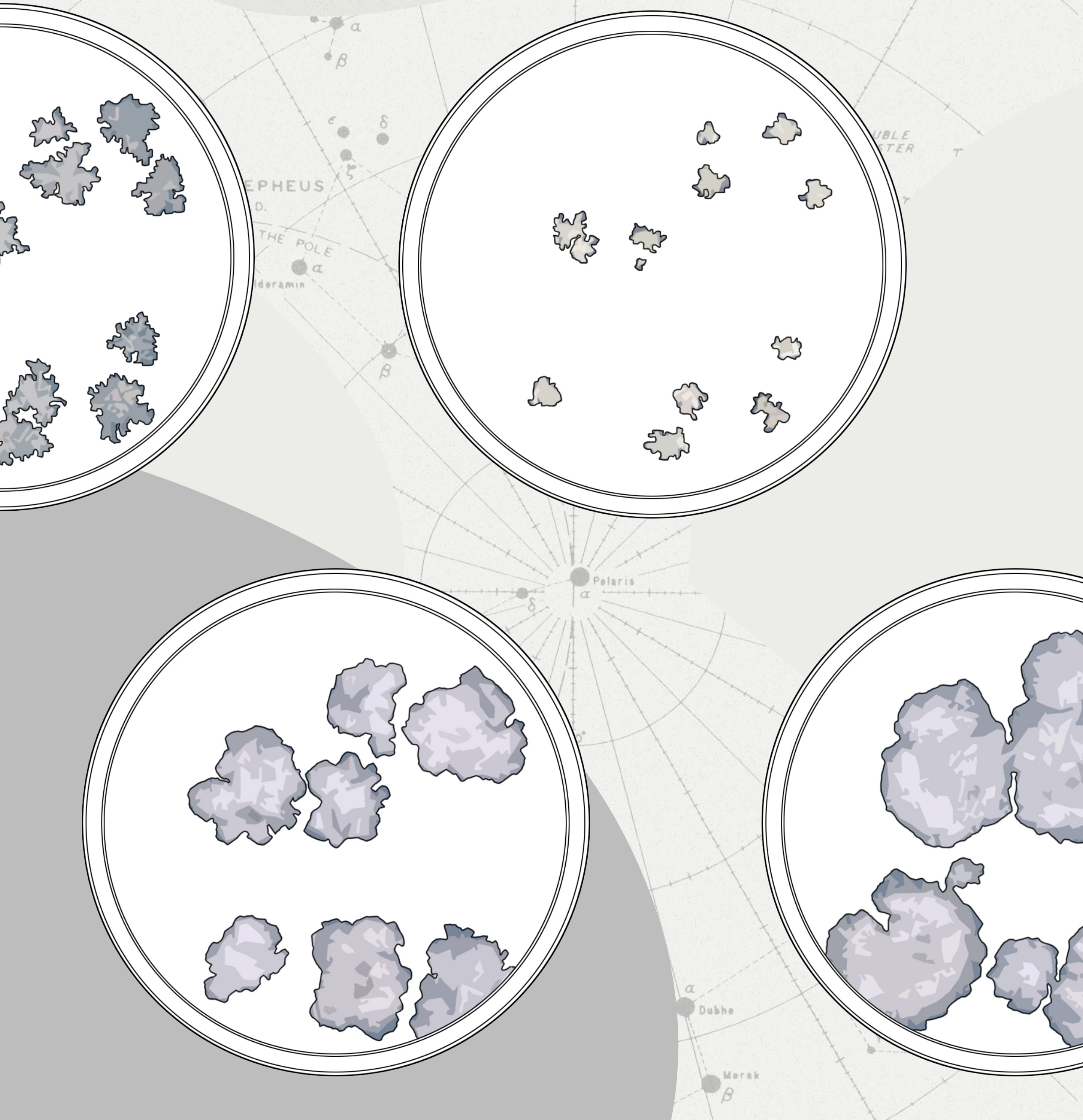
composition of stuff configurations (1), stuff cells (2) and stuff cell configurations (3) fully supporting someone's living needs.



II.

THEORY GENERATION

THE SELF-ORGANIZATION OF STUFF



II.

INTRODUCTION

In a house that is being used, stuff is constantly getting reordered, not by its properties, but in a dynamic relation to the other particles around. The items are moved through ad-hoc use - quick, intuitive and for direct purpose - and form bonds with each other, that are most of all functional. The toothpaste finds the toothbrush, the cushions find back the couch and stuff cells arise that contain all the functions needed for a certain activity. The system does not fall into chaos, but comes to life.

In this chapter the idea is introduced that stuff systems are complex systems with self-organizing abilities. Stuff systems differ from typical examples of complex systems because they can in principle be controlled individually (as demonstrated in *Overal Spullen*). However, in daily life, there is an interaction between the human being questioning what to do next and the possibilities the stuff around them is offering. This circular causality of both the next action and the configuration of stuff that makes the next action possible results in an intuitive and impromptu interrelation between user and stuff. Although people might be able to specifically plan the placement of their belongings, they don't. They are immersed inside the system themselves.

Left - The growth of bacterial colonies from nutrients in a closed petri-dish, an example of self-organization of the material. Illustration by author.

2.1 SPONTANEOUS ORDER

The crystallization of stuff is a form of order. It is a restriction of the freedom of the parts, or, in other words, the maintenance of a low level of entropy. This phenomenon happens spontaneously, in the sense that no intervention for the sake of 'ordering' is consciously performed. Spontaneous order is since the second half of the previous century recognized in multiple domains of research, in which the classic causal-mechanistic way of thinking could not explain the behavior of certain material, organic and societal systems, and forms one of the central notions in complexity theory.

Spontaneous order, or self-organization is the formation of spatial, temporal and spatio-temporal structures arising from local interactions. It is triggered by random fluctuations and amplified by the self-reinforcement or positive feedback of formed structure. It is the most exemplary property of complex systems, systems recognizable because of their network-like structure. Missing any one formalism to adequately capture all of their properties (Mikulecky, 2001), the global patterns of a complex system are explained by the cooperation and competition amongst the particles through time, that unfolds a structure with a highly dispersed and decentralized control (Waldrop, 1993).

2.2 STUFF AS A DOUBLY COMPLEX SYSTEM

Three types of complex systems are distinguished, that differ in the ability of the parts to adapt the local rules they follow. Material complex systems, such as the pattern formation between two reacting materials or the weathering of rocks through wind and water, cannot change the rules of the game according to their specific situation. Organic complex systems, however, such as fur patterns, cell structures and animal architecture, do change overtime, through evolution. A natural selection of system variables and local rules gradually specifies itself to the genetic variation with the

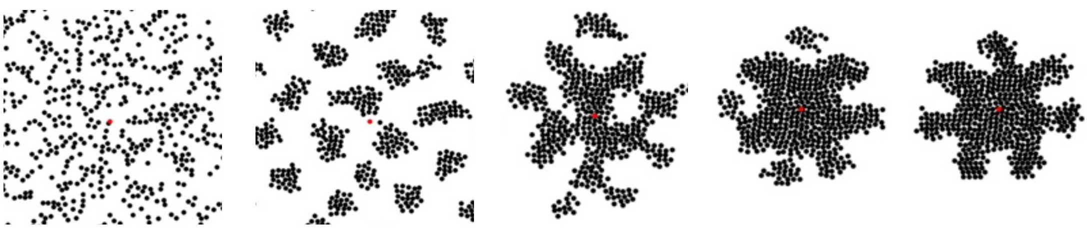


Fig 2.1: The process of self-organization, stylized representation.

phenotype best to survive (here the complex viewpoint on how the leopard got its spots[1]). Human systems form the third category, that of doubly complex systems. Since humans have the ability to mentally travel in time, foresee certain outcomes and change our behavior accordingly, the process of adaptation in, for example, economical, social or political systems, is direct. When a global pattern is recognized, it can be fueled, impaired or something else can be ignited. The local rules change when decisions change (Stolk, 2015).

Another example of a doubly complex system is a city. Although cities are in essence large-scale artifacts, they showcase properties of complex systems, such as in the patterning of their urban fabric (i.e. especially visible in older cities that grew over time, a little less in the Chicago city grid). Their complexity is explained in three ways, as described by Portugali (2016). Firstly, while the city as an environment emerges out of the interactional activities of its agents, this environment itself influences (enslaves) the agents again (1). The artifacts, the buildings, highways and streets, are the media of interaction (2) - decisions are not made by a direct communication on how to build the city at a set moment in time, but all individual decisions do react on what is already built and planned by others. There is thus a two-way causality between the acting agents and the acted-upon environment, which, together with the factor of iteration through time shows swarm-like properties of global pattern forming and path-dependency. As humans are complex beings themselves, the development of a city has a fast and active process of adaptation (3) which makes it doubly complex.

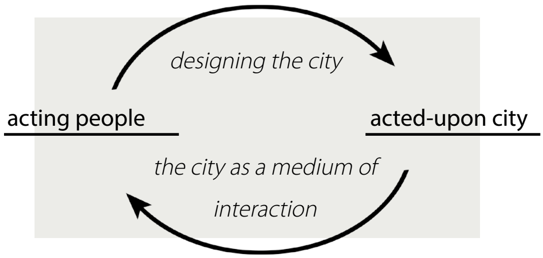


Fig 2.2: A city is a doubly complex system, because of the circular causality between acting people and the acted-upon city that is a medium of interaction itself.

Complex systems structure themselves throughout time, in a constant iteration of decisions; the current environment is the input of the next decision, the environment following that the input for the next. In cities this turn-taking between the decision-making individual and the environment is very obvious. Firstly because the city has a time-span of centuries; it existed before the inhabitant was born, and will continue to develop even after all current inhabitants are gone. Secondly, it is a collective. There are legal procedures determining any building

1 The typical 'myth' and title of many children's stories, amongst them one in the popular Just So Stories by Rudyard Kipling from 1902

plans; builders need to get the approval of the municipality, review committees and many other scales of organization. To design a complete city on your own is simply not possible. This is different in stuff systems, that are slower, smaller and mostly individual.

But although our cognitive and physical abilities in fact give us power to completely regulate our direct surroundings, the circular causality through the immersion in the environment we act upon, operates also here.

Although the dilemma in Complexity Theory of Cities why a city that is essentially an artifact still displays complex behavior could in stuff systems be even sharper, as there is the possibility to individually control all agents, also the solution to this dilemma applies. The continuously changing configuration of stuff around us is the media of interaction itself: in the same way, we act upon a system we are right inside of. Stuff influences us as much as we influence stuff.

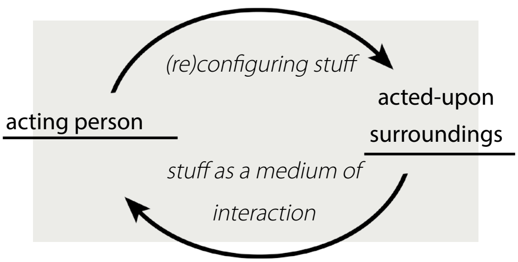


Fig 2.3: Although it is in fact possible to completely control our direct surroundings, the same circular causality as seen in cities exists also in stuff systems.

The doubly complex theory of Portugali will therefore be taken as the starting point for this research, as a requirement for complexity, that is explored at a smaller scale. This translation is possible as our relation with stuff is so direct, ad-hoc and intuitive.

2.3 A STATE OF SELF-ORGANIZATION

When considering stuff systems as complex, a third state can be added to the spectrum, one of self-organization, giving a triangle of possible stuff states with five additional processes. The processes numbered 6, 7, 8 and 9, in other words, all that do not lead to order through classification, can happen spontaneously, albeit under particular circumstances. Self-organization happens when one is engaging in an activity, in which the emergent properties of different belongings together will be needed. This can arise both from an ordered and a chaotic state, whose differences will be explored in chapter IV. The process of self-organization turning into disorder happens when the activity is ended; the relationship that bound the individual particles is lost and the system looses its emergent values. Things fall down or are, in the hassle of other activities, set aside to where they are not in the way; the typical free and random particle movement that is part of the chaotic state. Self-organization to order is the non-spontaneous process of tidying up directly after an activity.

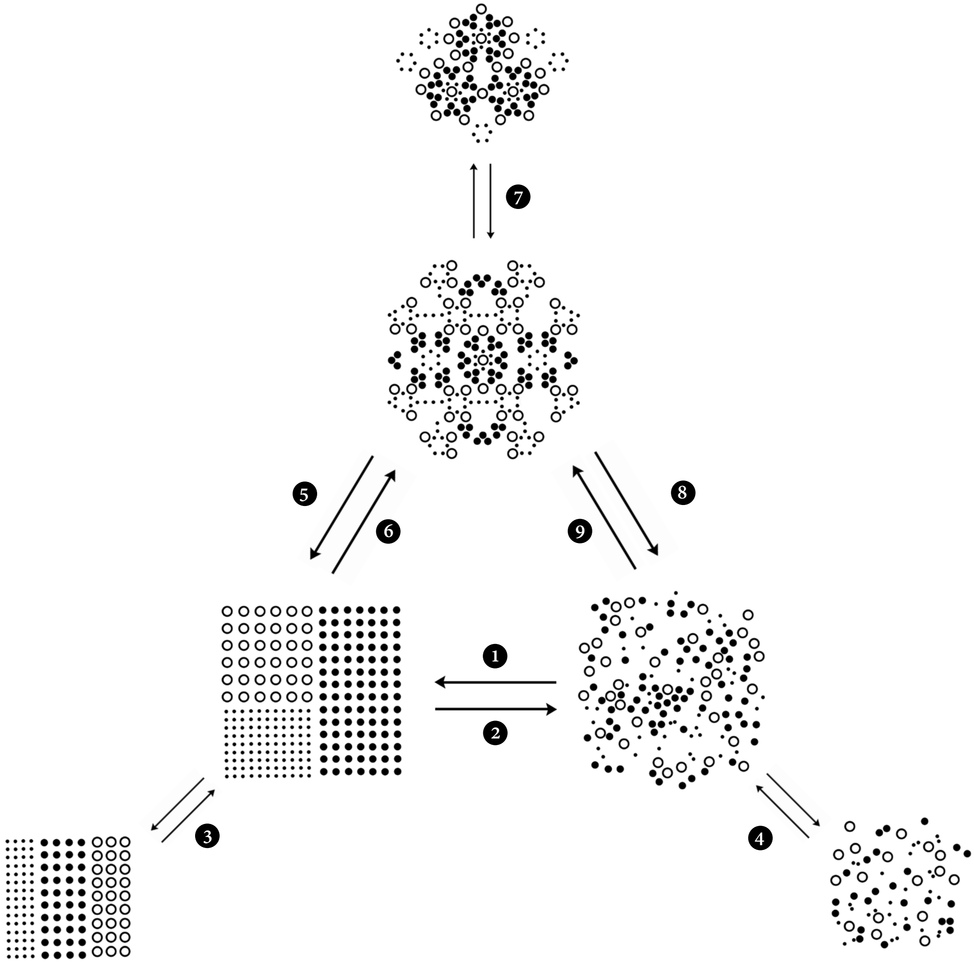


Fig 2.5 (overleaf): Five additional processes and their equivalents in a house.

* the words 'planned' and 'unplanned' are too limited, chapter IV dives further into the difference.

Fig 2.4 (above) : The identification of five additional processes between the states of order, chaos and self-organization.

S-O TO ORDER

Cleaning up directly after activity, by sorting the used artifacts on the properties of their parts.

conscious

Storing the left-over food from the pans into fridge containers. Tidying up the tools after hanging a painting on the wall.

ORDER TO S-O

Self-organization around the activity, in this case by picking specific parts that are easy to find by the properties by which they are sorted.

spontaneous - in case of an activity (planned*)

A pile of stuff moves from the desk to the bed and back to the desk.

S-O TO S-O

A self-organized pattern is always in motion; other than (linear) order it is dynamic by definition. It changes while the activity changes.

spontaneous - in case of an activity

Change from computer work to drawing work while behind your desk.

S-O TO CHAOS

As soon as you leave an activity, the configuration of stuff looses its emergent properties. Therefore the organization falls apart and diffuses into chaos.

spontaneous

Leaving stuff on the table without cleaning up; as other activities need the same space and stuff, it will eventually fall apart.

CHAOS TO S-O

In a messy room stuff lies around, which can generate unintended cross-links: combinations unexpectedly get emergent properties.

spontaneous - in case of an activity (unplanned*)

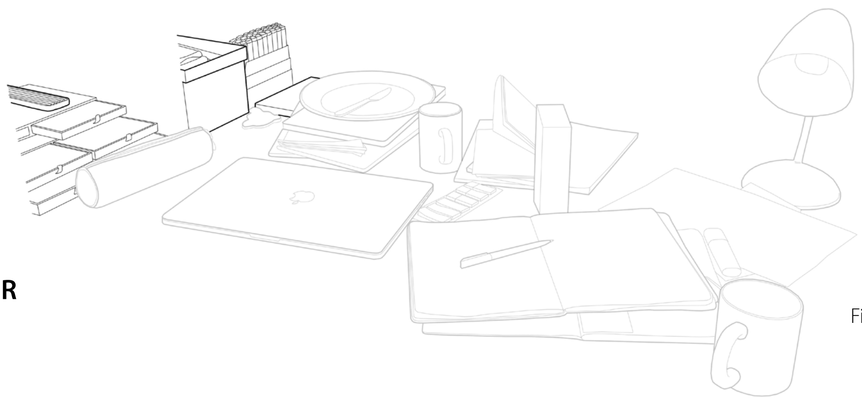
Starting to build a model out of random scraps you find around. Making the crossword in the paper as it is on the table anyway.

2.4 STUFF EXPLAINED

With this framework of three possible stuff states, order, disorder and self-organization, and the nine different transitional processes in between them, we can describe observed stuff configurations in a more accurate way. In the picture in fig. 2.6 that is taken of my desk, an ordered state at the left side is clearly distinguishable (fig. 2.7). The pencils and markers are sorted on their type and color, to obtain the advantages of ordering; it saves space, it gives a clear overview of what is available and it is easy to specifically pick a

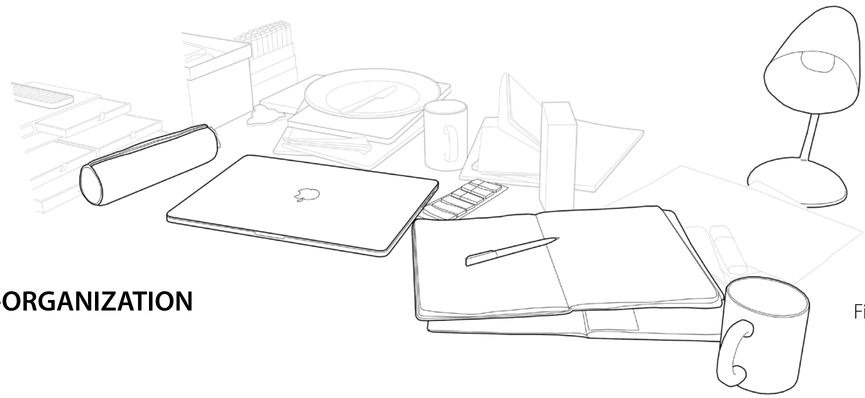
Fig 2.6: The desk on January 18th 2017, 00:11

desired part. On the desktop, closest to the chair, we see an example of self-organization (fig. 2.8). The laptop (which is closed for the picture, but open during the activity),



ORDER

Fig 2.7.



SELF-ORGANIZATION

Fig 2.8.

notebooks, pen, cup and light are organized around the activity and all support it; some more literally, like the pen, notebook and laptop, some in a more general role, like the cup of tea that supports the host. All artifacts in the stuff cell are part of a network in which their functions complement each other, in a dense cloud-like structure dimensioned around the (ergonomic) characteristics of the user and the activity.

The combination of the plate, knife, cup and chocolate sprinkles in the back used to be a form of self-organization around the activity 'breakfast' but was left and not cleaned up. The items lost their functions and were one-by-one moved to either a self-organizing centre where they had value again (e.g. re-using the cup), or where they stand less in the way. In this case, they are moved to the back of the desk (S-O to chaos, fig. 2.9), on top of some loose things that were already traveling around. These now lie on the bottom of the pile (chaos to chaos, fig. 2.10).

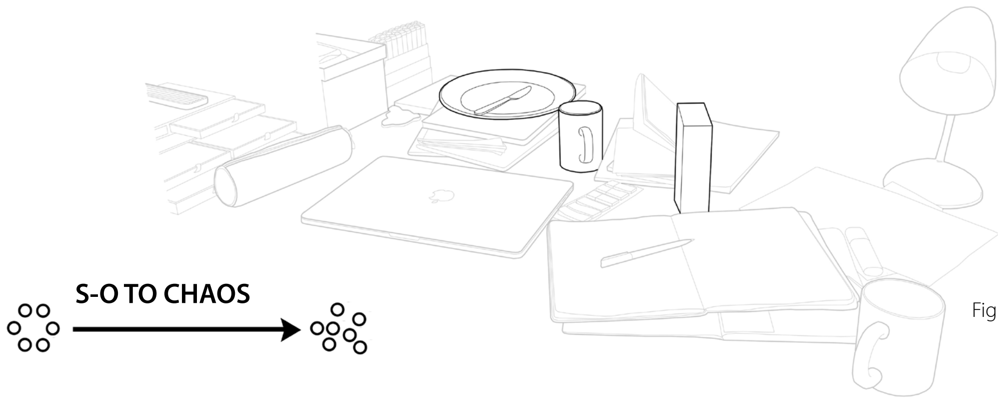


Fig 2.9.

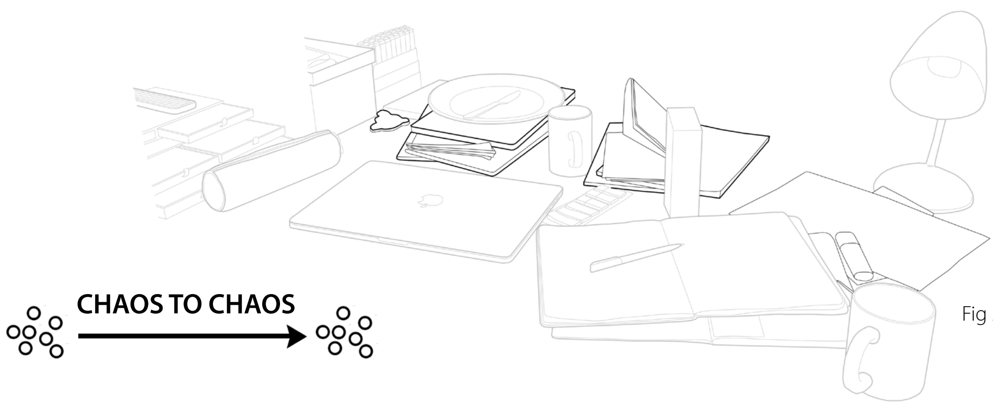


Fig 2.10.

2.5 MORPHOLOGY

This illustration might suggest that every item in a configuration can be 'labeled' as being in an ordered, chaotic or self-organized state, which is not the case. Instead, the states are a concentration of a certain type of organizational pattern - i.e. a global pattern (order), a global pattern emerged from local interactions (self-organization) or no pattern at all (chaos) - that constantly overlap. The states depend on each other; the sorted office supplies on the left (fig 2.7), for example, are something the activity itself (fig 2.8) constantly draws from and needs to keep its resilience. A 'stuff cell' is therefore more than what here is called a state of self-organization alone. It does have a nucleus, but no cell boundaries.

The clearest way to distinguish between the three states is therefore by their morphologies, that are all of a significantly different kind. Chaos is soup-like, as it consists of loose particles in a uniform mix. Order is grid-like, possible to split at any point without changing its arrangement. The pattern emerging from self-organization is quite different in nature; it is more of a crystal. The pattern is inseparable; whole and uniform throughout its scales (Kwinter, 1994 & 2001). Or as Schrödinger put it in his book *What is Life*: *"The difference in structure is of the same kind as that between an ordinary wallpaper in which the same pattern is repeated again and again in regular periodicity and a masterpiece of embroidery, say a Raphael tapestry, which shows no dull repetition, but an elaborate, coherent, meaningful design traced by the great master."*[1,2] *(Ch.1, p.2)*

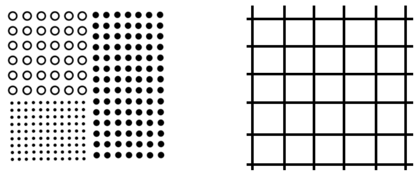


Fig 2.11. Order, the grid-like or the wall-paper.

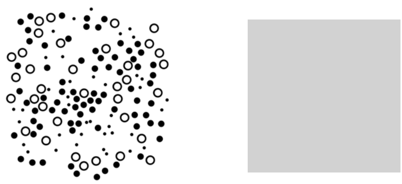


Fig 2.12. Chaos, the soup-like. Ultimate uniformity.

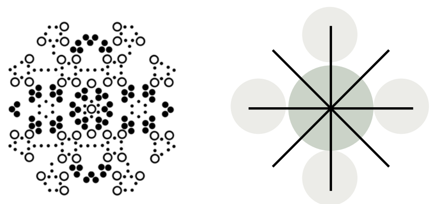


Fig 2.13. Self-organization, the crystal-like or the tapestry.

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1 Schrödinger here introduces the idea of aperiodic crystals, an organic chemical unity (and predecessor of the 'gene') in contrast to (common) periodic crystals and compares their forms.

2 After Schrödinger (and Kwinter as architectural theorist), many others have made this analogy with tapestries (also the more abstract Persian tapestries), amongst them Christopher Alexander in his extensive series *The Nature of Order* (2002a, 2002b).

THE PATTERNS OF GRIDS

Ordered items are sorted by their properties, which means that piles of ordered stuff are piles of the same kind of stuff; a bookshelf full of books, a pencil case full of pencils and a kitchen cupboard full of plates. Those similar items have a similar form. Another property is that ordered collections are arranged in a space-saving way, thus follow a grid with a space-filling pattern. Box-formed items give a rectangular grid, but this, of course, does not have to be the case.

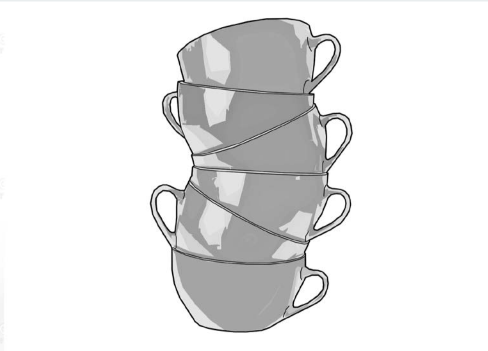


Fig 2.14: Cups with handles finding their optimal pattern given by their shape, gravity and minimizing their footprint.

Fig 2.15: Wine bottles in a space-filling pattern

The ordering of stuff is something which requires energy input, as it gives no emergent properties (except for being stored away as space-efficiently as possible). Still, the pattern that arises, can be seen as self-organizing. The rules, space-fillingness + gravity, are so decisive, that there is no conscious choice made by the person ordering; there is only one best option which is already given. It is the local rules (the side of an object that fits to the side of another) that create form.[1] The pattern comes forth from a material (singular) complexity, in which material finds its optimal form, given the forces acting on it.

Other self-organized grids are defined by form, space-fillingness, gravity and one or more additional rules. This is, for example, the possibility to have an overview (resulting in a sightline from all items to the observer), the possibility to dry (resulting in enough space for air flow and for water dripping off) or the possibility to easily reach all items without disturbing the others (resulting in a pattern with no inaccessible center).

1 Although this process can be defined as self-organization, in this research the definition of a self-organized pattern will remain that of one that cannot be split (like a Persian tapestry), without losing its emergent properties.

