UNFOLDING THE AESTHETICS OF COMPLEXITY

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Revised version of final report from the project "Cross-disciplinary studies of complexity and transformation" 070630.

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Summary

This report presents and evaluates the *Cross-disciplinary study in Complexity and Transformation* (C&T) between artists, physicists, designers, and architects. It involved experimental studies that combine *aesthetic strategies* and *rule based* mechanisms aimed to explore the theme complexity and transformation. During four workshops, 12 physical lab sessions were performed that offered different interpretations of the theme. These workshops were videofilmed from an insider's perspective, exposing a very candid exploratory process and dialogue.

The Swedish term *laboration* was adapted and anglicized to coin the cross-disciplinary, embodied activities during the lab sessions in the workshops. The interactive methodologies were practice-based supporting learning through experience. The similarities and clashes that arose between and across disciplines made it possible to recognize the essence of the aesthetic strategies concerning embodiment, play, gestalt and spatial staging.

The following three procedural models were developed focusing on ways to link concepts with aesthetic features and properties of complex phenomena: i) *Aesthetic phase transition*-model dealing with objects and events focusing on a sequence of aesthetic phase transition, ii) *Transformation*-model using inductive and deductive reasoning comparing contrasting concepts and features over time, iii) *Framing the dialogue*-model using a bipolar spectrum to frame complex behavior and support a multidisciplinary, individualized dialogue.

The C&T project recognized that knowledge is context-dependent and subjectively framed. The results of a questionnaire and interviews with the participants showed that aesthetic strategies can complement the systematic and precise reasoning characterizing physics to support an embodied understanding of the theme complexity and transformation. The report ends with a manifest called "Unfolding the aesthetics of complexity"

Keywords: Aesthetic, architecture, art, artifact, complexity, cross-disciplinary, design, embodiment, gestalt, play, transformation

Content


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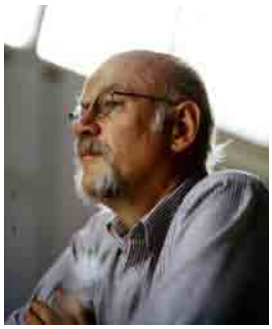
Christian Bohm


Ebba Matz


Elisabet Yanagisawa-Avén


Fredrik Berefelt


Gustaf Mårtensson


Lars Bergström


Monica Billger


Narendra Yamdagni


Pablo Miranda


Teo Enlund

Fig 1 14 participants in the C&T project.
Photo: C&T archive and Bengt Alm

1. Background

Contemporary artists have shifted their attention from isolated, aesthetic art objects to the *thematic* content that underlies a work of art or an installation. Physicists have always looked upon the world as energy, matter, and forces related in a spatially dynamic *context* - an isolated static object in space does not exist in the physicist's world. In effect, like physics, art has cultivated a creative approach in which change and genesis are more important than the static aesthetic expression of the artifact itself.

However, for designers, the changing event and the stable object are equally important. Designers are responsible for effecting *change* in society by reshaping and creating physical objects, spatial structures, and services to meet new needs and express contemporary desires. The expression of the *stable* object is important, but needs to be more closely integrated with the spatial, temporal and social context that it is designed for. This cultural shift from stability to theme - change - context will be addressed in this report through an aesthetic investigation of the nature of changing and complex phenomena.

1.1 Participants and guests

Participants in the project (figure 1)

1. *Cheryl Akner-Koler,* project leader, sculptor & professor at the Dept. of Industrial Design Konstfack.
2. *Narendra Yamdagni,* workshop leader, PhD, scientist in elementary particle physics at Albanova, Stockholm University (SU).
3. *Lars Bergström,* workshop leader, professor of theoretical physics at Albanova, SU.
4. *Arijana Kajfes,* workshop leader, artist, Interactive Institute.
5. *Monica Billger,* workshop leader, PhD, Dept. of Architecture at Chalmers University of Technology.
6. *Björn Norberg,* curator of the C&T exhibition, art historian, and producer at Splintermind.
7. *Pablo Miranda,* workshop leader, architect, researcher at the School of Architecture, Royal Institute of Technology (KTH) in Stockholm.
8. *Christian Bohm,* workshop leader, professor of physical system technology at Albanova, SU.
9. *Catharina Dyrssen,* PhD, associate professor at Architecture at Chalmers University of Technology
10. *Teo Enlund,* professor at the Dept. of Industrial Design, Konstfack.
11. *Ebba Matz,* artist and teacher.
12. *Gustaf Mårtensson,* PhD in fluid mechanics at KTH
13. *Fredrik Berefelt,* mathematician and astrophysics researcher in nonlinear systems.
14. *Elisabet Yanagisawa-Avén,* university lecturer in textiles at Konstfack.

Guests

15. *Stina Lindholm,* sculptor and designer, founder of Skulpturfabriken, Gotland.
16. *Gunilla Kihlgren,* glass artist, teacher at Konstfack
17. *Ester Appelgren,* doctoral candidate at KTH, NADA
18. *PO Hulth,* professor of experimental astroparticle physics at Albanova, SU.
19. *Peter Gärdenfors,* professor of cognitive science, Lund University.
20. *Jesper Andersson,* physicist, the MRI center at Karolinska Hospital.
21. *Carolina de la Fé,* assistant, student at the Department of Industrial Design, Konstfack.
22. *Thomas Burgess,* assistant, doctoral student in the AMANDA project, SU.
23. *Christina Burgess,* assistant, doctoral student in the AMANDA project, SU.
24. *Katje Sävström,* webdesigner, industrial designer, Front Design.

2. Introduction

2.1 Support from the research community

The year 2000 marked a major change in the scientific and art communities in Sweden. The Swedish government passed a bill (proposition 2000/2001:3) that gave the arts research status. The bill encouraged the development of networks between art schools and universities that have research experience, as well as the initiation of joint art and science projects.

The main argument for passing this bill was that artistic development projects play an important role in exploring new areas of human endeavor representing alternative sources for the development of knowledge. Another aim stated in the bill was to stimulate alternative methodologies that deal with "creative subjective values" as opposed to traditional research activities.

With the support of a three-year grant from the Swedish Research Council, a diverse art and science network of researchers, free artists, practitioners, and educators from the arts, physics, design, and architecture was formed to study the theme *Complexity and Transformation (C&T)*. This network represented a balance between genders as well as cultures, and a diversity of ages. A total of 43 people have been involved in the workshops and the building of the exhibitions in the project. See our website, **www.complexityandtransformation.com**, under the "People" link.

Research in the theory of complexity is established within the scientific community, as are methods of transformation. Therefore, the physicists came to this project with developed professional terminology. The art and design community, on the other hand, is seldom involved in establishing nomenclature, so each artist and designer approached the project with his/ her own individual relationship to the theme complexity and transformation. This combination of a collective sharp terminology from physics and freedom for individual interpretation from the arts illustrates an obvious clash in our cultures. This report will examine the effect of this clash.

2.2 Applied aesthetics

Alexander Baumgarten defined the term *aesthetic* in 1750 to mean the science of sensuous cognition. He considered aesthetics to be a scientific activity channeled through the senses to gain knowledge in any field (Shusterman 1992 [2000]). There is a growing movement today in aesthetics called pragmatist aesthetics, which builds, in part, on Baumgarten's definition and brings aesthetics deeper into fields of empirical science, as well as into the everyday world of experience in people's lives (Shusterman 1992 [2000]).

A central figure in this movement is John Dewey (1980 [1934]), who brought aesthetic experience out of the isolated gallery and museum world and immersed aesthetics in dynamic events within the complexity of contemporary life. Dewey focused on the immediate and concrete interaction with the physical conditions surrounding us, and appreciated what each individual can bring to the unique situation. Throughout his writings, Dewey stressed the importance of integrating aesthetics, emotions, perception and intellect. He stated that the synergy of these qualities presents the world to us as new, giving purpose to the individuals. The arts and design have a long tradition of relying on aesthetic inquiry as a means of understanding and interacting with the world we live in (Dewey 1980 [1934]).

The recent literature in the growing field of embodiment (which combines findings from neuroscience, physical anthropology, cognitive science and chaos theory) confirms the need for cultivating an open approach of pragmatist aesthetics. Research in embodiment brings insight into the role the body plays in shaping our consciousness. Antonio Damasio's work in neuroscience is central in this field. Damasio (2005, xvii [1994]) states:

> *The lower levels in the neural edifice of reason are the same ones that regulate the processing of emotions and feelings, along with the body functions necessary for an organism's survival. In turn, these lower levels maintain direct and mutual relationships with virtually every bodily organ, thus placing the body directly within the chain of operations that generate the highest reaches of reasoning, decision making and, by extension, social behavior and creativity. Emotion, feeling and biological regulation all play a role in human reason.*

Damasio explains that there is no separation between perceptual reasoning, emotional reactions, and conceptual thinking. They occur simultaneously in the same regions of the brain and are interdependent. He also defends the value of primitive survival responses, because he sees them as essential for unifying our way of reasoning (Damasio 2005, 261-7 [1994]) The methods for learning and doing in art and design reflect this insight into how our body helps us reason. The present project is dedicated to expanding aesthetic traditions of embodiment through explorative studies.

2.3 Aim and questions

The aim of the present exploratory project was to expand and gain new knowledge in the field of aesthetics by *problematizing* (Molander 1996, 69) aesthetic reasoning through studies of complex and changing phenomena in

a cross-disciplinary culture.
Some questions were:

1) How can aesthetic reasoning embrace a more temporal and context-sensitive awareness?
2) How can exploratory laborations offer experiences to learn about complexity and transformation?
3) How can aesthetic strategies for gaining knowledge from the complex real world help the scientific community deal with unpredictable and contradictory behavior?
4) How can the systematic and reductionist approach developed in physics have a positive impact on research development in the art and design communities?
5) Does a cross-disciplinary culture offer insight into formulating new aesthetic reasoning?

3. Workshops and laborations

The *Complexity and Transformation* theme was developed by a core group of four people from the arts and physics. The experience from our two previous projects/ exhibitions, *Empty Space* and *Infinity* (Akner-Koler and Bergström 2005ii), inspired the development of the theme of the present cross-disciplinary project. We needed to develop a theme that touched on questions that were relevant for all the members in the core group. Ideas such as formlessness, gravitational forces, life cycle, field, and breakdown were brought up, but were not broad enough to embrace everyone's interest. Finally, the inclusive theme, Complexity and Transformation (Davis 1995), was agreed on because it covered many of the themes we were discussing. The purpose of the theme was to guide the lab sessions in the workshops. We applied practice-based embodied methodologies supporting learning through experience (Billger and Dyrssen 2005).

Workshops - planning and procedures
The project consisted of four workshops between 2003 and 2005, with 12 lab sessions that explored complex and transforming phenomena between 2003-2005. The planning for each workshop required between five and ten meetings. The Swedish concept: *laboration* was adapted and anglicized to coin the cross-disciplinary embodied activities carried out during the explorative lab sessions. These laborations were planned by members of the core group plus six C&T participants and six assistants. Each workshop / laboration leader was asked to:

- create a laboration that expressed aspects of the *complexity and transformation* theme
- plan the laboration so that it touched on an unexplored area within their own field of expertise/ area of interest
- present their own intentions with the laboration
- make sure that both the planning process and the workshop is playful
- create a laboration that stimulated all our senses, aimed to support aesthetic reasoning

All participants were given a general idea of what we were attempting to do in the workshops, and the grant application explaining the details of the project was sent out (www.complexityandtransformation.com under "Text"). We were a very diverse group and we wanted to reflect and diffract this heterogeneity. The only preparation we asked of the participants was to get a good night's sleep and come on time to the workshop.

The participants (about 14–16 at each workshop) were divided into 3-4 cross-disciplinary groups, which were reorganized for each workshop to ensure that everyone had the chance to work together. At the onset of each laboration, the workshop leaders presented their own background and explained their intentions. The materials and tools were laid out with some general instructions to get the experiments started. The time span for most laborations was generous, allowing the groups to experiment and follow any path of exploration, as long as it involved sensuous experiences that tested the limits of the phenomena. The leaders participated in their own laborations on different levels. Sometimes they would move between the groups observing the experiments and/ or become a member of a group and get actively involved in the performance and discussions. The laborations all supported embodied experiences aimed to engage our sensitivities in the exploratory process. Our immediate reactions were important in order to guide interactivity with the changing events.

3.1 Four workshops and 12 laborations

The four workshops and 12 laborations are illustrated in the map in figure 2.

Workshop I: Vinterviken 2003
The **first** workshop, Vinterviken 2003, was led by an artist/ architect team. It began with a sensuous laboration presented by artist Cheryl Akner-Koler on *non-visual color* that stimulated our haptic and tactile senses aimed to enhance the embodied experience. This was followed by a 2nd laboration, *Material transformation*, exploring the transforming effects of heat and chemicals on organic materials. The idea behind this laboration was to take part of a transformation process that caused material breakdown of an organic material. Focus was on the gradual and radical changes that affected color, form, void, texture, smell, etc. This laboration brought about the *Aesthetic Phase*

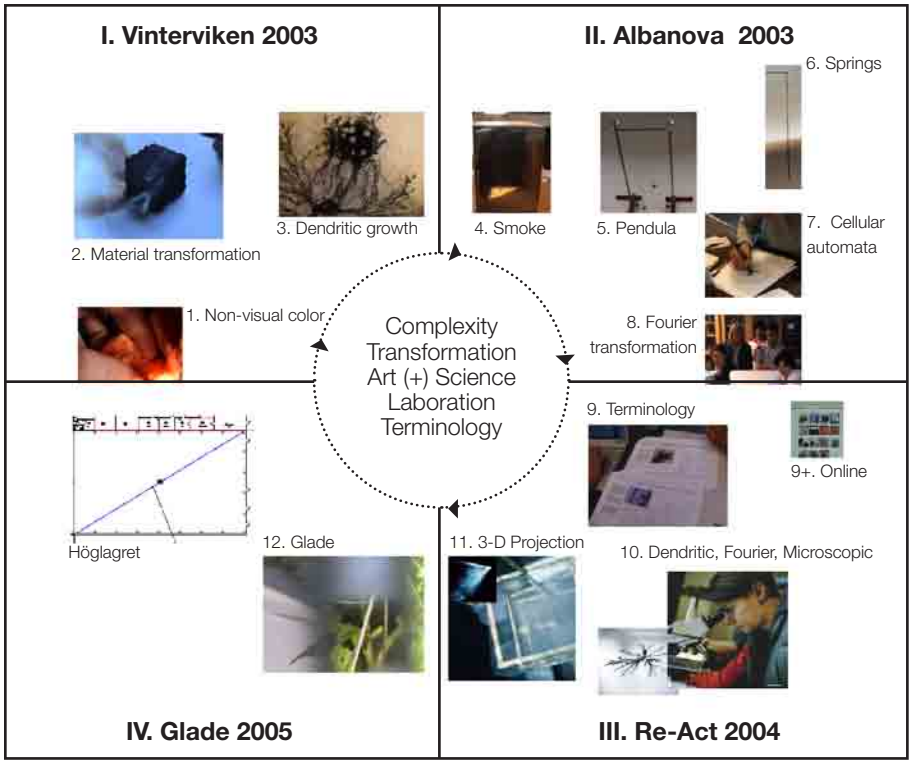

Fig. 2 Visual map arranged in chronological order starting from the upper left corner moving clockwise. The map is divided into four workshops and 12 laborations:

I. Vinterviken 2003:
1. Non-visual color, 2. Material transformation, 3. Dendritic growth.
II. Albanova 2003:
4. Smoke, 5. Pendula,
6. Consecutive springs, 7. Cellular automata,
8. Fourier transformation.
III. Re-Act 2004:
9. Terminology, 9+ online,
10. Dendritic, Fourier, microscopic,
11. 3-D projection
IV.Glade: 12 Glade.

Six main concepts are presented at the center of the map.

Transition-model, which is briefly described in section 4.4. The model is described in detail in the article *Transforming Aesthetics* (Akner-Koler et al. 2005).

Example of Laboration: The group performing the laboration initially chose to experiment with aubergine (egg plant). A solution of water mixed with sodium hydroxide, lemon and "Häxan" (witch = Swedish polishing cream) was heated and a cut piece of aubergine was emerged in the fluid. However, the aubergine did not change during the process. Instead, an unexpected event occurred, causing foam to emerge, becoming the center of attention. The transformation was therefore about changing from a murky liquid to foam (figure 3).

The 3rd laboration, *Dendritic growth*, conducted by artist Arijana Kajfes and architect Pablo Miranda, involved an electrochemical process that produced branching crystal structures called dendrites. The intention of the lab was to show how self-organizing structures could emerge from a very simple chemical solution. This solution represents a kind of free zone in which the crystal formation can grow. The growth pattern is a fractal structure, which means that it grows by making similar organizational decisions at all levels of growth (figure 4).The interesting concept that dendrites demonstrate is transformation from chaos to order. Randomly moving ions in the solution are attracted by an electrical current so that they behave in an extremely orderly and symmetrical way, creating stable crystal structures. These crystals appear almost organic and lifelike and challenge the arbitrary division between organic and inorganic, thereby demonstrating artificial life (Norberg et al 2005).

Kajfes' and Miranda's interest in this experimental study from the 1950s, inspired by Gordon Pask (Cariani 1993), was to see in what way the participants would try to interact with the dendritic growth pattern. For example, they might try to affect the *internal* function of the system by controlling the choice of metals, the level of electricity or the type of solution. They could also affect the growth pattern through *external* interaction, such as placing obstacles in the way of the branching pattern or perturbing the conditions by shaking the solution or introducing a magnetic field in the solution.

