THESIS FOR DEGREE OF DOCTOR OF PHILOSOPHY

FORM & FORMLESSNESS

QUESTIONING AESTHETIC ABSTRACTIONS THROUGH ART PROJECTS, CROSS-DISCIPLINARY STUDIES AND PRODUCT DESIGN EDUCATION

CHERYL AKNER-KOLER

The thesis offers methods and models that both support and challenge the normative concepts of beauty, with high relevance for teaching 3-D form-giving aesthetics and research by design methodologies.

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FORM & FORMLESSNESS

Questioning Aesthetic Abstractions through Art Projects, Cross-disciplinary Studies and Product Design Education

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RESEARCH COLLABORATION BETWEEN:

Department of Architecture
Chalmers University of Technology
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Examination rights – Chalmers

Department of Industrial Design
Konstfack University College of Arts, Crafts and Design
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This research is based on empirical, embodied studies aimed to generate and regenerate aesthetic reasoning through three approaches:

- an educational approach concerned with developing an aesthetic discipline, supporting a form-giving process aimed to create tangible artifacts.
- an art-based approach supporting an open exploration of distortion and formlessness.
- a multi-disciplinary exploratory approach concerned with aesthetic experiences shared in laboratories demonstrating complexity and transformation.

The overall aim of the thesis is to explore different types of aesthetic abstractions that elaborate aesthetic reasoning about form and formlessness. The thesis develops methods and models for aesthetic investigation that support, challenge and go beyond the normative concepts of beauty, with high relevance for teaching 3-D form-giving aesthetics and research by design methodologies. A central method applied throughout the entire research project is a cooperative inquiry method engaging students and experienced professionals as co-researchers in embodied/interactive physical form studies and laboratories.

The content of the thesis is presented in three parts relating to the approaches above:

- Part 1 defines an aesthetic nomenclature organized within a taxonomy of form in space. This aesthetic taxonomy is outlined in five levels based on essential aesthetic abstractions, emphasizing structure and inner movement in relation to the intention for the development of a gestalt. It originates from the educational program of Alexander Kostellow and Rowena Reed and has been further developed through an iterative educational process using a Concept-translation-form method, resulting in the Evolution of Form (EoF)-model. This EoF-model reciprocally weaves together geometric structures and organic principles into a sequence of seven stages. To question the normative principles of beauty inherent in the EoF-model, a bipolar +/- spectrum was introduced at each stage to expand the model, aiming for a more inclusive approach to aesthetics.

- Part 2 both challenges and expands the aesthetic reasoning in part 1 through i) solo sculptural exhibitions exploring properties of distortion and transparency in a constructivist art community ii) collaborative projects with physicists concerning infinity and studies of continuous complex curvatures and iii) explorative studies of material breakdown and non-visual studies with ID Masters students at Konstfack.

- Part 3 problematizes the taxonomy of form by applying methods and results from a cross-disciplinary study of complexity and transformation involving artists, physicists, designers and architects. The three year study explored temporal events of changing phenomena and formlessness that did not comply with any traditional aesthetic norms. Based on experience from 12 laboratories, three models were developed: The Transformation-model and Framing the dialogue-model were developed to physically interact with as well as to document and discuss change and transformation through bipolar reasoning. The Aesthetic phase transition-model was developed to capture the particular properties expressed in a transformation and unify stable objects with changing events.

In conclusion, the thesis claims the value of an inclusive aesthetic mode of abstract reasoning in the scientific and design communities. A provisional 3 modes of abstraction-model is presented placing numeric, linguistic and aesthetic modes of abstraction as interdependent within a spectrum from separation to contextualization.

Key words: Aesthetics, architecture, formgiving, gestalt, complexity, embodiment, art, design education, taxonomy.
**LIST OF PUBLICATIONS**

This thesis is based on the work contained in the following papers:

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**DISTRIBUTION OF WORK**

*(SPECIFICATION OF CONTRIBUTIONS BY EACH AUTHOR)*

**Work/ Paper IV: Exhibition and program**
Planning and production of the exhibition: Akner-Koler, Lars Bergström, Narendra Yamdagni and P.O. Hulth.
Lectures given by: Bergström, Akner-Koler, Narendra Yamdagni, Anna Berglind, Hulth and Monica Sand.

**Paper V**
Akner-Koler planned the outline of the paper. Lars Bergström prepared the visual material, analysis and discussion for the Calabi-Yau. Akner-Koler prepared the visual material, analysis and discussion for the development of the compound curvature sculpture and point clouds. Akner-Koler and Lars Bergström both contributed to writing the paper.

**Paper IX**
Akner-Koler planned the workshop and laboration. Monica Billger and Catharina Dyrssen were active participants in the laboration and gave theoretical and practical support for the development of the complexity and transformation project. Akner-Koler planned the outline of the paper. Akner-Koler and Catharina Dyrssen contributed to writing.