How material finds its optimal form can be an inspiration for designing the architecture

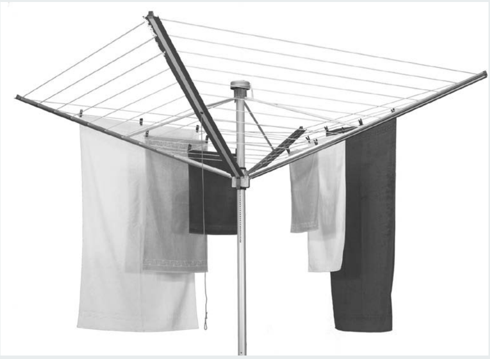


Fig 2.16: Rules: Space-fillingness + gravity + air flow.

Fig 2.17: Rules: Space-fillingness + gravity + possibility to be reached by the water from the spray arms + air flow.

Fig 2.18: Pattern of drying dishes too large for the rack. Rules: Space-fillingness + gravity + water dripping off.

supporting it (in this case the shelf, clothes line, wardrobe rod etc). This can be seen as a way of parametric design, in which the parameters of the local items create form, instead of the expressionist designer. In this sense, parametric design is the ultimate form of 'listening to the material'.

Fig 2.19: Support that makes a space-saving pattern possible, that avoids the wine glasses collecting dust inside.

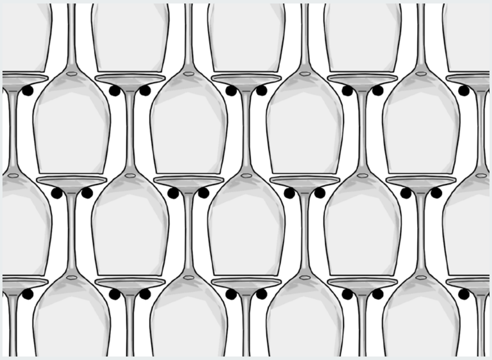


Fig 2.20: A more optimal wine rack design, in which more space is saved.

This idea can be of inspiration when designing for ordered patterns, such as for the storage spaces in a kitchen or attic of a house.

III.

THEORY DEVELOPMENT I

STUFF SYSTEM DYNAMICS

III.

INTRODUCTION

In the second half of the last century in multiple domains of research the insight grew that a classical causal-mechanistic way of thinking cannot explain all natural phenomena - much of what we see exists without a final purpose, without predefined steps and unfolds through movements that happen both simultaneously and sequentially. This was the birth of complexity theory, that in de midsts of the 1990s first was recognized as a science in itself, with its own rules and scientific framework. Still, complexity theory is a field of research that is essentially interdisciplinary. Models from different domains of study complement each other, all highlighting different features.

In this chapter we explore three theoretical models on the dynamics of complex systems throughout time. One stems from synergetics and is often used in CTC, the other two stem from ecology and are applied to describe complex processes in multiple domains (Davis & Nikolic, 2014). One by one these theories will be projected on the displacement of stuff in order to discover whether they can adequately describe our observations. This lens generates a vocabulary to describe a variety of elements and events.

Left - cross-scale dynamics in complex systems. Adapted from Gunderson & Holling (2002).

3.1 A SYNERGETIC VIEW

One of the basic theories on the process of self-organization stems from synergetics, an interdisciplinary science that from the mid-eighties researches the origination of patterns and structures in open systems. In the book *The Science of Structure* (1984), founder Hermann Haken, physicist and mathematician, proposes a model on self-organization defined by circular causality.

3.1.1 Order and control parameters

The process Haken describes starts bottom-up, as a local interaction between parts in a system out of its (thermal) equilibrium. A local fluctuation, which can be small, causes nearby parts to rearrange themselves and pattern starts to form. This global structure is represented in the figure by the top line and is called the *order parameter*. The individual parts gradually loose degrees of freedom as this overall structure forces them to rearrange, a process Haken terms *enslavement* (in this text referred to as *structuring*, because of its more neutral connotation). Without any disturbances this constant oscillation between top-down and bottom-up forces is a self-reinforcing process, a circular causation.

Different from thermodynamics, the complex systems this model describes are defined as open; they stay in a continuous interaction with their environment and exchange energy, material and information (Haken, 2012). The influences the environment poses on the system are included in the theory by the concept of control parameters. These are external factors, such as incoming light, a change in temperature or a material added to the system that has the ability to cause a systemic phase transition (Portugali, 2011). This changing condition thus alters the order parameters within the system itself until it finds a new mode of self-organization, a new balance.

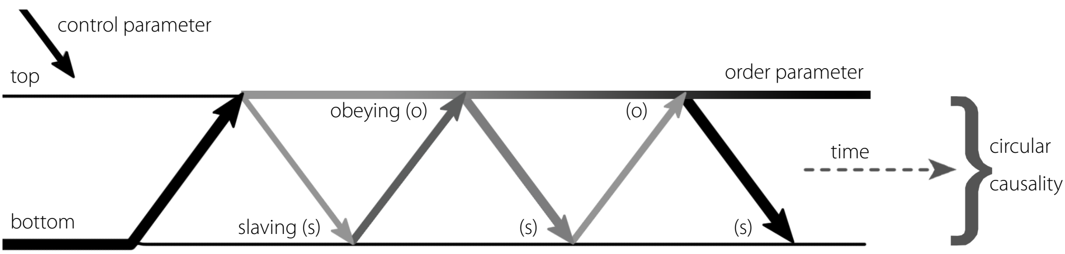


Fig 3.1: The model from synergetics, adjusted from Hermann Haken (1984). Local interaction between the particles create an order parameter, represented by the top line, that structures (enslaves) the parts again. Because of this circular causality, the order parameter grows stronger over time.

3.1.2 Internal control

The development of an order parameter, that in the process becomes more rigidly structured and gains an increasing ability to control, is the most characteristic process of self-organization. In a house, this can be found in the development of rooms or parts of rooms that often co-evolve with a certain activity; during the process more and more stuff is added to the place, which reduces the probability that other activities will be initiated there. This is especially visible just after moving, when both stuff and function quite quickly find their place. A clear example from the data set is the 'office' part of the room. Whereas the table was first relatively neutral, and would occasionally be used for dinners, model making or gift wrapping, it slowly grew specific. Throughout the year this 'office' has attracted a lot of stuff around it; first a tomado rack, a light and a magnet board, then a set of night stands holding supplies, a paper organizer and a poster to block the light from the window, next a pegboard with office supplies and display for letters and booklets, a pile of A3 paper to pick from, speakers for music and most lately some boxes for desk organization. This structure is even so controlling that, even though there are chairs on the other side of the table, it would feel unnatural to change sides. The order parameter is in this case the identity of 'desk'.

Fig 3.2 : Situation in the first weeks after moving (October) (ordered state)

Fig 3.3 : Situation in January (ordered state) - added two nightstands, a magnet board, paper ordner and improvisational 'blinds'.

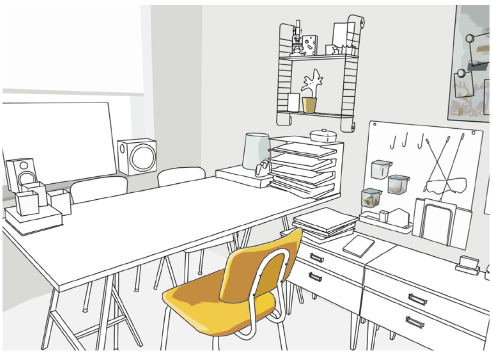


Fig 3.4 : Situation in July (ordered state) - added a pegboard, music installation and desk organizers.

Fig 3.2 - 3.4 (above): Analysis of the strengthening of a desk space by the configuration of stuff throughout a year. Taken from the picture of June 26th from data set 1.

The stronger, the less likely to move the table around or use it for something else and the easier the desk attracts stuff. When tidying up the room and finding some item that belongs in the right category, such as an eraser, it is logically moved to the 'office', even if there is already an eraser and it would be more of use somewhere else.

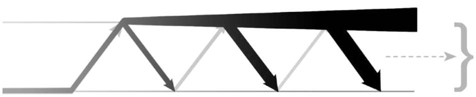


Fig 3.5: The order parameter strengthens over time and becomes more and more capable of structuring the parts.

3.1.3 External control

Stuff systems are in constant interaction with their environment; the conditions of the surroundings - light, sound or silence, or temperature - can, just like in thermodynamic systems, exert pressure on the organization in the system. These control parameters can cause the self-organizing system to either adapt itself to overcome these changes or completely collapse. In other words, it changes towards a critical point, which, when reached, induces a rigorous transition.

A change of conditions is a frequent occurrence in a house. When someone is reading in the garden, but after dinner it has become dark, the activity can initially not be continued. However, the stuff system might prove resilient enough to withstand this challenge, e.g. an outdoor light is taken from the shed and added to the cell. When the next day it turns out to be too cold to comfortably sit in the garden and attempts to warm oneself up prove not to be satisfactory, the activity is either discontinued or restarted somewhere else. Both the place and activity loose some of their stuff, thereby some of their structure, and are again more susceptible to bottom-up influences. The order parameter builds up anew.

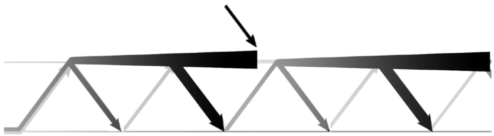


Fig 3.6: The order parameter looses its structure, and a new order parameter builds up, again susceptible to (random) bottom-up events (see also fig 3.11).

3.1.4 The Diderot effect

Additionally, stuff systems are open systems, because of the constant exchange of individual parts with the rest of the world. New items enter the system and existing ones are thrown or given away.

The model of synergetics is able to give a complex description of the related Diderot effect, a phenomenon in consumption theory described by McCracken (1988) and named after Denis Diderot, who wrote about it in an essay (1769). After buying a luxury new robe, that did not fit the rest of his more ordinary collection of stuff, Diderot felt the urge to replace all his belongings with higher-quality substitutes.

" My old robe was one with the other rags that surrounded me. A straw chair, a wooden table, a rug from Bergamo, a wood plank that held up a few books, a few smoky prints without frames, hung by its corners on that tapestry. Between these prints three or four suspended plasters formed, along with my old robe, the most harmonious indigence. All is now discordant. No more coordination, no more unity, no more beauty."

- Denis Diderot.

From: Regrets for my Old Dressing Gown, or a warning to those who have more taste than fortune, 1769

The effect works in two ways (McCracken, 1988). Firstly it can constrain the consumer in what they buy, as only items that fit the overall style, aesthetic or level of quality of the whole are considered. Secondly, when a deviant item enters the collection, it can change the overall order so that every other item feels as if it should be replaced.

In the first case the existing parts fit so perfectly together that their order parameter is rigid enough to enslave all possibly newly bought parts. When these cannot obey to the existing order parameter, they do not enter the system at all.

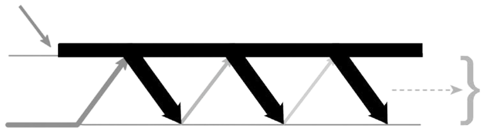


Fig 3.7: The strong order parameter of the existing parts decides what enters the house.

In the second case, the newly obtained item is the start of a new order parameter and thus takes over the structure of what binds the elements together, starting a self-reinforcing effect of enslaving the other items because of their specificness in level of quality, or style, shape or color. [1]

Fig 3.8: The new item brings, because of its characterisics, a strong order parameter right away. Existing items have to obey and if they cannot, leave the system. Items that are newly bought are structured, alike figure 3.7.

1 A friend recently described the situation in which she bought a bright red couch, and noticed how many other items in her interior were over the course of few months replaced with either another red accent, or a color strong enough to handle the redness of the rest.

3.2 A CYCLE THROUGH PHASES

Another widely used conceptual model in complex system theory is that of the adaptive cycle (Holling, 1986) that highlights the dynamics of systems throughout time. This model, originally stemming from ecology, explains how complex systems not only self-organize into a solidified structure but also 'experiment' and innovate.

3.2.1 Model of four phases

Any complex system continuously iterates through four phases, or ecosystem functions: the exploitation phase (r), the conservation phase (K), the release phase (Ω) and the reorganization phase (α). In general the trajectory alternates between longer periods of slow accumulation, the building up of a structure (from exploitation to conservation, r to K), and shorter periods that create opportunities for new innovations (from release to reorganization, Ω to α) (Gunderson & Holling, 2002). During the processes of accumulation generally stability increases and often material builds up, in the example of ecosystems in the form of, among other things, nutrients or biomass (Holling, 2001). As the system matures, it commonly becomes of more value for other systems of the same scale as it develops its possibilities and network. After a certain amount of time, however, it is unavoidable that resources will be depleted, together with the fact that the connectivity and therefore dependence of the system

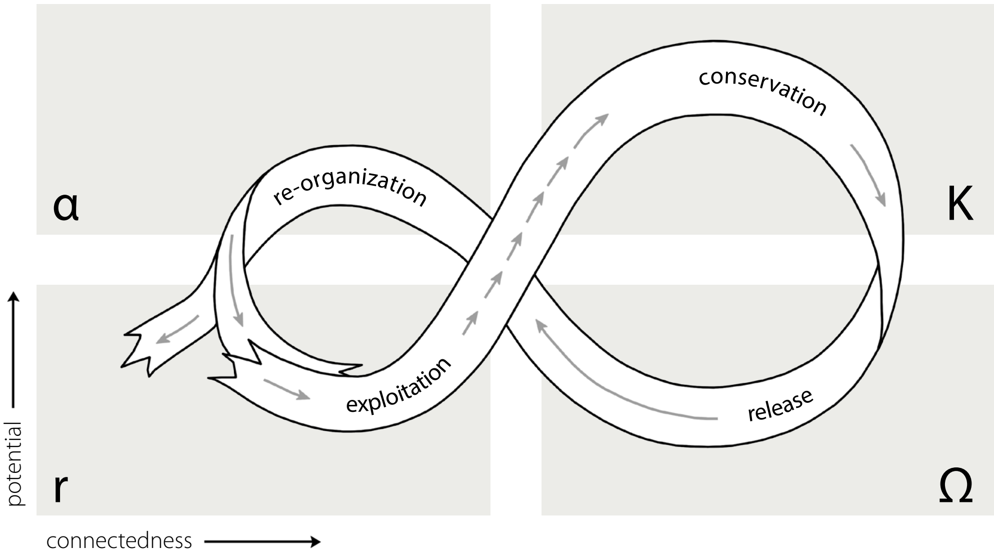


Fig 3.9: The four system states plotted along the two axes of potential and connectedness. The breakage on the left shows incoming and outgoing particles. Shorter arrows indicate more time, a lower speed. After Gunderson and Holling (2002).

on its niche grows more and more rigid. In a moment of release the tight organization is lost and a more chaotic and free state of the particles make room for a new structure to form or, in the terms of Haken, makes room for a new order parameter to arise. In this phase of re-organization, or the early stage of self-organization, random coincidences can highly affect the path of the system. Within the chaotic surroundings it is easily possible to attract particles to follow a certain structure.

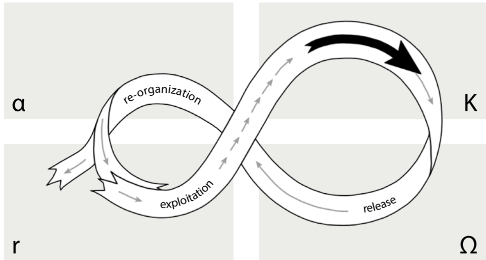


Fig 3.10: The structure of the system, which is in its exploitation phase, is conserved though the accumulation of material.

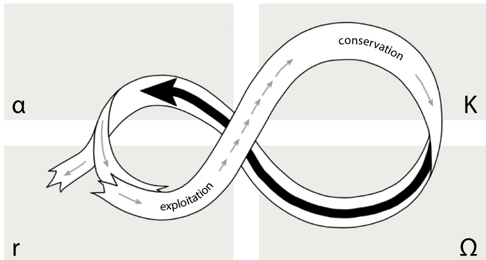


Fig 3.11: The system is not resilient enough to withstand the changing conditions and collapses, moving into a new volatile state of re-organization.

3.2.2 Four phases of a stuff cell

The previous paragraph described how a stuff cell in a garden survived the lack of light through the addition of a lamp, but collapsed when a drop in temperature could not be managed. The stuff cell was in its exploitation phase, as it already developed a structure with useful emergent properties (i.e. the possibility to comfortably sit and enjoy a book). When the first challenge occurred, the system could conserve itself through the addition of more stuff. As described by Gunderson and Holling (2002), the system is conserved for a longer time, through the accumulation of material.

In the second case, the system was too rigid to survive the changing conditions - thus reaching a critical point - and collapsed. It re-organized itself in another place, and both the garden and the system around the activity found themselves in the open and volatile phase that is typical in this new beginning. In this unstable state the system is open for suggestions, local interactions changing its path. When there happens to be a pen, a box of tea or a standing desk, for example, there is a chance it noticeably steers the course of the activity and thus changes the stuff cell, whereas in the initial situation actively obtaining those items would not have come to one's mind.

3.3.CROSS-SCALE DYNAMICS

In the introduction Holling's term panarchy quickly passed in review. This is a substitute word to 'hierarchy' (which sounds too top-down and determined for the matter) given to describe the (vertical) nestedness of adaptive cycles of different scale levels within each other; think of a cell, a leaf, a branch, a tree and a forest. An exponential relationship (hence: *Powers of Ten*) between both the size of the system and the lifetime of its adaptive cycle seems to apply in many cases. The smaller systems are faster and the larger systems are slower. Fig 3.12 shows this concept on a logarithmic scale in both space and time (Gunderson & Holling 2002).

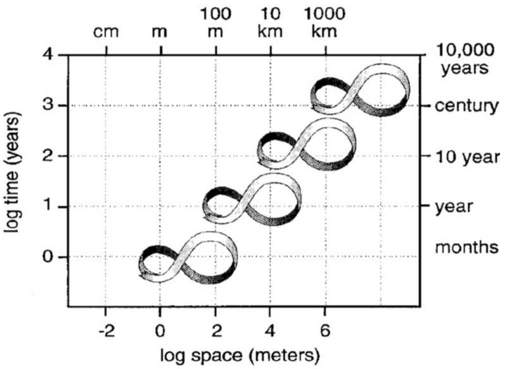


Fig 3.12: The exponential correlations in size and time span, stylized scheme. From Gunderson and Holling (2002).

3.3.1 A cross-scale model

Two things distinguish the panarchical representation from the traditional hierarchical ones (Holling, 2001). Firstly the fact that the whole of it is intrinsically dynamic; it consists of widely varied adaptive cycles, which are sometimes rigid and domineering and other times open for innovation and renewal. Secondly because of connections between different scale levels, described with the verbs 'revolt' and 'remember'.

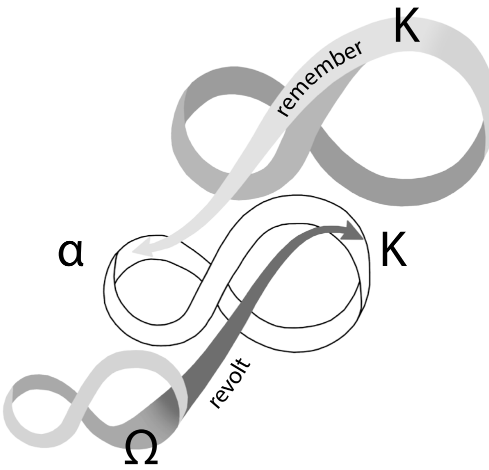


Fig 3.13: The cross-scale relationships of revolting and remembering. Adapted from Gunderson & Holling (2002).

Revolting, rebelling or upward causation of a smaller system happens when it enters its Ω-phase; the collapse can cascade to the larger and slower level and trigger a crisis. This is most likely to happen when the larger system is at the end of its K-phase, as it is vulnerable already.

Remembering, or downward causation, is when the structure of a larger and slower system defines the action of the smaller and faster system, particularly after its collapse, in the chaotic and unstable moment of re-organization. If the larger system is in its rigid and strongly structured K-phase, it is especially influential.

3.3.2 Cross-scale stuff systems

Also in stuff systems, we can see that different scales of organization influence each other in the way described above.

Remembering occurs when a larger and slower system is in its highly developed K-phase, something that in a house can be clearly seen in activities that are paired with very specific stuff configurations. These actions, such as sleeping, showering, brushing teeth or, in the case described in paragraph 3.1.2, working in the home office, are often repetitive and can be referred to as highly scripted behavior (Abelson, 1981) in which the action (and therefore, the interaction with stuff) is intuitive, habitual and embodied.

When a more spontaneous activity, such as sorting out clothes, needs a large surface, the bed is an easy and logical place to partake. As long as the activity is performed, the stuff cell will maintain itself. However, at bedtime both the stuff cell around the bed and the activity of sleeping, that together form a larger and slower system, will 'remember' the place belongs to them; it is highly unlikely that this disturbance will cause the inhabitant to sleep somewhere else or not sleep at all. A similar event happens when in the midst of cooking, an activity that mostly consists of a series of smaller stuff cells in the kitchen, the table is used after putting smaller stuff cells (reading the newspaper, filling in crosswords) aside.

Fig 3.14: The smaller and faster system of sorting out clothes will be cleaned up or moved as soon as the highly scripted activity of sleeping, in the stuff cell of the bed, is initiated. It is highly unlikely to happen the other way around.

From the other side, smaller systems can revolt against a settled system, especially when this is in the unstable phase in which it is about to collapse. The Diderot effect as described in paragraph 3.1.4 is a clear example of this, as one small item can because of its specific style, aesthetic or color, force the entire system to find a new balance. This effect can also be seen in the configuration of furniture, especially when a living space is limited; the movement of one piece of furniture or the initiative of one small stuff cell in an unusual place triggers a cascade of displacements, possibly leading to a completely new room arrangement. In other words, one can say that the collapse of a system is brought about by a shortage of stuff or space at a specific point, which can be pushed by one single event - a straw that breaks the camel's back.

3.4 DYNAMICS AND CONTROL

Holling already projects this model on different domains, such as physical systems, meteorological systems, biological and ecological systems, and also political events or businesses. His conclusion is that although the model remains a sustainable explanation, the exercise to find exceptions does lead to different variants with for example an unusual rhythm or an oscillation between two phases (2001). Amongst them are human systems, that are defined by 'foresight'.

The three elementary models on complex system dynamics in this chapter describe material and organic complex systems, in which the parts are not able to (directly) adapt their local rules through conscious decisions. Since stuff systems are human systems, the fact that a human being is conscious of what is happening around them has to be taken into account. The most important human cognitive ability in this context is that of *chronesthesia*, the cognitive ability of humans to be consciously aware of subjective time

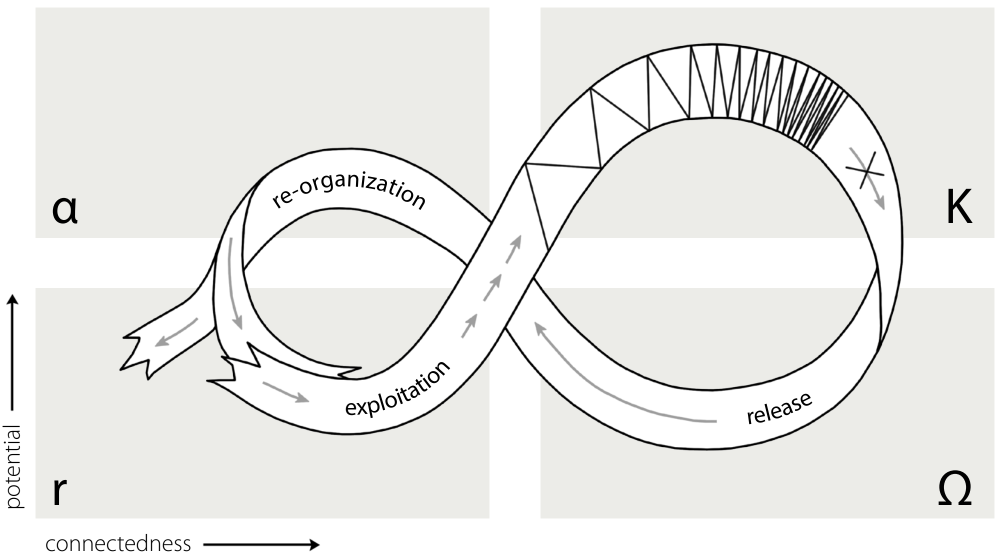


Fig 3.15: A general tendency is to expoit potential and avoid a sudden (unpredictable) collapse.

(Tulving, 1983). This enables to mentally travel back and forward in time, recalling and imagining events. More than an ability, chronesthesia is a default function of the brain and impossible to *not* do; people spend up to 50 percent of their awake hours thinking about events in the past or future (Raichle et al., 2001).

Awareness of the dynamics of a situation and the possibility to imagine possible futures can alter the model in a variety of ways, which is a study on its own. In general and as suggested by Holling (2001) people tend to both stabilize variety and exploit opportunity. Translated back to the model, this means that the exploitation and conservation phases are kept alive as long as possible, thus actively preventing a collapse through targeted action (fig 3.15). This is for instance done by increasing the resilience of the system to changing (climatic) conditions (i.e. by timely purchasing a fan or heating system) or averting rebellious parts to enter the house (i.e. not impulsively buying a bright red couch). Of course, when consciousness is high and the system is well understood, the dynamics can be steered even more dramatically by, for example, triggering a collapse, or directing the rise of an order parameter in the re-organization phase by giving forethoughtful hints.

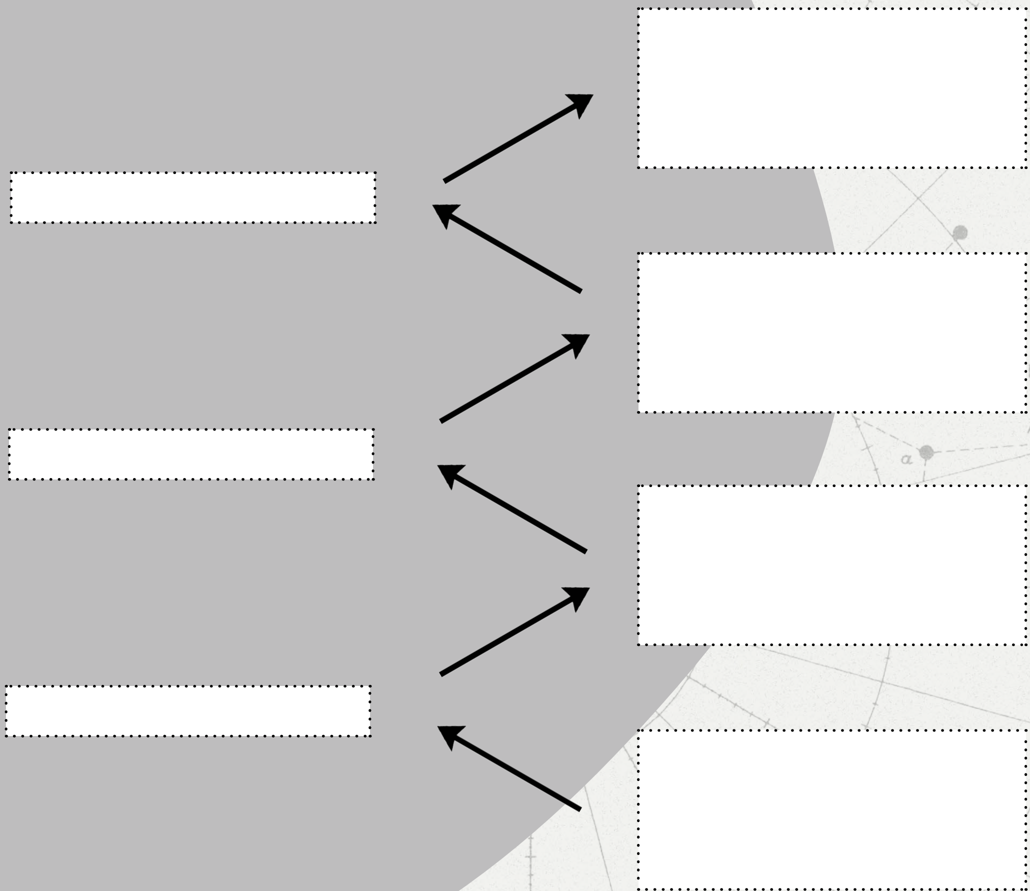
It seems that this planning behavior, which is associated with chronesthesia (Portugali, 2011) in stuff systems mostly occurs in higher scale levels. The placement of furniture is something of which various options are consciously considered while imagining possible futures. Stuff cells around this placed furniture, however, are more intuitive. The exact position of stuff on a table when working is not mapped out, but seems to be given by direct behavior.