Workshop II: Albanova 2003

The **second** workshop was led by physicists at Albanova, Stockholm University. The 4th to 6th laborations, conducted by Narendra Yamdagni, explored non-linear phenomena in *turbulent smoke, double pendula* and three *consecutive springs*. The aim of these laborations was to study, through direct and indirect activities, how different phenomena can change from predictable behavior to unpredictable and chaotic behavior.

The 4th laboration, *Smoke*, explored smoke from a cone of incense placed in a box with a window made

Fig. 3a

Fig. 3b

Fig. 3c

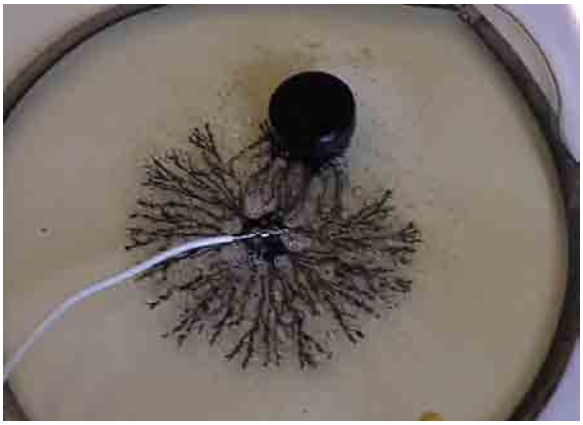

Fig. 4a

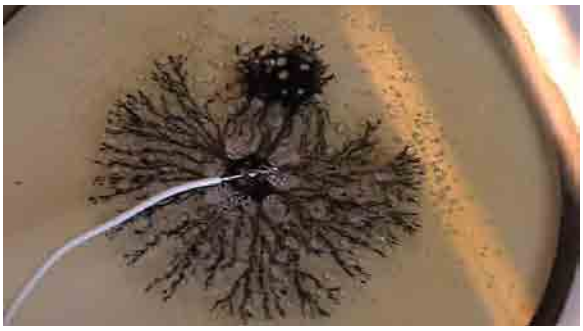

Fig. 4b

Fig. 5a

Fig. 5b

Fig. 5c

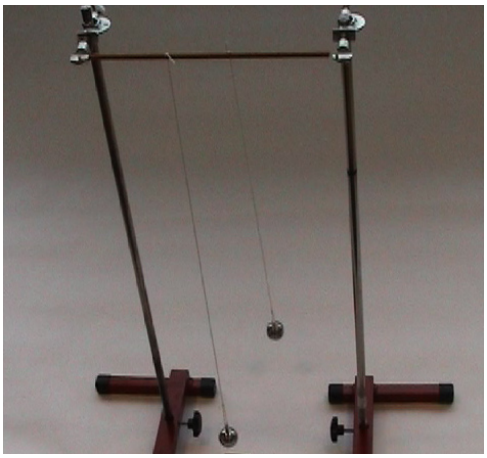

Fig. 6a

Fig. 6b

Fig. 3 Laboration Material transformation.
a. A murky liquid.
b. An unpredictable thick layer of emerging white foam.
c. Bubbles and foam.
Photo: C&T archive.

Fig. 4 Laboration *Dendritic growth* of zink crystals (Photo: C&T archive).
a. Dendritic growth laboration showing symmetrical crystal pattern.
b. Perturbing growth patterns with magnet.
Photo: C&T archive.

Fig. 5 Laboration Smoke
a. Incense in protected box.
b. Opened door.
c. Turbulent flow of smoke.
Photo: C&T archive.

Fig. 6 Laboration *Pendula*
a. Pendula
b. Detail
Photo: C&T archive.

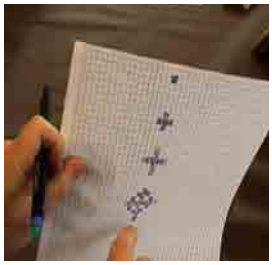

Fig. 7a

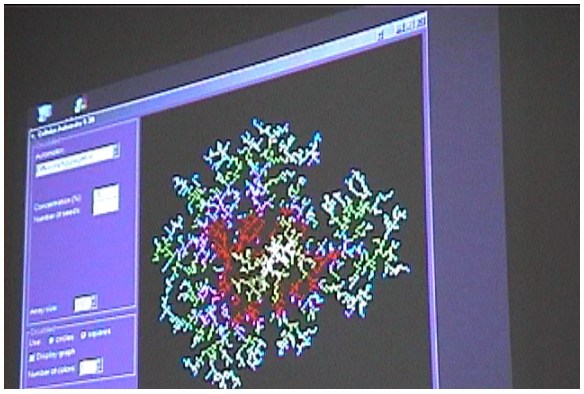

Fig. 7b

Fig. 7
a Cellular automata created by coloring squares on a graph paper.
b Computer generated cellular automata. Photo: C&T archive.

Fig. 8a

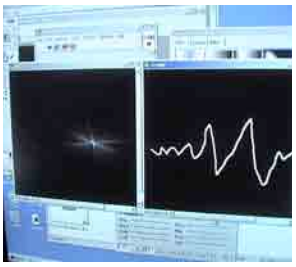

Fig. 8b

Fig 8
Laboration *Fourier transformation.*
a. Five participants observing Fourier transformation on a computer screen.
b. Computer screen of Fourier transformation.
Photo: C&T archive.

of overhead film protecting it from the air streams in the room. The stream of smoke that immediately rose from the cone formed a straight pillar, illustrating the linear and predictable nature of smoke. However, at a certain critical distance from the energy source at the cone, the smoke became turbulent and chaotic. To perturb the smoke, the overhead film was removed allowing air currents outside of the box to disturb the pattern of the smoke. For example, when the door opened at the opposite end of the room the smoke suddenly change course, demonstrating a "perfect example of complexity" (Lars Bergström, personal communication), i.e. a totally unrelated event from a distant place changed the behavior pattern of the smoke (figure 5).

The 5th laboration, *Pendula,* demonstrated how the predictable movement of an active pendulum could transfer energy through an axis to a passive pendulum, causing it to move in a chaotic way that did not have any recognizable correlation with the movement of the active one (figure 6).

Finally, in the 6th laboration, *Consecutive springs*, 2-3 springs with three different weights were hung underneath each other and pulled straight down. The oscillating movement that would have occurred when a single spring was extended did not occur with three; instead, the collective movement caused asymmetrical, chaotic activities in many directions.

The 7th laboration, *Cellular automata,* was introduced through lectures by Lars Bergström and Narendra Yamdagni explaining the mechanistic rule-based process controlled by a grid of cells that had two states, on or off. Simple local rules control how the cells react to information from their nearest neighbor. These strict operational regulations made it possible to generate extremely complex patterns, on a visual level (Wolfram 2002). The laboration presented the idea of cellular automata through a simple method of coloring squares on graph paper (figure 7).

The 8th laboration, *Fourier transformation*, was planned by Christian Bohm and two doctoral students at Albanova, Christine and Thomas Burgess. The laboration demonstrated ways of transforming information from visual stimuli and sound through *Fourier* filters, which reinterpret position and time (figure 8). This laboration showed a classic way of simplifying complex phenomena by abstracting information through grids that transform the mathematical information into an array of spatial structures. The aesthetic similarities between the original phenomena and the different Fourier transformed patterns were very difficult to recognize on a aesthetic level. To appreciate the transformation, one needed to understand how the program registered,

Fig. 9a

Fig. 9b

Fig. 10a

Fig. 10b

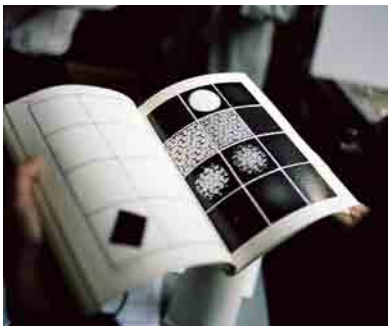

Fig. 10c

Fig. 9 Laboration Terminology.
a. Notes taken during the laboration.
b. Terminology station in studio space at Vinterviken.
Photo: C&T archive and Bengt Alm (9b).

Fig. 10 Laboration Dendritic, Fourier, microscopic.
a. Participants looking through a microscope.
b. Dendrites. **c.** Catalogue showing Fourier transformation. Photo: Bengt Alm.

transformed, and redistributed information. Recognizing similarities between sound effects and the Fourier wave pattern was much easier than understanding how visual phenomena were transformed.

Workshop III: Re-Act 2004

The **third** workshop, Re-Act, was run by all the above artists and physicists together. It merged concepts and materials from the first two workshops and continued to explore new laborations based on our theme of complex and changing phenomena. The 9th laboration, *terminology*, aimed to develop insight into aesthetic strategies and concepts that emerged in this cross-disciplinary culture. An on-line, pre-workshop event called *retinal reaction* was arranged, which involved a survey about spontaneous reactions to selected frames from the C&T film archive. Four pictures were sent out over four consecutive days, with a request for a one-minute response to each picture from the participants (figure 9).

These comments and pictures were then made available to each group as a way to begin to analyze spontaneous visual reactions. The films from which the picture frames came were viewed and a comparative study was done between the on-line reactions to isolated frames and the entire films, which revealed process-based events. This laboration inspired the later development of two models: i) the *Transformation-model* and ii) the *Aesthetic phase transition-model*, which are presented in section 4.4.

The 10th laboration, *Dendritic, Fourier, microscopic*, by Arijana Kajfes, Narendra Yamdagni and Pablo Miranda, focused on the question of correlation between microscopic structures and the macro structure on a visual scale in reference to dendritic growth (figure 10). The dendrite crystal structures were restricted almost to two dimensions (a thin film of copper sulphate solution between two glass sheets and using wires of 25 micrometers in diameter as electrodes). The idea was to visualize, through a microscope, the step-by-step, crystal-to-crystal growth pattern producing a dendrite and compare this pattern with the macro level of the entire crystal pattern. Based on this experience, a mathematical virtual model of the dendritic electrochemical deposition was developed by programming cellular automata patterns. The program could generate surprisingly similar patterns that matched the experimentally observed pattern. Similar issues were also discussed in the 3rd and 7th laborations.

The 11th laboration, *3-D film projection,* was prepared by Cheryl Akner-Koler together with assistant Carolina de la Fé. The films from the C&T archive were projected on surfaces of different shapes: curved, bent, and flat.

Fig. 11a

Fig. 11b

Fig. 11c

Fig. 11 Laboration *3-D film projection*.
a. Film projection through a frame on a curved surface.
b. Film projection on a geometric, elliptical cylinder.
c. Film projection in space demonstrating Brown`s phenomenon.
Photo: Bengt Alm.

Projection experiments were conducted using 20 different transparent and opaque framed materials. The frames could be held up in various combinations to see how the films looked from the front and back in addition to their continued projection through the material to the next frame (figure 11). This laboration was partly developed in collaboration with a team of artists and architects who created *Streaming Architecture Projection Space* – SAPS (URL: http://www.streamingarchitecture.com).

Between the planning and execution of the third workshop, we created two independent work groups. An exhibition group collaborated with Splintermind and ssark medialab to develop a full-scale prototype of a surrounding visual projection surface for streaming video SAPS. 02. This streaming video room was exhibited at Galleri ArtPlatform in Stockholm in November 2004.

We also organized an academic writing group that met periodically to stimulate the development of concepts and models. Four articles were written, published, and presented at the Joining Forces design conference in Helsinki in 2005 (Akner-Koler et al. 2005, Billger and Dyrssen 2005, Norberg et al. 2005).

Workshop IV: Glade 2005

The **fourth** and final workshop involved the 12th laboration, *Glade*, lead by interior architect Monica Billger and her assistants, focusing on the phenomenon of a *glade* (figure 12). Through playful exploratory methods out in the landscape surrounding Vinterviken, different spaces were selected as glades to demonstrate gray zones between e.g. enclosure and openness, dark and light etc. Since a glade is never a clearly defined space with sharp boundaries this laboration illustrated ways to deal with ambiguous boundaries. A further explanation of this laboration is found in section 4.4 under the heading Ambiguity.

The Glade workshop occurred only four months before the opening of our final C&T exhibition. We therefore spent the second day of the workshop to plan the exhibition/ performance space at Höglagret; an enormous industrial storage space behind Konstfack. For more information on the exhibition/ performance, see section 4.2, heading Spatial staging.

This last workshop also included interviews with thirteen participants. The recordings of these interviews give a good account of the individual interpretations of the project. The interviews are summarized in section 5.3, heading Interviews, and they are also published on our website, www.complexityandtransformation.com.

Fig. 12 Laboration Glade.
Photo: C&T archive

3.2 Visual and audio documentation

A large video film archive comprising over 70 videocassettes was developed during the three-year C&T project and became the most essential means for developing an understanding of the applied strategies and models. The planning meetings, lectures, most of the performances during laborations, formal and informal discussions and interviews were documented with DV mini video cameras. During the planning meetings, the cameras were mainly used to record the verbal discussions with little focus on the visual activities. However, both the contextual sounds, dialogue, and social interaction between the participants, as well as the visual properties of the transforming and changing phenomena, were of equal importance during the laborations.

The video documentation methods differed depending on the type of laboration, the interaction in the group, and the intentions of the person operating the camera. The documentation procedures and compositional framing for video filming outlined below were defined during the project. To help recognize and describe these approaches, we were inspired by Jacques Aumont's (1990, 106–129) research in film aesthetics.

- *Centered fixed:* The camera was placed on a tripod or held in a relatively fixed position directly centered over the phenomenon. The dendritic growth laboration was contained within a very limited area and suitable to be framed in this way.

- *Centered mobile:* The camera was hand-held, which offered freedom of movement for documentation. These films captured more of the environment and the people interacting in the laboration, as well as the particular properties of the phenomenon. One example of this method was the turbulent smoke laboration.

- *Decentered mobile*: The camera was hand-held and the aim was to develop a more creative composition and expression rather than a straightforward documentation of the phenomenon. The 3-D projection/ transparency laborations inspired this kind of framing.

- *Pushing the limits of the equipment*: The camera was treated as an experimental instrument producing unique images through playing with different effects like swinging it from a rope or placing reflective and absorbent materials around the lens to see what type of images could be created. The glade laboration inspired the investigation of blur and light transitions.

Reviewing and editing

Amateur film technology (Apple's iMovie) made it possible, both financially and technically, to review and edit the films. Most of the editing was done after the workshops. However, during the material transformation laboration, we asked the participants to edit a short film that captured interesting aspects of their study. In the dendritic laboration and Re-Act workshop, we reviewed and discussed a selection of films (figure 13). The editing procedures were simple; our aim was to show the genesis of the images. We cut the films in short sequential events capturing the starting conditions and the different stages of transformation, including the final stage (if possible). We could speed up the process, but we did not use any visual techniques that would otherwise alter the temporal sequence of

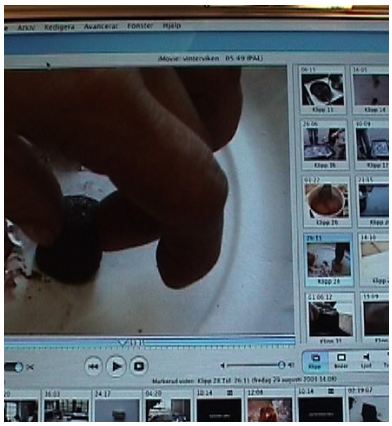

Fig. 13a

Fig. 13b

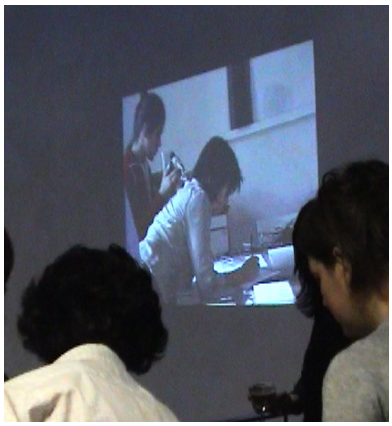

Fig. 13c

Fig. 13 Reviewing, editing and showing films from the C&T archive.
a. Editing a video film in the program iMovie. **b.** Example of a decentered mobile framing from the 3-D projection laboration. **c.** A film project at a dinner party showing centered fixed framing from the dendritic laboration.
Photo: C&T archive and Bengt Alm (13b).

the event or the original intent of the films. In the spirit of *real-time art*, all of the creative decision-making was done by the C&T participants during the laborations; our editing aimed only to showcase this interaction (Norberg & Søndergaard 2005).

4. Definitions, strategies and model development

4.1 Defining the terms Complexity and Transformation

As stated in the introduction, the theme *complexity and transformation* was not defined at the start of the project. As the project progressed it became apparent that the theme was very controversial for all of the participants. One aim of the project was to gain experience of complex and changing phenomena, which could in themselves act as "exemplar" (Molander 1996, 192) of the theme. However some verbal definitions were developed through discussions during and after the C&T workshops:

Aesthetics´ definition of complexity and transformation

- Complexity and transformation is about perceiving things in context. It is about coming into being and fading out of existence as well as unpredictable behavior versus persistency of form. It is also about exploring the moment when change occurs, when new properties emerge and when relationships and conditions are modified, mutated, deteriorated and so on.

Physics offers several different definitions of complexity and transformation, both as separate terms as well as in combination.

Physics´ definition of transformation

A transformation can be understood in two ways:

- As filter transformation converting a description of one form to another description of the same form, by using mathematical and physical operations.
- As material transformation expressing different phases, e.g. from solid to gas.

Physics´ definition of complexity also including transformation

Here are four definitions of complexity formulated by physicists:

- Complexity is a balance between order and disorder.
- Complexity is about three or more forces interacting, competing and collaborating to create a balanced, yet transforming system.
- A measure of complexity is the minimum amount of information (algorithmic, topological, computational etc) necessary to describe the system. It can also be measured in terms of the memory space used by the algorithm defining the computation. (The contrary is also true: a very simple fractal algorithm that defines rules for local relationships can give rise to very complex behavior).
- Definition by Murray Gell-Mann (2003).

  A measure of something like complexity for an entity in the real world, all such quantities are to some extent context-dependent or even subjective. They depend on the coarse graining [level of detail] of the description of the entity, on the previous knowledge and understanding of the world that is assumed.

Gell-Man's definition of complexity gives interesting parallels to the contextual and subjective nature of the art and

design process. The awareness that knowledge is context-dependent and subjectively framed is a shift in perspective in the natural sciences, from the search for the general/ universal to the particular/ unique (Nelson and Stolterman 2003). Complexity theory has opened the natural sciences to take into account the backgrounds of the individuals asking the questions as well as the particular properties and conditions of the subject matter in its unique context. This brings more attention to the *interaction* between parts and forces in a dynamic context and less to the *isolated, inherent properties* within the parts (March 1996, 51).

4.2 Aesthetic strategies

The present report focuses primarily on explaining how the collective efforts of artists, physicists, designers and architects can contribute to modifying or radically developing new aesthetic methodologies that can complement and be integrated within the art/ design and scientific communities. Since this project is designed to stimulate aesthetic reasoning, both artists and scientists have been concerned with exploring complex phenomena and transformation through ways that stimulate perception. A combination of literature study in aesthetics - mainly focusing on Dewey (1980 [1934]), Shusterman (2000 [1992]), Schiller (1995 [1795]), and Dahlin (2002) - and discussions during the C&T workshops lead to the following definition of some *aesthetic strategies*:

Aesthetic strategies support a plan of action that stimulates sensuous reactions and reasoning on a holistic level. An aesthetic strategy is carried out through perceptual real-world experiences that engage our emotions and require conceptual and personal involvement in an event over time.

Although the definition of aesthetic strategies came from traditions in the arts, there is also a strong tradition in physics relying on an aesthetic sense. String theorist Brian Greene states that when a theory is being constructed, there are certain periods when there is little rational ground guiding theoretical development. During these periods, aesthetic reasoning may be the best method to apply (Green 2000, 166). Greene says that "we are generally not interested in a theory if it has no capacity to resemble anything we encounter in the world around us." This statement also supports the need to connect theory with our real-world experiences.

The following four aesthetic strategies were applied during the present project:

- Embodiment
- Play
- Gestalt
- Spatial staging

Embodiment

> *The mind is inherently embodied, reason is shaped by the body, and since most thought is unconscious, the mind cannot know simply by self-reflection. Empirical study is necessary.*
> Lakoff and Johnson (1999)

In their book on embodiment, George Lakoff and Mark Johnson (1999) argued that our basic philosophical beliefs are shaped by how we understand the processes of reasoning. They challenge Western philosophical tradition, which supports the Cartesian thesis that the mind is separated from the body and that reason is developed through a higher conceptual consciousness (figure 14).

During the present three-year project, we collectively shared numerous embodied experiences that were strongly connected to the theme complexity and transformation. Below is a list of descriptive words that capture the spontaneous flow of sensory impressions one group encountered during a period of fifteen minutes in the Dendritic Growth laboration (figure 15):

> *"stretching toward the periphery—core of crystals—tightly packed—a lot of leakage—fractal pattern—contraction and release—fragile—speed up the growth process—bubbles burst—tear open—rough texture—dark copper red/brown—darker at the edges—hidden element—dissolving the ring—sucking it in—a creature—plop—tries to retain symmetry—sweat—very thick—indiscernible form—extremely organic structure from non-organic substances—in and out of balance—growth—it is no longer confined—destruction—poor thing!—it is trying to push it away—branch-like patterns—coral—copper contours surround—bubbles—fuzzy structures—pumping rhythm—body… it's alive!—now it's boiling—introvert (in reference to the bubble)—bubbles don"t have the same tension—cyclical"* = a total of 44 sensory impressions

During the inspired events of group discovery, all these words were articulated in a very precise and decisive manner. Grounded in the real embodied experience, everyone in the group expressed very accessible, descriptive features

Fig. 14a

Fig. 14b

Fig. 14c

Fig. 14d

Fig. 14e

Fig. 14a–e Group interaction and physical experimentation from the workshops. Photo: C&T archive

that had direct correlation with very specific properties and occurrences. This consciousness of the situation does not necessarily need to be shared verbally; it can be expressed through gestures, sounds etc. It is therefore essential to see the video films, as they show many activities that carry non-verbal communication.

We can begin to uncover and articulate the concepts that we have experienced and to retrace their origin back to the particular incident at the workshop because of our documentary films. It was not easy to present the conceptual and verbalized awareness expressed during the exploratory and interactive laborations in formal discussions. When each group presented their impressions and discoveries from hours of experimentation to the other groups, only very little of the above enriched and detailed language was accessible. This insight, we believe, exposes the heart of the problem in establishing aesthetic research. The immediate, embodied experience that helps to reach aesthetic awareness catalyzes these conscious connections between physical percepts and abstract concepts. Yet, if the analytical phase is separated from the *situation* context, there is a great risk for the experience to erode (Molander 1996).

Play

From the beginning of the present project, it was apparent that we needed to create an atmosphere that supported an open exchange of ideas during the workshops. A common way to get people relaxed and curious about each other and to enhance communication is to create a playful atmosphere (figure 16). We therefore encouraged an unorthodox, playfulness similar to the way that designers and artists often use in their working process (Stafford 1994). We made it clear to everyone involved in the workshops that, in spite of the difficult theme we were studying, it was essential that we were here to have fun and rely on perception and intuition. We wanted each participant to be wholeheartedly engaged in the process without any feeling of censorship or external controls and demands. Friedrich Schiller's *Aesthetic Letters* from 1795 offers insight into the need for play and its relationship to aesthetics:

> *The sensuous drive wants change; it wants time to have a content. The drive to give form wants time to stand still, to keep change from taking place. The drive in which both are in alliance with each other is the drive to play. Play should thus be directed to suspend time, to unite being with absolute existence, change with identity.* (Friedrich Schiller 1995, 77 [1795], translation by the author.)

Schiller thus emphasizes that play emancipates our senses and strives to suspend time in order to feel a sense of

Fig. 15a

Fig. 15b

Fig. 15c

Fig. 15d

Fig. 15e

Fig. 15a–e The laboration Dendritic growth inspired many sensory impressions. Photo: C&T archive

immediateness, presence and freedom. Play strives to bring us in touch with a richer awareness of the complex perceptual world and directly affects how we create and conceptualize our relationship to it. Schiller sees play as a necessary activity to "expand" our consciousness and bring life to the gestalt process (Schiller 1995, 82 [1795]). He defends his insight into the central role that play has, despite the general view of play being frivolous and irresponsible. He sees play as the balance to the rational.

If play catalyzes aesthetic experience and expression, according to Schiller, it should become one of the most valuable strategies that art and design research can offer the scientific community.

Gestalt

An important aesthetic strategy needed in many of the laborations relied on the participants ability to share their sense of a gestalt, supporting their intentions and holistic reasoning. Since the laborations were not run by strict protocols and the participants were encouraged to interact directly with the phenomena, they had to improvise in order to define their own ways of using the materials.

Spatial staging

The aesthetic strategy *spatial staging* was developed as an alternative to traditional scientific evaluation methods. Spatial staging implies a holistic way of bringing together diverse activities and viewpoints within a project in a common space in order to re-live and re-examine them. The process of defining activities in space integrated with a seminar program offers i) the most direct way to transfer the "experiential content" (Biggs 2004) of first-hand experience of the project to others, and ii) a final opportunity for the participants in the project to connect ideas and activities that support a collective understanding of the project in a given space and at a given point in time.

The chosen exhibition space, "Höglagret", behind Konstfack was an enormous industrial building, 14 meters high and 1,500 square meters in area. Two artists, Arijana Kajfes and Ebba Matz, from the C&T group created an exhibition space that brought together materials and concepts from the four C&T workshops (2003 - 2005) into a spatial and temporal organization. This involved: selecting and setting up a number of laborations, editing a series of film clips for two large projection screens, designing a seminar room to support the joint lectures and discussions, hanging 13 small loudspeakers for recorded evaluation interviews with C&T participants, presenting an interactive art piece, displaying an LCD rolling text box showing C&T concepts etc.

The exhibition space was open to the public on four occasions. Twelve of the C&T participants were actively engaged in the demonstrations, performances, lectures and discussions. At any given time, at least six participants were involved in the event/ program.

This type of spatial staging gave us opportunities to continue to learn more about the content of the project and how we all attempted to summarize our experiences. Today, as we reflect on the entire project, we can easily envision its spatial and temporal staging. The visual image of the space (figure 17) acts as a map to navigate through the project.

Fig. 16a

Fig. 16c

Fig. 16b

Fig. 16 Examples of play in the different laborations. **a.** Non-visual color study relying on haptic and tactile experiences in relationship to color. **b.** Two participants create a glade by rigging up a mirror reflecting into a crack in a granite wall. **c.** Two participants chemically treat a cube of black pudding by spraying it with motor oil during their experiment in the material transformation laboration. Photo: C&T archive.

4.3 Concept- and model development

Cross-disciplinary clash

Through the aesthetic strategies of embodiment, play, gestalt and spatial staging, we have managed to keep concepts close to percepts. During the C&T project we strived to balance both the drive to gain a holistic experience of phenomena and the drive to categorize and define qualities, properties and relationships within phenomena. We had no problem agreeing on the value of performing laborations or giving didactic lectures about natural laws etc. However, a strong *clash* between our different disciplines arose when a majority of the artists and some designers were more or less skeptical of the development of terminology and writing conference articles or scientific papers. The argument was that the verbal lectures in the workshops and exhibitions offered enough information. While listening to the lectures it was obvious who the individual was that promoted a certain idea.

Writing scientific articles about concept development tends to leave out the complex experiential aspects and freedom for individual interpretation of the nature of various phenomena. This experiential aspect and individual diversity was pivotal issues throughout the entire project. John Dewey also felt similar skepticism and argued against defining categories and terms, because they *reduce* the total holistic experience and "ties the material down to rigid immobility" (Shusterman 2000 [1992]). The question was thus how to develop a better understanding of the C&T project and communicate this to the scientific community?

With this in mind we recognized the *clash* as vital and still tried to see where our reasoning "cut and cross cut" (Deleuze and Guattari 2003 [1991]) within the clash in order to go further. Figure 19 shows a visual image that reminds us to expect clashes within this kind of cross-disciplinary projects. Clashes violate, in some way, very basic assumptions that build up our identity. Fredrika Spindler (2004) explained this violation as necessary if we aim to learn something "radically" (meaning from the root) different through experiences. Regarding the C&T project we could return to a common shared experience through the video film archive and re-examine what triggered a particular clash. It is interesting to note that the strongest clashes occurred when we took part in planning meetings or discussions that were separated from the physical laborations.

Concepts regarding complexity and transformation

Figure 20 shows a map of concepts developed from lectures and discussions during the C&T project as well as

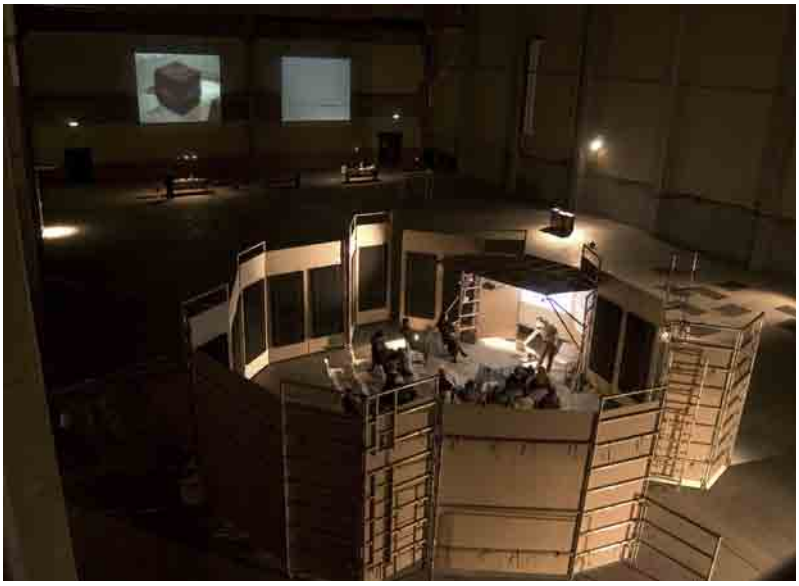

Fig. 17 Photo: Marcus Öhrn.

Fig. 18 Photo: Anna Löfgren.

Fig. 17–18 Final C&T spatial staging at Höglagret in November 2005.
17. Bird's eye view of the exhibition hall. **18.** Films showing examples of complex phenomena.

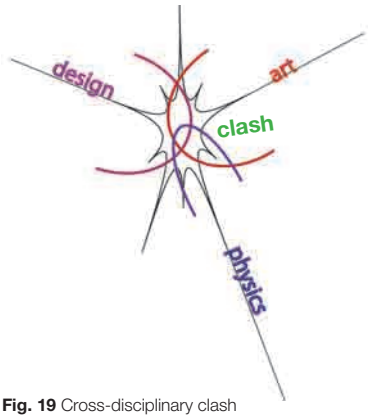

Fig. 19 Cross-disciplinary clash

from literature in the field of complexity. The five fist pairs of concepts are arranged as bipolar concepts.

Francis Heylighen´s (1988) article "Building a science of complexity" states that the science of complexity requires balance on the edge of chaos and that to deal with chaos there is needs for an

> *… awareness that there are phenomena which cannot be reduced to their separate parts. This has led to a philosophy which may be seen as the opposite of reductionism, and which is called holism. The study of complexity demands a transcendence of the holism-reductionism polarity. We need an approach which allows to model systems which are both distinct (in an abstract way separable) and connected (cannot be separated without loosing part of their original meaning).*

Heylighen thus searched for a way to merge reductionistic with holistic thinking in the scientific study of complexity.

Ambiguity

An example of such merging of the holistic-reductionism polarity can be found in the last C&T laboration, *Glade.* This study gave the opportunity to explore a natural phenomenon that touched on a very emotional, yet precise feeling (especially in the Swedish culture) about a diffuse and ambiguous situation. This laboration gave the most intense experiences, since it evoked childhood memories connecting the participants to the particular landscape they grew up in (figure 21).

One of the groups attempted to define aesthetic criteria for *glade* and developed a unit of measurement on a 0-1 scale. To outline the aesthetic criteria for glade was first dependent on if the participants´ references were a deciduous forest (e.g. birch, elm etc) or a conifer forest (e.g. fur, pine). The quality of light and enclosure, as well as the transition between forest and glade, are very different in these types of forests. Eventually ten criteria were defined with respect to the different subjective interpretations and a "Heidegger" unit was established. "Heidegger" refers to his concept *glade*. This work was all performed in a playful spirit with lots of laugher and joking around.

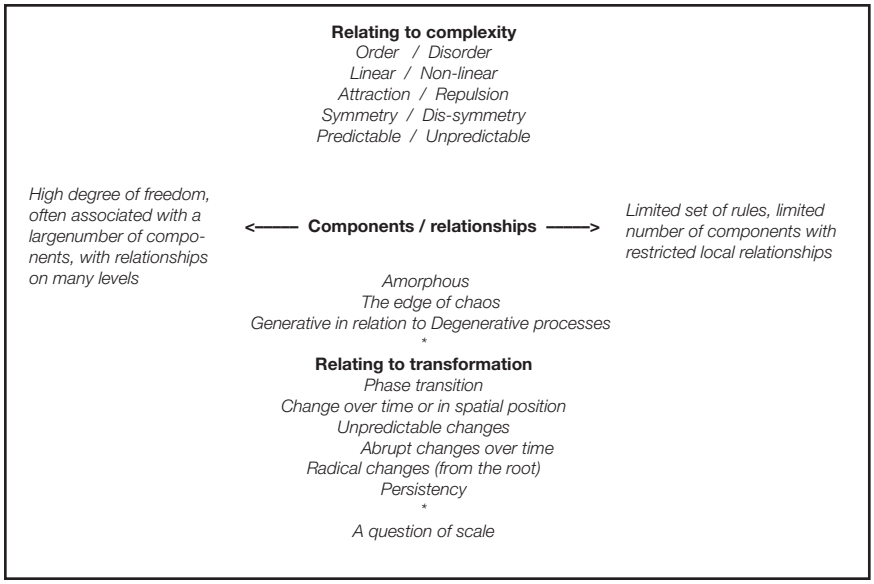

Fig. 20 Map of concepts regarding the theme complexity and transformation.

Due to the cross-disciplinary background of the participants there was as much interest in finding measurable criteria for the dimensions of glade as well as aesthetic criteria relating to features that were ambiguous. Dealing with ambiguity is an essential part of the traditions of aesthetic training in art and design since it provides ways to deal with light transitions and elasticity of color in a complex environment (Billger 1999).

Model development

During and after the C&T project three aesthetic models were developed. These models were first presented in the original C&T report from 2005 and further developed to be presented in two conferences.