In reflection we can say that complex system dynamics quite sufficiently describes the self-organization of stuff, yet under one condition. For order to emerge in a way defined by both bottom-up and top-down forces, a two-way interaction needs to present. This necessary 'feedback-sensitivity' is present when either the system is substantially larger and slower than the planning and controlling of individuals can reach (such as in a city), or when the interaction is so direct, ad-hoc and intuitive that long-term planning is not even considered. The latter is visible when people create the space they are immersed in by direct action, such as in the flux of (small-scale) stuff.

In the next chapter the basic understanding of stuff system dynamics though the singularly complex models given in this chapter will be extended into a doubly complex theory, in which the cognitive capabilities of humans are embedded.

IV. THEORY DEVELOPMENT II

PROCESSES OF INTERACTION



IV.

INTRODUCTION

The previous chapter explored the dynamics of the self-organization of stuff in a singularly complex way, parallelling it with systems in, amongst others, ecology. But there is something to resolve, as stuff itself does not move. In the end, it is only possible to explain the process through the interaction with living and acting human beings.

In this chapter a model is developed to respond to this problem, linking the configuration of stuff to the cognitive abilities of people. Before looking at global patterns, we zoom in on the most local decisions; the act of picking up a pen, of moving chair or setting the table. According to action identification theory, these little moments of decision are not always conscious processes, but simply become automatic subordinate components to our larger goals (Vallacher & Wegner, 1987), and thus can self-organize into action.

Left - Stylized scheme of the two-way interaction between 'searching' and 'stumbling upon'. By author.

4.1 STUFF - ACTION - IDENTIFICATION

4.1.1 Affordances as a medium of interaction

Logically, stuff is related to activity, as it makes activity possible. However, it is not the individual things that offer us much; when we think about it, it is striking how little we can do with a bowl, a corkscrew or a bag. These offer the human body the somewhat useless possibility to 'hold them' or 'rotate them', but their actual service seems first to be directed to other artifacts, such as soup, a bottle with a cork or groceries that need to be carried. It is in a configuration that the actual emergent properties arise; combined with a spoon we can eat the soup, with a chair, a table and glass of water we can have a meal, and as more bowls of soup and chairs are added we can enjoy a dinner with friends. The more particles self-organize into a stuff cell, the more the configuration affords us.

Affordances is a term used in perceptual psychology, first explained by J.J. Gibson in the article 'The theory of affordances' (1977) and explored more deeply in 'The ecological approach to visual perception' (1979). Affordances of the environment are, Gibson defines, "what it offers the animal, what it provides or furnishes, either for good or for ill" (1979). Whereas classical perceptual psychology considers the mind as a black box that receives information, processes it and subsequently performs an action, ecological perceptual psychology links perception to action in a direct and complementary relationship (Gaver, 1991). It is therefore that this term lately became commonplace in interaction design, and is being explored in the field of architecture[1].

What Gibson suggests is that these possibilities of action are also what is perceived. Through a constant analysis of the environment in terms of affordances, our perception is not sensory-based, but information-based; we do not perceive stairs, but the affordance of stair-climbing (1979). This approach, that as a result makes the perception of the environment dependent on personal physical abilities as well as cultural values (e.g. strength, skills, beliefs) proved to be of value in explaining complex, open-ended events in everyday life (Gaver, 1991). A complementary relationship between the acting organism and the acted-upon environment is inherent to the term.

Artifacts as a medium of interaction, as described by Portugali (2016), can therefore be understood in terms of affordances; they are both an action possibility and a perceived

1 Such as by studio RAAAF (Rietveld Architecture +Art+Affordances)

action possibility[2]. On the concrete and physical level of individual artifacts this is quite direct; a hand grip affords to be held and communicates accordingly. This interaction is often consciously planned by the designer and awaits to be performed by its user. The configuration of multiple artifacts, however, is essentially dynamic. The displacement of stuff is a continuous ad-hoc assemblage of affordances by the inhabitant itself. Stuff forms a landscape of affordances, from concrete to abstract, and therefore resembles a city, where texts, buildings and roads are external representations of ideas, intentions, memories and thoughts (Portugali, 2016), yet in a very individual, personal and day-to-day manner. By creating action possibilities we create the perception of action possibilities and thus communicate with ourselves.

4.1.2 Action identification as a medium of interaction

All action and all action possibility is related to internal ideas, cognitive representations of what one is doing or could be doing: action identities. The direction of this relationship has been a theme that in classical psychology has split opinions (Vallacher & Wegner, 1987). By some the cognitive identification of the action is regarded as something reflective that is constructed through a judgement of the situation (a.o. self-perception theory and psychoanalysis), while others see it as a template for subsequent behavior; after a mental representation of what one is going to do is constructed, the action is performed (a.o. psychology around the control of muscle movements). Both domains seem not to be able to explain the phenomenon of self-organizing stuff; an either top-down or completely bottom-up approach both miss the two-way interdependence that is necessary.

Action identification theory, introduced by R. Vallacher, presumes that as soon as we step out of the laboratory, both our thoughts and the sequence of actions we perform are anything but calm and straightforward. The mind is a turbulent and chaotic theatre of thoughts where at a fast pace all kinds of

2 In literature on the topic, the term affordances is explained in multiple ways, which fall into these two main categories. When affordances are defined as something we perceive through an object (a.o. Rietveld & Kiverstein, 2014), this means that cultural background, personal values and earlier experiences are inherent to the term. The affordances are, in some way, finite - we perceive certain things and other things not. Other times the term is used as the infinite amount of action possibilities that the environment has to offer, something that is always existing. This infinite collection is present independent of the viewer (a.o. Gaver, 1991 and Gibson, 1979). Still perception is an unmissable factor - *" Affordances exist whether or not they are perceived, but it is because they are inherently about important properties that they need to be perceived. "* (Gibson, 1979. p.143). In this text the definition as both action possibility and perceived action possibility is used, and clarified where needed.

ideas, complementary, contradictory or even completely unrelated, pass by. Zooming in on the actual process of doing things the relationship between everyday actions and our thoughts on them might be not unidirectional but cyclical (Vallacher & Wegner, 1987) (Vallacher & Kaufman, 1996). The theory of action identification explores the idea of a causal interdependence between the two, on the local level of small and simultaneous decisions, that could be the key to defining complex global patterns.

The underlying concept is that every activity can be described in multiple ways. One can, for example, be 'preparing a salad', but could also be 'eating healthily', 'chopping tomatoes' or 'being creative with left-overs'. These identities find themselves in a hierarchical linkage, on a scale from higher level to lower level descriptions, defined by the words 'by' (higher to lower) and 'to' (lower to higher); one prepares a salad *by* chopping tomatoes *by* moving a knife up and down *by* using the muscles in one's hand. One makes coffee *to* get energized *to* have a productive day (Goldman, 1970). Higher and lower level actions have quite different characteristics. Whereas low level identities express (muscle) movements, high level identities describe the action in relation to its context, often suggesting a larger meaning, goal or significance (Vallacher & Wegner, 1987).

People in principle tend to maintain their activity with regard to the current prepotent action identity in mind (Vallacher & Wegner, 1987). The cognitive concept of what one is doing regulates the behavior as it distinguishes suggestions on the continuation of the activity as either relevant or not, which means that it serves as an order parameter structuring the action. Moreover, when a low level activity is prepotent, people are eager to adopt any clue for a higher identity when it pops up (Vallacher & Wegner, 1987), even when the high levels have questionable connections to the lower level details (Vallacher & Kaufman, 1996). This sensitivity to clues for a higher level identity (e.g. in the form of an idea on the relevance of their action in a larger context) makes the process path-dependent; a relatively random occurrence can entirely change the course of the system. The emergence from a mechanistic depiction of behavior into a single comprehensive identity, the theory suggests, is a product of volatile mental activity, a global pattern arising from relatively wild and uncontrolled local interactions.

" Such instances of instability represent more than noise or breakdown in a system. To the contrary, far from being unavoidable at best or dysfunctional at worst, instability plays a critical role in the functioning of many different kinds of systems. Simply put, the fluctuations among different states and patterns characterizing the unstable system

provides the raw material for subsequent self-organization in the system. "

- Vallacher & Kaufman (1996, p. 265)

4.1.3 Affordances as external memory

Action identities are a constant reminder of what we are doing and serve as an order parameter structuring the activity after being emerged from a miscellany of thoughts and ideas that together form more and more abstract concepts. In all these respects they are similar to affordances. Affordances having emerged from concrete to abstract in the same way, at the same time being a communicative medium that appears to us as something identified; a corner for reading, a desk for drawing, a window sill for plant nursing. Affordances and action identities work complementary in the self-organization of action, as internal (cognitive) and external (physical) phenomena of the same kind. This implies that the configuration of stuff is an ad-hoc constructed extension of the brain, like a life-sized drawing, to-do list or post-it note.

This can be illustrated by imagining coming home after a day at work, some free time ahead and no particular plan in mind. What if some robotic system would every day completely tidy up the living room by putting all items in order, stacked on the shelves and hidden behind cupboard doors? The space would feel uninspiring and as if it could have been everyone's. It is when you come home that you want to see things and be given ideas, opted by the external memory from before you left. *"I can read the paper! There was a project I was working on! That CD I bought new, I should still listen to it!"*

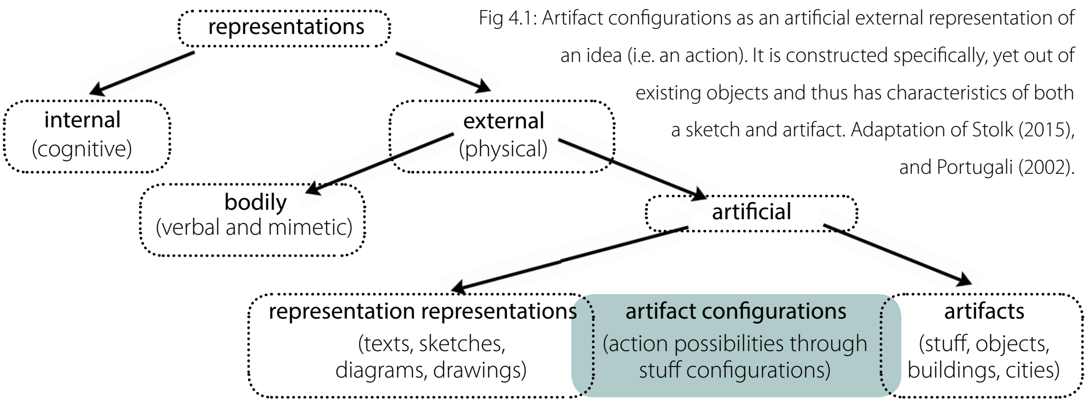


Fig 4.1: Artifact configurations as an artificial external representation of an idea (i.e. an action). It is constructed specifically, yet out of existing objects and thus has characteristics of both a sketch and artifact. Adaptation of Stolk (2015), and Portugali (2002).

4.2 LOWER AND HIGHER LEVELS

The first main principle of action identification theory holds, as we have seen, that action is maintained with respect to its prepotent identity. The second states that there is a tendency to jump to a higher level identity if possible; when constant focus on one's fingers while playing the piano becomes unnecessary, people are likely to describe their activity as 'making music' or 'entertaining friends'. Lastly, the third principle holds that when action cannot be maintained in terms of its prepotent identity, there is a tendency for a lower level identity to become prepotent (again). This mostly occurs in one of two scenarios. Either something goes wrong, the piano player makes a mistake and is suddenly forced to focus on the exact placement of their fingers again (unintended), or a task is too difficult to understand as a whole, and is therefore split up in smaller tasks to perform step by step (intended) (Vallacher & Wegner, 1987).

Lowering levels is quite easily caused by stuff, and the concept is often explained so. When something breaks, for example, gets lost or is used up, it disturbs the ongoing activity and becomes the focus of attention. An experiment conducted by Wegner et al. (1984) shows how odd tools inhibit people from reaching higher levels at all; coffee drinkers given heavy and oddly shaped cups described their activity as 'lifting the cup', while others given normal cups talked about 'taking a break' and 'getting energized'. In other words, one can say that an action identity cannot be reached or maintained when corresponding affordances, the external action possibilities, are not or no longer present.

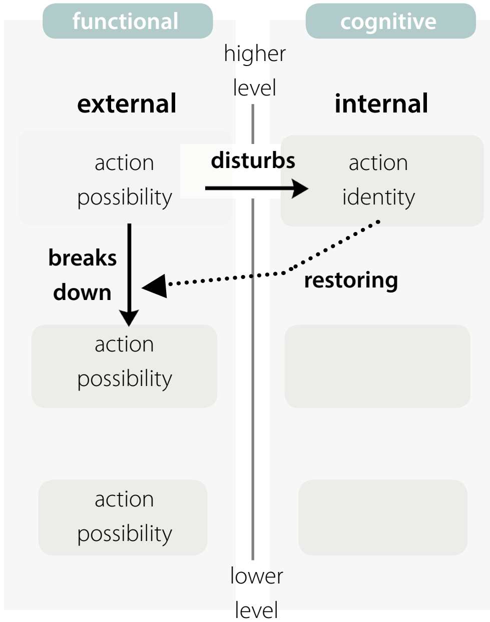


Fig 4.2: The external action possiblities (affordances) and internal action identity correspond. When the action possibility 'breaks' (e.g. caused by the malfunctioning of stuff) the action identity can no longer be maintained. Generally, but not always, the attention moves to how the action possibility can be restored (e.g. by repairing, replacing or refilling something).

Higher levels are reached by thoughts and suggestions on the activity in a larger context, that can especially in the volatile first phase be quite random and even unrelated to the matter (Vallacher & Wegner, 1987). We can add to this notion that not only internal ideas (fig 4.3), but also external ideas in the form of affordances fulfil this role (fig 4.4). Stuff that lies around can unexpectedly generate ideas and be of value, and thus lift the activity to a higher level. Especially starting from low levels this process seems to indeed happen almost by chance. When entering your home after work, it can be either an article in the paper, a book lying on the coffee table or a radio program that happens to first grab your attention. When doodling on a piece of paper a colored pen, magazine, or pair of scissors lying around can suddenly become the source of inspiration that changes the course of the activity.

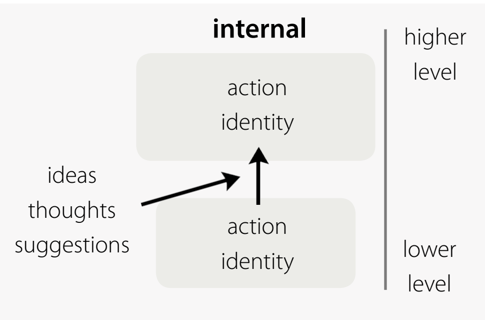


Fig 4.3: A higher level reached through internal ideas

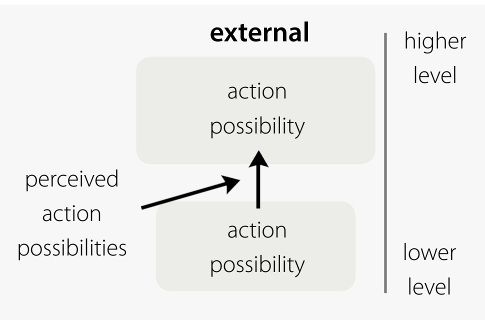


Fig 4.4: A higher level reached through external inspiration in the form of affordances.

Additionally, the action identity can exclusively become higher level when the affordances correspond. When the initially aimless doodling progresses to a higher level 'drawing a birthday card', a piece of carton and envelope need to be obtained to fulfil its full action possibility. The easier to obtain those items, the less clear the cognitive idea of the action needs to be. If lying around already, the step to making a card can be easily made, even when still unsure whether it is going to work out (fig 4.5); if not in the house, the idea must be more clearly pictured and seem promising enough for a trip to the store (fig 4.6).

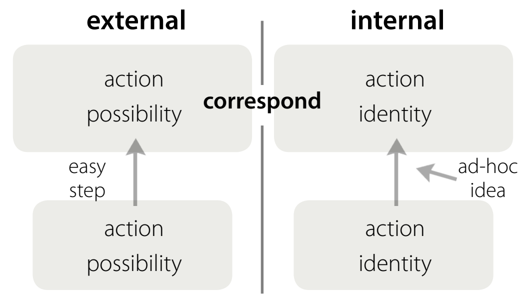


Fig 4.5: A sudden, ad-hoc, random idea is still tested if the action possibility is easy to create.

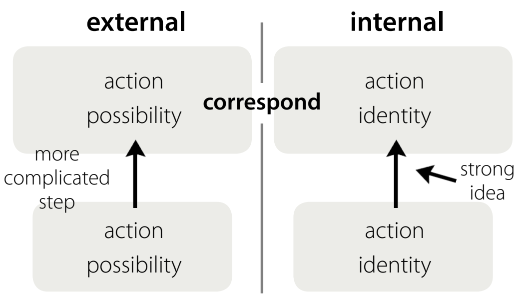


Fig 4.6: When creating the action possibility requires planning behavior, the idea needs to be more promising and predictable before it happens.

4.3. INTERNAL - EXTERNAL

The above indicates that stuff can enter a centre of self-organization in two ways. Either after being specifically searched for by the user themselves (which happens more easily when requiring less effort), or by presenting itself with its action possibilities and thus bringing the user to ideas for another or a higher level activity than the prepotent one.

In the former case, the process is started from an internal representation forming the external action possibilities through configuring stuff. In the latter, it is the external (physical) perception of an action possibility after which an internal (cognitive) idea is formed. These two directions, 'searching' and 'stumbling upon', continuously oscillate. While an action can be initiated through an action possibility that presents itself, it is mostly the act of specific searching that completes the stuff cell so it affords to perform the activity. A magazine on the table might inspire the user to 'relax with a magazine' (external to internal), but before the action can be performed, they will first search for something to sit on (internal to external), etc. In this process of self-organization the order parameter develops throughout the process. Either a wooden chair at the table or a lounge chair is found to 'sit on', both affording a higher level

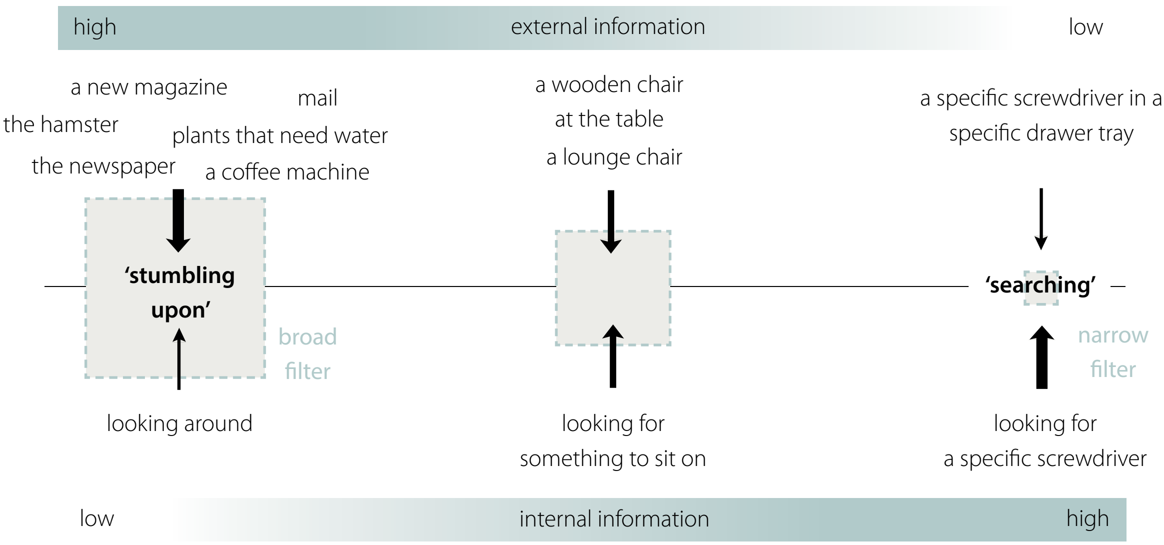


Fig 4.7: The gradient between an action happening from external inspiration by a percieved action possibility and the specific searching for the creation of an action possibility. This gradient is the specificness of a 'filter', through which the surroundings are scanned for affordances. When the internal information is clear, the external information can be less clear and the activity will still happen (e.g. the artifact can be hidden in a drawer somewhere). When the external information is clear (i.e. the affordance is in plain sight) the internal information can be less defined and the activity can still happen.

action of a different context. The next higher level completion of the stuff cell is done while searching for different affordances; a cup of coffee and a pen in the more serious setting of the wooden chair at the table, a footstool and animal paw slippers in the more relaxing context of the lounge chair.

As mapped out in fig 4.7 there is no clear cut between those two directions. On the contrary, they overlap when an affordance is searched for, but several possibilities are still open; the searching happens within a certain category. As long as an artifact offers the pursued action possibility (e.g. 'something to sit on'), one can still be inspired by other and higher levels the artifact affords (e.g. 'sitting actively at a table' or 'sitting back and relaxing').

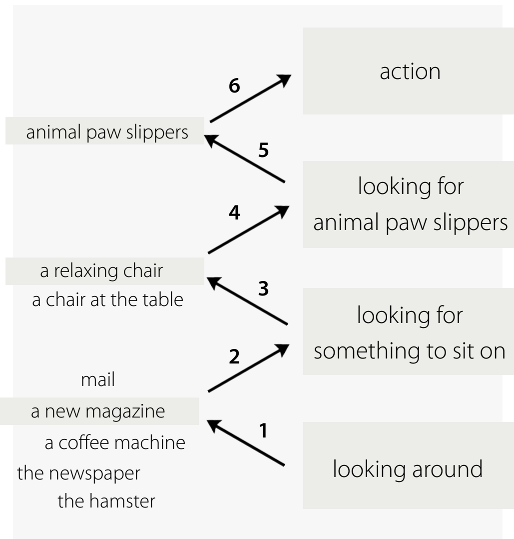


Fig 4.8: The self-organizing process from non-activity to sitting in a lounge chair with a magazine and animal paw slippers. Over time, the activity grows more specific.

1 - Looking around in the category 'something to do'
2 - Constructing a mental image of an affordance (reading a magazine, while sitting / e.g. "enjoying the afternoon")
3 - Looking around in the category 'something to sit on'
4 - Constructing a mental image of the affordance (reading a magazine while sitting comfortably / e.g. "cocooning")
5 - Looking around specifically for animal paw slippers.
6 - Completion of the affordance.

The decision which artifact to use can be made exclusively through external information (*"I am a new magazine, read me"*), or exclusively through internal information (*a specific screwdriver is searched for in a specific drawer tray*), but mostly it is a combination of both. Tasks that are formed through an interplay between external and internal information, in which an initially takes more and more concrete form, are termed cognitively complex (Portugali & Stolk, 2014). The problem and solution co-evolve. The emergence of action identity and action possibilities in the form of configurations of stuff is such a task.

4.4 FROM LOCAL INTERACTION TO GLOBAL PATTERNS

4.4.1 Order and chaos

Stuff that is ordered by its properties is easy to specifically locate back, when known what to look for. In a library, the ultimate example of an ordered collection of stuff, a book can be found in minutes by searching for the first letter, then narrowing down to the second

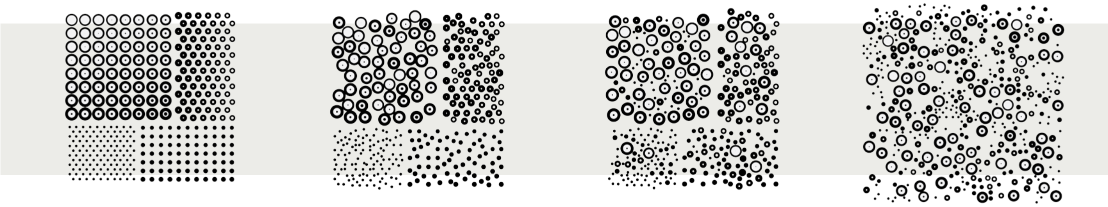


Fig 4.9: Ordered chaos. Larger and slower scale: order. Smaller and faster scale: chaos

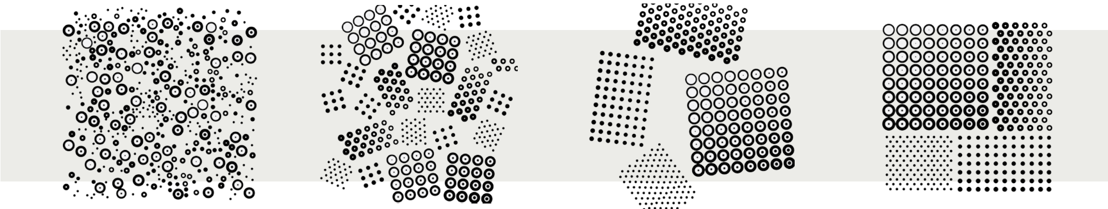


Fig 4.10: Chaotic order. Larger and slower scale: chaos. Smaller and faster scale: order

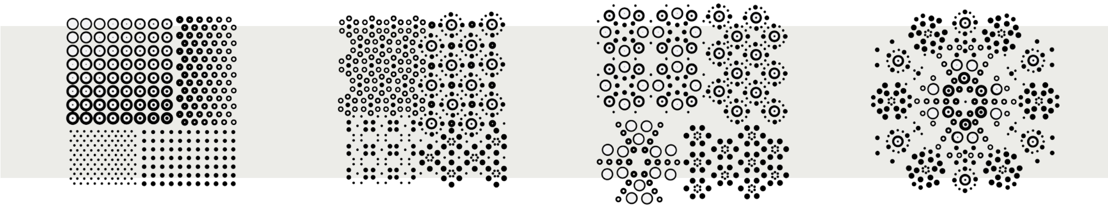


Fig 4.11: Ordered self-organization. Larger and slower scale: order. Smaller and faster scale: self-organization

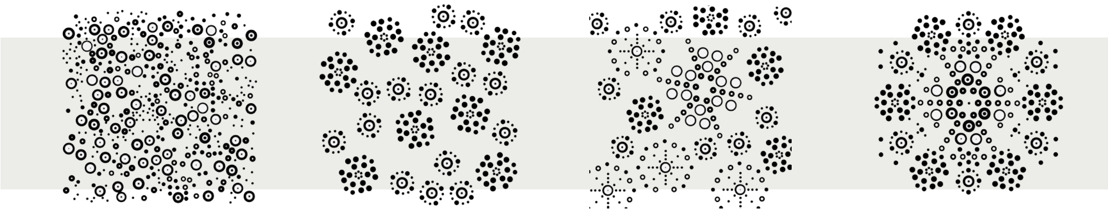


Fig 4.12: Chaotic self-organization: Larger and slower scale: chaos. Smaller and faster scale: self-organization

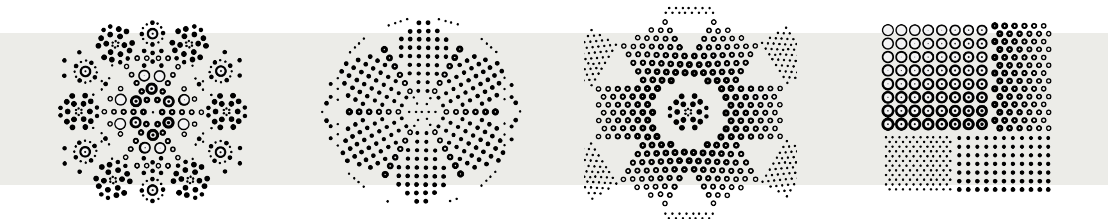


Fig 4.13: Self-organized order. Larger and slower scale: self-organization. Smaller and faster scale: chaos

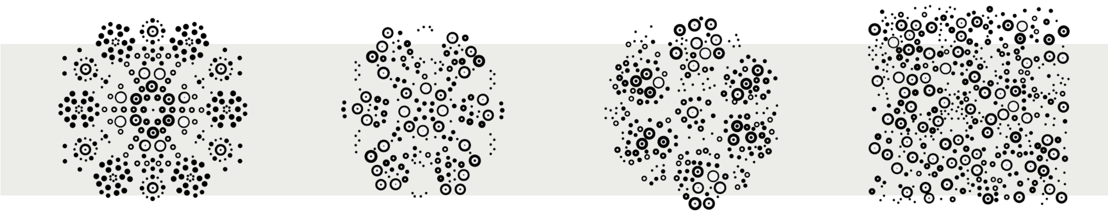


Fig 4.14: Self-organized chaos. Larger and slower scale: self-organization. Smaller and faster scale: order

letter, the third letter etcetera. For this search not much external information is needed; a small indicator on the back of the book is enough. When systematically numbered, the item can, even in a closed storage system with thousands of books, be found quickly.