1. The *Aesthetic phase transition*-model (figure 22) was presented and published in the proceeding of the conference Joining forces in Helsinki 2005 (Akner-Koler et al. 2005).

   The model unites changing events and stable object over time. It singles out a sequence of particular phases that are aesthetically easy to recognize. Each phase carries some features from the previous phase in order to connect the framed objects together. The transition demonstrates both subtle, predictable changes as well as creative and unpredictable changes.

2. The *Transformation*-model was presented and published in the Symmetry festival conference in Budapest, Hungary in 2006 (Akner-Koler 2006). It developed from an earlier model presented in the original C&T report from 2005.

   The general idea with this model is to combine inductive and deducting reasoning. A ”frozen feature” in a complex changing phenomenon is pointed out by the participants and a concept that describes the feature is decided on. A second, contrasting concept is discussed in parallel with a continuing study of the same phenomenon. When the contrasting concept matches changing features in the same area as first feature, this sequence of changes marks a complex event. The model is thus used to uncover complex behavior.

3. The *Framing the dialogue*-model (figure 24) also incorporates the transformation model. It developed from the arguments in the original C&T report and has been published in the Symmetry festival conference in Budapest, Hungary in 2006 (Akner-Koler 2006).

The purpose of this model is to encourage a contextualized dialogue framed within a bipolar spectrum, supporting multi-disciplinary exchange of concepts and percepts. The dialogue arising from shared events will usually expose the background, values and prior experiences of the individual participants.

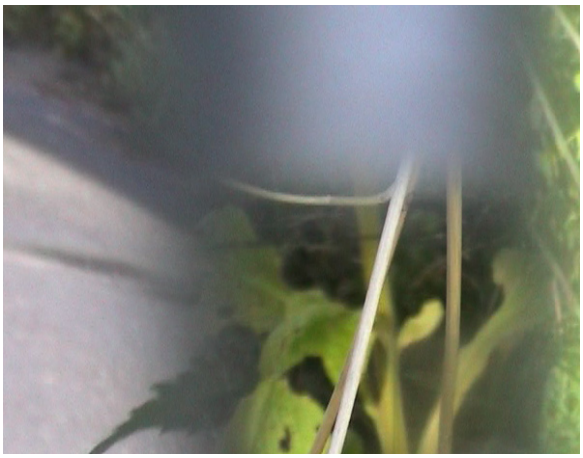

Fig. 21 Glade: A study of ambiguity.
Photo: C&T archive

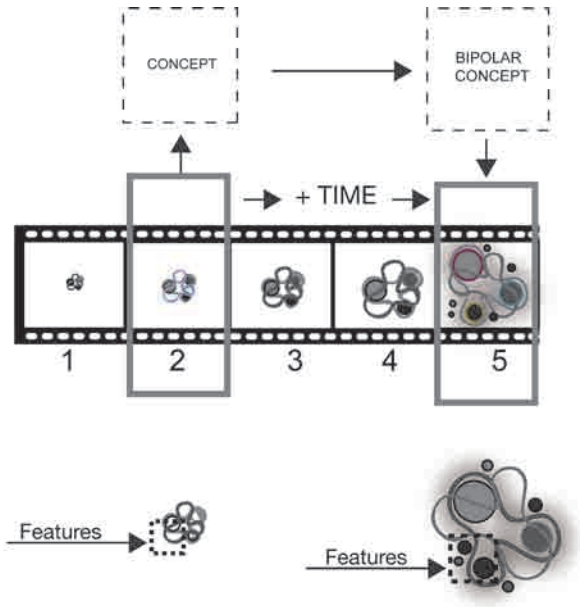

Fig. 23 *Transformation*-model

Fig. 22 Aesthetic phase transition-model.
Photo: C&T archive

5. Discussion

5.1 Comparing aesthetic strategies with rule-based mechanisms

The following discussion compares the 12 laborations in terms of how they stimulated *Aesthetic strategies* (as presented above in 4.2) and *Rule-based mechanisms* (Goldsmith 2001) that apply rigorous, well-defined rules or mechanical principles. Figure 25 lists the 12 C&T laborations in relation to the leaders and workshops. In figure 26 the laborations are mapped out along a spectrum from aesthetic strategies to rule-based mechanisms.

Aesthetic strategies

The four laborations (1, 2, 4 &12) that clustered at the aesthetic strategies pole relied on everyday experiences concerned with e.g . color, food preparation, smoke and landscape. All these laborations encouraged the participants to bring in new materials to perturb and test the limits of a particular phenomenon/ task. The induced changes could be followed intuitively and demonstrated a direct feedback between action and reaction. Some of the laborations stimulated strong emotional reactions, because they directly engaged haptic sensations (e.g . #1, Non-visual color) or relied on childhood memories (e.g . #12, Glade) that were very private. Three of these laborations were offered by artists/architects and one by a physicist.

Rule-based mechanisms

The two laborations (7 & 10) that clustered at the rule-based mechanism pole demonstrated the possibilities for expressing complex patterns and emerging properties by following rules and controlling conditions. The laborations did not encourage introducing new materials or perturbing the system. One of laborations was developed by physicists and the other by artists/ architects and physicists.

The remaining laborations showed that artists and architects predominantly offered aesthetic strategies while rule-based mechanisms were predominantly planned by

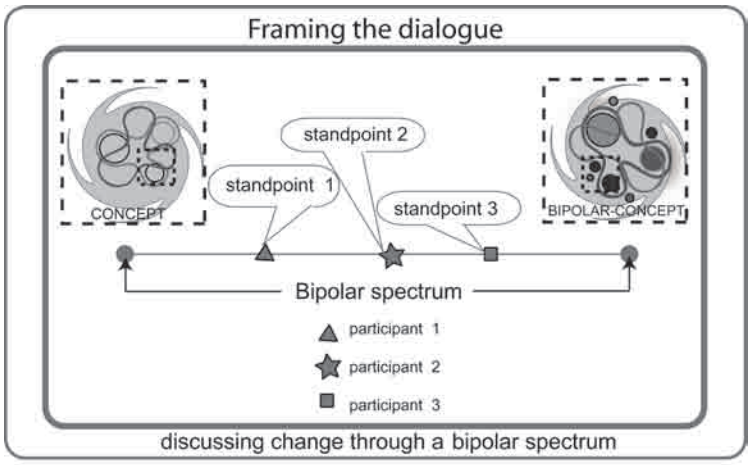

Fig. 24 *Framing the dialogue-model.*

physicists. However, laborations 3, 4 and 10 show exceptions. Perhaps figure 26 shows more about the interests of the individuals that developed the laborations rather than a general trend reflecting a discipline.

The questionnaire and interviews presented in section 6.2 also show that there was no bias amongst the participants as to which laboration (aesthetic or rule-based) was preferred in relation to exploring the C&T theme. Many of the physicists were, for example, interested in heat transformation of an eggplant that followed no rule-based mechanisms and many of the artists and architects were interested in the strict rule-based mechanisms of cellular automata. A conclusion of this study is that both aesthetic strategies and rule-based mechanisms are needed to grasp the theme complexity and transformation.

5.2 Addressing the questions

For a more detailed discussion about the models developed during and after theC&T workshops the reader is referred to two published articles (Akner-Koler 2006, Akner-Koler et al 2005).

The five questions formulated in Introduction are discussed below:

1. **How can aesthetic reasoning embrace a more temporal and context-sensitive awareness?**
   This question was addressed by developing three models:
   - *Aesthetic phase transition*-model
   - *Transformation*-model
   - *Framing the dialogue*-model

   All three models are based on the pluralistic experience from the shared laborations. The important message is that aesthetic changes focus the participants´ attention on temporal events in context. An unconditional searching for similarities and contrasts offers an opportunity to discuss the phenomenon in a precise way. The diverse ways that participants explain and value changes of a phenomenon is more important than trying to agree on one common view.

   Architect Catharina Dyrssen (2006, 122, 126), who was also a C&T participant, has brought up the ideas of “key points” and “links” that hold an event together. Recognizing such points and links requires going back and forth between “movement/ a change of position” and “precision”, which is found in the exact moment itself. Dyrssen thus emphasizes a union between movement and precision that does not compromise one over the other. James Crutchfield´s (2003) studies in complexity led him to a similar awareness. He states that the appearance of patterns and dynamics changes are inseparable. Through aesthetic experiences that bonds temporal events and exact object together we can more easily deal with complexity.

2. **How can exploratory laborations offer experiences to learn about complexity and transformation?**
   We found that through exploratory laborations we have managed to better understand what the concept complexity embodies by bringing it “down to earth” and into everyday experiences (Nørretrander 2003). The shared experience during the laborations also

	Laborations	Leaders	Workshop
1	Non-visual color	Art	W I
2	Material transformation	Art	W I
3	Dendritic growth crystals	Art/Arch	W I
4	Smoke	Phy	W II
5	Pendula	Phy	W II
6	Consecutive springs	Phy	W II
7	Cellular automata	Phy	W II
8	Fourier transformation	Phy	W II
9	Terminology	Art	W III
10	Dendritic, Fourier, Microscopic	Art/Phy/Arch	W III
11	3-D projection	Art/Des	W III
12	Glade	Arch	W IV
	Artist= Art, Physicists= Phy, Designers= Des, Architects= Arch		

Fig. 25 List of all 12 laborations and leaders.

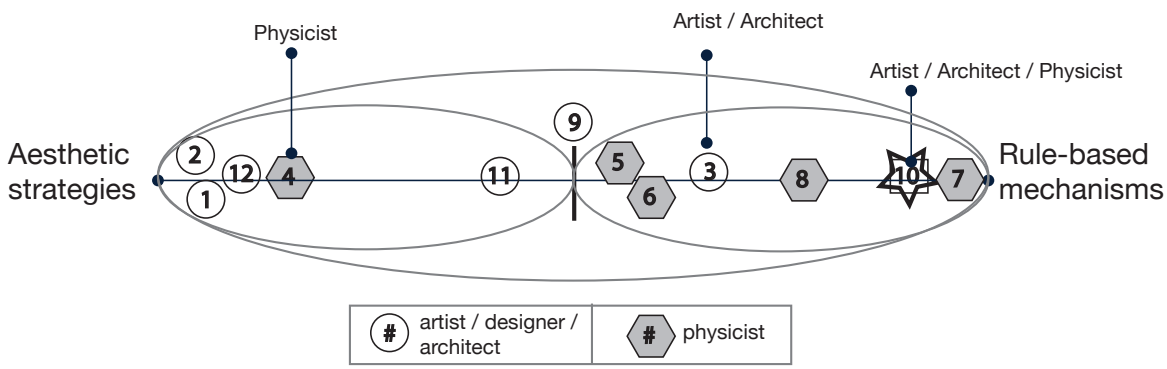

Fig. 26 Spectrum ranging from aesthetic strategies to rule-based mechanisms.

made it clear as to what the workshop leaders meant with his/ her intention. A phenomenon can express complex and unpredictable behavior for one participant, yet seem fairly simple for another, depending on how the participants zoom in on the phenomenon. By listening to each other react, reason and interact with an ongoing laboration, one could gain insight into how each participant in the group related to complex phenomena. Since the C&T workshops supported playful laborations, the participants could relax and take part in the activities on many levels.

3. How can aesthetic strategies for gaining knowledge from the complex real world help the scientific community deal with unpredictable and contradictory behavior?

Through aesthetic strategies one can manage to grasp the overall behavior and gestalt of a phenomenon by accepting that some relationships and details of a phenomenon are blurred and perhaps contradictory. Aesthetics are concerned with coherency, i.e. how things hold together, rather than systematic logic. Without aesthetic strategies we would be overwhelmed by all the complexity of the real world.

To offer the scientific community experimental methods for developing concepts about complexity through aesthetic strategies, it is vital to support individual expression and contextual relevance. The Transformation-model and the Framing the dialogue-model (Akner-Koler 2006ii) offer ways to handle terminology that can fluctuate, yet still be exact in relation to both the particular context and the intention of the individual. The models build on each other and use polarities to expose complex behavior and opposing ideas held by participants (Edenholt 2004). The definition of one extreme pole, e.g. symmetry, can only find meaning in relation to the other pole, dis-symmetry. This attitude of framing a dialogue in order to work in

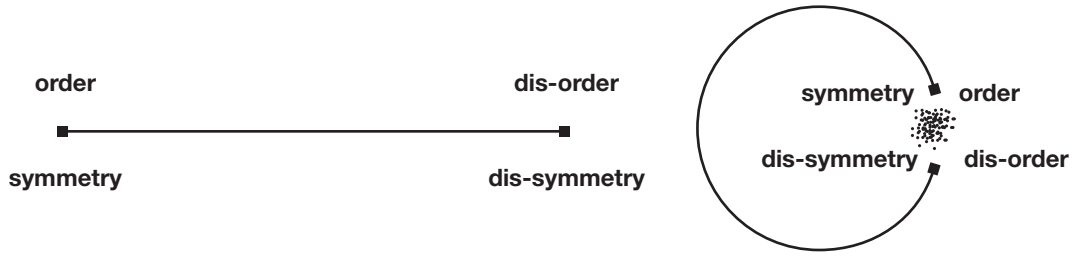

Fig. 27 Illustration by Akner-Koler of Lorand´s argument that polarities are not necessarily to be seen as poles at opposite ends of a line. Instead, a circular model brings the extreme poles together.

the gray zone between these poles aims to sharpen, yet contextualize, concept development.

An interesting feature that seems to be true for many of these opposing concepts is that both poles tend to end up in the same state when pushed to the limit. Philosopher Ruth Lorand (2003-2004) defines extreme symmetrical order as a form of disorder - dissymmetry instead of ultimate order, because when all of the qualities that break symmetry are taken away, then everything is redundant. Lorand states that redundancy and lack of differentiation give no sense of direction or order, which is similar to the sense of chaos that is defined as 100% random movement (figure 27). In other words, an extreme uncompromised standpoint, such as the search for order, is in itself a compromise and ends up in disorder. This insight into flexible terms through polarities may open doors for art and design to begin to appreciate a need for terminology.

4. **How can a systematic and rule-based approach developed in physics have a positive impact on research development in the art and design communities?**
The C&T physicists had a much more developed conceptual understanding of complexity due to precise terminology developed in relation to both theoretical and experimental research concerning complex behavior. Their interest in using terms in a specific and disciplined way made their lectures more informative and the intentions of the workshop leaders were easier to grasp. In the interviews there were a number of artist and architect that stressed the importance of developing sharp terminology that does not allow too much room for interpretation. Defining terms could therefore improve our conceptual understanding of complexity in the arts. However, there was also a strong skepticism for developing exact terminology from artists/designers, because of risk of becoming too generalized. The arts defend the right to approach the world in a unique way. Concepts gain new relevance when applied within a particular context (Deleuze and Guattari 2003, 16-7 [1991]). Each context shifts the meaning and such a shift could carry strong relevance for art and design. Another reason for avoiding fixed terminology is to maintain a high degree of freedom, which allows for deviation and individual statements. There is thus both support and doubt as to adopting a more disciplined approach to concept development in relation to experimental findings. The risk is to lose freedom of expression.

5. **Does a cross-disciplinary culture offer insight into formulating new aesthetic reasoning?**
This question is answered in section 6.3 - Manifest: *Unfolding the Aesthetics of Complexity*.

6. Evaluation and future plans

Respect for individual interpretation has been an important issue throughout the C&T project. It has been reflected in planning, laborations, discussions and evaluation of the project.
The compiled answers to the questionnaire and interviews are discussed briefly below and has been published (in Swedish) at www.complexityandtransformation.com under the link “Text – questionnaire” and “Sound – interview”.

6.1 Questionnaire

A questionnaire comprising 25 questions was formulated concerning the first two workshops in 2003 (response rate 100 %). The answers were recorded on a 1-4 value scale with individual comments.

The questions mainly dealt with whether the intent of the

workshop leaders was well communicated through the introductory lectures, the initial instructions and physical set-up of the laborations. Other questions concerned how to share the results of the laborations as well as the spontaneous conversations and concluding discussions during and at the end of the laborations. The results showed that the laborations were appreciated, because they kept the workshops concrete. The laboration on Material transformation could have had a longer introductory lecture that explained in more detail what the transformations were meant to demonstrate. There was some frustration about not knowing what the intention of the workshop leader was. Otherwise it inspired playfulness and perception and was very interactive, but did not offer enough intellectual stimulation. The lectures explaining the laboration on Dendritic growth were both very appreciated. The majority of participants considered the experiments very interesting, because one could experience emergent properties immediately. The intentions of the workshop leaders were clear, however, the analogies inspired by the laborations were not as obvious in all of the groups, especially not in a group that ran into technical problems. The criticism for this laboration was that some people experienced working with technical instruments as very problematic.

The non-linear laborations in the second workshop were explained very clearly in terms of the principles that drive the phenomena. The workshop leader was clear about his intentions, which carried over to the experiments. The smoke laboration was the most successful due to its inherent simplicity and profound visual power. Everyone succeeded in experiencing the linear and non-linear transformation. The pendulum and consecutive springs were a little more difficult to set up and the instructions were not made clear for everyone. The non-linear behavioral pattern of the pendula was very subtle and depended on setting up the laboration properly. The two lectures on cellular automata (with connections to Fourier transformation) were considered very didactic, creative and inspiring. The instructions about how to produce a cellular automata pattern were clear and the simple method of drawing on graph paper was appreciated without any technical problems to deal with. Since cellular automata codes are very simple, there were a few participants that did not feel motivated enough to discover the implications of such simplicity. On the other hand, many participants discovered how this simple mechanism could create very complex solutions. The lectures, laborations and discussions problematized the general assumption that complex systems are created by complex relationships.

The lectures on Fourier transformation of sound and visual media were very well presented with some models visualizing fundamental principles.

Some important suggestions were:

- The group discussions should be more organized in order to bring out more voices. This would help to formulate a better cross-disciplinary understanding of different experiences
- The laborations could be improved by being clearer about what the workshop leader intended.

6.2 Interviews

Thirteen interviews were conducted by two C&T participants, Teo Enlund and Björn Norberg, during the workshop "Glade" 2005. A circular overview map (figure 2) was made that presented the four workshops and the 12 laborations in a chronological sequence. This map helped the participants freely discuss any of the laborations and how they related to each other as well as discuss the major theme and concepts. The recorded interviews were conducted within a time span of 7-20 minutes each (figure 28). The results of the interviews showed that the first two workshops, Vinterviken and Albanova, made the strongest impression on the participants. The element of play during the laborations was appreciated by most participants as well as the open, unconditional aim to expand our knowledge about complexity and transformation rather than solve a defined problem.

Equally appreciated were the lectures that were given at each workshop, especially the in-depth lectures from the physicists aiming to expose the structures and methods of trying to control complexity. The combination of lectures that related directly to the laborations was a very positive experience that supported communication. A weakness of the C&T project was that some participants felt, at times, it was too exploratory and needed a more active moderator to give focus and clarity. There was also too little time set aside during the workshops for an in-depth analysis of what the field of aesthetics embraces and how we could renew aesthetics. The evaluation and much of the model development of the project has been done after the last workshop. It was very difficult to involve participants to write articles or essays about their experiences. The three articles that were written required a lot of time and were motivated by finding an issue that linked with the participants´ work outside the project.

Fig 28 The interviews of 13 participants were recorded and transferred to mp3 players with speakers hung at ear-level over 13 rubber mats. The public could then walk through this field of voices and listen to the individual interviews of the C&T project. Photo: Anna Löfgren

6.3 Manifest: Unfolding the aesthetics of complexity

Through insight from literature in the field of complexity, combined with our cross-disciplinary approach in applying aesthetics strategies and rule-based mechanisms during the C&T project the following *manifest* emerged to deal with uncertainties and complexity.

Unfolding the Aesthetics of Complexity
This manifest needs to be discussed in a multi-disciplinary research community, but mostly it needs to be empirically and aesthetically explored!

Place aesthetics in the complex everyday world of events

Develop an awareness of context-dependences

Rely on embodied experiences

Support playfulness

See order in relation to disorder and regularities in relation to irregularities

Learn to expect unpredictable behavior

Develop an awareness of gestalt, by grasping the interrelationship between parts to the whole (and vice versa)

Recognize the background and subjective profile of the individuals that are part of a group/ team.

Emphasize basic level concepts that carry links through the physical and social worlds to aesthetics and allow for an embodied down-to-earth exchange of ideas.

Bond concepts together with percepts in the same room at the same time

Mind the gap between aesthetic strategies and rule-based mechanisms.

Keep an open aesthetic attitude to ambiguous situations and amorphous conditions.

Allow for both sharp questions in the search for understanding mechanisms and principles of change as well as a holistic awareness that strives to bring together seemingly contradictory properties into a coherent whole

Support multi-disciplinary laborations that:

- *place the complex real world phenomena at the center*
- *invite the participants to playfully interact with the phenomena*
- *allow for immediate reactions to guide exploratory studies*
- *avoid controlling agendas*
- *keep an open domestic dialogue going*

6.4 Future plans

From cross-disciplinary to trans-disciplinary

Our future plans include applying for a new trans-disciplinary project that builds on the experiences from this C&T project. The project proposal will aim to define a context-oriented project that solves a particular, authentic problem. It will catalyze both problem solving design activities leading to a tangible product and/ or services/ events as well as knowledge development within the field of aesthetics. We are discussing driving a project that would include the life sciences and perhaps be situated in the Polar circle.

Acknowledgements

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PAPER VIII

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CONTEXTUALIZING AESTHETIC REASONING THROUGH A LABORATION ON DENDRITIC GROWTH GENERATING AND REGENERATING AESTHETIC CONCEPTS THROUGH CROSS-DISCIPLINARY STUDIES

Cheryl Akner-Koler

In Proceedings: Symmetry festival 2006, Budapest Hungary August 12-18, 2006
(URL: http://www.conferences.hu/symmetry2006)

Abstract

A group of artists, physicists, designers, and architects conducted a cross-disciplinary study on complexity and transformation. The aim was to renew aesthetic reasoning through concrete laborations that playfully explore changing events. The article focuses on a laboration with dendritic crystal structures as they grow, adapt to obstacles in the environment and eventually degenerate. Methods and models for developing aesthetic reasoning are presented by placing concepts in a bipolar spectrum applied within a proposed *Transformation* model. This model is further developed in a *Framing the Dialogue* model that supports exploratory reasoning. Symmetry, asymmetry, and dissymmetry are discussed in relation to crystal patterns.

Keywords: Pragmatist aesthetics, sensuous, cognition, bipolar spectrum, design, art, science, contextualization, mode 2, transformation, symmetry, asymmetry, dissymmetry

Introduction

Through funding from the Swedish Research Council, a three-year (2003–2005) project called *Cross-Disciplinary Studies in Complexity and Transformation (C&T)* was set up. The theme of "complexity and transformation" was chosen because it deals with issues of contextualization, emerging properties and change that are all current issues faced by artists and designers as well as scientists. The aim of the study was to renew and challenge aesthetic reasoning and to reconnect the scientific community with the *science of sensuous cognition.* In the present paper, this reconnection is explained through a laboration on dendritic growth and deterioration that integrated aesthetic strategies and procedures into scientific laboratory experimentation.

The project engaged a group of twenty artists, physicists, designers, and architects to explore the theme of complexity and transformation. It was organized from the Konstfack University College of Arts, Crafts, and Design by the author in direct partnership with the Department of Physics at Stockholm University and in collaboration with the Chalmers School of Architecture and three other partner schools and institutes.

Due to the cross-disciplinary nature of this study, communication was an important issue throughout the entire project. This paper presents some of the methods and models that enhanced the development of aesthetically viable concepts that worked between disciplines. By applying a bipolar spectrum to selected frames within the dendritic films, we were able to capture the complex behavior of the crystal growth in a explorative way. The focus of the discussion is to encourage an open dialogue about change and transformation. This open dialogue aims to establish a platform for discussing the interdependency of traditional concepts in direct relationship to radical concepts.

Aesthetics and mode 2 science

There is a growing movement today in aesthetics called *pragmatist aesthetics*, which builds in part on Alexander Baumgarten's 1735 definition of aesthetics as the *science of sensuous cognition* (Shusterman 1992/2000, 263–7). *Sensuous* refers to the fusion of all of our senses, while *cognition* means to know. This pragmatist movement brings aesthetics into the sciences as well as into the everyday experiences of people's lives. A central figure in this movement is John Dewey (1934/1980), who attempted to bring the aesthetic experience out of the *isolated* gallery and museum world and immersed aesthetics into *dynamic events* within the complexity of contemporary life. Dewey supported our immediate and concrete interaction with our surroundings and appreciated what each individual can bring to that unique situation. Throughout his writings, Dewey stressed the importance of recognizing aesthetics, emotions, perception, and intellect as all being integrated. He states that through the synergy of these qualities, the world is constantly presented to us as new, giving purpose to the individual.

The current pragmatist aesthetic movement is in a much better position to gain knowledge through our senses than when Baumgarten introduced the concept of *aesthetics* in 1735, or even when Dewey was active in the field in the first half of the twentieth century. This is because there is a fundamental change in the way we see scientific knowledge today. Helga Nowotny and other scholars point out that the most important change is from Mode 1's mono-disciplinary, reductionistic thinking and single methodologies to Mode 2's transdisciplinary focus, which aims to open communication between science and society during the production of knowledge (Nowotny 2001). An important attribute of Mode 2 is that the problem is formulated in its full context, with social, physical, spatial, temporal, and ethical dimensions represented. Developing this kind of contextualized knowledge requires alternative ways of conducting research that are able to deal with human perception, changing environments, etc. The *contextualization* of knowledge has traditionally characterized the art and design processes, because it supports sensuous, embodied, and individualized experiences. A pragmatic-aesthetic approach aims to place perception and human values at the center and may offer an alternative way of developing knowledge that strives to make more sense of the complex world.

Motivation

My motivation to serve as project leader of the C&T project was strongly influenced by the aesthetic traditions of the art and design communities, which emphasize the importance of embodiment. This tradition involves the need for firsthand experiences in order to gain a sensuous understanding of *events* or situations. It is about *basic-level experiences* that are gained through physically working with materials in the real world (Lakoff and Johnson 1999, 28–30). The C&T study aimed to expand and question my more traditional aesthetic knowledge developed for industrial design (Akner-Koler 1994). The theoretical and practical background of these traditions stems from the aesthetic way of reasoning that Rowena Reed and Alexander Kostellow developed during the first part of the twentieth century (Greet 2002). Through my studies with Rowena Reed and my own work in further developing Reed and Kostellow's foundation (Akner-Koler 2006), I reached the limits of their modernistic *geo-organic* paradigm, which includes aspects such as:

- referring to geometric law-bound structures.
- applying essential abstractions that minimize form to axis
- framing elements and relationships in a 3-D (X, Y, Z) spatial matrix
- working with hidden symmetry that controls asymmetry (Molnar 1997/2005).

Aims and questions

This paper aims to renew aesthetic thinking. The specific questions addressed here are:

1) How can we generate and regenerate concepts for aesthetic reasoning that deal with contextualization of knowledge?
2) How can we link aesthetic concepts with changing events over time?
3) How can we develop methods and models to renew aesthetic reasoning in an interdisciplinary and transdisciplinary culture?
4) How can a bipolar spectrum of concepts help to define complex events?

Methods

Workshop procedure

Please see the final C&T report for a full description of the procedure (Akner-Koler 2006). In short, the C&T project was divided into four workshops with a total of twelve different laborations that were planned and led by members of the cross-disciplinary group of participants. Each laboration presented complex phenomena that explored changing events over time and/or methods of transformation. All laborations were filmed, creating a C&T film archive. The C&T project is now completed and

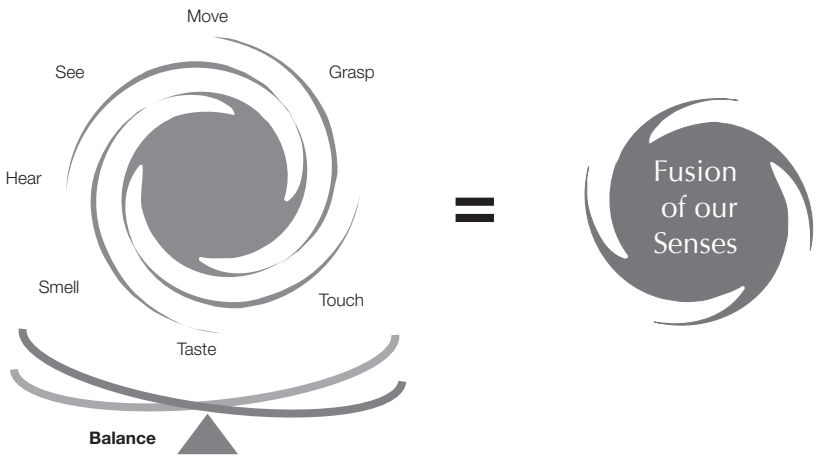

Fig. 1 Model: Fusion of our senses. The small icon to the right will later be used to summarize the idea of the fusion of our senses.

is treated here as a case study within a PhD research project on aesthetic reasoning. The empirical material gathered in the C&T project has helped develop ways to lift aesthetic reasoning into an open arena where both *aesthetic disciplines* (art, crafts, design, and architecture) and traditionally *non-aesthetic disciplines* can meet. The idea was to activate both an interdisciplinary and a transdisciplinary (Nowotny 2001) aesthetic awareness involving the further development of a *science of sensuous cognition*.

Initially, a group of participants from different art/design and physics disciplines were invited to a workshop for exploratory studies in complexity and transformation. The group was heterogeneous in terms of gender, age, and ethnic background, and the members were subdivided into smaller groups of 3–4 participants. The workshop leaders chose a complex phenomenon involving an area of exploration that was of interest to them. The workshop had to involve *basic-level experiences* designed to support playfulness; i.e., there should be no strict protocol. The workshop leaders held presentations explaining the intention of the workshop. This was done in a domestic language using multimedia support, and no one played the role of the *expert*. The participants set up th laborations themselves with minimal help from the leaders. Experimentation was encouraged. The model in figure 2 graphically maps out the stages of one of the laborations.

Dendritic growth laboration

One of the laborations in the C&T project explored dendritic crystal growth. It was selected because it presents complex behavior over time in the following ways: a) exhibits growth and deterioration patterns, b) building up and breaking down symmetry, c) showing sensitivity to context, d) demonstrating emerging properties, e) allowing exploration through basic-level experiences.

The laboration was lead by artist Arijana Kajfes and architect Pablo Miranda and involved an electro-chemical process that produced branching crystal structures called *dendrites.* The intention of the laboration was to show how a self-organizing structure could emerge from a simple salt solute representing a kind of “free zone” in which the crystal formation grew. The generative pattern is a fractal structure, which means that it grows by following similar local rules at all levels of growth. An electrode attracts randomly moving ions in the solution, making them behave systematically and creating stable, symmetrical crystal structures. These growing crystal patterns appear almost organic and lifelike, challenging the arbitrary division between organic and inorganic, or artificial, life (Norberg et al 2005).

The introductory lecture to this laboration a compared various computational cellular automata programs (Wolfram 2002) with the growth and adapting mechanisms of the dendrites in their environment. This scientific experimental study from the 1950s, inspired by the work of Gordon Pask (Cariani 1993), was reintroduced because it offered a physical real-time experience of generative processes. The leaders were interested in how the participants would explore different ways of interacting with the dendritic growth pattern and how the laboration would

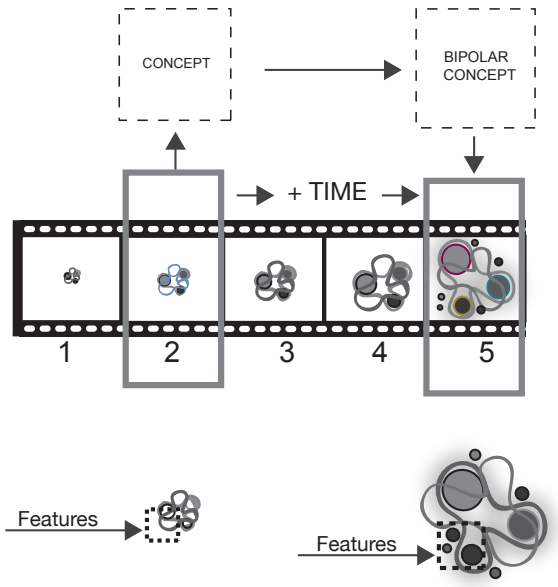

Fig. 2 Model: Transformation. Frames 2 and 5 in the model illustrate two different stages in the transformation process.

stimulate analogies that supported creative activities. The present paper describes one of a dozen dendritic experiments in which the participants interacted with the developmental pattern of the dendrites and deliberately induced asymmetrical and dissymmetrical changes. Aesthetic reasoning was invoked to grasp both gradual and radical changes such as growth, modification, mutation, and breakdown.

> *…without experimentation there can be no discoveries, and without discoveries no regeneration.*
> László Moholy-Nagy (1969, 31)

Results and proposed models

Due to the cross-disciplinary nature and the explorative/empirical approach of this study, most of the methods that were used were especially tailored and evolved as the project progressed. Therefore, the methods could just as easily be presented under "Results". Throughout the project, the previous experiments directly affected, modified, and questioned procedures for the next experiment. This "problem" of evolving, discarding, and combining methods and results stems from the open and *heterogeneous* methodological approach applied in art and design (Dyrssen, 2006).

Model: Fusion of our senses

There is no firm agreement today as to how many senses we have. According to Passar and Smith (2001, Chapter 4), the entire sensory system includes: vision, hearing, taste, smell, touch, Kinaesthetics (movement), haptic senses (grasping), and equilibrioception, involving individual and multiple organs. Recent research in perception shows that our senses are task-oriented and interact with each other as a function of performance (Motluk 2001). Since my work builds on Alexander Baumgarten's definition of aesthetics as the *fusing* of our senses (Shusterman 1992/2000, 263–7), I found it important to visually summarize our sensory system to fit Baumgarten's definition and the embodied experience this study explored.

The proposed visualization model in figure 1 was developed to integrate two issues:

1) The spiraling form embodies Baumgarten's idea of *fusing* the senses in a real world context.
2) The scale refers to the sense of equilibrium that dynamically balances aesthetic values.

Development of concepts

All laborations were filmed. The video-films were reviewed and edited by the participants, who were asked to focus on visual and audio sequences showing active engagement concerning the C&T theme. The selected sequences documented a complex process from beginning to end. The dialogue from these sequences were transcribed to document the pluralistic approach of the participants. This text was then organized into four categories: object, function, social and emotional. The categories were inspired by Lakoff and Johnson's (1999, 29) work on embodiment and concept development.