This type of ordered organization works efficiently, but only for planned behavior. It does not generate any ideas, which is why most libraries, for instance, offer displays with recently published or recommended books for visitors to stumble upon. It is the, to a certain extent, random placement of stuff that sparks coincidences and makes moments of contingency and serendipity possible.

4.4.2 The multi-scale gradient between order and chaos

As the self-organization of action and the self-organization of stuff happens through the constant alternation between searching and stumbling upon, both order and chaos is needed. Indeed, we can recognize the patterns of both states in almost every room.

The patterns of order and chaos are multi-scale; on a high level things can be ordered in categories, whereas zoomed in on those categories themselves, the items are not sorted any further; a kitchen cupboard is filled with cups and mugs ('something to drink from'), but inside the cups are randomly placed. The category itself is hidden (behind a door) and will be specifically searched for, but when opened the cups individually present themselves by their visual information and inspire the user to pick a desired one. The other way around an ordered system can be split in subsystems that are more randomly spread around the house, such as when having multiple bookshelves (one for work-related, one for hobby-related and one for fictional books, and a smaller pile of newly bought ones), which give more life to a house than a clean and hidden archive.

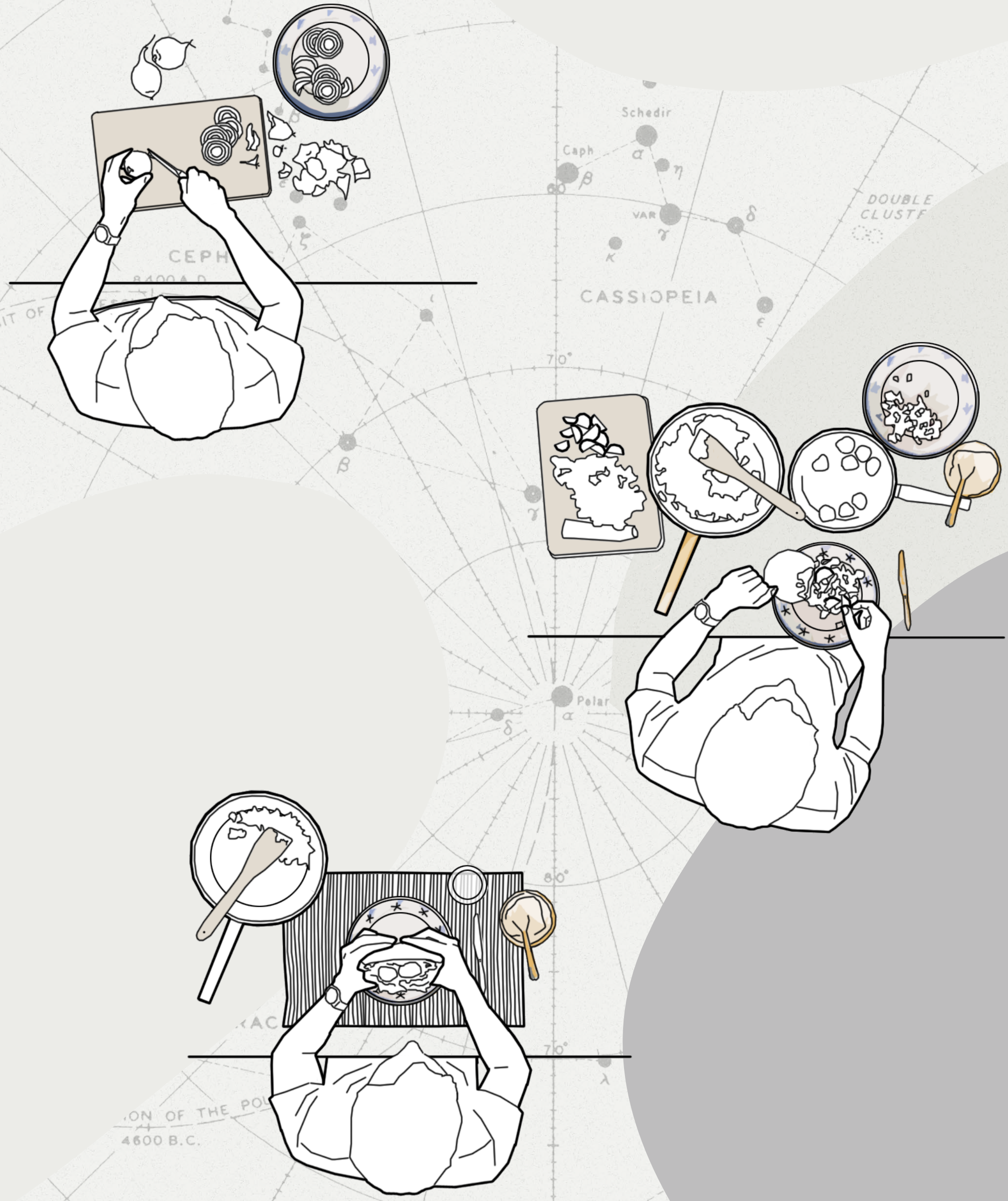
The overall patterns to be found are multi-scale combinations of the soup-like and the grid-like - see fig 4.9 and 4.10.

4.4.3 The gradient to self-organization

When we project the same method of combining patterns with different scale levels on the crystal-like pattern to be found around activities, we get outcomes that are equally recognizable. An example of 'ordered self-organization' (fig 4.11) are little compositions of stuff on shelves; one of chaotic self-organization' (fig 4.12) are pans with different dishes on the table; and one of 'self-organized order' (fig 4.13) are small piles of sorted books around a working place. The processes of self-organization described above thus creates crystals from order and chaos in a leveled way, working its way from local to global.

V. THEORY DEVELOPMENT III

DISSECTING THE STUFF CELL



V.

INTRODUCTION

The most striking form of the self-organization of stuff is the crystal that expands itself around the body: the stuff cell. Since stuff is an endless resource and the combinations to be made are limitless, no two stuff cells are the same. Nonetheless, they all share some elementary properties regarding their structure.

In this chapter the second data set will be used to explore how the self-organization of stuff leads to physical form. First, some generic clusters of stuff within the cells, recognizable by their distinct role and patterns, the 'organelles', are defined. Secondly, those are analysed in the emergence of stuff cells throughout time. Most importantly, those observations are linked back to the theory developed so far. Can the models on the dynamics of complex systems and the doubly complex view proposed in the previous chapter explain *form*? This part of the research is the synthesis of theory and observations, and hence both the final phase in the theoretical development, and a test.

Left - Illustration of a stuff cell throughout time. By author.

5.1 GENERIC ELEMENTS

Like the cells in a body, stuff cells are highly specific in the activities they grow around. Despite their differences, however, a basic anatomy can be recognized, that arises as a logical outcome of the processes and building materials creating all. Local rules construct no blueprint, but do lead into common paths that create forms with reoccurring elements and roles. Similar to how body cells share the fact that they all have a cell boundary and cytoplasm, and most a nucleus, mitochondria and ribosomes, stuff cells show generic components in their physical structure. These are not pieces of stuff, but clusters of organization playing a distinct role in relation to the whole.

In this paragraphs five of those roles, derived from studying data set II, will be identified, determined and discussed.

5.1.1 Input / sources

Almost every activity involves the processing of *something*; a material or non-material input stream that is used over time. This resource often finds itself on the side of the stuff cell and is consumed in the course of the action; flowers are picked up to be arranged in a vase, sheets of wood are used to saw in functional pieces, tomatoes are sliced to mix through the salad or books are consulted for information.

This input stream is often imported from outside the stuff cell as a batch of the same objects; it is collected from the storage or the store. This 'pile-by-kind' (Tversky, 2016) is positioned at the side of the stuff cell, in contrast to the one-to-one organization happening in its core.

Considering higher levels of scale, this kind of source has traveled through a sequence of

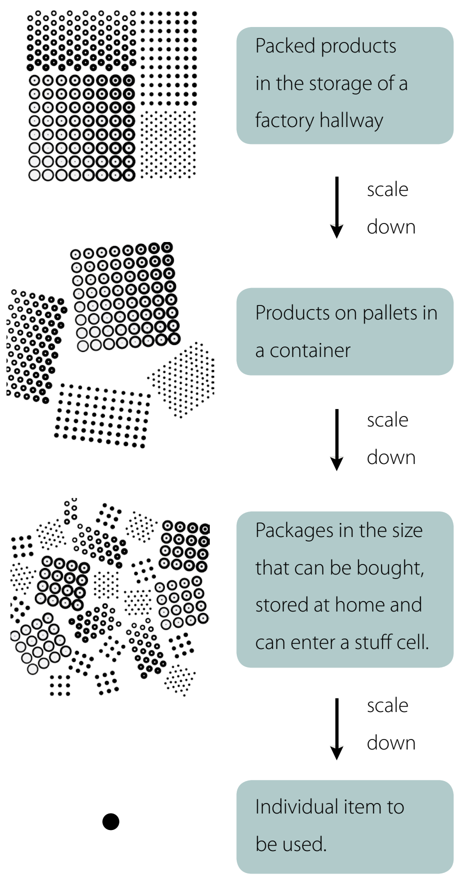


Fig 5.1: Sources often arrive in 'piles-by-kind', ordered because of the space-saving properties of grids.

smaller and smaller systems. In this process it is sequentially being split into segments until reaching a consumable size; products travel from the storage hall of a factory to a container, a pallet, a shop shelf and eventually a storage space at home. Because of its space-saving properties, the organizational pattern is that of an ordered grid.

5.1.2 Output / products

While the sources shrink, other piles of products build up in the course of the activity. This input is processed into piles of products. In the picnic on the front page, the full stomachs can be seen as an output product, and so can the trash, empty bags and pile of dirty plates and trays.

Output streams leave the system in similar scaled steps as the makes the input streams come in, often only a little less ordered. A piece of stuff that, for instance, left over and not of use for the host anymore, is first moved

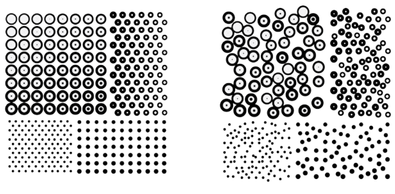


Fig 5.2: Output is produced in different streams. Hence, these are often naturally sorted, but not always to the smallest level of scale. A litter bin is an example of 'ordered chaos'.

to the side of the workplace, then put in the litter bin under the table, the larger bin in the kitchen, the waste collection point in the street and is eventually collected and processed outside the city. A pattern of one-to-one-correspondence at the place of the actual activity gradually finds its way back to piles-by-kind, such as a stack of drawings, a pile of dishes, a compost heap or a full bin bag. If a clear overview and space-saving is important, this happens in a grid pattern, similar to fig 5.1. If not, it follows a pattern of 'ordered chaos'.

5.1.3 Working fields

What all stuff cells have in common is a place of assemblage, where individual items meet in a one-to-one way. This place is the central point of the stuff cell, where the actual activity takes place; the dish pan where the plates are being washed, the pan in which a meal is being prepared and a game board being played on. These working fields are the 'home' of the activity; the focus can move to other elements at the side, but always travels back to this center of operation. Most of the time they find themselves right in front of the user.

Stuff cells tend to have more than one working field that orders itself in a hierarchical way. Right in front of the user the primary working field (e.g. an easel with a painting in progress) can be found, while to the sides smaller centers of assemblage, secondary working fields, (e.g. a glass of water to rinse the brush and a palette to mix paint) support it.

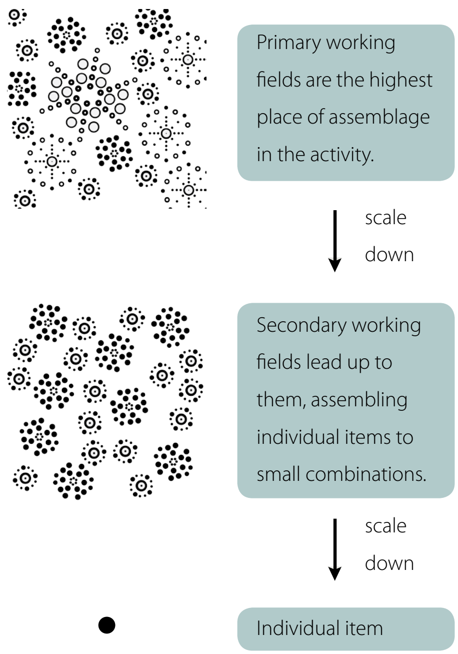


Fig 5.3: Working fields in a hierarchical scale sequence.

5.1.4 Tools

Another category is that of tools, devices used to perform the activity as an extension of the human body (hands and fingernails are tools, but as we are talking about stuff here exclusively external instruments are considered). Tools are elements to perform the activity *with*, and unlike most input streams not 'used up'. Instead, they typically travel between different stuff cells, especially when generic and multi-purpose. Although it differs per stuff cell what is a tool, typical examples are a pair of scissors, a computer mouse or a hammer. Also larger instruments such as a band saw, a piano or a bike can fulfil this role.

5.1.5 Support

The last recognizable role is that of general support, both for the activity and for the host. Items such as lamps, curtains, but also cups of coffee, direct their purpose not so much to the activity specifically, but provide the basic conditions necessary to perform it. Some of those conditions are easy to create on the spot, others are more controlled by the environment. Productive stuff cells are often recognizable because of the circle of empty cups they leave around, instead of the fact that they crystallize directly next to a coffee machine, while for other basic needs, such as electricity this works the other way around. In this role of support we can clearly observe an iterative process between searching for what already is, and creating the right conditions by oneself.

This is considered further in chapter VI, where stuff cells are regarded in relation to their environment.

5.1.6 A dynamic theatre

The difference between input streams and tools is often clear, but can at times be overlapping. Is a pencil a tool to draw with, or a material resource of charcoal? And is a book providing quotes a tool to work with or a non-material resource of information? The same accounts for tools and support; is a chair a tool to sit on, or a basic need essential to start at all? Stuff forms a complex ecology in which the roles particles take are not only dynamic, but also ambiguous in nature. It is therefore not the precise categorization of every artifact that is of interest here, but a general pattern recognition (one time more eloquent than the other) that gives us a basic vocabulary to discuss within.

Even in the smallest of stuff cells those five basic elements can be found. Brushing one's teeth begins with the search for tools (a tooth brush) and sources (the tooth paste), in a place that provides the right conditions. Next, the activity starts by putting tooth paste on the brush and subsequently brushing the teeth themselves; to sequential moments of assemblage. The output, that builds up during the activity, in this case used tooth paste and the dirt brushed off, is disposed, to become the input of a process on a larger scale.

Although it seems so ordinary and everyday, a stuff cell is the smallest unit of metabolism to be found in architecture. It is a basic form of life, that eats, digests and secretes. To do so it both finds and creates for itself a place with light or darkness, silence or sounds, a certain temperature, a working surface and a desired level of privacy.

5.2 STUFF CELLS THROUGH TIME

As we have seen before, stuff cells are no ready-made entities but have a dynamic existence defined by exploitation, conservation, restructuring and renewal. Now that some basic elements have been termed, it is possible to further zoom in on the emergence of stuff cells through time and describe the observations in a useful vocabulary.

On the next page a stuff cell from the second data set is drawn in different points in time. This example of preparing and eating a pita bread with falafel is chosen because it involves a large number of ingredients, artifacts and actions, but is additionally not unusual. Cooking is an activity we perform almost every day, but it involves a high number of agents.

5.2.1 From primary to secondary

In all three stills a primary working field can be distinguished; first it is the cutting board on which the onions are chopped, then it is the pita bread on the plate, that is filled with all the ingredients, and third it is the mouth in which the meal is tasted, grinded and digested. Stuff accumulates around this central point over time, as tools and support are added to the cell when needed; a process of growth when the system is in its phase of exploitation. The activity stops when the onions are cut, the bread is filled and the meal is finished or, in other words, when the resources are depleted. Next follows a phase of release and the emergence of a new order parameter.

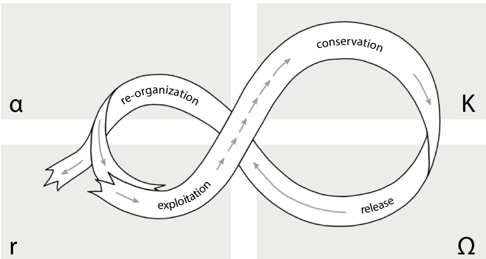


Fig 5.4: The dynamics of complex systems equals that of stuff cells. The three examples on the right all find themselves in the exploitation phase and thus are three different successive stages.

The three stills are all picturing an exploitation phase of a stuff cell system, however, from three distinctly different successive stages. What orders their form most is the primary working field where the other stuff circles around. This is the order parameter, that in every stage is restructured anew.

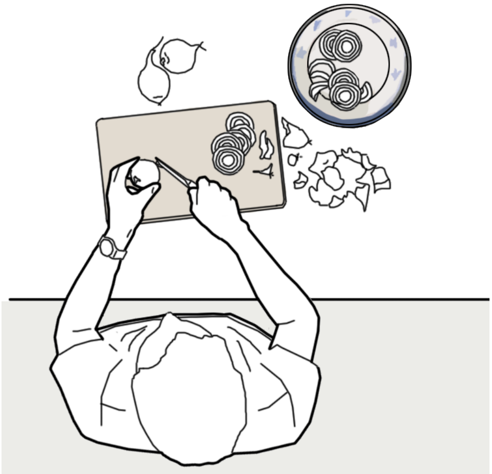
5.2.2 The panarchy of stuff cell form

In the second phase the primary working field of the first phase, the cutting board, is still present, but now acts as a source since the output product of the first phase, chopped onions, is the input for the second. The cutting board can potentially get the role of a secondary working field, when a piece too big is stumbled upon and is quickly cut in half. However, when this happens it does no longer change the layout of the stuff cell as a whole; it is as if the more complex activity of filling the bread entails the cutting within it.

The successive stages are not only different acts of assemblage (chopping onions, cutting tomatoes, preparing the sauce), but time by time also jump to higher levels, in which the primary working field becomes secondary to the new one, until it becomes tertiary to an even newer one. As illustrated in figure 5.8, the growth of a stuff cell is something panarchic.

5.3 THEORY

Now, is it possible to link these processes to the theory developed so far? As we have seen in the previous chapter, individual stuff affords almost nothing except for some basic motor movements, whereas when combined more and more becomes possible. This logically explains the above observations; to perform an activity the affordances to do so need to be present, and therefore be prepared first. An uncut onion does not afford to be put in the bread, whereas onion slices do, a piece of bread with separate ingredients does not afford to be (easily) eaten, whereas a filled pita does.



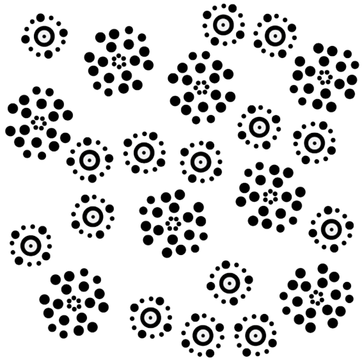
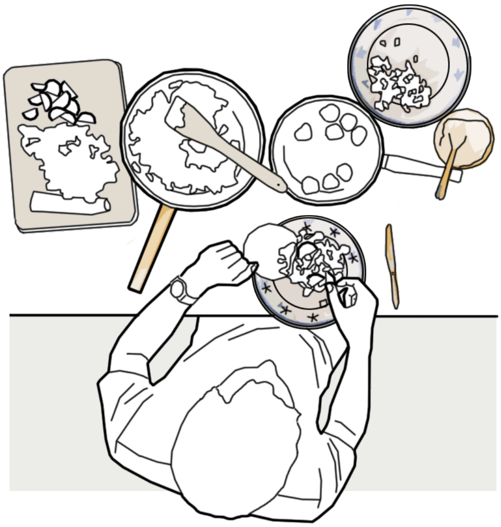


Fig 5.5: Phase one: individual items (onions, a knife, a cutting board) together form small assemblages.



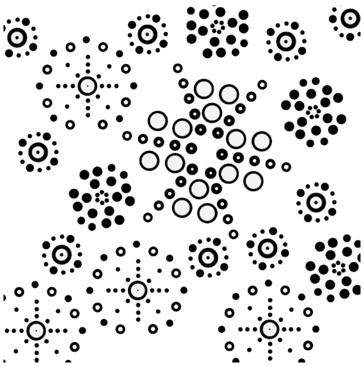


Fig 5.6: Phase two: those small assemblages are assembled further into a larger assemblage (the bread).

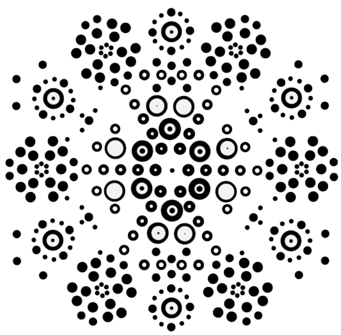


Fig 5.7: Phase three: this larger assemblage is processed through eating it, making the body itself the primary working field.

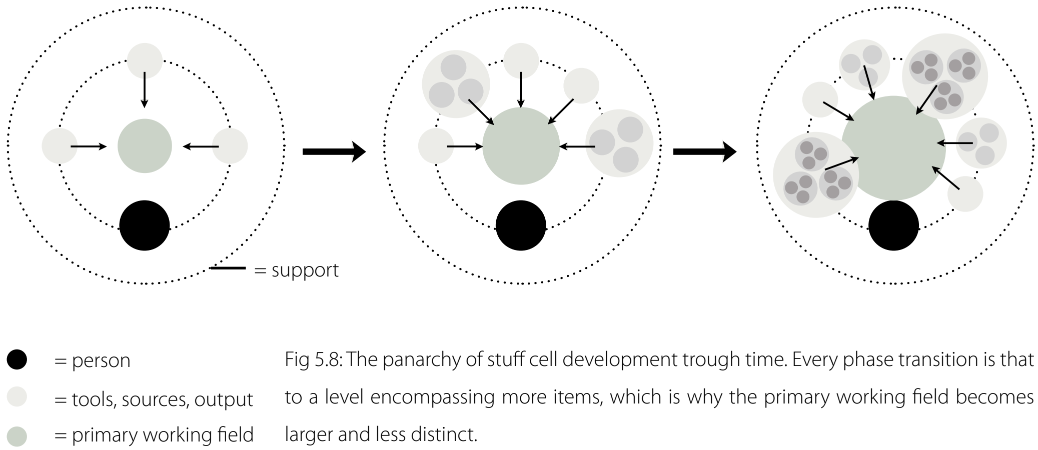


Fig 5.8: The panarchy of stuff cell development trough time. Every phase transition is that to a level encompassing more items, which is why the primary working field becomes larger and less distinct.

5.3.1 Order parameters

Primary working fields are the place of assemblage, and therefore where the most abstract affordance yet is being created. Primary working fields and affordances are phenomena of the same kind, and so is action identification. Being both constructed and perceived at the same time, affordances form an order parameter, a reminder that structures the activity. Action identities work in the same way in an internal, cognitive manner. The primary working field is the result of the (doubly) self-organizing process between the two and forms the order parameter of the stuff cell in its physical form.

5.3.2 Emergence

It is therefore assumable that how primary working fields emerge in a growing stuff cell can be explained in the same way as the emergence of action identities. Projecting the three basic principles of action identification theory would imply that the prepotent primary working field in principle maintains itself, unless higher levels become available (principle 1). When this happens (principle 2), which in this case is when the affordances for a higher level assemblage are present, the primary working field moves to a higher level. In this transformation it becomes more and more encompassing, as it can entail smaller activities within itself. Only when a lower level affordance is significantly disturbed (principle 3) and cannot be quickly and mindlessly repaired, the stuff cell breaks down and makes restoring this affordance the primary working field, until the requirements for the higher level assemblage can (again) be met (Vallacher & Wegner, 1987).

And indeed, it seems that when a high level action identity, such as 'enjoying dinner' or 'being in nature' is prepotent, the primary working field is regarded as increasingly encompassing. It then includes the paintings on the wall, the background sounds and the good company, the grass, the trees and the sky. Affordances of high level action identities are as abstract as 'atmosphere' and the distinction of a clear primary working field simultaneously disappears.

The focal point of the user within a stuff cell continuously changes, both from point to point and from detailed to broad. But it is only when both the action identity and action possibility induce a systemic phase transition to a higher or lower level that the actual layout of the stuff cell changes. In a volatile phase of re-organization a new primary working field becomes the prepotent order parameter where all other stuff finds its way around.

5.4 STUFF CELLS BREEDS

The basic anatomy of every stuff cell is that of a primary working field with sources, tools and products around an outer layer of general support providing the basic conditions (see

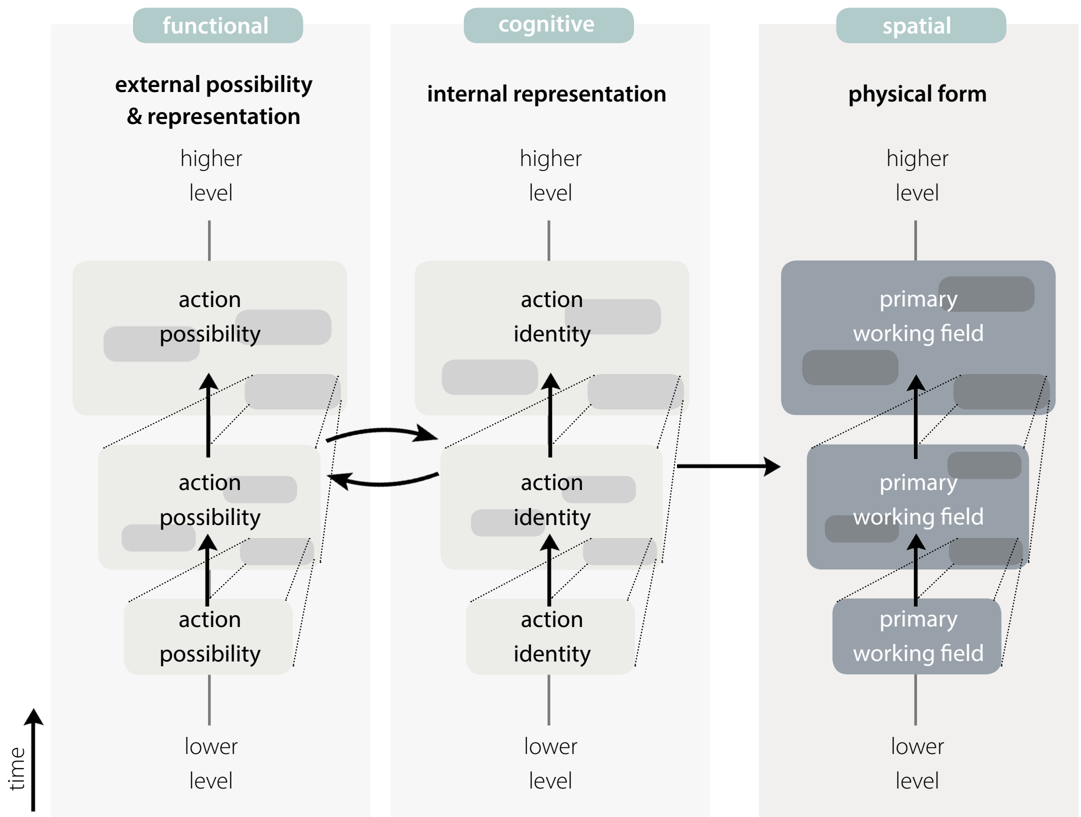


Fig 5.9. Affordances (action possibilities & perceived action possibilities), action identities and primary working fields are phenomena of the same kind - the first two in a constant interdependence, the last as their physical outcome in the form of a stuff cell. All are panarchic, multiple lower levels are included in the higher level (indicated by the dotted lines).

also fig. 5.8). This is the case in, for example, individuals stuff cells that take place at a table. Nonetheless, some stuff-cell-specific variables lead to different breeds.

The first is when the primary working field is notably large. Following the study of Freundschuh and Egenhofer (1997), a distinction can be made between two types of working fields, defined in their relation to the human body. A manipulable working field can be experienced and handled without displacing the body, whereas a non-manipulable working field is only possible to see and work on when one walks around. Washing the car, sanding a table, cutting the

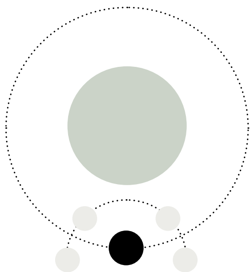


Fig 5.10: Stuff cell with a non-manipulable working field. The person walks around it, taking the smaller items (such as tools) with them.

hedge and mowing the lawn are all examples in which the stuff cell host moves themselves, together with some stuff (a bucket with water, a hedge trimmer, a lawnmower) on and around the primary working field.

The other two breeds are related to stuff cell sharedness. When more than one person performs an activity in which both the same working fields and other roles are shared, the form does not substantially change. Often, however, only one of both is, leading to the examples on the right.

Possibly there are more of those variables leading into different structures - this is a case for further research.

5.5 LIFE AND FORM

What is life?, is the question Schrödinger wanted to address in 1944. This question proved to be not easy to answer over the years. Most definitions include that life is manifested by growth through metabolism - something that is a clear property of stuff cells. Of course, the system comes to life through the interaction with their living hosts, and cannot be sustained without them. Nevertheless, it is striking how far the analogy between a cell and a stuff cell reaches.

Stuff cells as phenomena are not only explained through self-organization by the theory on affordances and action identification, but seem like a direct physical result of it. Their structure is panarchical, and in the phases of exploitation and conservation moves to more and more abstract and encompassing levels. They same process is reflected in the functional, cognitive and the spatial.

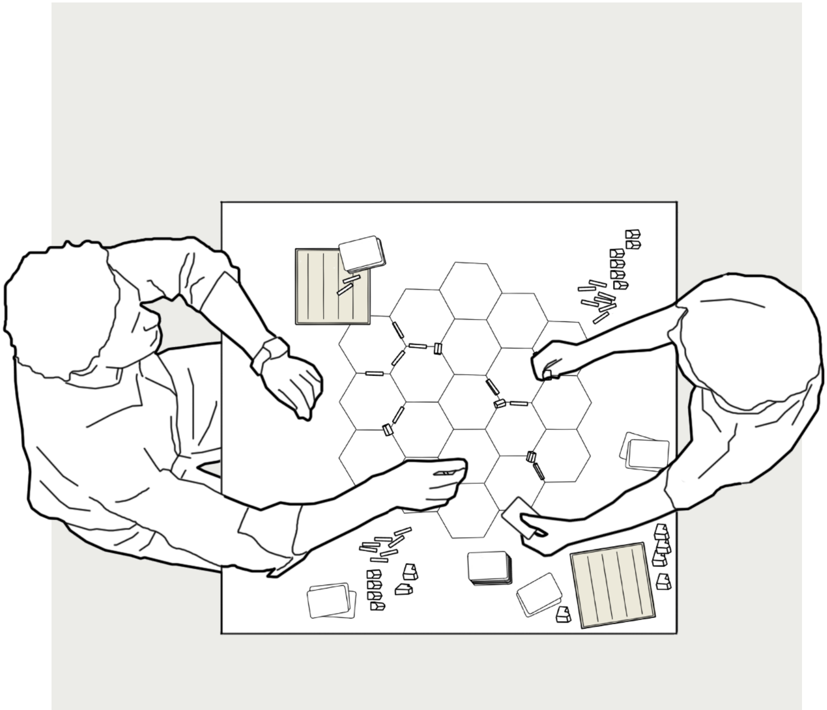


Fig 5.11: Example of a shared stuff cell in which the sources are individual, but the primary working field is shared: playing a board game.

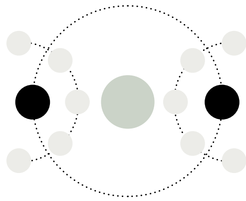
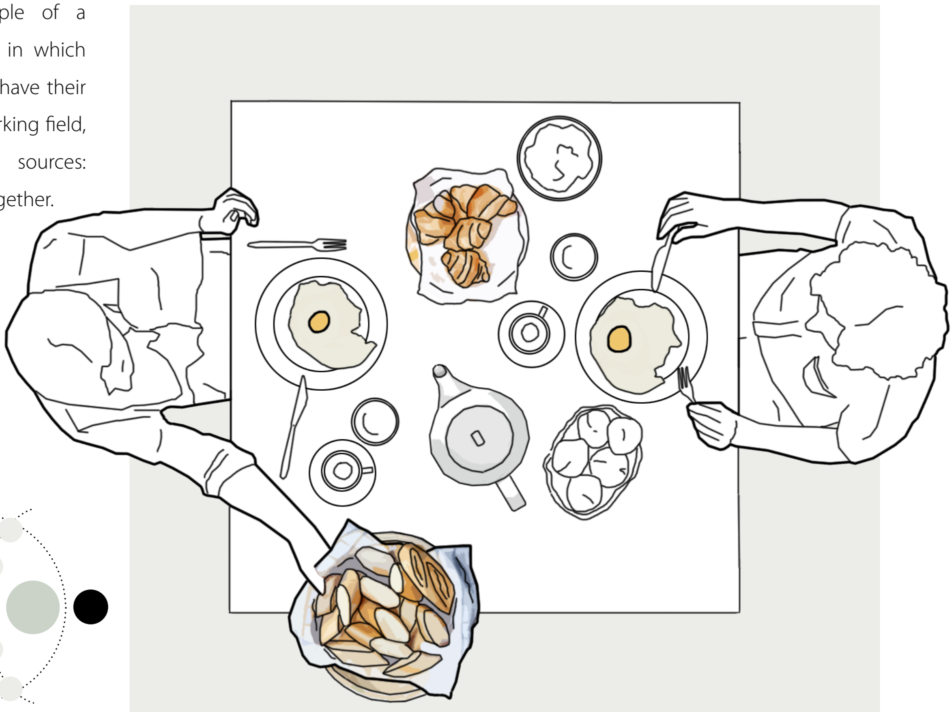
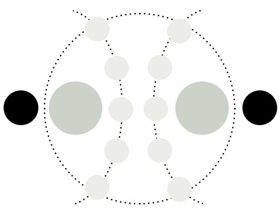


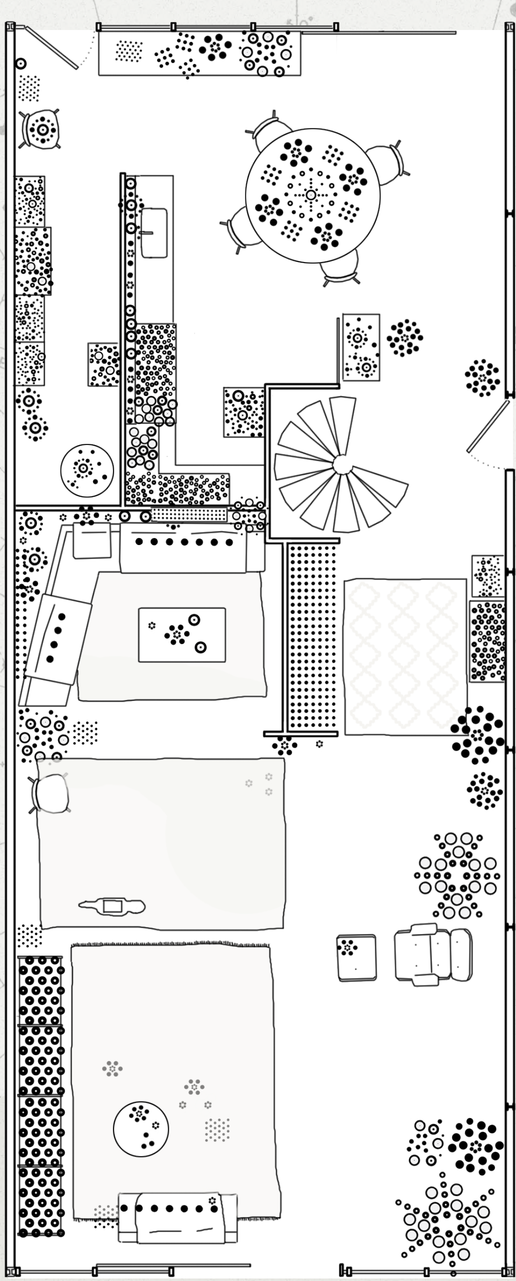
Fig 5.12: Example of a shared stuff cell in which both individuals have their own primary working field, but share the sources: having a meal together.





VI. WAYS OF UNDERSTANDING

STUFF IN ITS SURROUNDINGS



VI.

INTRODUCTION

Complexity thinking is a way of looking at the world. Much more than seeing the similarities between global patterns themselves, looking through complexity spectacles highlights the local processes that unfold into them, leading to ever-differentness and innovation. Exploring stuff in this manner has lead to a variety of topics so far; systems states, complex system dynamics, the growth from lower to higher levels, multi-scale patterns, and the unfolding of physical form through the iteration of these processes.

Making this explicit leads to other ways of understanding the roles and forms of stuff in the built environment. No longer is stuff a passive last layer, to be taken care of by the inhabitant. This infill is a living something, that constantly exchanges material and information with the systems around it.

This last chapter consists of three parts discussing a direction of thinking that could lead to a more complex understanding of stuff in its surroundings; first, by seeing stuff in a dynamic panarchy of systems, all subject to cycles of structuring and collapse and in continuous cross-scale interactions; second, by proposing the multi-scale organization states and their patterns, as both a method for analysis and an (implicit or explicit) tool within the design process; third, by exploring stuff in relation to conditions, a self-reinforcing process that is both defined by and defining space. These three directions are no fully developed design methods yet, but indicate promising paths for linking the self-organization of stuff to spatial design, that will be further explored in the rest of this project.

Left - Floor plan of the Eames House, patterned with stuff. By author.

6.1 RECOGNIZING DYNAMICS ACROSS SCALES

"There is no such thing as a building", Brand quotes the architectural theorist Duffy (1992) in his famous book 'How Buildings Learn'. Instead, he argues that a building in principle consists of several layers of built components, all with a different longevity. In a drawing of six layers, all with their own lifecycle, he illustrates his argument (Brand, 1994).

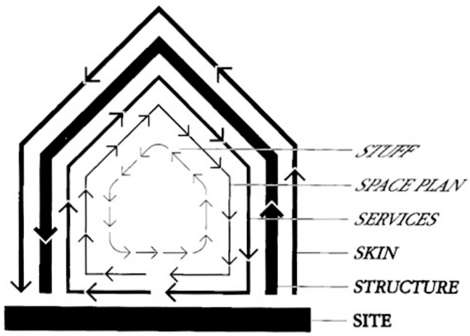


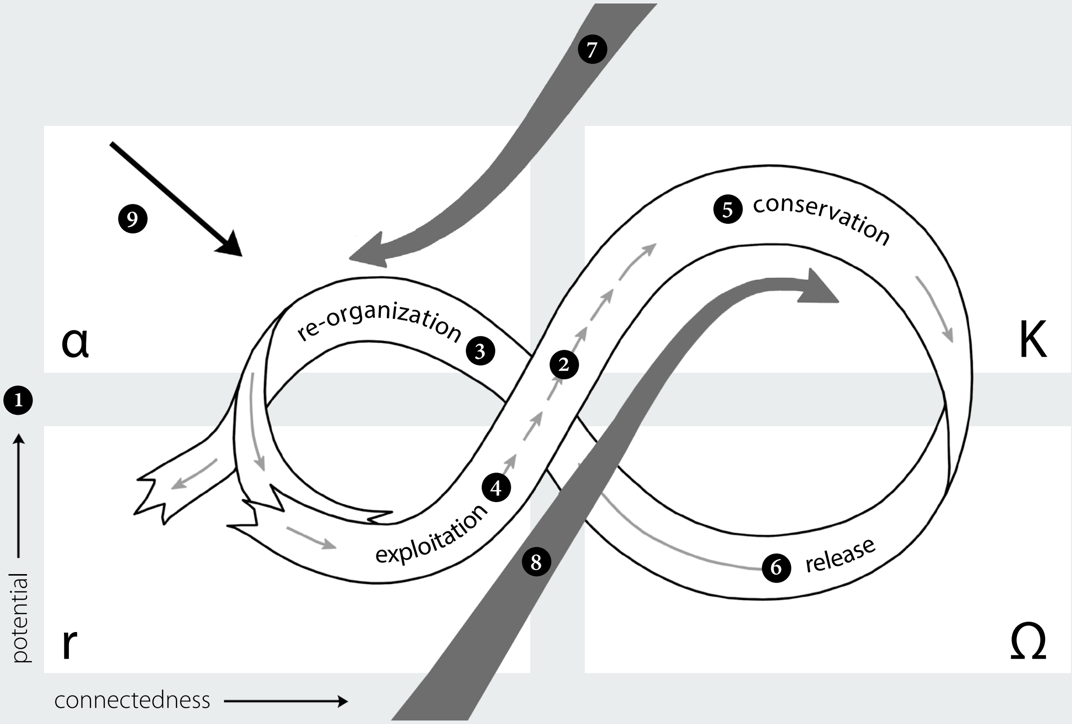
Fig 6.1: Shearing layers of change as illustrated by Brand (1994), based on Duffy (1992): stuff, space plan, services, skin, structure and site.

Stuff is the fastest of all six and is subject to an unrelenting flux. The other layers, such as structure, skin and services that are the responsibility of the architect, have a slower pace. Still, they are separate systems with separate dynamics and when designed as one 'finished' whole can start shearing, thereby tearing the building apart. Studying the lifecycles of systems in different scales, Brand argues, is the norm in ecology, and can be a useful lesson for architecture (1994).

Now we have made explicit how generic principles on complex system dynamics from ecology (and other areas of research that draw similar conclusions) manifest themselves in the smallest of those layers, it is possible to recognize patterns when zooming out. Although more consciously decided upon, the lifecycles of structure, skin and services in the end equally have phases of exploitation (building), conservation (maintenance), release (demolition) and re-organization (e.g. the process of design). The interactions between those scales can be explicated using the model and vocabulary developed; providing a more dynamic understanding of a building as a whole and throughout time.

This view on the building as a sequence of dynamic scales can be, more than helping to divide levels of control, a good insight into how this control continuously jumps to other levels. It thereby becomes a tool for targeted interventions in a building as a living body.

Fig 6.2 (right): Overview of the most important theories and vocabulary of complex systems as an instrument to describe and predict the dynamics of shearing layers.



1 Complex system

= a network-like system of which the global organization can be explained by the local interactions of the parts.

2 Emergence of the order parameter

= the emergence of an order parameter organizing the system through structuring the parts, a process of positive feedback.

3 Re-organization phase (α)

= Volatile and chaotic phase in which random fluctuations can drastically alter the path of the system.

4 Exploitation phase (r)

= Phase in which material accumulates into an emerging structure

5 Conservation phase (K)

= Rigid phase in which a system shows emergent properties, but becomes increasingly susceptible to breakage.

6 Release phase (Ω)

= Phase in which the system looses its structure and falls into a chaotic state.

7 Remembering (downward causation)

= Structuring enforced by a larger system.

8 Revolting (upward causation)

= Disturbance caused by a smaller and faster system in its release phase.

9 Control parameter

= external influence (e.g. conditions) able to trigger a systemic phase transition.

6.2 IDENTIFYING MULTI-SCALE PATTERNS

Secondly, we can use the multi-scale patterns constructed in chapter IV as a method of analysis, mapping out the organization of stuff in different areas in a building. In most cases almost all of these patterns are present somewhere, as they serve certain roles in the whole of the system; ordered resources serve cells of self-organization and smaller configurations in sight inspire them. Nevertheless, the distribution and dynamics of those patterns differs per person, program and building, and can be insightful for architects.

6.2.1 Pattern dots, pattern cards

The method of mapping out organizational patterns in fact locates all items in a house, but in an abstract and simplified manner. One way to do this is by roughly placing smaller and larger dots that represent individual items on a floor plan, such as is demonstrated on page 93 in the Eames House (Case Study House, no 8). Following this, larger multi-scale patterns can be identified (the dotting method).

A more ad-hoc way to make the analysis is by using the card set, to be found in appendix III (the card method). This is easiest by similarly moving up through the scales, starting with the small cards and when a larger pattern can be recognized, exchanging them for larger ones. This method is less precise, but easier to perform on the spot. It is also better for researching dynamics within those patterns, for the cards can be shifted around.

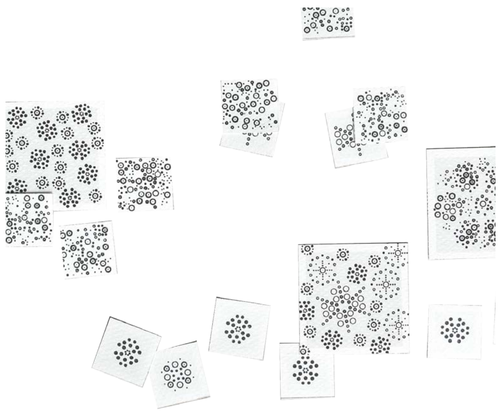


Fig 6.3: Using the pattern cards to make a quick 'map' of the stuff patterns in a room.

6.2.2 A method of analysis

Mapping out an existing buildings using this method, can (as found so far) give insight in three different ways.

1. Personalities

Everyone has a different relation with stuff and outlining the patterns of stuff in a house tells us much about the inhabitant and their personality. The Eames, for example, were famous for their love of stuff; they had a vast collection of furniture, books, souvenirs, tapestries, plants and African masks and carefully placed them in their house in varying compositions. This shows in the patterned map as many small centers of self-organization, or stuff configurations (corresponding with no. 1 on page 37). Some other people choose to place things much more out of sight, giving their house a minimalistic atmosphere. Hence, these items will follow a more space-saving pattern: one of order.

When mapping out the dynamics of these patterns through time, another variable is noticeable; something we can call the *mess threshold*. In every interior, chaos will eventually arise, but the tolerance towards it significantly differs between people. This means that the lifecycle of stuff cells wil generally be shorter and, additionally, less chaos will be around.

Another variable is the pace in which stuff is displaced. Whereas some people hardly ever touch most of their stuff, others love to potter around their house and get lost in all of their belongings. These are mostly active people, that are full of ideas about what next to create or what new hobby to start. Also children are, of course, a perfect example of people who throw things around.

2. Programs

Different programs give different patterns, which can be an insightful awareness when one, for example, has to design for a specific function. An artist's studio holds many smaller and larger places for (intuitive) assemblage, whereas a gym is a relatively clean and ordered place where people can easily find what they are looking for. A good bookstore is ordered but at times displaying titles in surprising combinations to give the visitor new ideas.

A useful method for architects is using the pattern overview to analyse well-functioning examples of buildings that hold the program to design for. The design can thus be anticipated on how it might eventually be used and what spaces are needed in the midst of action. Additionally, when repeated for a number of examples, it may be possible to directly relate designed architectural form to the patterns observed. Where do people install themselves? Where are things logically stored? What are the places where left-over stuff naturally accumulates?

3. Generic - specific

Lastly, mapping stuff patterns over a period of time shows a second pattern: one of solid and liquid. The frequency in which patterns change is a variable that differs per place. In every building examples can be found of high stuff-density places that nevertheless stay the same. Often a house contains some 'overflow areas' (a scullery, toolshed or a part of the attic) that are always chaotic. An archive of old stuff kept for memories, but not for daily use, is often ordered for longer periods of time. Examples of self-organization that are long conserved are a shower, bed or toilet. These are stuff cells around highly scripted behavior, intuitive and always the same.

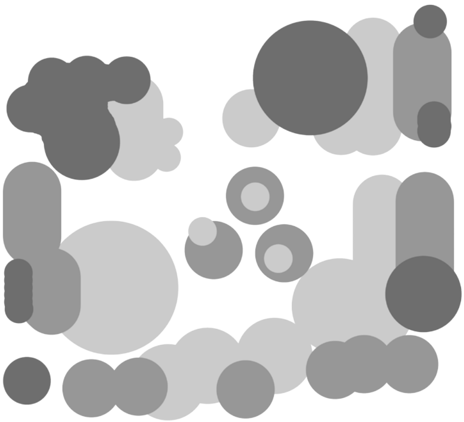


Fig 6.4: A pattern of 'solid' and 'liquid' in my room, based on the information from data set 1. The dark gray patches have essentially stayed the same over almost the course of a year, the middle gray patches have changed a few times in this period and the lighter patches change their pattern once a week or more.

A possible position to take as architect is, for instance, to design more specifically for long-term ordered and highly scripted places, through, for example, a clever space-saving shelf system in the attic and a thoughtful shower design in which all phases of the ritual find their place. Other less-defined spaces are kept open, leaving room for messiness and spontaneous ideas.

6.2.3 A method for design

Designing is imagining possible futures. The designer of a building constantly pictures the building in use, and therefore (consciously or unconsciously) generates an organizational pattern of imaginary stuff.

In making this part of the design process explicit, form and infill can be coupled as a complementary pair in a direct way. The designer is able to make conscious decisions on what to trigger, what to regulate and also where to stop designing. Being aware of the multi-scale patterns forming in stuff systems, does not only make the whole of this more comprehensible, as the method is abstract and does not label specific artifacts and functions, also it generates a more complex and dynamic idea of stuff through time than the typical furniture template.

A designer can choose to use the dotting or the card method on their design, to make explicit what could happen where. This can, instead of a method for designing, also be one for communication. When used a couple of times, however, the patterns can hardly be unseen. Eventually the awareness itself becomes a skill of the designer.

THE EAMES HOUSE

In 1945 Charles Eames and Eero Saarinen started the design of two houses, a part of the Case Study Houses program of the magazine *Arts & Architecture*. One of them was for Charles himself and his partner in life and work, Ray Eames. The design, two units (a living unit and a studio) made up from a steel frame with a standard system of open and closed walls, was simple. But as the Eames were famous for their love of collecting and displaying stuff, there home became a complex configuration of items. *"Bringing the ordinary, everyday and the 'as found' to a higher level became characteristic of the Eames, particularly in the eclectic mix of ingeneously configured objects in their home",* so *The House Book* (2001, p. 110) describes them. This, together with the fact it is so well documented, makes a good case study for stuff pattern analysis, as demonstrated overleaf.

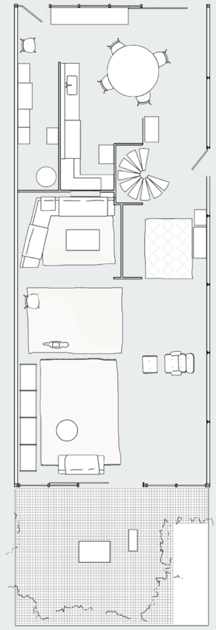


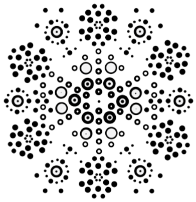
Fig 6.5 (below): Picture of the living area in the Eames house, taken in front of the small partition wall, facing the garden.

Fig 6.6: Floor plan of the living unit of the Eames house.

SELF-ORGANIZATION

A set table for breakfast.

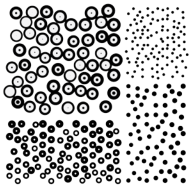
Fig 6.7: Eames Foundation.



ORDERED CHAOS

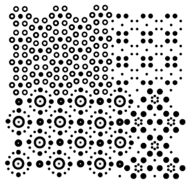
Cups, plates and pans in the kitchen cupboards.

Fig 6.8: Inhabitat, 2012.



ORDERED SELF-ORGANIZATION

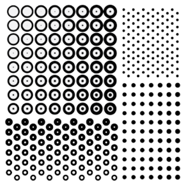
Meticulously composed configurations find an ordered pattern through the shape of the surface behind the couch. Fig 6.9: Eames Foundation.



ORDER

Books are ordered in the bookshelf.

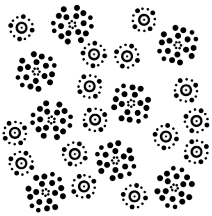
Fig 6.10: Eames Foundation.



CHAOTIC SELF-ORGANIZATION

Small configurations of stuff are scattered around the room.

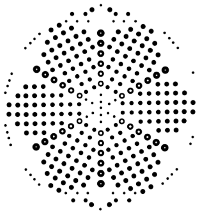
Fig 6.11: Eames Foundation.