A list of concepts was *extracted* from i) the insight gained from reviewing the entire video, ii) the edited sequences and categorization of transcribed text, iii) the lectures during the workshop, and iv) the individual interests of the participants during the editing. These concepts were then defined and polarized into opposing concepts, creating bipolar pairs (see figure 4).

Figure 2 shows a comprehensive model offering an overview of the procedures, methods and models developed during and after the C&T workshops (Akner-Koler 2006).

The transformation model in figure 2 consists of seven stages, all of which are based on embodied experience (the *fusion of our senses* icon).

The participants:

- set up an experiment of complex changing phenomena planned by the workshop leader
- film the laboration from their own perspective
- review the films and start a discussion about features that are of interest to the group
- freeze a moment in the complex event that captures interesting features
- match a concept (from the theme) with particular features within the framed object
- point to relevant areas within the object illustrating particular features concerning the concept (Biggs 2004)
- continue to review the film, searching for a second concept that offers a contrast to the first concept for a bipolar effect. Simultaneously, the participants review the same film to find features that tie in with the second concept and are also of interest to the group

Guide to the Transformation model

The first concept is developed through inductive reasoning. A particular moment in the film is framed that captures engaged participation in the phenomenon. Arrows/markers/boxes point to the features and activities that are relevant within the framed object. The features from this framed moment are articulated and a single concept from figure 4 is agreed upon. The concept is defined in a concise, yet domestic language. It is important that everyone agrees on the definition in relation to the shared context. Defining the second concept involves a back-and-forth process between developing a contrasting concept to the initial one and reviewing the film. Finding and defining the second concept can take time. The contrasting concept does not have to be mutually exclusive to the first, but should convey a sense of opposition. When the bipolar concept and features are eventually found, a second frame is introduced and particular features are marked out. Contrast, contradiction, and competing forces mark the behavior of complex, transforming systems (Crutchfield 2003). If you cannot find contrasting features, the system is probably not complex (see Discussion).

Laboration: Dendritic crystal growth and deterioration

The results presented here were developed through viewing and editing the audiovisual material from the videos of the various C&T laborations after the project was completed. The transcribed paragraph below is an excerpt from a dialogue during a 10-minute film sequence of the dendritic laboration, as shown in figures 3a–c. The candid dialogue, expressing emotional reactions, aesthetic sensitivities, speculations, and various strategies of interaction, offers important insights into the multiple, yet coherent, views of the participants:

> *They grow so quickly—it looks quite different from the other experiment—copper reddish brown—thicker—dissolving the ring—it looks like the branches are finally behaving decently ... they seem to know what it is all about—Look here, it's like Robin Hood… the branch is stealing crystals from the other ones—sucking them away—The bars are placed at an efficient distance, about halfway from the electrode—Wow, it's taking a short cut—It must be using the least possible energy to cover a longer distance—straight rectangular bars—the symmetry is broken—asymmetry—Now it's short-circuited—Here are some heat bubbles … it's boiling … and here are more on the other side as well—the bubbles really mess up the crystals—the bubbles burst—Wow! Now the bubbled area is dissolving and crystal structures were never formed here—There is just a lot of stuff*

The three isolated picture frames in figures 3a–3b were edited from a video of the dendritic growth laboration and are meant to represent the entire video film sequence. The film shows an experiment using a tin chloride solution surrounded by a copper ring. Figure 3a shows a fairly symmetrical, concentric growth pattern of the dendritic crystals. Figure 3b was taken five minutes later. The crystals are attracted to the copper bars, introducing asymmetrical features (arrows). Figure 3c, taken after another 5 minutes, shows that the copper bars now behave as obstacles, blocking the stable growth patterns, creating a dissymmetrical, entangled substance that breaks down the symmetry and asymmetry developed at an earlier time. The chaotic activity created by heat bubbles around the

Fig. 3a

Fig. 3b

Fig. 3c

Fig. 3a–c These figures represent an alternative to showing a video.

obstacles further disturbs the crystal growth.

Some of the above-recorded dialogue during the experiment has been structured by applying a modification of Lakoff and Johnson's four categories (see above):

- *Object/substance* = crystals – reddish-brown – branch-like – copper, bar, straight, rectangular – miniature tree
- *Functional action* = spreading – growing – stretching out – taking a shortcut and messing up the pattern – transforming – making contact – bubbles bursting – heat bubbles messing up the crystals – extremely organic structures developing from non-organic substances – short-circuiting
- *Social awareness* = one is catching up – they seem to have different strategies – handshake – Robin Hood – stealing crystals from the other ones
- *Emotional expression* = glad –> this is cool; threatened –> weird; astonished –> wow.

Bipolar concepts as a method of concept development

Problems with nomenclature

Throughout our study of complexity and transformation, we have been confronted with concepts and responses from the fields of physics, design, art, and architecture that attempt to describe and explain the complex behaviors of changing events within the context of each laboration. Since research in complexity theory and transformation is established within the scientific community, the physicists came to this project with well-developed professional terminology. The art and design community, on the other hand, has no established research on the subject of complexity (for that matter, until recently, research in art and design has not been supported in the scientific community). This lack of research can explain, in part, the skepticism that artists and designers often have towards establishing nomenclature. The artists and designers approached the project with their own individual interpretation of the theme of complexity and transformation. This combination of a collective concise terminology from physics and the freedom for individual interpretation from art and design highlighted an obvious clash in our cultures.

The skepticism towards concise generic definitions from the art and design community can also be understood as a reaction to generalization. Artists and designers realize that a concept gains unique relevance when applied to a particular context and perceived at a particular movement (Delueze and Guattari 1991/2003, 164–167). Thus, each shift of context affects the meaning of the concept, and in the art and design field this shift carries great relevance. In his defense of the immediacy of art as experience, John Dewey claimed that categories and terms reduce the total holistic experience and "tie the material down to rigid immobility" (Shusterman 1992/2000, 16). By allowing concepts to be very open-ended and flexible, we can readjust our understanding of a situation or creation as we work with materials and content. The art and design community searches for ways to articulate experiences through a language that is flexible and contextualized.

Bipolar concepts

One way of dealing with these seemingly contradictory needs between art's interest in open-ended, contextualized concepts and science's need for concise terminology is to contextualize and polarize concepts. Both approaches can be included if we use contrast and contradiction to explore concepts that are linked to particular concrete and temporal events. This makes it possible to allow

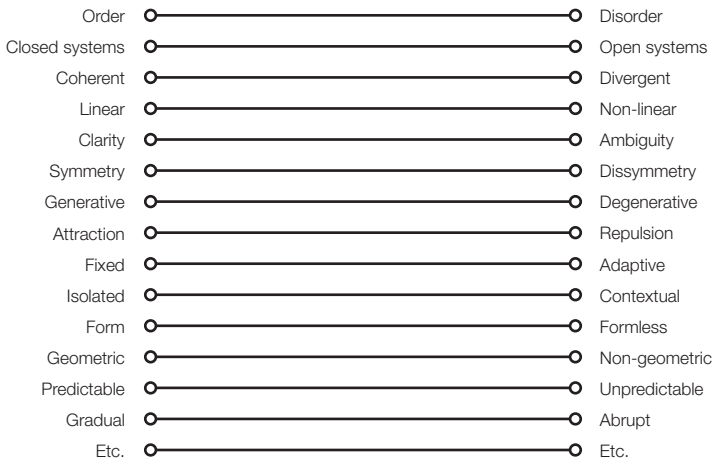

Fig. 4 Bipolar concepts provide a starting point for articulating aesthetic experiences. One of the concepts in each pair is usually more "established," while the other represents a more "radical" (new) line of reasoning (the scope of this article does not involve a definition of the above concepts).

for concise terminology at the poles while at the same time supporting flexible interpretation along a spectrum between them, showing their interdependency (Lorand 2000, 28–45). Since the events or laborations present complex real-world phenomena in the process of adapting to changes in the environment, the event itself will express conflicting features and relationships over time, such as generative/degenerative, growth/deterioration, attraction/repulsion. Due to such changes, the phenomena must be continually updated and reevaluated.

The reason for creating opposing concepts in this study was to frame a discussion (figure 9) that could move between the poles, without necessarily spending too much time debating the extreme definitions of each pole. Lorand (2000, 28–45) explains how extreme poles tend to "enter the full condition of [their] inverse logic". However, the methods and models presented here focus on the oscillation of concepts between the (never-clearly-defined) poles.

Applying the Transformation model

The *Transformation* model in figure 2 is applied to the laboration on dendritic crystal growth as shown in figures 5–6. The framed crystals in figures 5a and 6b are shown at two different stages, linked to the concepts of *symmetry* (5b) and *dissymmetry* (6a).

The predictable, symmetrical growth pattern of a dendritic crystal structure is controlled by an electrical current through the single electrode at the center of the copper ring. A symmetrical pattern is created because of the homogeneous conditions at this stage and the inherent symmetrical nature of crystal growth.

10 minutes later—transformation

The film is now reviewed to find a bipolar concept that both contrasts with the first concept and describes features of the event.

Figure 6b shows the same crystal structure as in figure 5a, but transformed into a dissymmetrical shape due to the strong attracting forces of the copper bars in the solution. At this point in the growth process, these bars disturb the conditions, introducing changes that create a messy tangled substance. The translucent bubble areas (arrows) are caused by excessive energy that cannot be channeled into creating an ordered, branchlike crystal structure. The straight edges of the copper bars also act as an obstacle, causing more dissymmetrical behavior.

The values attached to the terms *symmetry* and *dissymmetry* varied greatly between the artists and the physicists. The arts tend to consider symmetry redundant and uneventful, while many of the physicists appreciate symmetry as a means of defining order and structure.

Dissymmetry, on the other hand, was a very ambiguous term for both groups. The art and design group saw breaking symmetry as having a positive connotation, while the physics group attached more negative connotations to it. (The science of complexity is now slowly changing with regard to how scientists value broken symmetry). We often felt a strong clash in our discussions about symmetry. This clash eventually inspired the reevaluation of this very established term. In order to really understand dissymmetry, we must analyze the features of symmetry and discuss synonyms and other related issues between the contrasting poles.

Figure 7a shows how the first stage in figure 2 (the

Fig. 5a

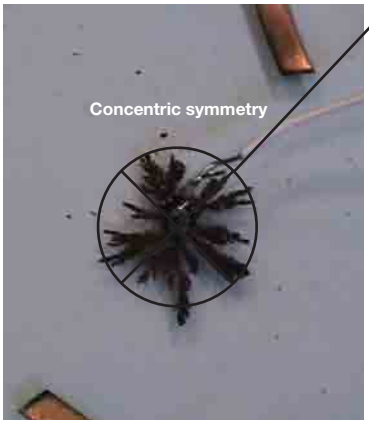

Fig. 5b

Symmetry
An evenly balanced set of relationships that create stable order through repetition along an axis or points. Symmetry infers stability.

Fig. 5a The framed dendritic crystals exhibit a concentric, symmetrical growth pattern.
Fig. 5b Definition of the concept of *symmetry*.

Fig.6a

Fig. 6b

Dis-symmetry
Chaos, lack of order, due to problems caused by internal and external factors that distort, break down or oppose symmetry. Dis-symmetry infers instability.

Fig. 6a A copper bar disturbs crystal growth pattern.
Fig. 6b Definition of the concept of *dissymmetry.*

Transformation model) is condensed into one compound icon through a sequence of three developmental steps:

i) Fusion of our senses
ii) A frozen moment is chosen within a changing phenomenon
iii) A concept is chosen from figure 4. An arrow *is pointed* (Biggs 2004) to the particular area in the phenomenon, linking the concept to a concrete description.

These three steps in figure 7a are then combined to create a compound icon (iv), which is used in figure 8 below as one of the poles. A similar condensing procedure occurs in the second stage of figure 2, creating a second icon at the opposite pole (figure 7b). As shown in figure 8, the two compound icons in figure 7 are placed in a bipolar spectrum, framing the dialogue.

The three participants in figure 8 are asked to discuss how they value the features of the phenomenon in focus by placing a mark somewhere between the two poles. For example, if the bipolar spectrum is about symmetry and dissymmetry, perhaps one participant is very interested and knowledgeable about the concept of symmetry and can see indirect and hidden symmetrical order underlying an asymmetrical composition. This preunderstanding (Molander 1996, 258) will probably make him or her place a marker closer to the symmetry pole due to this bias towards symmetry.

The other two participants—who are not as interested in the idea of symmetry—may only see the asymmetrical features and disregard any indirect correlation to a symmetrical structure. The markers thus visualize individual reactions and reasoning. By stating their aesthetic standpoints, the participants can initiate a more articulated discussion that deals with their differences rather than aiming to reach an agreement. Saddek Rehal's (2004) recent thesis on developing a communication tool that links concepts with 2-D images points to the problems verbal language can generate in the design process. His work shows the importance of allowing individual interpretations to be voiced in order to open up communication and avoid creating premature conventions or norms.

Figure 8 shows an emphasis on embodied, action-oriented experiments with no ultimate aim to come to a consensus. On the contrary, the entire process from the *Transformation* model to the *Framing the Dialogue* model is meant to articulate our differences and to support a dynamic dialogue that is sensitive to individual preferences, preunderstandings, and biases (Molander 1996, Chapter 10).

Our common aesthetic experience with dendritic growth provides an *examplar* (Molander 1996, 189–91), which embodies the phenomenon we are trying to learn about. The shared experience we have about the growing force of symmetry—as well as destructive ways of dissymmetry—is coherent and holistic, despite the contrasting behavior. By setting up the experiment, placing copper bars in the solution, and occasionally changing the electrical current, we interacted with the phenomenon and disturbed the process. The concepts are only a part of the experience we gained from this laboration. When we discuss dendritic growth today we can still easily return to this shared activity and use this experience

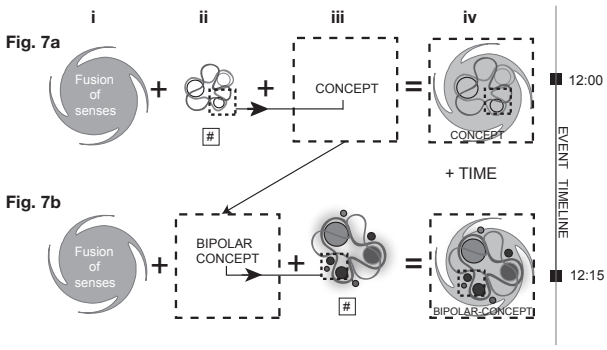

Fig. 7a–b Compound icons through condensation.

Fig. 8

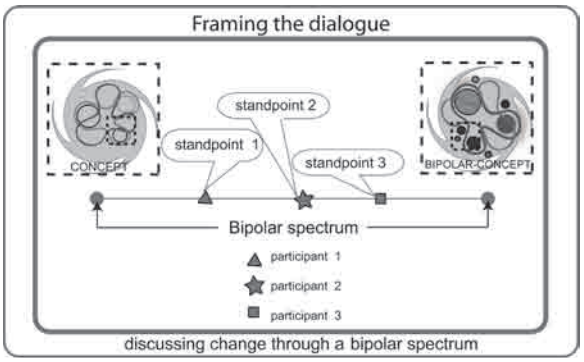

Fig. 8 Model: Framing the dialogue through a bipolar spectrum.

and concepts very concretely because the concepts are linked to the phenomenon. Since the phenomenon itself is coherent, we can better deal with the pluralistic interpretation of the participants.

Discussion

The proposed *Transformation* and *Framing the Dialogue* models offer tools that help to:

1) Recognize complex behavior in real-world events
2) Link aesthetic concepts to specific features of changing events over time
3) Generate and regenerate aesthetic concepts through a bipolar spectrum, which brings about *radical* aesthetic concepts that are interdependent with *established* aesthetic concepts within the same event
4) Deal with problems of cross- and transdisciplinary communication by reformulating concise terminology in a domestic language as well as supporting a diversity of ideas through a comparative value scale between poles
5) Reclaim the value of aesthetic experience shared in an art/design/science community.

These models can be applied to workshops or research projects across or between disciplines that aim to give insight into how to develop contextualized knowledge and gain insight into the unpredictable nature of complexity and transformation through aesthetics.

There are several lines of support for this approach of linking concepts with aesthetic reactions and reasoning, although most do not refer to aesthetics as such. Instead they refer to the concrete experience, play, images, intentional objects, etc. Perceptual psychologist Edith Ackermann (1996) emphasizes the importance of conceptual development linked to *play* in the concrete world. Ackermann's research in the learning sciences shows that we reach an advanced cognitive state if we fuse abstract thinking with the concrete experiences aimed to engage participants and contextualize knowledge.

I interpret *play* as a fundamental part of aesthetics and refer back to Fredrik Schiller's (1795/1995, 77–82) work. Saddek Rehal's (2004) recent PhD thesis also supports the importance of exposing individual biases and preferences by linking concepts with images. Rehal's work uses photos rather then real concrete experience, but his approach to pluralistic interpretation connected with images is very revealing.

The *Framing the Dialogue* model presented here uses insight from Rehal's thesis. I underline the importance of voicing many concepts within a bipolar spectrum rather then polarizing the entire discussion. The poles only attempt to frame or define boundaries for the discussion. It is the complexity of the concrete examples that invite a pluralistic discussion, because the concrete world does not usually express itself in simple polar features alone.

Richard Shusterman's (1992/2000, 90–93) research in pragmatist aesthetics also argues for what he calls *sense-making*, which is dependent on "common intentional objects" around which we can develop an exploratory and/or critical dialogue. Both Shusterman and

James Dewey refer to this kind of sense-making as an aesthetic act.