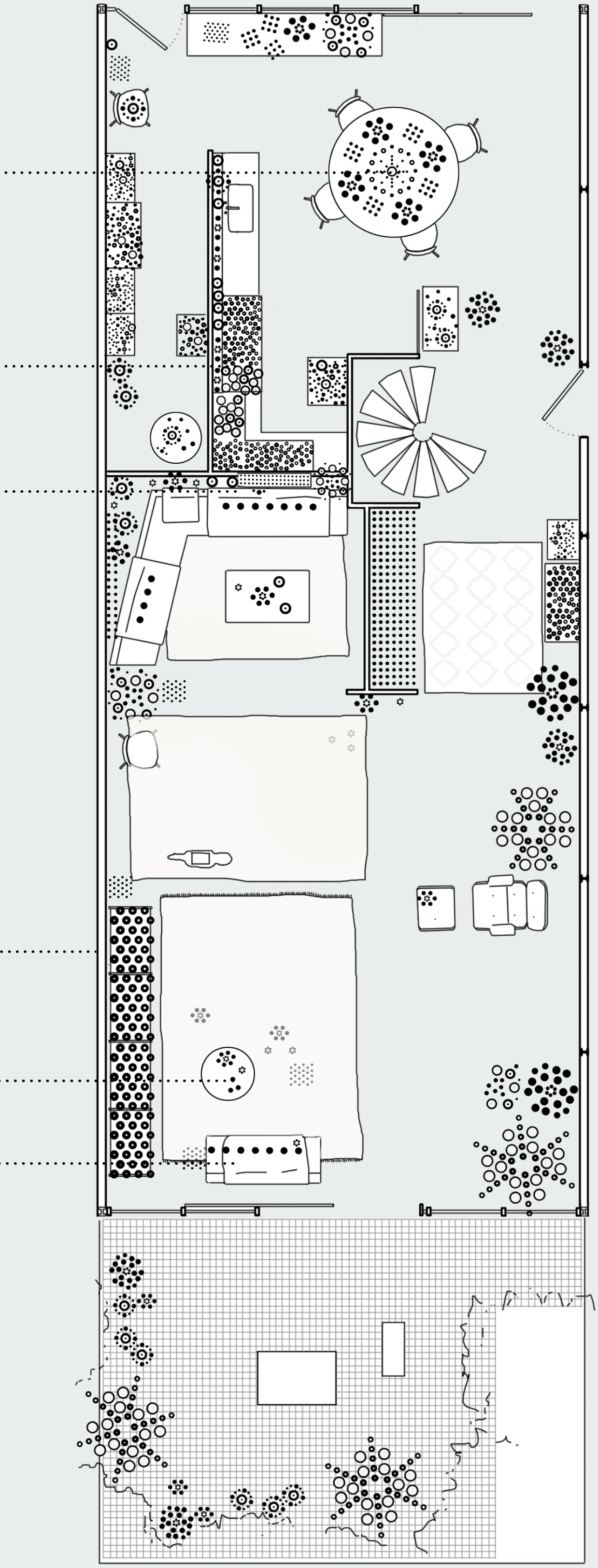


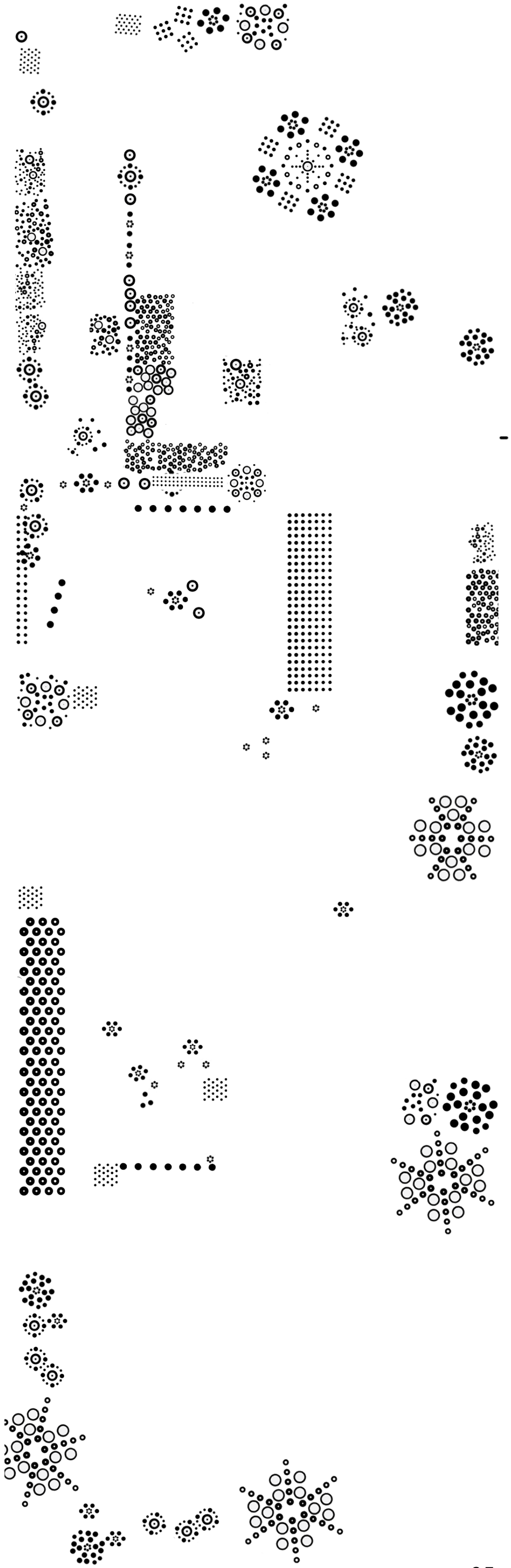
SELF-ORGANIZED ORDER

Books concentrate in shelves, parts of shelves, a pile and then a single book, towards the couch.

Fig 6.12: Leslie Williamson, 2006. Published 2010.







6.3 UNDERSTANDING LIFE IN ITS SURROUNDINGS

When stuff self-organizes, a logical approach to the task of architecture in the story, would be that it should create the right conditions. This can exist of, for instance, supporting the process by providing a comfortable climate.

Stuff cells search for the right conditions. When someone needs to sit down, start working or go sunbathing, the environment is screened for a place that fulfills those needs. These conditions are the requirements and therefore the control parameter of the system. When this layer of basic needs breaks down when the power goes down, the sun sets or the neighbor starts to drill a hole in the wall, the activity has a high probability to collapse.

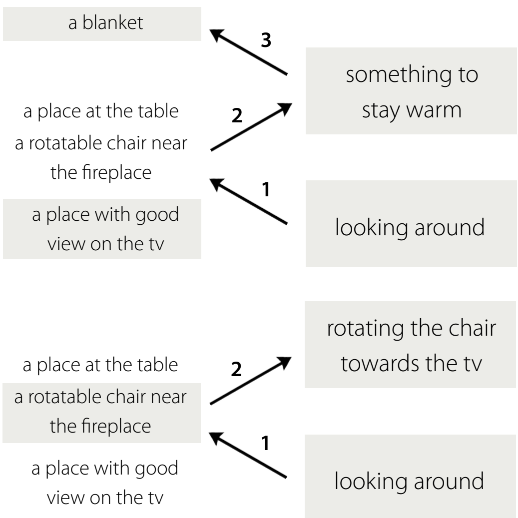


Fig 6.13 and 6.14: Searching for and finishing conditions.

By accumulating stuff, the user also creates their own conditions. Either the requirements are completed, so that the action can be started (see fig. 6.13 and 6.14), or the accumulation of stuff serves to withstand a changing external influence so that it can be sustained.

The insight for design is twofold. Firstly, the right conditions not only attract and stimulate the self-organization of stuff, but are as a result even reinforced. This leads to a pattern of conditions, such as in a house where the bedroom is kept cooler and the bathroom warmer than the rest of the house, whereas the conditions are initially the same. Secondly, this process is eased with the right affordances. In the example below, the chair is already percieved by its rotatability, and the colder place for the presence of a blanket nearby. When one wants these patterns to emerge by themselves, the possibilities to create them should be existent and displayed.

A condition that deserves more attention is that of publicness. Stuff not only seems especially sensitive to publicness, but, by definition, also determines it by its own existence. On the following pages the parameter of publicness is further explored.

STUFF & PUBLICNESS

A stuff cell is the definition of a territory. It marks off a space, not only for a specific activity, but most of all for a specific person. Although the picnic at the cover is situated in a public space, it is highly unlikely other people would install themselves right next to it, even when the couple has left their spot. In a stuff cell someone literally makes themselves at home.

From the other side, a similar dependence can be recognized. In a public space such as a busy street it is improbable to set up a folding table and have dinner, whereas this is not abnormal in a collective inner garden. When a large group of people suddenly walks into your office space, it feels alien to start unpacking more stuff and enlarge your 'terrain', while as soon as they leave again, extending the activity by developing its stuff cell feels natural and unrestrained.

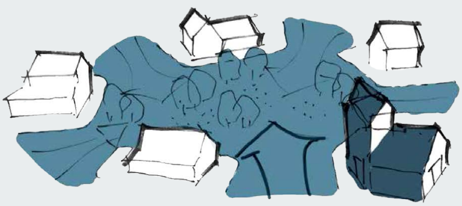
6.3.1 DOMAINS AS A CONTROL PARAMETER

The publicness of a space is a control parameter of stuff systems; one to which they prove to be highly sensitive as even the tiniest changes (e.g. someone entering a room) can have a significant effect. In this intermezzo the relationship between degrees of publicness and the development of stuff cells is explored, by means of a thought experiment; for different degrees of publicness, a stuff cell is considered that is as extensive as possible, while still experienced as natural.

The common distinction between private and public as a property ignores the fact that the experience of publicness transcends the boundaries of ownership. As an alternative, Lyn Lofland (1985, 1998) proposes the term *realm*, later extended by Van der Wal and Van Dorst (2014; Van der Wal, Van Dorst, Leuenberger, Vonk & Van Vugt, 2016), in a theory of four *domains*[1]. These experienced layers of publicness are essentially dynamic and defined by the relationship between the people that use the space and the way they encounter each other. Below, the four domains proposed by Van der Wal and Van Dorst (2014) - public, parochial, collective and private - are discussed, in which the private domain is split in two: a shared private space (a shared home) and a completely individual private space.

1 The term realm was translated to the Dutch 'domein' by Hajer & Reijndorp (2001), which is the reason that in this text the term 'domain' is used.

1. Public domain



The public domain is described by Lofland as a realm that is inhabited importantly, though not entirely, by persons who are unacquainted with one another. It is a world of strangers (Lofland, 1985). Public space is characterized by typical behavioral codes, such as taking the role of observer rather than attracting attention and limiting extensive conversations with strangers (Lofland, 1998). Typical examples are busy streets, stations, the main areas of airports and the hallway of a hospital.

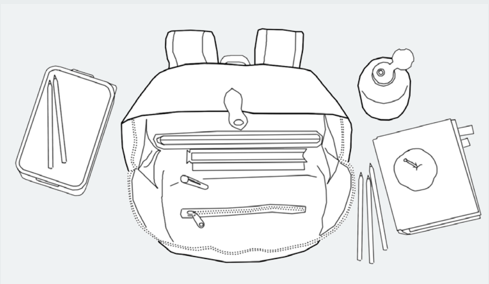
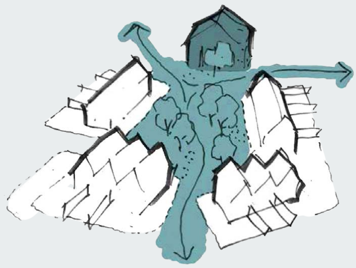


Fig 6.15: A stuff cell in the public domain: unpacking a bag.

A public domain is no solid breeding ground for stuff cells. As unknown people walk by at a high pace, having stuff out of sight or out of reach evokes an uncomfortable feeling. One will only settle down when there is no other option, when, for instance, one is in need of something at the bottom of one's bag. The stuff cell is typically smaller than the human body and protected by arm and legs. It normally exists no longer than a few minutes.

A situation that demonstrates the above is right after the security check at an airport. In the middle of a crowd of unknown people that nervously rush by, one has to put on a belt, a watch, shoes, tie the laces, keep an eye on ticket, passport and wallet all at the same time. This stuff cell is too large for the type of space, and feels unnatural and awkward.

2. Parochial domain



The parochial domain is more enclosed than the public realm, and is characterized by a sense of commonality among acquaintances and neighbors, involved in interpersonal networks, located within communities. (Hunter, 1985; Lofland, 1998). A parochial domain is one in which bits of collective or private domain can come to existence, such as in a park, the streets in a small village, a courtyard or in the faculty building of a university. The type of relationship is that of 'known strangers' - one of recognition. The difference between the parochial and public domain is therefore equivalent to that of a village and a city (Van Dorst, 2005).

A parochial domain is already more inviting for starting stuff cells. It is imaginable that certain activities that do not fit in the house - repairing a bike, washing the car - take place outside in this more protected atmosphere. Also the picnic on the cover is situated in a parochial domain. It is an open place, not one to leave stuff behind (longer than a few minutes), but it is generally accepted that people lay hold on a spot for around a half-day.

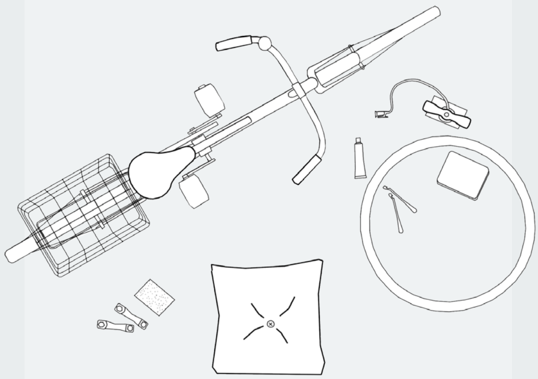


Fig 6.16: A stuff cell in the parochial domain: repairing a bike.

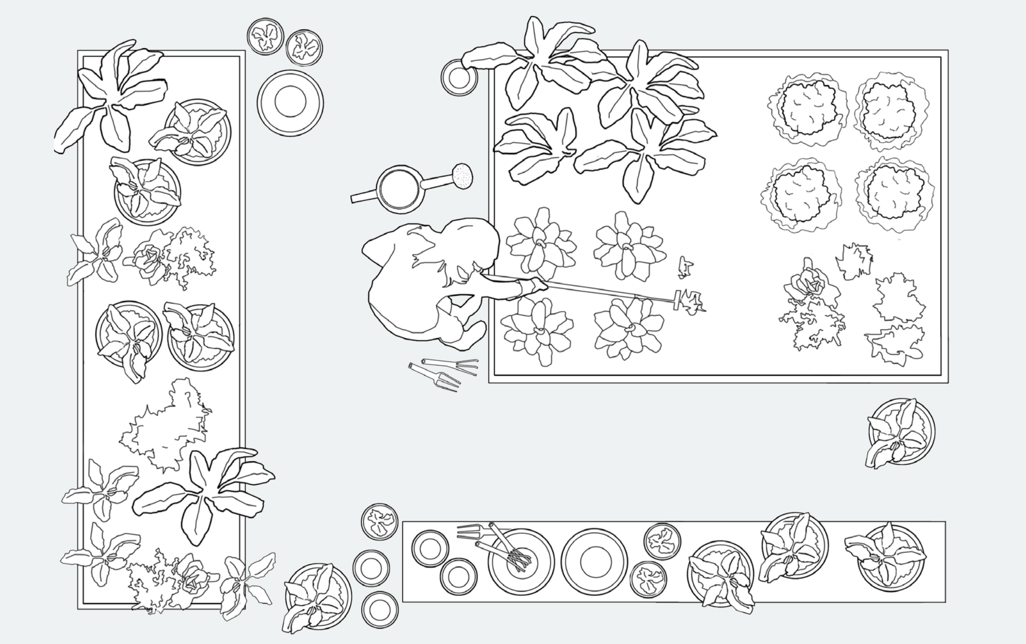
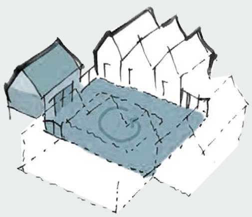


Fig 6.17: A shared stuff cell in the collective domain: communal garden.

3. **Collective domain**



The collective domain is characterized by a collective activity people engage in. What bonds them is a shared interest and goal (Van der Wal & Van Dorst, 2014). Most office spaces, shared gardens, shared studio spaces, but also class rooms or a nursery are examples of collective spaces. In contrast to the parochial domain, it is not open, but defined by boundaries. Its members are known, for they have, for example, a membership.

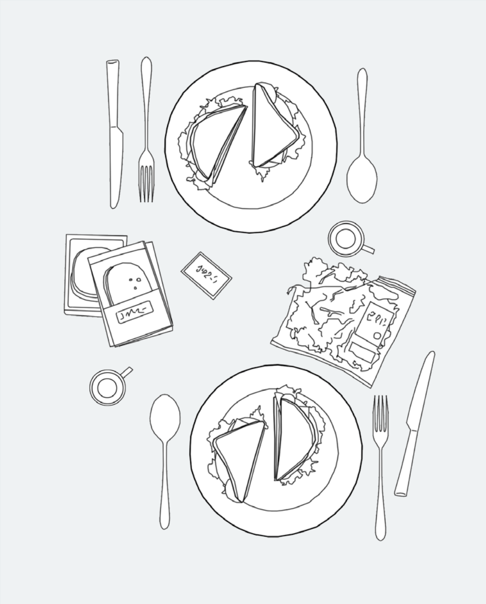
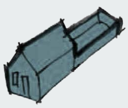


Fig 6.18: A shared stuff cell in a shared private domain.

This domain is an interesting one in relation to self-organizing stuff. As the place is protected, it is possible to leave things lying around. However, this is merely socially accepted when related to the collective activity; a collection of pots in a communal garden is fine, but a rusty bike would not be appreciated. When functioning properly a collective space can even become a collective 'external memory'; stuff can communicate the activities that need to be done without the members meeting in real life.

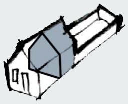
4. Private domain (shared)



A private domain is characterized by ties of intimacy among primary group members who are located within households and personal networks. (Lofland, 1998; Hunter, 1985). Examples of shared, yet private domains are a kitchen, living room, garden or shed; spaces that are shared with house mates or family members, and will not be entered by uninvited individuals.

Since the level of individual control in a house is high and the others using the space are mostly well-known, informed and non-judgmental, it is a perfect domain for stuff cells. It is possible to leave things behind overnight and continue the activity later on - which makes possible that stuff is used as a reminder, an external memory, that can easily be shared as others live in the same 'mindset'. The only holdback can be that space is limited. Activities might have to compete for a room or working surface, which is why they eventually have to be cleaned up

5. Private domain (individual)



The individual private domain is a place where no other person than oneself comes in without knocking; such as a study room or studio space. More recent examples include the 'man cave' and the 'she shed'; by the Urban Dictionary defined as a corner or area of a dwelling reserved for a (male/female) person to be in solitary condition, in order to work and play, and engage in activities without any interruption (urbandictionary.com, 2017). These places are much written about on internet; typically the person in question puts much effort in the décor of the place, so that it reflects their character in a desired way.

Stuff cells in private domains like those can grow for months or even years without ever being disturbed. As the identity of the host is reflected in all elements in the room and their configuration, there is hardly any distinction between the stuff cell and the space around it. All merges into one private place, an external representation of activity, character and personal values.

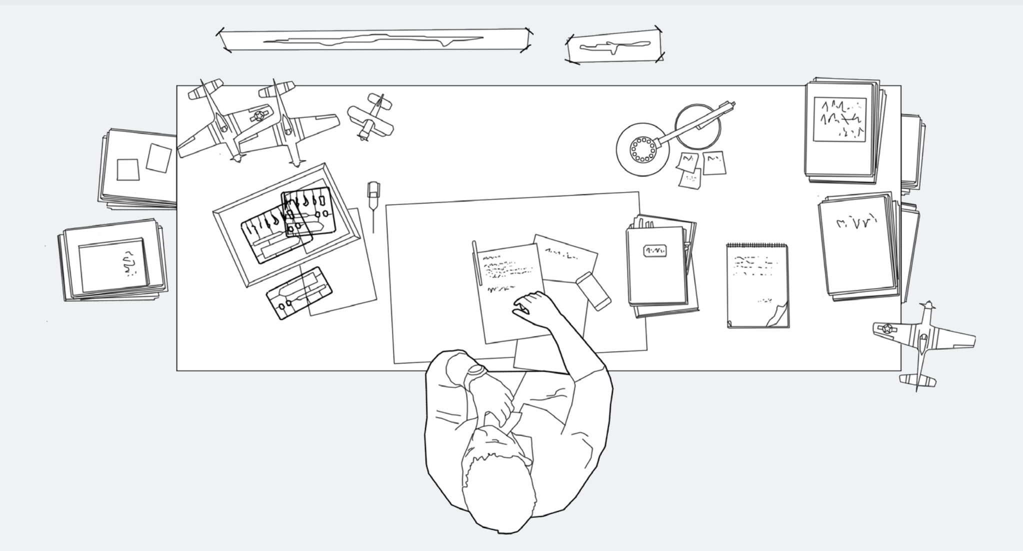


Fig 6.19: A stuff cell in an individual private domain.

Images of domains by plein06 (2016)

6.3.2 DOMAINS AND STUFF CELLS

The causal relationship between the level of publicness and the self-organization of stuff seems definite; the more a space is experienced as private, the more an (individual) stuff cell can develop. This is not the least influenced by the time things can be left out of sight (from seconds in a public domain, to between minutes and an hour in a parochial domain to forever in an individual space). Shared stuff cells thrive best in the middle domains, that are protected enough to not be experienced as rushed and anonymous.

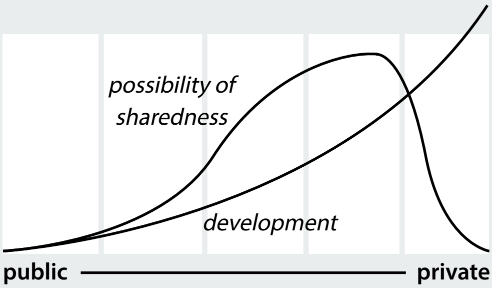


Fig 6.20: Stylized graph of development (number of objects, abstractness of action identification) and sharedness of stuff cells over the different domains.

Another factor possibly playing a role, is the degree to which the identity of the individual and their activity is in accordance with the identity of the space as a whole. In more private spaces, someone does not only exercise more individual control on their surroundings, but also shares the space with like-minded people, such as intimates or people engaging in the same activity, agreeing on what is socially accepted. The more public places are commonly not adjustable to one's specific needs and are shared with a diverse group of people with different objectives. The 'fit' of a stuff cell in its surroundings seems to be a reliable prediction of its development.

6.3.4 STUFF IS COMMUNICATION

Domains are dynamic, a fact illustrated by Lofland with the example of a 'traveling pack'. This is a group of friends that by laughing and talking loudly takes over a public space as a private domain; the larger the group, the more confident it seems to display behavior typical for a gathering at home (1985). This shows how fluid domains are; a public property can within seconds be claimed as private. Apparently the presence of a group of people, in this case aided by their indifferent behavior and noisiness, can in itself change what level of publicness is experienced.

Setting out stuff is the demarcation of a domain in a similar way. Generally a stuff cell (either individual or shared) develops a higher level of privateness when more developed. This is clearly visible when considering camp sites with no fixed places; the small and modest tents of bikers, who cannot bring much stuff, feel fine to walk by closely, and even to camp in a close distance of. Tents of families that obviously spend the entire holiday at their chosen spot, and whose tent is surrounded by toys, chairs, tables, parasols and wind screens, somehow command more respect. One would not as easily 'trespass'.

On the surroundings space, on the other hand, stuff cells have an inviting effect. A tent on a field of green shows that the place is generally agreed upon to be meant for camping and individually claiming a piece of the terrain is approved behavior. This makes good social experiments in public space, comparable to those of the Situationists. As soon as a stuff cell is started in the middle of a busy street (e.g. by starting a picnic or repairing a bike), one does not only create a piece of private terrain, but gives the street as a whole a more village-like identity in which it is suddenly socially accepted to claim space. Public becomes parochial.

Apparently, next to action possibility and the exchange of information with one (future) self, stuff is also, and very boldly, a means to communicate with one's surroundings. It makes that a space can be experienced as more private, both in a demarcating (close by) and an inviting (further away) manner.

6.3.5 THE SELF-ORGANIZATION OF PUBLICNESS

Stuff indicates privateness, and privateness communicates to others what is accepted. Thus stuff cell development and privateness find themselves in a circular causality. This means that the effect both have on each other is, in general, self-reinforcing and thus self-organizing.

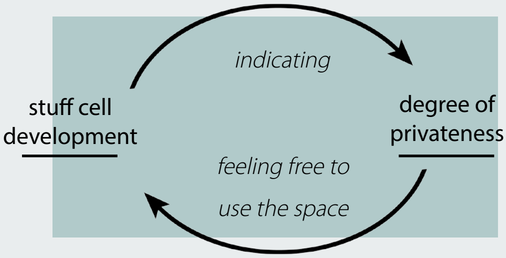
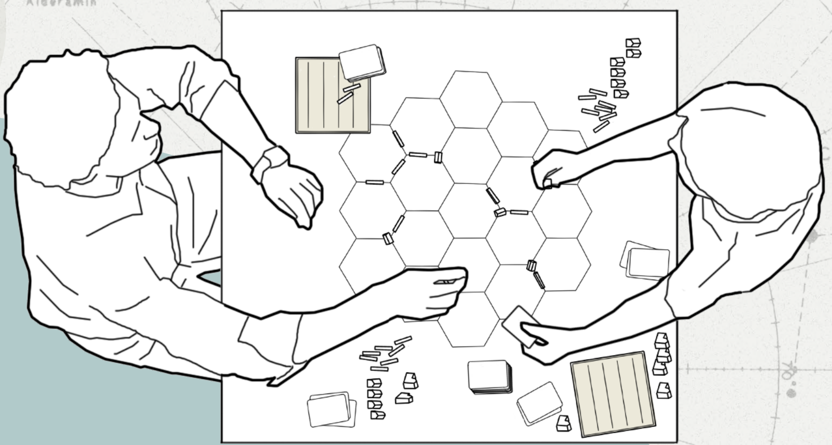


Fig 6.21: Stuff cells and domains in a circular causality.

According to Van Dorst and Van der Wal (2014) a clear readability of domains in non-defined spaces (such as hallways and corridors in apartment buildings), can help in creating and communicating a social agreement on how to behave (Van der Wal et al., 2016). They propose clarifying the type of domain through introducing affordances that stimulate appropriate behavior. To this the above insight can add the dimension of time. Publicness is not only a dynamic condition, but is a process of settlement, that starts from volatile beginnings and gradually grows into a rigid structure. The indication of a domain through conscious (designed) interventions can thus be strengthened by easing the possibility for people to demarcate their (individual or shared) terrain. Also the opposite, marking a space as exclusively public, can be used to keep light, air and accessibility in place that otherwise would congest.

CONCLUSION

& DISCUSSION



C.

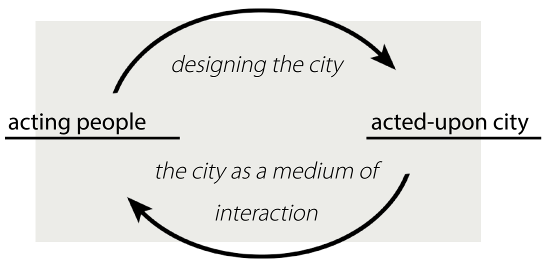
c.1 CONCLUSION

The starting point for this research was an unmistakable fascination for the process of self-organization. At first sight, spontaneous ordering is something that occurs in nature in systems with a countless number of components, whereas the man-made built environment is essentially simple. It consists of finished plans and its shapes are constructed from blueprints that arrange the world through lines. But as complexity theory of cities has shown, this is a matter of perspective.

Not only when zooming out to the whole of a city through time, but also when zooming in to the most direct surroundings of people, patterns become visible that a classical explanation of order falling into chaos fails to explain. This can be vividly seen when looking at stuff, that crystallizes around places and activities in one-to-one configurations. The aim of this abductive research is to find an explanation for this observation by exploring stuff from a complex perspective. Can the spontaneous organization of stuff be a process of self-organization?

This question immediately raises a problem, as stuff cannot create connections by itself. All of its patterns have to be explained through the interaction with conscious people with cognitive abilities. Here we follow the theory of Portugali explaining why cities display complex behavior; they are not solely the environment acted upon, but are also the medium of interaction and the input of cognitive processes (2011, 2016). This doubly complex model acts as the basic premise of this research, that aims to translate it to a smaller scale.

Fig c.1: The city as a doubly complex system as the basic premise of the research, which is translated to a smaller scale level.



Doing so, however, leads to another obstacle. Cities are large-scale collectives and exist over hundreds of years, which makes that the urban fabric can never be individually controlled. Translating this theory to the scale of stuff, means an answer has to be given to why, also on a scale where every item can in fact be arranged, it is still the accumulation of local interactions that, at least partly, creates its form. This is possible, of course, because of the directness of this human-stuff interaction. Whereas decisions in a city are large scale plans that take place once in a while, but are considered altogether over a prolonged period of time, the decisions to move stuff are small, occur in a high frequency and very directly follow perception.

Projecting a theory of self-organization on stuff thus has two requirements. The first is the assumption that there exists a bidirectional link between action and perception. The theory of affordances, originating from psychology and recently introduced in interaction design and architecture, presents a framework for this interaction, stating that the perception of our environment happens through action possibilities or what objects afford us to do. Affordances themselves are constantly ad-hoc created by the configuration of stuff, which is again what we perceive; a circular causality implying a process of self-organization. The second is an interaction between action and cognition. This is explored by action identification theory, also from psychology, that proposes a two-way interplay between the cognitive construct of action (what one thinks one is doing) and action itself. This similarly indicates a self-organizing process, in which the action identity works as an order parameter filtering incoming information and structuring the activity.

When these interactions take place, the organization of stuff is the result of this doubly complex process, in which both external information, (affordances) and internal information (action identities) serve as an order parameter creating structure over time. These requirements are not always met. When no activities take place, nothing happens. If stuff is allocated to a specific place beforehand and is displaced according to the drawings, there is no self-organization either. A high feedback-sensitivity between action and environment occurs especially when people are immersed in a space and create it from within.

If so, the above theory can very directly describe the forms and patterns that arise between artifacts. All stuff cells include a central point, the primary working field. This place, in front of the user and in the middle of all other stuff, acts as the order parameter of its global form. It is also the place of the most complete one-to-one assemblage of artifacts and thus is the core of what the stuff configuration affords to do and where the 'actual' activity takes place. This primary working field follows the same complex dynamics as action identities and affordances when it continually makes phase transitions to higher or lower panarchical levels, thereby organizing the stuff around it. The figure below gives an overview of stuff as a complex system.

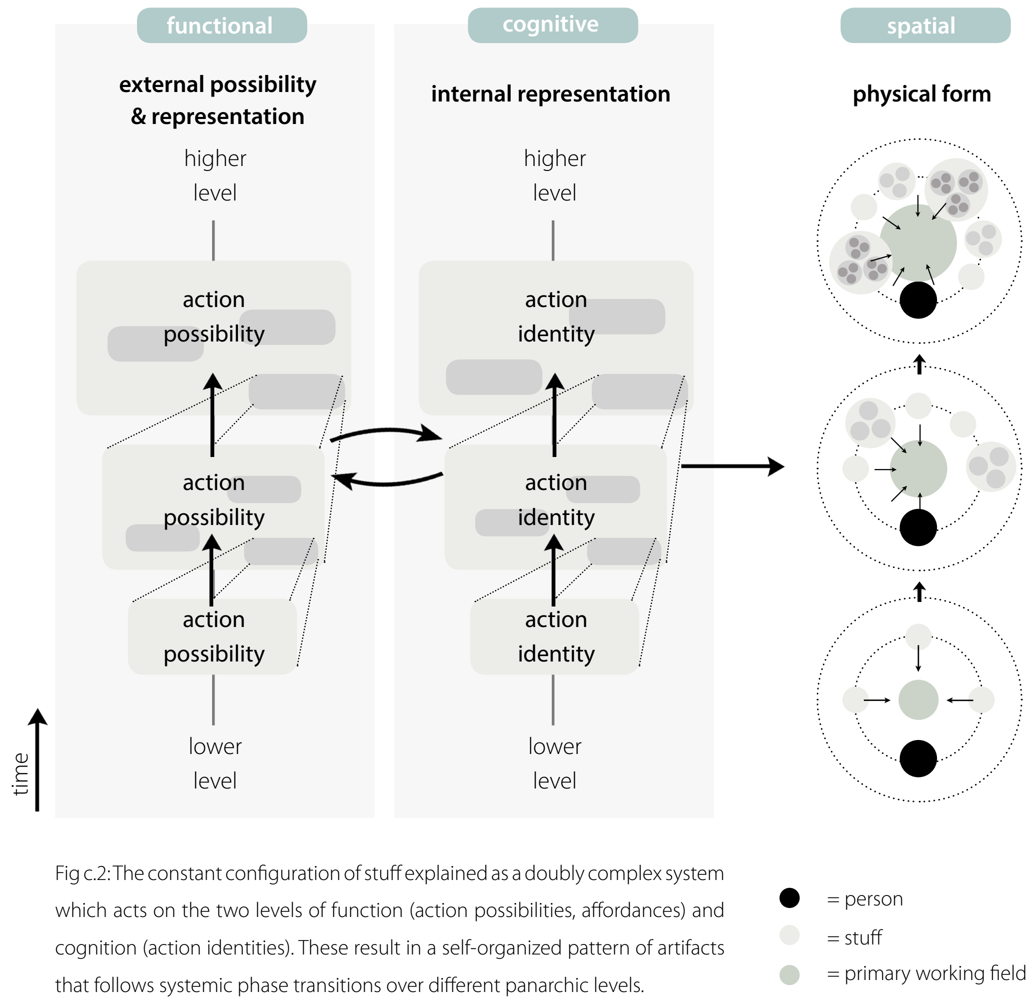


Fig c.2: The constant configuration of stuff explained as a doubly complex system which acts on the two levels of function (action possibilities, affordances) and cognition (action identities). These result in a self-organized pattern of artifacts that follows systemic phase transitions over different panarchic levels.

c.2 OUTCOMES

In the abductive theory of method new models are explored via a process of theory generation and theory development, resulting in various explanations to be reflected upon. The most important criterion for this reflection is that of consilience, or explanatory breadth, stating that the best theory is the one that can explain the greatest range of facts (Haig, 2005). As the development of the above theory was a constant process of iteration, this research has built upon one explanation, which differs from the classical paradigm. This model, that describes the configurations of stuff as a doubly complex system can describe our observations where a simple order-chaos alternation fails, and is therefore, following this criterion, the best explanation. The limitations of this research are in the method; abduction searches the theory that is currently most complete, but gives no proof of law. This means that the conclusions of this research are per definition open for new suggestions and improvement.

This research was not initiated because of the direct relevance of a societal problem. Instead, its starting point was the opportunity around a scientific problem; the idea that findings from other disciplines could shed a new light on a phenomenon that is all around us. The outcome is therefore not a list of principles that work as a direct guidance for design, but a theoretical model that provides a different perspective to observe what already is.

But most importantly, in this process of constructing theory, the self-organization of stuff is made explicit. As shown in the last chapter we now have a basic vocabulary, a pattern library and a clearer idea about the impact of control parameters to properly discuss what we see. This again results in more precise observations. Instead of something non-existing or mythical (even scary), the constant displacement of stuff can become a topic for discussion in the process of design. A general framework, that can from now on be built upon, no longer excuses architects to see stuff as something personal that is impossible to relate to, neither as something to take complete control over. The self-organization of stuff is an integral part of every building, and can, with the ways of understanding given above, be thoughtfully considered.

c.3 IMPLICATIONS

How people interact with their environment is a fundamental topic for architecture. Self-organization gives a thoroughly different perspective than the classical explanation, which is why a discussion on the implications of this view can be endless. In this paragraph three common and related design discussions are reflected upon with the results of the research, in a first attempt to formulate what this theory implies for architecture. Consecutively, these are the trend of minimalism and decluttering, the discussion on design control and the question on whether we, when stuff self-organizes, need design at all.

c.3.1 Self-organization vs minimalism: creativity and innovation

The self-organization of stuff requires a constant interaction with activity. Because of the circular causality between the two, this reasoning can be turned around; activity requires the self-organization of stuff. In this light we can reflect on the trend of decluttering, or minimalism, that since around five years has gained immense popularity, to be noticed in the abundance of organization gurus and the thousands of youtube videos on how to adopt the lifestyle (Bijlo, 2016; Bottelier, 2016; Brodesser-Akner, 2016). Lately, however, an increasing number of people has backed out, stating that minimalism makes their life calm first, then boring (Urist, 2017). Messiness again gains popularity, such as pleaded for by economist Tim Harford. Values like creativity, acceptance and resilience are integral to disorder as it can help generate ideas, he states (Harford, 2016).

Fig c.3: Internet meme satirizing architects and their workspaces.

This research concludes that actual creation is not messiness but self-organization, which indeed needs random ideas to both develop and innovate (and not grow in one rigid pattern). To engage in creative activities, stuff is needed to both fulfil the required affordances and to generate ideas, which explains why extreme minimalism can lead to passive behavior. The creative process also needs order to specifically pick artifacts as soon as the cognitive idea on what to do arises, which is why also owning an overwhelming amount of stuff can eventually lead to passive behavior. An alternating pattern between the two states, both in space and throughout time, is according to the theory most vivid, and luckily also most natural. Preplanned activities, in which the internal information on what to do is unambiguous, are more efficient when artifacts are ordered, but even here slightly messy workplaces have led to great inventions. The possibility for *adhocism*, as Charles Jencks and Nathan Silver describe the improvised assemblage of stuff so beautifully (1972), is sacrificed when everything is strictly allocated a place.

c.3.2 Self-organization vs control: an external brain

The fact that the emergence of action is a cognitive complex process, in which internal and external information alternate, implies that stuff is an active and essential part of our thinking. Besides generating ideas in the process, stuff is also an ad-hoc constructed part of our memory; through the external information we create, we can communicate with our later selves. Stuff serves as a reminder and structures activities (by the stuff in a stuff cell), daily life (by the stuff cells in a house) and even identity (by the whole of stuff in someone's life). Stuff generates its own language, in which the artifacts are words, but their formations are the sentences that carry meaning.

This second result makes it possible to react to practices of architectural design in which all elements are perfectly harmonized, such as buildings that are strongly committed to a certain style. In buildings that are mainly created to be experienced by the senses, such as a cathedral, design control is a justified approach. In houses, however, a strict top-down control is very risky as it can, according to the theory, even impair cognition. The need for people to use a space as a mind map, or a large drawing, to continuously add to and reflect upon, makes adaptability essential. In a completely controlled environment without the ability to do so, people cannot extend their memory via their surroundings, and thus miss the possibility to structure their thinking in this way.

c.3.3 Self-organization vs the question: do we need design at all?

Fig c.4: MIT's Building 20 in Cambridge, Massachusetts. A simple wooden frame made up the main construction.

One anecdote that keeps coming back in literature on the topic is that of MIT's Building 20 (Brandon, 1994; Harford, 2016). When the institute found itself in need for extra space in the middle of the Second World War, the young architect Don Winston was given the task to design a 18,500 square meters barrack as quick as he could. The first designs were ready in the evening and the construction phase that followed was finished only a couple of weeks later. The building soon became infamous for its uncomfortability; in the summer it was too hot, in the winter it was too cold, all was dusty and way finding was extremely difficult. It was cheap, weird and incredibly ugly.

Nevertheless, Building 20, was loved by all of its occupants. They found in it the perfect place to experiment, not despite but because of its sloppiness (Harford, 2016). Made for temporary use in wartime, the building miraculously survived until 1998. In the years in between it had seen the invention of the first atomic clock; *Spacewar*, the first arcade game; the theories on linguistics by Noam Chomsky and those on cognitive science by Jerry Letvinn; and even an improvised anechoic chamber, in which John Cage first imagined *4'33"*. By the time of its demolition, Building 20 had been home to nine Nobel Prize winners.

Building 20 is a legendary example of a place that empowers self-organization of stuff. But it also reveals one of the most fundamental questions that this research raises for architecture. Self-organization is a phenomenon that seems to occur anyway, regardless of what we design. Do we need design at all?

Reflecting on this question from the perspective of the research gives three possible answers. First of all, Building 20 is a building, and not an empty lot. Although primitively, it provides for basic needs at least to a point where stuff can take care of the rest. Where it was leaking, buckets caught the dripping water, but at least it did not rain. When it was too cold, people wore thick sweaters, but

Fig c.5: People bumping into each other in the long corridors of Building 20. Many disciplines crossed each other's paths.

at least it did not freeze. The building, just by being a building, created the most essential conditions as a starting point where stuff cells could further build upon.

Secondly, Building 20 was famous for its awkwardness. The counterintuitive layout of and irrational corridor and office numbering, let people regularly bump into each other or enter the wrong room. Because of all the different disciplines sharing the building (simply everyone that did not fit elsewhere on the campus), scientists from all different fields met, leading to the most surprising collaborations and innovations. This seemingly occurred through a lack of 'design', but can also be seen as a feature of the building. The design was great in generating random external input for people to stumble upon, leading to ideas from unexpected perspectives.

Fig c.6: The improvised Rad Lab in Building 20 during the Second World War.

Thirdly, the building allowed for extreme reconfigurability. Power cables and water pipes were exposed and easy to reach, and besides were visibly old and cheap. Nobody cared what was done to the place; people painted the rooms, used doors as tables and even expanded their territory into adjacent offices by completely pulling down walls (MIT Institute Archives, 1998; Harford, 2016). Whereas scientists in other buildings had to wait for months to get permission for their experimental set-ups, in Building 20 these could be improvised in hours. In other words, almost all possible affordances could be ad-hoc constructed, which not only resulted in many experiments and activities, but also gave the occupants the possibility to give their room and the building as a whole its own identity (MIT Institute Archives, 1998). More than pure 'flexibility', when alterations are reset as easily as they are made, the process was that of constant rebuilding, a course of iteration. Although Building 20 might have been erected in a few weeks in 1943, the actual construction took place in the 55 years that followed.

Do we need design at all? Building 20 shows we do, for exactly those three reasons. The encouragement of the self-organization of stuff happens when the extremes of the weather are, at least to some extent, evened out, when unexpected inspiration is at hand and, most importantly, when this can be converted to the creation of affordances by the adaptation of one's surroundings. Although not in final or polished form, by providing these three things, Building 20 was surely a manifestation of design.

c.4 TOWARDS DESIGN

Chapter six described ways of understanding the self-organization of stuff, through which it could be observed, recognized and eventually be incorporated in the process of design. By using a complexity vocabulary, we can describe the life cycles of stuff and other layers in a building in a dynamic way; by using a pattern library, we can use stuff as a tool of analysis and make attempts to simulate it in our designs; and by understanding control parameters we can link it to conditions that can be provided for by architectural design. When we want to stimulate this process, which can be for a number of reasons, we can take in mind what is said above; create the right conditions, add some randomness and make the design transformable to everything imaginable.

As shortly noticed in the introduction, there is one other interesting avenue to explore. The self-organization of stuff is an ever-present driving force, that actually creates form. In fact, Spoerri used it to paint. As architecture is undeniably about order, could we not extrapolate this potency? Is it, with the knowledge we now have, possible to let architecture emerge from within, in time, as a constant game between the found and the looked for, the parts and the system, the system and its surroundings?

The theoretical conclusions of the search are no final chapter. On the contrary, the new ways of understanding the described phenomena on paper, are an open call to designers and decisionmakers in the real world. The self-organization of stuff is by no means a requirement, it simply *is*. It is the endlessly complex process, that, regardless of our awareness, lets places come to life.

A complex systems perspective adds to design the dimension of time. Interventions are understood as creating various possible scenarios, which means that within the design process these should be simulated to reflect upon. In this process, the computer, that can generate global patterns from local rules (lines of code) in seconds, is a valuable tool. Because of their increasing power, programming might become a significant actor in future design, especially concerning 'wicked' (interdisciplinary and multifactorial) problems (Westley & McGowan, 2014).

Simultaneous with this research, I have played around with agent-based modeling with the help of Netlogo, a program that runs iterations of code while randomizing the turn-taking order of the agents, thus mimicking simultaneity of their decisions[1]. This was a quick and relatively easy way to get a feeling for self-organization, and has given me much insight in its behavior.

Using code to create patterns, showed very directly one of the universal principles of pattern formation; it requires a balance of two opposing processes (Ball, 2012). In one of the first trials, that of fig c.9, two opposite tendencies competed, but still the canvas grew full quickly which stopped the process. Fig c.10 shows a second version, in which some 'eating' agents were added every so many iterations, keeping the system in balance.

What was especially insightful was observing what happened after changing the conditions or sensitivity to the conditions during runtime. This showed how initial condition parameters are highly determinative for the system's development, but when settled, the system only rigorously changes when a specific tipping point is reached. These condition can exist of fixed objects (e.g. drawn with the mouse), resembling architecture in a process of self-organizing stuff.

Simulating the cognitively complex system of the self-organization of stuff is too complicated for Netlogo, but could possibly be reached with a learning algorithm, that can over time even diversify parameters such as personalities or even moods. Agent-based-modeling can in this way, not only in urban design, but also in architecture, be a promising path for future design, informing the designer about the impact of decisions.

1 In the real world agents act simultaneously, something that is in fact possible to compute, but requires a lot of computer power, whereas this method gives approximately the same results.

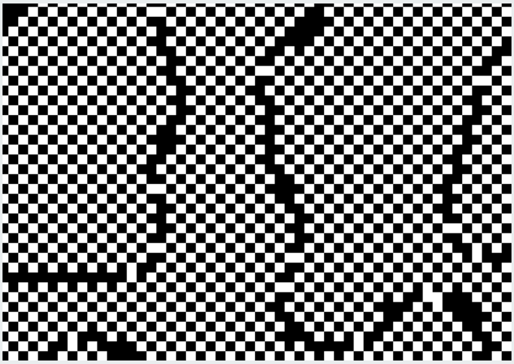


Fig c.7: Reaction ~ diffusion (low resolution Turing pattern)

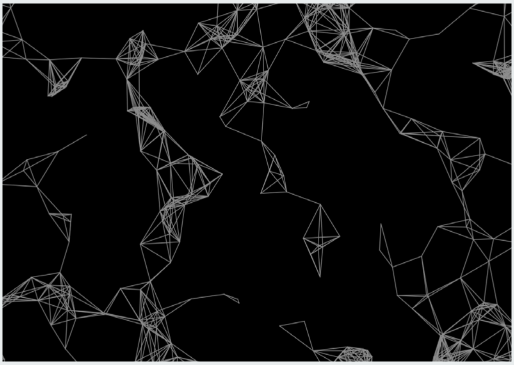


Fig c.8: Diffusion ~ group-forming, alternation every *n* iterations

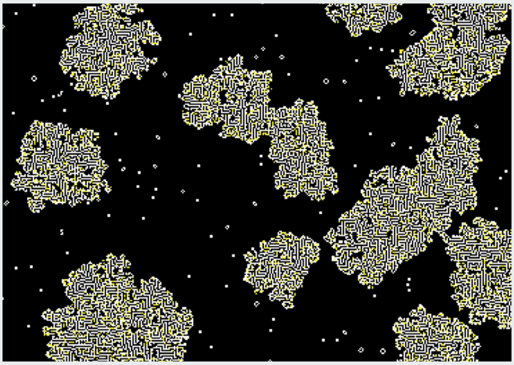


Fig c.9: Growing ~ not being built in (Conway variation)

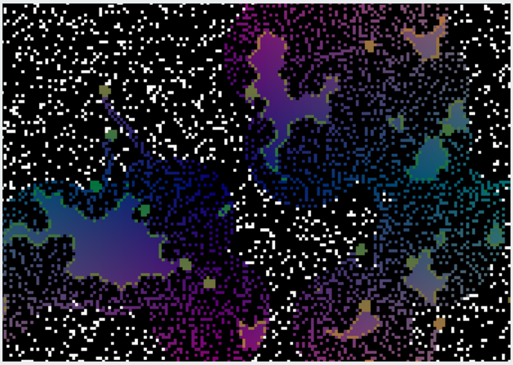


Fig c.10: Eating ~ being eaten, alternation every *n* iterations

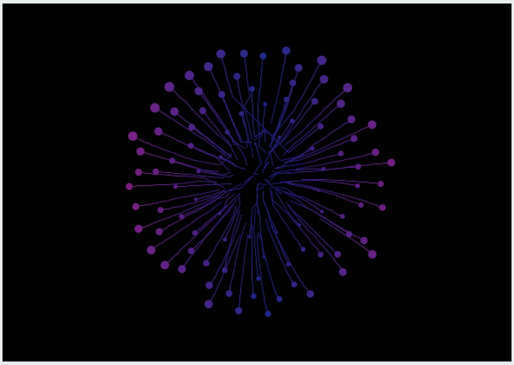


Fig c.11: Concentration ~ diffusion, alternation every *n* iterations


Fig c.12: Diffusion ~ group-forming, alternation every *n* iterations

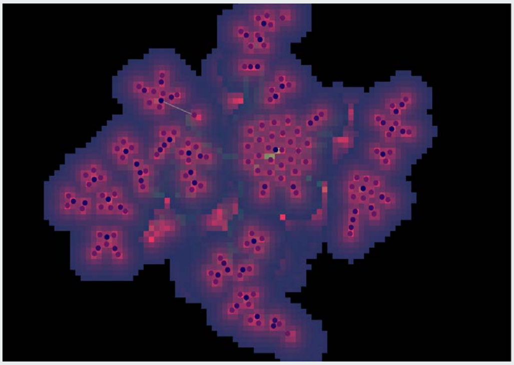


Fig c.13: Preference close to others ~ springs between links

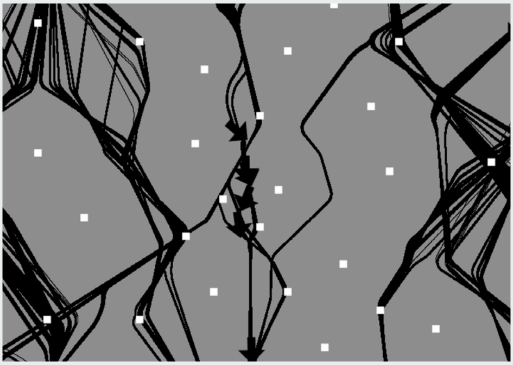


Fig c.14: Walking forward ~ avoiding dots

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IMAGES

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Fig 6.8: [Photograph] Inhabitat (date unknown). Retrieved from http://inhabitat.com/the-eames-house-sparked-new-thinking-in-modern-living/

Fig 6.9: [Photograph] Eames Foundation (date unknown). Retrieved from: http://mendetc.com/wp-content/uploads/2013/10/E3.jpg

Fig 6.10 and **6.11**: [Photograph] Eames Foundation (date unknown). Retrieved from http://3uypwq47po4k1f9ovd3spwzn.wpengine.netdna-cdn.com/wp-content/uploads/eames4594.jpg

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Fig c.3: [internetmeme] Author and date unknown. Retrieved from https://architizer-prod.imgix.net/media/1480360811410What_vs_Where.jpg?q=60&auto=format,compress&cs=strip&w=1080

Fig c.4: [Postcard] Author and date unknown. Retrieved from https://57099434b3-custmedia.vresp.com/c48d0722c4/MIT%20Building%2020%202.jpg

Fig c.5: [Photograph] MIT Institute Archives (date unknown). Retrieved from https://libraries.mit.edu/archives/mithistory/building20/building20.html

Fig c.6: [Photograph] MIT Institute Archives (date unknown). Retrieved from http://mit2016.mit.edu/sites/default/files/radlab.jpg

Other images by author.

GLOSSARY

Action identity

= Cognitive construct of the activity engaged in, or what one thinks one is doing. Serves as an order parameter filtering incoming information and structuring the activity.

Adaptive cycle

= Conceptual model originating from ecology describing the phases in the life cycle of a system and their relation to the phases of smaller and faster and larger and slower systems.

Affordance

= 1) Action possibility of an artifact or configuration of artifacts. What it affords to do.
= 2) Perceived action possibility of an artifact or configuration of artifacts.

Agent

= See: particle/part

Bottom-up

= Directed from local to global. Often falsely used as a synonym for self-organization, which happens in the alternation between both top-down and bottom-up.

Chaos

= State of disorder, in which a system lacks organization and the loose particles have a maximum freedom to move. This eventually leads to uniformity, or complete 'mixed-upness'.

Circular causality

= Causal interdependence between the order parameter and obeying particles, leading into a process of positive feedback.

Complexity

= Property of a system whose properties cannot be adequately described by any one formalism, as they emerge from local interactions between the components.

Complex system

= Dynamic network of agents acting in parallel, constantly acting and reacting to what the other agents are doing. Global patterns are explained by the cooperation and competition amongst the particles through time, that unfolds a structure with a highly dispersed and decentralized control. Also: complex adaptive system.

Complex adaptive system

= See: complex system

Condition

= Factor in the environment influencing the behavior of a system and thus acting as a control parameter. Here often referred to as climatic (light, sound, temperature, etc.).

Conservation phase (K)
= Rigid phase in the adaptive cycle in which a system shows emergent properties, but becomes increasingly susceptible for breakage.

Control parameter
= External parameter, determining the behavior of a system and able to cause a systemic phase transition. Term from synergetics.

Diderot-effect
= Effect when a deviant item enters a stuff collection, and causes the user to feel as if other items should be replaced to fit its style, aesthetic or level of quality.

Domain
= Zone where a level of publicness is experienced. Dynamic and variable. Also: realm.

Emergent property
= Property of a whole system, that disappears when the connection between the parts is lost.

Entropy
= the measurement of a systems disorder, or 'mixedupness'. High entropy indicates chaos and thus a high freedom of the parts.

Exploitation phase (r)
= Phase in the adaptive cycle in which material accumulates into an emerging structure.

Horizontal nestedness
= Interdependence between systems within the same scale level.

Order
= The state of a system in which the particles are arranged and thus have lost their freedom. In this text order is used to indicate (top-down) order by classification, as opposed to chaos and self-organization.

Order parameter
= Global structure in a system that is able to structure/enslave the particles. Term from synergetics.

Panarchy
= Framework for understanding complex systems in a both horizontally and vertically nested linkage. Similar to hierarchy, but without normativity; higher levels are not better, but encompassing the lower.

Particle/part

= Local element in the system, making decision according to the behavior of the other particles. A particle can be another complex system in itself, making the structure panarchic. Also: agent.

Path-dependency

= Dependence of events on a system's history, or the fact that small amplifications can have significant effects later in time, even though they themselves are no longer relevant. A property of complex systems.

Positive feedback

= Enhancing of an effect by its own influence on the process which gives rise to it. Self-reinforcement.

Primary working field

= Term introduced to describe the place of highest assemblage in a stuff cell, often to be found just in front of the user.

Release phase (Ω)

= Phase in the adaptive cycle in which the system looses its structure and falls into a chaotic state.

Remembering

= Downward causation. Structuring enforced by a larger and slower system.

Re-organization phase (α)

= Volatile and chaotic phase in the adaptive cycle in which random fluctuations can drastically alter the path of the system.

Resilience

= The capability of a system to recover from disturbances.

Revolting

= Upward causation. Disturbance caused by a smaller and faster system in its release phase.

Second law of thermodynamics

= Law stating that the level of entropy in an isolated system can only increase over time, or in other words, that order will always fall into chaos. As, amongst others, Schrödinger suggested, this law fails to explain life.

Self-organization

= Formation of spatial, temporal and spatio-temporal structures arising from local interactions in a complex system. Self-organization is triggered by random fluctuations and amplified by the self-reinforcement or positive feedback of formed structure.

Spontaneous order

= See: self-organization

Synergetics

= Interdisciplinary science, originating from physics, explaining the formation and self-organization of patterns and structures in open systems.