Philosopher Bengt Molander (1996, 189–3) argues that the experiment itself supplies the holistic imagery that identifies the phenomena that give rise to the research questions. He also points out that the experiment becomes an *examplar*, which often serves to unite a research team's understanding of the problem in focus. The concept is also supported by research in embodiment, which recognizes the interdependency between mind, body, and contextual conditions. Antonio Damasio's (1994/2005, 150) empirical studies of cognitive dysfunction in patients with brain damage showed how thinking with the body is merged with the mind. Lakoff & Johnson's (1999, 28–30) research on *basic-level experiences* provides further support for embodiment as an essential way of developing meaningful communication.

Concept, domestic language and dialogue

The *Framing the Dialogue* model in figure 8 aims to open up a dialogue based on the clash of our differences. It was initially inspired by the discussions of the theme of complexity and transformation during the planning phases of the C&T workshops. This theme, complexity and transformation, is not easy to define even from a monodisciplinary view. Since we agreed not to formulate a common definition at the start of the project, we accepted pluralism from the start. We were interested in learning about our different disciplines and individual preferences as we explored various phenomena that embodied the theme. As Gilles Deleuze and Felix Guattari (1991/2003, 15–17) explain, there is no single definition of a concept. They claim that every concept needs to be understood in relation to a *field of experience.* Since each discipline has its own field of experience, the definition of any concept would be in relation to that experience. What the C&T project offered was a common real-world experience that we could return to during our discussions. The dendritic laboration could be considered a temporarily shared game board that recognized vast conceptual differences (cross-disciplinary participants), while at the same time, its bipolar framing allowed discoveries that expanded each participant's own conceptual framework.

The need for a domestic language, or a *lesser language*, is a key to communication between disciplines and cultures. Gilles Deleuze (2004, 7–14) states that we can always exchange one word for another and that a pluralistic language rather than an exact one inspires open communication, because it allows for uncertainty and a chance for misunderstanding, which in turn provokes deeper inquiry. Delueze argues that a domestic language brings life into the exploration, because it invites personal, spontaneous responses to play a role in communication. Good ideas are found "between" fields and chance must be welcomed. Because the art and design community is very much a part of the everyday world, the language used by artists and designers is not controlled by professional nomenclature. Instead, there is a diverse language in the practicing art and design community that mixes popular, domestic language with various degrees of professional language.

Strengths of a bipolar spectrum

What is gained through working with contrasting concepts and a bipolar spectrum? By defining the conceptual extreme poles, one recognizes their interdependency, implying that they cannot exist on their own. Ruth Lorand (2003–2004) explains how this dependency arises by pushing both concepts to their extremes. If we try to determine examples of extreme poles by excluding every feature or value that is represented at the opposite pole, the poles become absurd or meaningless. Therefore, by allowing some overlap, we give the poles more relevance, which emphasizes their interdependency. Secondly, bipolarity offers a measure of complexity. If two opposing concepts (figure 4) can apply to one coherent event, then the event has a certain level of complexity. Contradictory behavior over time is therefore a feature of complexity. By problematizing the extreme poles through the *Framing the Dialogue* model, we can develop an awareness of values. Murray Gell-Mann (2003) argues that natural scientists tend to search for order based on discovering regularities and that they tend to see order where it does not exist. If we were conceptually prepared to expect and *want* irregularities as we search for regularities, this would help us discover order that is relevant to the system and conceptually prepare us for change, contradiction, and the unpredictable nature of complex systems.

Weaknesses of connecting imagery with concepts

Embodied first-hand aesthetic experiences on both a perceptual and a conceptual level offer stable imagery (Lakoff and Johnson 1999, 48), which highlights the importance of learning through our senses. However, if this stable imagery is shared as a second-hand experience, through 2-D visual pictures instead of real exploratory experience, these images have the potential to be an obstacle instead. According to Michael Stöltzner (2005, 9), visual images that are bound to a concept are very difficult to change when knowledge evolves and the properties of the image no longer parallel our present understanding of the concept. Stöltzer's criticism is based on the illustrations and artistic imagery that of-

ten portray scientific concepts in exhibitions and books. These images can sometimes be misleading and give a false sense of what complex concepts may involve. He states that there is a tendency to produce 2-D pictures with very little critical reasoning.

The present study was undertaken to counteract the problems of superficial and non-contextualized imagery that Stöltzner warns of. One of the main aims of this study was to aesthetically explore complex phenomena on more than a visual level in order to challenge and renew aesthetic expressions. By supporting process-based aesthetic reasoning that studies the origin and emergence of complex phenomena, we can deal with aesthetic plurality and adaptability, demonstrated in the real, complex world (Akner-Koler 2005). By participating in long-term processes in the complex real world and learning to recognize and create meaningful aesthetic abstractions and imagery, we can create a dynamic balance between reason and sensuous experiences (Sällström 1999, 13–16). We are also better prepared to update and improve imagery when concepts begin to change or our understanding of the imagery develops to a deeper level.

Conclusions

As the scientific community shifts towards Mode 2 and the contextualization of knowledge (Nowotny 2001 & Nilsson 2004), alternative scientific approaches need to be developed that can handle uncertainties and complexities. This paper argues for the reintroduction of aesthetics as a *science of sensuous cognition* that recognizes the perceptual sensitivities of researchers and participants as a source of knowledge enhancement. This entails a much more explorative attitude toward the advancement of science, technology, design, and art that deals with complexity.

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PAPER IX

PART 1
Developing an aesthetic taxonomy of form

- **Paper I**
  Akner-Koler, Cheryl. 2006.
  Expanding the boundaries of form theory. Developing the model Evolution of Form.
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PART 2
Expanding & challenging the Evolution of form-model

- **Paper III**
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- **Paper V**
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- **Paper VI**
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PART 3
Formlessness - opposing the aesthetic taxonomy of form

- **Paper VII**
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  Cross-disciplinary study of complexity and transformation: Evaluation for the Swedish Research Council (Vetenskapsrådet).

- **Paper VIII**
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- **Paper IX**
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  Cross-disciplinary study in complexity and transformation: Transforming aesthetics. Paper presented at Proceedings Joining forces conference ERA, University of Art and Design, September 22-24, in Helsinki, Finland. (http://www.uiah.fi/page.asp?path=1866;1919;4179;4698;11302)

- **Work/ Paper X**
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CROSS-DISCIPLINARY STUDY IN COMPLEXITY AND TRANSFORMATION: TRANSFORMING AESTHETICS

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ABSTRACT

Through a cross-disciplinary study involving artists, physicists, designers, and architects, exploratory experiments were conducted on the theme *complexity and transformation*. The aim of the experiment was to lift aesthetic reasoning into a dynamic and inclusive way of working that involved the participant. The *process-based aesthetics* model is presented here, which proposes a balance between *event* and object/*object*. A central concept within this model is the *aesthetic phase transition,* which was developed through results from empirical studies of degenerative material transformation. Concluding thoughts concern how the creative industry can become more innovative by recognizing the importance of an aesthetic consciousness at all levels of development.

Keywords: pragmatic aesthetics, embodiment, complexity, gestalt, multisensory, cross-disciplinary, transformation, art, design, ecology

1 INTRODUCTION

Through the support of the Swedish Research Council, a three-year art/science project entitled "*Cross-disciplinary studies in complexity and transformation*" was started in 2003. This project brought together a group of twenty artists, physicists, designers, and architects to conduct a number of workshops that are structured around *aesthetically* based experimental studies of complex and changing phenomena. These workshops were planned to stimulate perception, physical involvement and creative/systematic evaluation. The theme *complexity* was chosen because it is a concept that deals with holistic systems that place *order* in relation to *disorder* (Heylighen 1996) and allows or even invites contradictions of order for the sake of an enriched design process (Venturi 1966). The second theme, *transformation*, has to do with:
1) innovative change over *time,* as well as 2) *spatial* reorientation of elements and relationships using filters/patterns. Accepting the dichotomies inherent in complex systems and the unpredictable nature of change is therefore a central aspect of this project.

Why an aesthetic focus in this cross-disciplinary study? An important aim here is to begin the process of transforming aesthetics by examining phenomena that lie at the periphery of, or beyond, the current established aesthetic boundaries. Art, architecture, design, and crafts are all fields that are traditionally involved in aesthetic activities, and there is a great deal of energy channeled into exploring new aesthetic expressions. However, there is little effort concerned with renewing the field of *pragmatic aesthetics* to keep up with these changes. Physics is based on the rigorous traditions of mathematics and natural sciences, yet within the field of physics it is an accepted fact that aesthetic judgment is applied in research (Greene 1999). Therefore, at some level, aesthetics affects the direction of scientific discovery.

> *While a theory is being constructed, its incomplete state of development often prevents its detailed experimental consequences from being assessed. Nevertheless, physicists must make choices and exercise judgment about the research direction in which to take their partially completed theory. ... It is certainly the case that some decisions made by theoretical physicists are founded upon aesthetic sense. ...Of course, nothing assures that this strategy leads to truth. Maybe, deep down, the universe has a less elegant structure than our experiences have led us to believe, or maybe we will find that our current aesthetic criteria need significant refining when applied in ever less familiar contexts. Nevertheless, especially as we enter an era in which our theories describe realms of the*

> *universe that are increasingly difficult to probe experimentally, physicists do rely on such an aesthetic… So far this [aesthetic] approach has provided a powerful and insightful guide.*
>
> Theoretical physicist Brian Greene 1999 pp. 166–167

Although aesthetics are of central importance in many fields that deal with complex issues, our current aesthetic discourse is not yet open to innovative renewal.

Pragmatic aesthetics

The concept of aesthetics can be traced back to two main schools of thought: 1) Analytical aesthetics aims to separate aesthetic theory from practice and to institutionalize aesthetics as belonging only to the fine arts; 2) Pragmatic aesthetics defines aesthetics as perceptual, involved experience in the everyday world, which aims to unify theory and practice (Dahlin 2002, pp. 15–16). There is, of course, a gray zone between these two schools of thought; however, we argue from a primarily pragmatic view in this paper.

Dewey has outlined the main conditions of *pragmatic aesthetics* (Dewey 1980, pp. 38–44). He considers aesthetic experience as one that is immediately felt and has a unifying holistic quality. His view of aesthetics involves a process of events that brings together *intellectual* and *practical experiences* through emotions. *Emotions* guide a course of action and give energy to shape perceptual stimuli into a unique aesthetic experience.

Aims and questions

This paper points to the importance of aesthetic reasoning in art, design, and scientific discovery, and aims to answer the following questions:

1. *Event/object*
   Is it possible to renew pragmatic aesthetics so that our understanding of complex and changing processes over time (event) can be integrated with aesthetic traditions that focus on relatively stable conditions of form in space (object)?

2. *Limits of beauty*
   Can we retain an open attitude toward aesthetics, which includes degeneration processes and ecological awareness and questions the limits inherent in the concept of beauty?

3. *Involved participants offer alternative aesthetic methods*
   Can the involvement of the participant in the aesthetic event offer an alternative, holistic method for gaining and shaping knowledge in cross-disciplinary cultures?

A summary of this project, *Cross-disciplinary studies in complexity and transformation,* can be found in the Swedish Research Council's yearbook: *Metod & Praktik 2005 (Lind 2005).*

2 MATERIAL AND METHODS: EMPIRICAL, EMBODIED STUDIES

> *The mind is inherently embodied, reason is shaped by the body, and since most thought is unconscious, the mind cannot know simply by self-reflection. Empirical study is necessary.*
>
> Georg Lakoff and Mark Johnson 1999

Four 2-day workshops, structured around empirical, embodied studies, were conducted in 2003–2005 with the following themes in chronological order:

- Material transformation—generative and degenerative
- Simplicity/complexity—spatial transformation
- Reexamining the film archive with the intent to analyze content and explore film projection methods (ReAct).
- Glade: Light–color–texture: degrees of enclosed and open space

Nearly all of the twenty participants have been engaged as workshop leaders during one or more workshops. Each workshop was organized around several different sessions that could include various lab stations. The workshop leaders were given full freedom to develop an *empirical study* that interpreted the theme "Complexity and Transformation" from their own unique perspective using an embodied approach (see also Results, "Embodied thinking"). The

workshops started with a presentation of a practical and/or theoretical background and then moved on to experiments with physical phenomena requiring interaction, intervention, and playfulness. In all workshops, we posed the problem of challenging our aesthetic norms as well as expanding our experiential and aesthetic understanding of complex structures and transforming processes.

Material transformation—degenerative

The conceptual model and concepts presented in this paper are mainly derived from the experience and analysis of the material created during the first 2-day workshop: *Material transformation—degenerative*. The first day was led by Akner-Koler and began with a short warm-up exercise in *haptic* experiences (Fig. 1). The exercise was intended to stimulate feelings of touch: texture, temperature, density, and volume. This exercise aimed to counterbalance the dominance of our visual senses. Directly following this experience was a five-hour study and presentation primarily concerned with *degenerative transformation* through chemical treatment and heat processes that break down structures (Fig. 2a–d).

Fig 1. Haptic—color *Fig. 2a. Eggplant* *Fig 2b. Lard* *Fig 2c. Black pudding* *Fig 2d. Parsnip*

Fig. 1, haptic experience of color, and Figs. 2a–2d show examples of degenerative material transformation in eggplant, lard, black pudding, and parsnip.

The following is a general description of the four lab stations that were set up for the session on degenerative material transformation. Each station had one energy (heat) source: microwave, radiation, gas, and steam; plus instruments, containers, and chemicals to prepare the organic material. DVD mini video cameras were available at each lab station for documentation and Macintosh computers to edit the film. The participants were divided into four different cross-disciplinary groups with three members in each group (e.g., physicist, artist, designer). The organic materials included: vegetables such as aubergine/eggplant, potatoes, ginger, etc., as well as processed foods such as tofu and black pudding. The reason for choosing these organic materials is that they are fairly solid and homogenous, with few seeds or differentiated

structures. The instructions were simply to transform the original material by applying heat and chemicals (the chemicals were those available in an art studio). There was no functional purpose for the transformation and no predetermined protocol to follow. All that was asked was to actively take part, intervene, discuss/converse, and document the transformation process through notes and filmmaking. We asked the participants to keep an open aesthetic attitude during the experiments. In this particular session, we were interested in documenting the inherent structural changes of organic material under heat and chemical stress. By filming the experiments, we managed to capture the sound, dialogue, motion, and visual properties of transformation over time. When the groups had experienced all four stations, they were asked to edit a short film that captured the aspects of their work that gave examples of complex and transforming phenomena. We ran the films forward and then watched the same events in reverse, both at slow and fast speed. The films were then edited into sequences that captured contrasting aesthetic changes as well as interesting dialogue. (Amateur film technology (iMovie) made it possible, both financially and technically, to edit the films.)

3 RESULTS AND DISCUSSION: GENERATING A PROCESS-BASED MODEL

An analysis of the material, notes and documentary films from the lab station using gas produced the following model and concepts:

PROCESS-BASED AESTHETICS AS A MODEL

Process-based aesthetics is about exploring both time-related *events* and isolated, embedded *objects* within events. By alternating between *event* and *object*, we aim to lift aesthetics into a dynamic mode of reasoning. Event means inclusion; it refers to performance over time, involvement and interaction with the phenomena, synthesis, and holistic gestalt. Object means exclusion, freezing time, creating distance, discerning into parts and structural elements, and abstract analysis. Process-based aesthetics recognizes that the course of transformation can be presented coherently by showing the interdependency between complex changing phenomena (event) and stable substances and structures (object). Due to the limits inherent in the 2-D media of this article, we will focus on the insight gained by freezing a moment within an event.

This suspension of time lets us look for qualities that are constant and essential at each moment (Zeki 1999), and how these properties link together the different phases within the event.

The experimental situation that shaped the concept, *process-based aesthetics,* evolved through three steps:

1. The first was an open exploratory study in the *degenerative material transformation* workshop, which offered shared *embodied aesthetic experience* that involved all of our senses. This study gave us the *experiential component* (Biggs 2004) and *coherency* that focused the development of the model.
2. The second approach was a workshop (ReAct) designed to reexamine, reflect on, and experiment with the material and films from the earlier sessions in three cross-disciplinary groups that took on different sub-themes: a) material transformation, b) dendritic growth/cellular automata, and c) turbulence. These groups aimed to develop insight, concepts, gestalt, models, poetry, etc., that could develop a deeper understanding of what complexity and transformation involved. In the material transformation group (Catharina Dyressen, Fredrik Berefelt, Elisabet Yanagisawa-Aven, Cheryl Akner-Koler), we reflected on our prior experiences studying the visual and auditory activities of the workshop events in the documentary films. By shifting between the process of transformation and the objects that were transformed, we began to formulate the concept of *process-based aesthetics*. Using this method of film observation, we began to question the aesthetic decisions made as we edited the films. What motivated where and how we cut the films?
3. The third approach involved several two to three-hour seminars, e-mail evaluations, and creative/academic writing and reading that focused on very selected material. This phase offered a chance to bring in the other participants who had taken part in the experience. During this phase, we limited our attention to the particular transformation of eggplant. This article is a result of these three steps.