System
= Regularly interacting or interdependent group of items forming a unified whole.

Top-down
= directed from global to local.

Vertical nestedness
= Interdependence between systems of smaller and faster and larger and slower scale levels.

APPENDIX I.

DATA SET 1

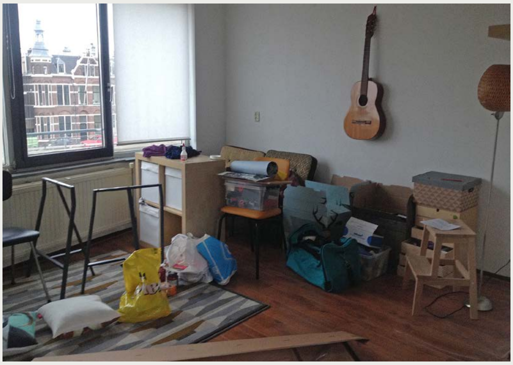
Data set of pictures taken of the reconfiguration of stuff in my room during a year of living from the 5th of October 2016 to the 25th of September 2017

Some dates are an approximation


October 5th - Moving in


October 5th - Moving in

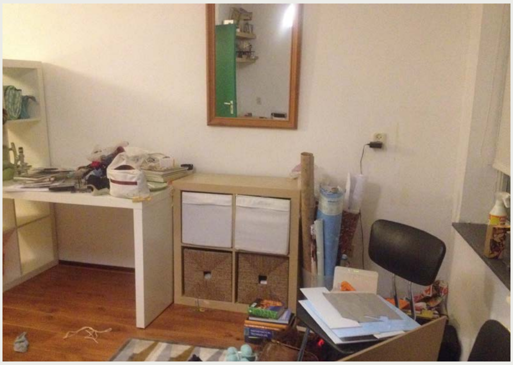

October 5th - Moving in


October 5th - Moving in, after IKEA


October 5th - Moving in, after IKEA, evening


October 5th - Moving in, after IKEA, evening


October 6th - The next day

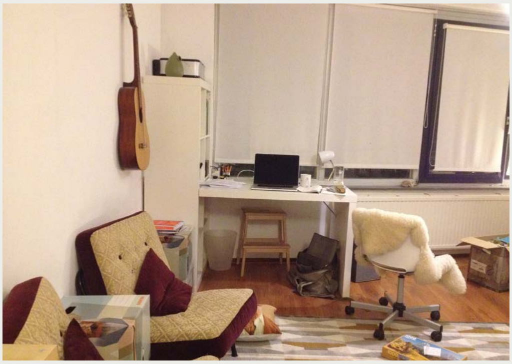

October 6th - The next day, evening

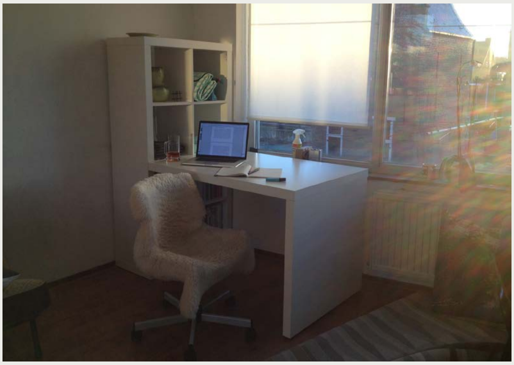

October 7th - Cleaning up the chaos


October 7th - Moving furniture around


October 12th - Housemate is helping


October 12th - Sorting out clothes


October 12th - Moved desk


October 17th - Moved desk


October 18th - New corner in use


October 19th - Sorted clothes


October 21st - Marktplaats chair brought in


October 23th - New place for the chair


October 26th - Sorting out papers


November 1st - Dinner on paper, table still untreated


November 3rd - Woodstaining the table

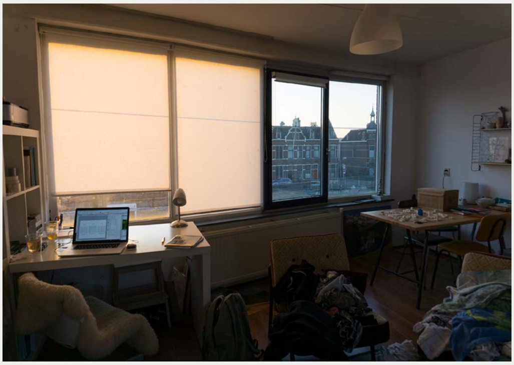

November 5th - Woodstaining the table, second time


December 3rd - Making Sinterklaassurprises


December 10th - desk


January 6th - New stuff on tomado rack


January 10th - Clean table

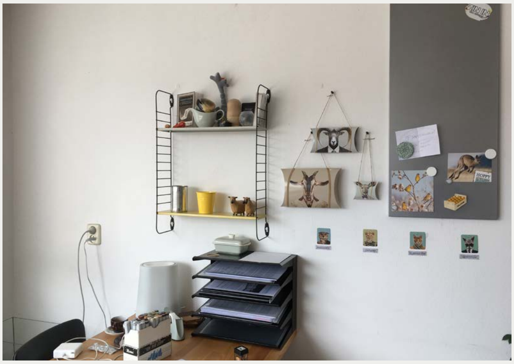

January 12th - Playing with lego


January 15th - Broken curtain


March 1st - Sorting out papers


March 5th - New furniture


April 5th - Displacing furniture

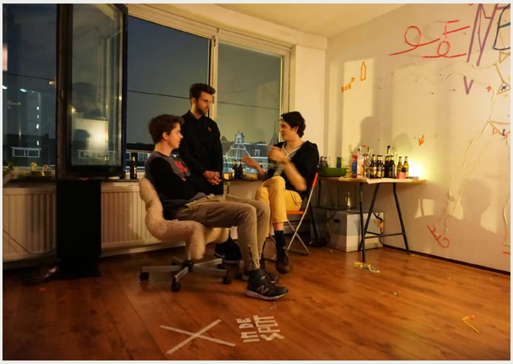

April 10th - Upgraded desk


April 21st - Study group


April 22nd - Sort of settled

May 6th - Pre party preparations

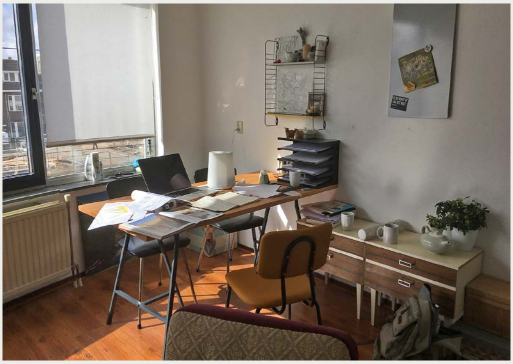

May 6th - Party


May 7th - Afterparty

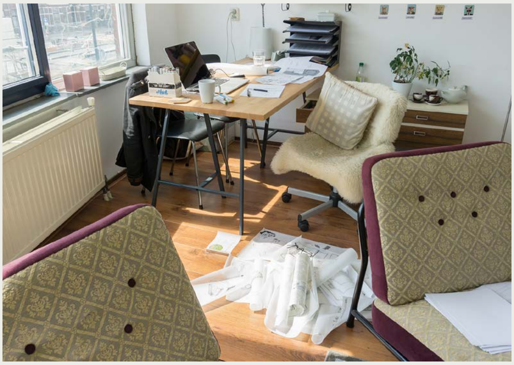
May 7th - After afterparty

May 7th - After afterparty


May 7th - Cleaned up


May 12th - Designing


May 13th - Designing


May 20th - Failed designs


May 20th - Table from a piece of wood and a fish tank


June 3rd - After birthday, flowers and presents

June 11th - Peg board

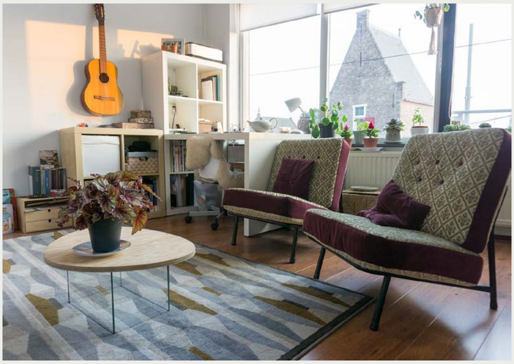

June 19th - Home cinema


June 26th - Working

June 26th - Working

June 26th - Cleaned up

June 30th - Desk



Augustus 9th - New plants

Augustus 9th - New plants

September 15th - Sunset

September 18th - Playing the pattern game

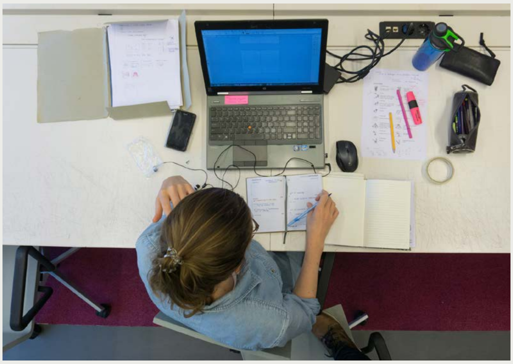
October 5th - Exactly a year after moving in. Day of handing in this thesis. Incredible mess.

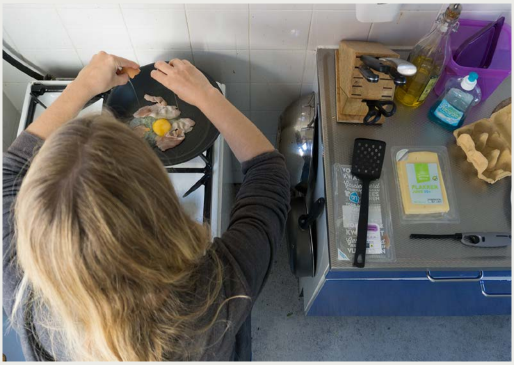
APPENDIX II.

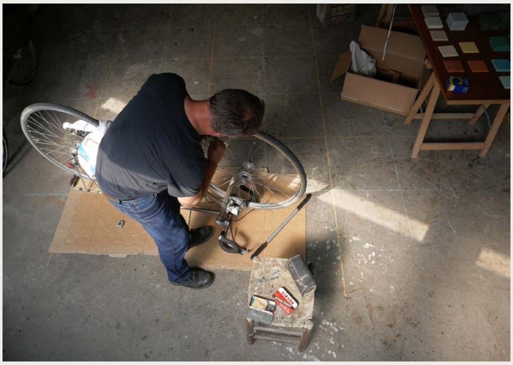
DATA SET 2

Data set of pictures taken of from various stuff cells, both inside
and outside the house.

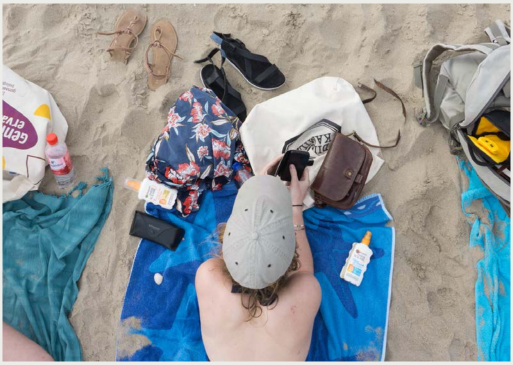

Doing the dishes


Studying


Baking an egg

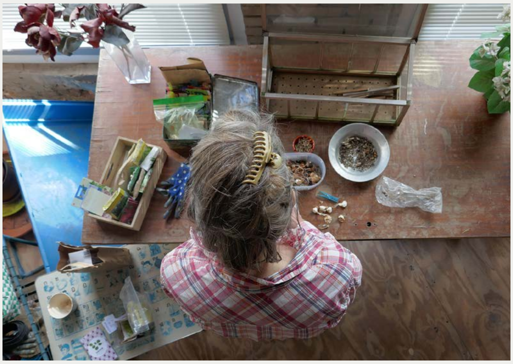

Replacing a tire


Playing piano


Lying at the beach


Chipping cement off tiles

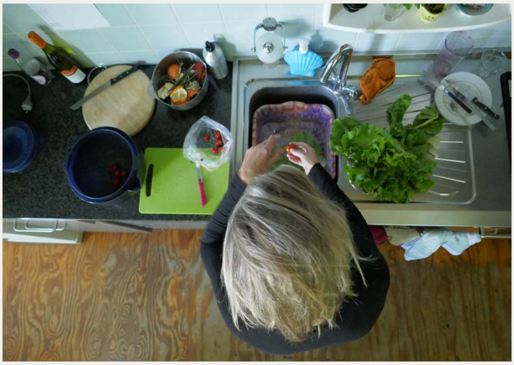

Tracing a photo



Planting flower bulbs

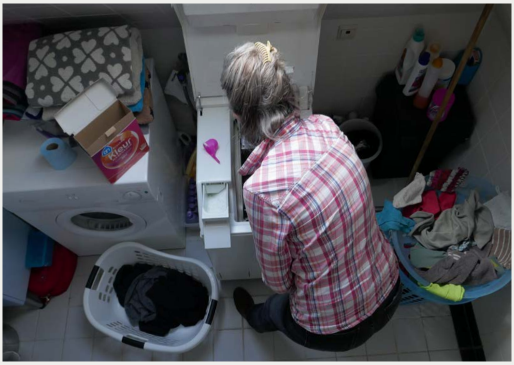
Brushing teeth

Chilling out



Washing vegetables

Doing the laundry



Doing the laundry

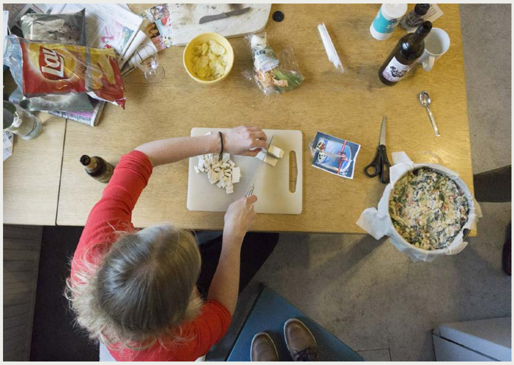
Serving pasta

Moving bricks

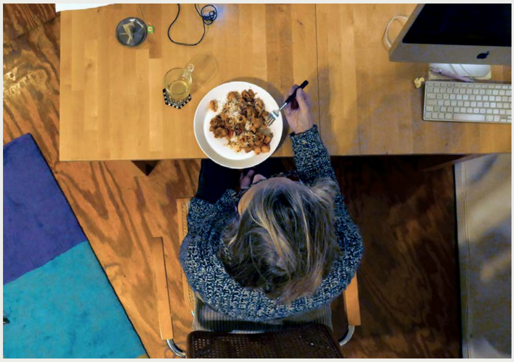
Reading the newspaper

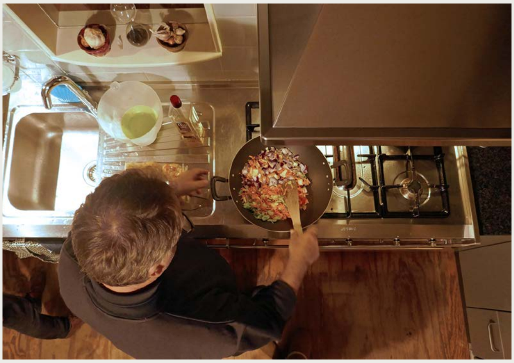

Pruning the ivy


Working on an architecture project


Cutting feta


Filling a vegetable tart

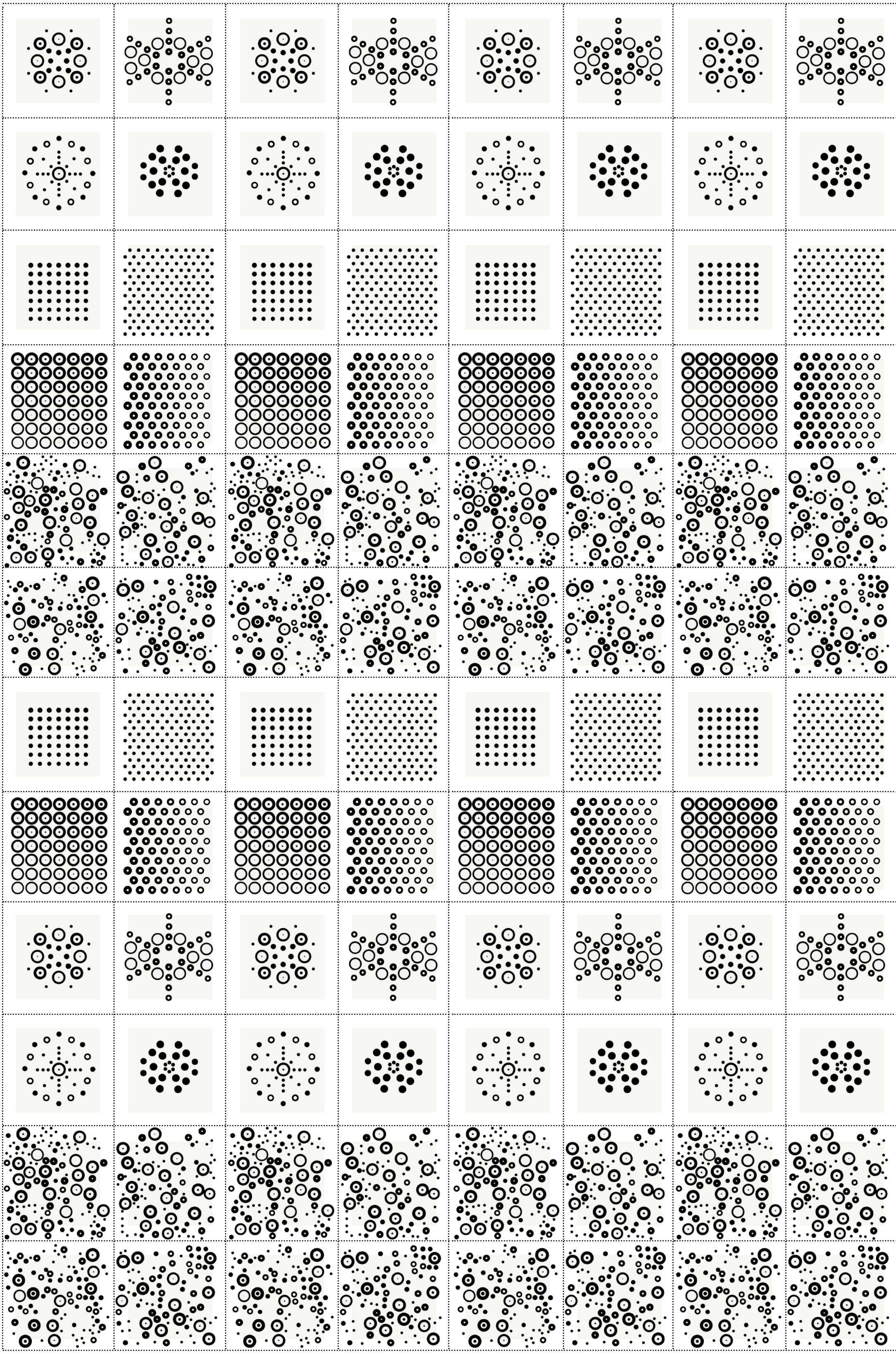

Having dinner


Cooking pasta sauce

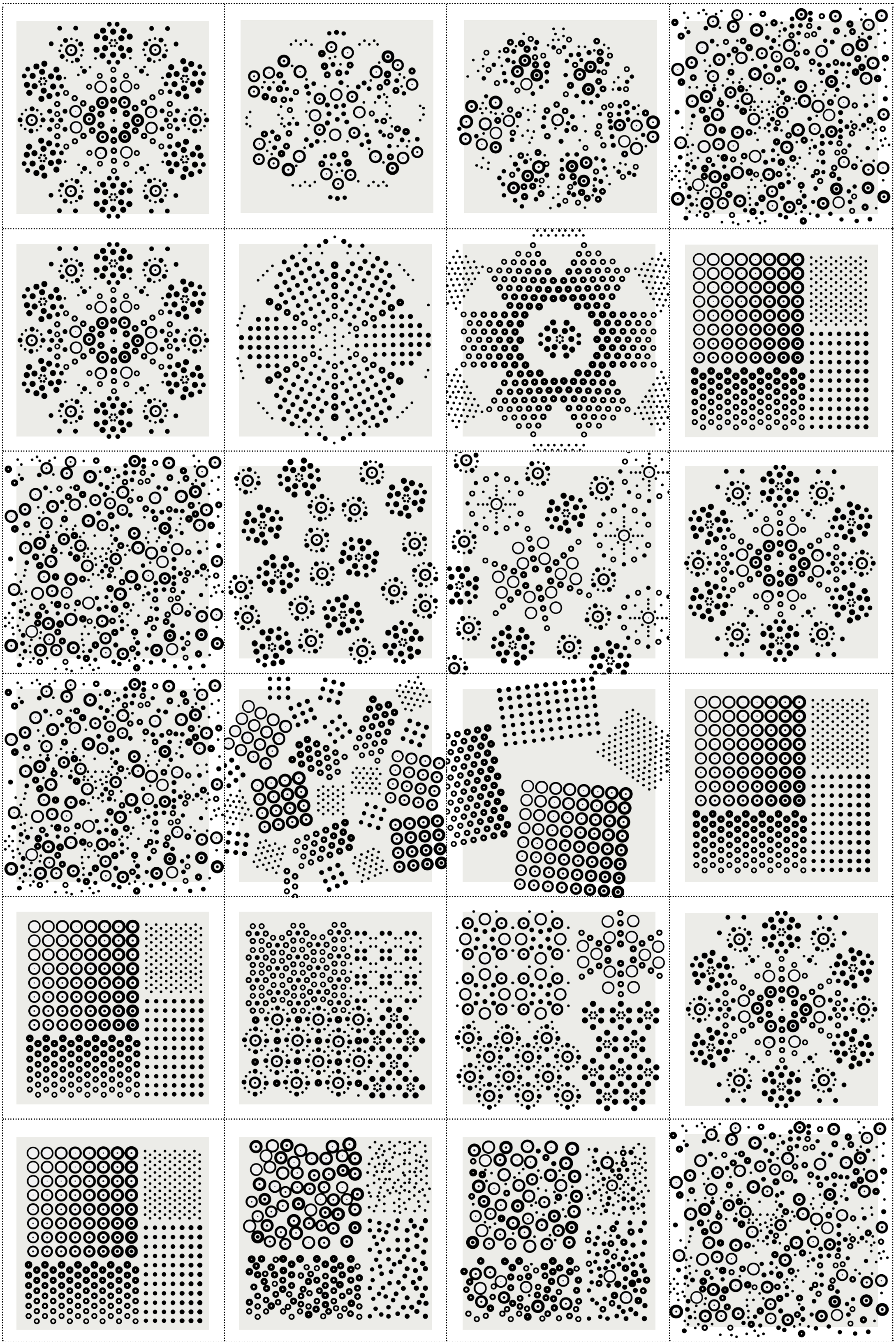

Studying

APPENDIX III.

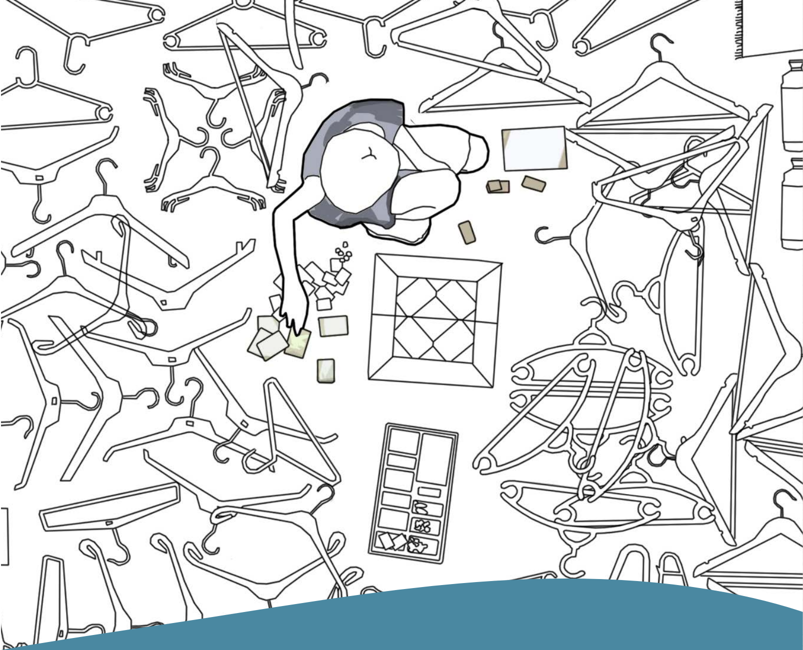
THE PATTERN CARD SET



so	so	so	so	so	so	so	so
so	so	so	so	so	so	so	so
o	o	o	o	o	o	o	o
o	o	o	o	o	o	o	o
c	c	c	c	c	c	c	c
c	c	c	c	c	c	c	c
o	o	o	o	o	o	o	o
o	o	o	o	o	o	o	o
so	so	so	so	so	so	so	so
so	so	so	so	so	so	so	so
c	c	c	c	c	c	c	c
c	c	c	c	c	c	c	c



larger/slower **CHAOTIC** *smaller/faster* **CHAOS**	*larger/slower* SELF ORGANIZED *smaller/faster* **CHAOS**	*larger/slower* **SELF ORGANIZED** *smaller/faster* CHAOS	*larger/slower* **SELF-ORGANIZED** *smaller/faster* **SELF ORGANIZATION**
larger/slower **ORDERED** *smaller/faster* **ORDER**	*larger/slower* SELF ORGANIZED *smaller/faster* **ORDER**	*larger/slower* **SELF ORGANIZED** *smaller/faster* ORDER	*larger/slower* **SELF-ORGANIZED** *smaller/faster* **SELF ORGANIZATION**
larger/slower **SELF-ORGANIZED** *smaller/faster* **SELF ORGANIZATION**	*larger/slower* CHAOTIC *smaller/faster* **SELF ORGANIZATION**	*larger/slower* **CHAOTIC** *smaller/faster* SELF ORGANIZATION	*larger/slower* **CHAOTIC** *smaller/faster* **CHAOS**
larger/slower **ORDERED** *smaller/faster* **ORDER**	*larger/slower* CHAOTIC *smaller/faster* **ORDER**	*larger/slower* **CHAOTIC** *smaller/faster* ORDER	*larger/slower* **CHAOTIC** *smaller/faster* **CHAOS**
larger/slower **SELF-ORGANIZED** *smaller/faster* **SELF ORGANIZATION**	*larger/slower* ORDERED *smaller/faster* **SELF ORGANIZATION**	*larger/slower* **ORDERED** *smaller/faster* SELF ORGANIZATION	*larger/slower* **ORDERED** *smaller/faster* **ORDER**
larger/slower CHAOTIC *smaller/faster* **CHAOS**	*larger/slower* ORDERED *smaller/faster* **CHAOS**	*larger/slower* **ORDERED** *smaller/faster* CHAOS	*larger/slower* **ORDERED** *smaller/faster* **ORDER**



Every researcher thinks their discipline explains the world. Everything is physics, everything is chemistry and everything is economics. But in fact, everything is the self-organization of stuff.

The built environment is never finished, yet always in use. It might not be as perfect as we would like it to be, but neither does it fall apart if we let go control. On the contrary, the spontaneous ordering of our surroundings - the self-organization of stuff - is what happens while we are busy doing other things. It is through the tiniest interactions with stuff, picking up a pen, moving a chair and making a meal, that all sorts of configurations miraculously evolve.

If buildings are living bodies, this is a thesis exploring molecules, chemical reactions and microbiology.