Aesthetic phase transition

The exploratory studies of aubergine/eggplant in the *Material transformation* laboration offers rich examples of process-based aesthetics and the two complementary ways of reasoning: event and object. When we arranged the single picture frames in chronological order (Fig. 3a–3e), it was easy to compare the abstract patterns, structures, textures, etc., and discuss what was going

on in each picture. When we discussed this sequence of pictures at one of our study groups, the term *phase transition* came up. The definition in physics of phase transition has to do with material changing from one state to another, such as ice to water to steam. The change itself can be gradual or abrupt. In the case of the eggplant, the physical phase transition was from organic material to charcoal. However, visually we recognized at least five unique *aesthetic phase transitions*. Each transition demonstrated both subtle, predictable changes and creative, unpredictable changes. The predictable changes require perceptual skills that recognize similarities. The unpredictable changes introduce abrupt *innovative qualities* that could not be foreseen (without prior experience), like the appearance of white powder on the coal black surface. In retrospect, these changes that are represented in Figs. 3a–3e seem very obvious and trivial, but in fact they are radical and creative (see also Discussion).


Fig. 3a


Fig. 3b


Fig. 3c


Fig. 3d


Fig. 3e

The description below is based on suspending the event creating the following five objects:

Fig 3a: Eggplant “natural” with white porous substance and purple-colored skin.

Fig 3b: The smooth white surfaces become brown and uneven and the edges are delineated.
* The group intervened in the process and decided to dip the eggplant in a chlorine solution.

Fig 3c: The volume shrinks and the surfaces are transformed into dark charcoal with a cracked pattern across the surfaces.

Fig 3d: The entire form becomes a glowing, orange gestalt.

Fig 3e: Powdery white surfaces appear on and around the form.


Fig. 4a


Fig. 4b

When we removed three phases and changed the chronological order, it was no longer possible to see any sign of transformation. Figures 4a (alias 3e) and 4b (alias 3b) are decontextualized and isolated objects with no obvious relationship to a common event.

Embodied thinking

By performing the experiment of material transformation, one is actively involved with constantly updating the aesthetic experience in relation to the changes taking place. There is no time for deeper analysis and reflection, because you are actively involved in the changing process. Due to the constant flow of energy (in this case gas) and the spontaneous involvement of the participants in the event, there is always something happening. We needed to rely on our *embodied thinking* (Lakoff and Johnson 1999) to keep up with the transformation. In our case study, we noted that when an aesthetic phase transition was maturing in a dramatic way, the participants were often quiet. The embodied expression of the phenomenon was shared naturally through tacit experience. We gained knowledge of the activity through *perceptual import* (Langer 1953) and the overall aesthetic experience. Current research in embodiment (Lakoff and Johnson 1999) suggests that our ways of reasoning arise from the commonalities between our mind and body immersed in the environment in which we live. Through perception and motor activity, we build up a pool of experience that greatly affects how we act and think on both a survival level and a cultural/social level. According to Lakoff and Johnson, this embodied thinking is largely non-linguistic. This means that our actions and the results of our actions through objects that we produce and manipulate, are central for understanding how we think.

Aesthetic dialogue and behavior

Going back through the film archive from the workshops, we recognized the following actions: 1) Perceptual and aesthetic reactions, 2) Scientific inquiry, 3) Aesthetic preferences/judgments, 4) Aesthetic abstraction, 5) Aesthetic action, 6) Empathy, 7) Metaphoric association.

Perceptual and aesthetic reactions such as "*Look how quickly the smoke swirls around the edges*" are interwoven with questions concerned with scientific inquiry that seek to explain/speculate about why certain phenomena occur; for example, "*Do you think that the heat speeds up the oxidation process, which, in turn, changes the white surface to brown? But why brown?"* Aesthetic preferences were also shared that summed up personal judgments, with comments like "*Look at this ugly rough deformity that sticks out*" or "*Yuck! That smells terrible*" or "*The glow is warm … and beautiful*" reflect such judgments. Aesthetic abstractions were, on the whole, fairly limited during the performance, with the exception of a few individuals. Statements such as "*The direction and position of the dominant element are*

unbalanced " or "*The curved axis has a with a strong accent*" were uncommon. Aesthetic action is when a suggestion is formulated that affects an aesthetic process such as, "*I wonder how white we can make it*" or " *I think we should take away the outer layer and see if the inside is also black.*" We also expressed empathy for the struggle the organic material was going through, as expressed in statements like "*This black pudding is so stubborn, I can see it isn't interested in transforming.*" There were also references to metaphorical associations such as "*The witch has been awakened.*"

These comments offer a little insight into the event in which the object is embedded. The above dialogues express the reactions from our visual and non-visual senses, such as kinetic, haptic and smell, as well as some semiotic and narrative involvement. To give more insight into the activities, discussions, and atmosphere of the *event*, we refer to the performance/exhibition planned in November 2005 at Konstfack/Höglagret. We are also working on a website that will eventually open up our archives.

4 CONCLUDING DISCUSSION

Finally, we would like to refer to the comments we received from the referee who judged our abstract for this Helsinki conference, "Joining Forces," in 2005. He/she wrote:

> Interesting, although the underlying concept of designing seems to be rather traditional (object-oriented/physical phenomena). Is it really these aspects of the design process that the "scientific and business communities" are interested in?

It is this attitude in the research communities that we would like to address with this paper. There is a strong tendency in current general research culture to avoid "object-oriented/physical phenomena" in the real mundane world, dismissing it as trivial. We argue that it is through aesthetic/perceptual studies of, and interaction with, physical events and phenomena—which do not overlook substance/object/object—we can find alternative methods and theories that may carry new insight into understanding innovative processes. The definition of innovation used here is based on Håkan Edholt's (2004) research, which recognizes an interdependency between systematic and creative performance. The radical and unpredictable changes of the transformed eggplant are in direct relationship to its organic structural qualities as well as the other conditions of heat, chemical, and social interactions through transformation.

Although performing experiments in degenerative material transformation may seem contrary to the constructive and generative aims of design, there are many parallels with design.

The intensive transformation process (of eggplant) embodies many aesthetic qualities in a time-bound process (figure 3 a–3e), mirroring the exploratory ways that design works (Geydenryd 1998 pp. 123–124). Designers' formgiving strategy can often involve exposing "material" to the influence of external energy, forces and stress, which invites or inflicts change. Every aesthetic reaction and judgment of these qualities can stimulate an act that can affect how the transformation (design) process develops. Relying on our senses to value these changes in relation to past, current, and possible future events is also reminiscent of the design process. In other words, we propose that this experiment of transforming eggplant simulates aspects of the design process by creating situations that engage aesthetic exploratory practice, and support a participatory action within this process.

Yet, contrary to the design process, the degenerative material transformation does not aim to solve any design task. The aim was to cast light on a collective aesthetic process involving an object, where the final status of that object/object—a traditional design result or product—was not the focus. Process-based aesthetics shifts interest to phase transitions throughout the process and treats the object and the final result as embodied phases within the process, rather than as an ultimate goal in itself. In this case study of burning eggplant, the organic material was the catalyst of the design game, to trigger actions, reactions, interaction, and reflection.

OPEN ATTITUDE OF AESTHETICS

Through the study of degenerative material transformation that dealt with deformation, decay, deterioration, shrinkage, etc., we were able to direct aesthetic awareness toward conditions that traditionally lie outside the concept of beauty. In the dialogue from the films, it is clear that what is typically classified as ugly, such as burnt eggplant, gives a dramatic aesthetic experience where emotions and value

Fig. 5 Dissecting the charcoaled aubergine

judgments are expressed. Some participants direct their attention to the cracks on the eggplant, which they feel express a sense of beauty. Likewise, aesthetic involvement could be mobilized by dissecting the eggplant to expose its inner, raw meat.

One initial motivation for opening aesthetics to accept complex structures and degenerative material transformation grew out of the limitations found in classical and modern aesthetics based on geometrical, ideal forms, from which other shapes/forms are generated (Akner-Koler 1994). These form and space traditions still dictate the conditions for beauty, at least for design and architecture, and ignore what we have begun to refer to in our cross-disciplinary group as the "amorphic field." A parallel motivation was that traditional "design" aesthetics excludes any concepts that deal with ecological reasoning such as entropy, decay, erosion, and life-cycle degeneration phases, etc. (footnote1).

How one chooses to organize knowledge and expression through aesthetic experience should not be restricted to the limited realm of beauty, especially considering that the concept of beauty is constantly transforming over time as well as being subjected to individual preferences. The scope of aesthetics should be inclusive, not exclusive, to engage in a multitude of expressions. This open attitude of aesthetics is shared by several philosophers, artists, and researchers such as Dewey (1980 p. 130), Greenaway (1995, film productions), Brian Green (1995) and Krauss & Bois (1997) Marr (1982).

To conclude: We propose that the creative industries, as well as the scientific and design community, can learn to be more innovative by recognizing that an open aesthetic consciousness, at any level of development, can directly shape our understanding of the complex and dynamic events in which we are all presently immersed.

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footnote 1. In 1996, Konstfack received state funding to develop, spread, and apply knowledge concerning ecology. The *Transformation and Conjuration* exhibition, featuring Akner-Koler's sculptural work together with the work of artist Kjartan Slettemark in 1996 at the Future Museum in Borlänge, marked one of the activities inspired by this theme. Akner-Koler's sculptures gave examples of how ecological thinking could influence form theory and practice, while Slettermark's contributions changed lifeless junk into sculptural life forms. Included in this exhibition were the results, by industrial design students, from a course led by Akner-Koler on aesthetic studies and product applications in ecological cyclical processes (Degerman and Törner 1996).

5 PARTICIPANTS

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WORK/PAPER X

PART 1
Developing an aesthetic taxonomy of form

- **Paper I**
  Akner-Koler, Cheryl. 2006.
  Expanding the boundaries of form theory. Developing the model Evolution of Form.
  Paper presented at Proceedings: Wonder Ground Design Research Society International Conference, IADE, November 1-4, in Lisbon, Portugal. (http://www.iade.pt/drs2006/wonderground/proceedings/fullpapers/DRS2006_0260.pdf)

- **Paper II**
  Akner-Koler, Cheryl. 1994.
  Three dimensional visual analysis.
  Printed by Swedish National Education Board, Stockholm, Sweden. Reprinted 2000. ISBN: 91-87178-16-5. Translated to Korean by Chunshik Kim. Chohyong Education Ltd 2000.

PART 2
Expanding & challenging the Evolution of form-model

- **Paper III**
  Akner-Koler, Cheryl. 2006.
  Twisting, blurring and dissolving the hard edges of constructivism. Partaking in exhibition and catalogue essay in *Konstruktiv tendens 25*, ed. Françoise Ribeyrolles-Marcus, 14-17. Stockholm: Konstruktiv tendens.

- **Work/ Paper IV**
  Akner-Koler, Cheryl, Bergström, Lars, Yamdagni, Narendra and P.O. Hulth. 2002.
  "Infinity" (exhibition and program) shown September 17-29 at Kulturhuset, in Stockholm, Sweden. (www.formandformlessness.com)

- **Paper V**
  Akner-Koler, Cheryl and Lars Bergström. 2005.
  Complex curvatures in form theory and string theory. *Leonardo,* Vol. 38, No. 3: 226-231.

- **Paper VI**
  Akner-Koler, Cheryl. 2006.
  Challenging and expanding the Evolution of Form-model. Paper presented at Proceedings: 5th Nordcode seminar & workshop Connecting fields, May 10-12, in Oslo, Norway.
  (http://nordcode.tkk.fi/oslo.html)

PART 3
Formlessness - opposing the aesthetic taxonomy of form

- **Paper VII**
  Akner-Koler, Cheryl. 2007 (revised version).
  Unfolding the aesthetics of complexity
  Cross-disciplinary study of complexity and transformation: Evaluation for the Swedish Research Council (Vetenskapsrådet).

- **Paper VIII**
  Akner-Koler, Cheryl. 2006.
  Contextualizing aesthetic reasoning through a laboration on dendritic growth. Generating and regenerating aesthetic concepts through cross-disciplinary studies. Paper presented at Proceedings: Symmetry Festival, August 12-18, in Budapest, Hungary.
  (http://www.conferences.hu/symmetry2006)

- **Paper IX**
  Akner-Koler, Cheryl, Billger, Monica and Catharina Dyrssen. 2005.
  Cross-disciplinary study in complexity and transformation: Transforming aesthetics. Paper presented at Proceedings Joining forces conference ERA, University of Art and Design, September 22-24, in Helsinki, Finland. (http://www.uiah.fi/page.asp?path=1866;1919;4179;4698;11302)

- **Work/ Paper X**
  Akner-Koler, Cheryl (project leader and producer), Norberg, Björn (co-producer) Kajfes, Arijana and Ebba Matz (exhibition concept.) 2005.
  "Cross-disciplinary study of complexity & transformation" (exhibition & program.) Shown November at Höglagret, in Stockholm, Sweden.(http://www.complexityandtransformation.com.

HÖGLAGRET PERFORMANCE /EXHIBITION NOV 10,12,17,19- 2005
CROSS-DISCIPLINARY STUDIES OF COMPLEXITY AND TRANSFORMATION

Akner-Koler, Cheryl (project leader and producer) and Norberg, Björn (co-producer) Kajfes, Arijana and Matz, Ebba exhibition concept: Cross-disciplinary study of complexity & transformation, exhibition & program, Höglagret, Stockholm, Sweden Nov. 2005 (URL: http://www.complexityandtransformation.com)

This Work/Paper X is primarily presented by photographic documentation of the exhibition, (see Paper VII for an in-depth description of the collaboration that drove the project).

The cross-disciplinary project on Complexity and Transformation was summarized in the form of an exhibition, exploratory laboratory experiments and a dialogue lecture series.

The spatial staging of the project´s activities provided an alternative, holistic method for bringing together a diverse number of exploratory and experimental studies.

The project was organized through Konstfack and Albanova at Stockholm University in collaboration with Chalmers University of Technology in Göteborg, Smart Studio at the Interactive Studio and the Royal Institute of Technology in Stockholm.

The final spatial staging presented a selection of concrete laboratory exercises, film clips from video documentation during workshops as well as recorded interviews giving insight into individual interpretations from the project participants. In parallel, there was a seminar series with lectures and open discussions.

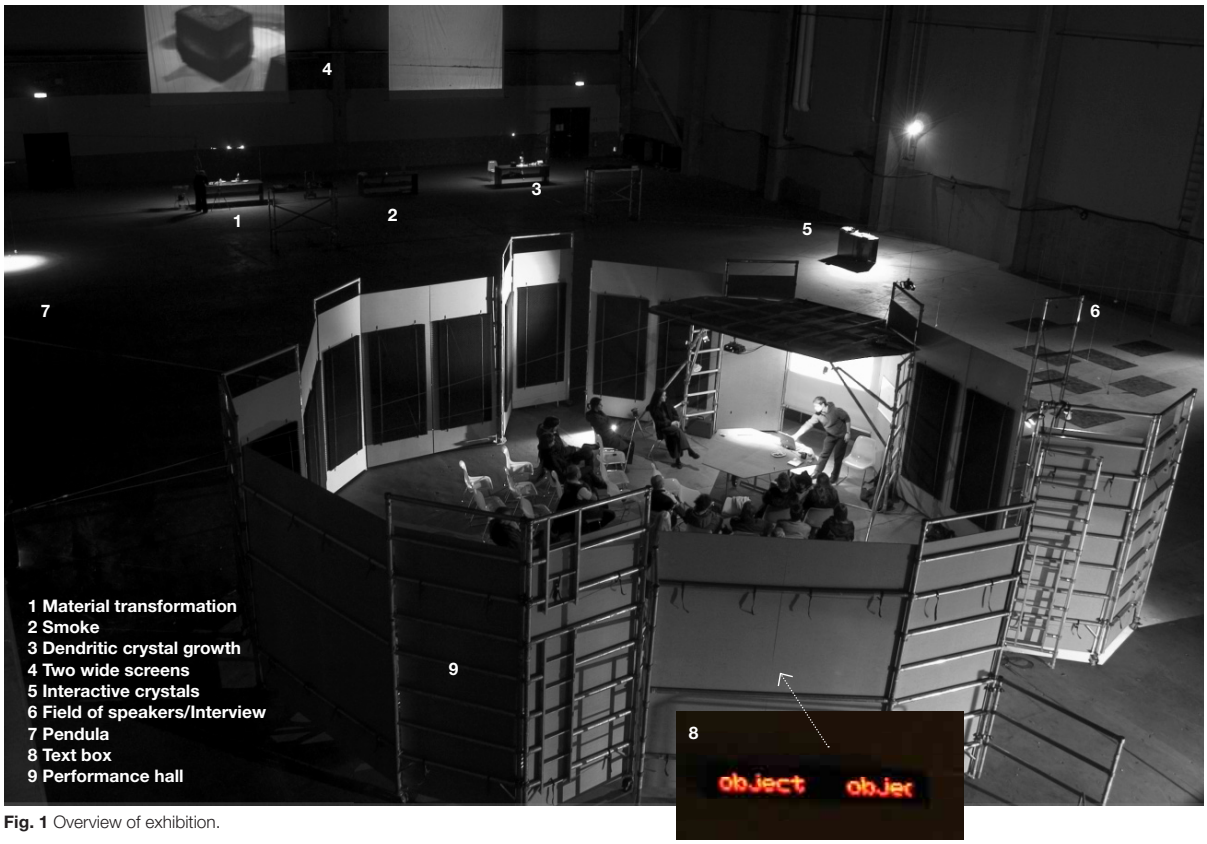

Fig. 1 Overview of exhibition.

Fig. 2 Two wide screens.

Fig. 3a–b Material transformation.

Fig. 3b

Photo: Fig. 1-3 Marcus Öhrn

Fig. 4 Smoke. Photo: Bengt Alm.

Fig. 5b

Fig. 5a–b Dendritic crystal growth. Photo: Anna Löfgren.