**Work/ Paper X (exhibition and program)**
Exhibition participants: Teo Enlund, Christian Bohm, Gustaf Mårtensson, Pablo Miranda, Elisabet Yanagisawa Aven.
Assistant: Carolina de la Fé.
Moderators: Teo Enlund, Björn Norberg, Arijana Kajfes, Catharina Dyrssen, Cheryl Akner-Koler.
Graphics: Mario Sierra

**Additional publications by the author**


TO MY HUSBAND GUNNAR
FOR HIS INFINITE SUPPORT
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As the field of design becomes broader by involving knowledge gained from many other disciplines, the common ground that traditionally supported the profession is transforming. The historical identity of design as a profession that produces “tangible, physical artifacts” is no longer a central issue (Buchanan 2001). Instead, design can be defined as a pluralistic activity that affects the way we live in the everyday world, by creating services, knowledge, events, and artifacts. Two common activities that the broad design culture tends to agree on are planning and organizing things into holistic solutions and inquiring into the real nature of things (Nelson and Stolterman 2003, 39–46, 117–130). Designers, and particularly industrial designers, are experienced in dealing with the interaction between people, events, and things in a real-world context. The field of design has therefore developed ways of reasoning that can work with contextualized problems that carry a high level of complexity. In my research, I position the arts and aesthetic reasoning as crucial factors in the development of the design profession and its ability to deal with contextual and complex problems. It is therefore necessary to develop the field so that we continue to explore the unpredictable and spiraling nature (Jonas 2003) of the design process. I argue that we need the arts to keep the field of design open, because the arts question the normative boundaries within which the design profession tends to work. To achieve this, the embodied reactions and self-governing ways of the arts must be woven into the design fabric along with our practical skills, methods of investigation and abstraction, together with the development of design theory.

1.1 Area of research investigation

The area of investigation in the present thesis covers the role that aesthetic reactions and abstractions play in holistic thinking about creating artifacts in a changing process. I begin by studying the organizing capacity of form on the concrete and abstract levels, tailored within a formgiving culture. The design process uses form to test and explore questions, values and potential solutions. I will investigate the pluralistic nature of form in space and its usefulness in the development of our cognitive and emotional abilities for problem solving. The emphasis should be on our need to become engaged and active in physical and emotional events in the real complex world, which takes us far beyond the law-bound principles of geometry and traditional design aesthetics.

Approach

I developed this research project from two different approaches:

• from an educator’s approach in teaching form analysis, aimed to prepare industrial designers for the formgiving process of creating physical products/artifacts.
• from an artist’s approach, working with the theme formlessness in solo, collaborative and cross-disciplinary studies in complexity and transformation with physicists and other artists, designers and architects as well as explorative studies with current and former students.

Point of departure

My point of departure starts with my experience as a personal teacher’s assistant for and student of Rowena Reed-Kostellow for two years in the late 1970s. During these years I became immersed in the coherent and structured approach toward understanding visual abstractions of form and space that she and her husband, Alexander Kostellow, developed at the Pratt Institute in New York City, USA. (To avoid confusion, in the present thesis, Rowena Reed-Kostellow will be referred to as “Reed” and Alexander Kostellow as “Kostellow”). Through their close collaborative working relationship, Reed and Kostellow created a
comprehensive educational program for foundation-year courses in the structure of visual relationships, as well as courses for industrial designers (Greet 2002). These courses successively introduced different levels of visual complexity through concrete experiences in a variety of different two-dimensional (2D) and three-dimensional (3D) media. Their program offered a system of terms, concepts, principles, and procedures that supported perceptual and conceptual involvement of the active designer and artist under the different phases of their education (Greet 2002) (see also chapter 2, “Theoretical background and framework”).

1.2 Form and formgiving

My main interest is in supporting the skillful aesthetic involvement of designers during the formgiving stages within the industrial design process. I have adopted, anglicized and updated the term formgiving from the Swedish word formgivning, meaning the conceptual and perceptual process of developing the product gestalt into a physical form, as an integrated aesthetic process within the industrial design process. The industrial design program at Konstfack was founded in 1980 as the first formal industrial design (ID) education in Sweden. Konstfack’s department of ID developed from an arts and crafts tradition that supported formgiving.

My research efforts have spanned over a period of twenty years, with several phases of development. I began with a three-year grant in 1990–1993 from the Swedish Department of Education (in Swedish: Universitets- och Högskoleämbetet, UHÄ) that supported the development of industrial design education. The grant was formulated by professor Lars Lallerstedt, who founded the Department of Industrial Design at Konstfack. Prior to this grant, I had been responsible for the development of our foundation program in 3-D form from the middle of the 80s, that prepared our students for the coming formgiving challenges they would meet during traditional product development. As the program developed, I produced teaching material that outlined the principles and methods applied in each course. This material was published in 1994 as a textbook under the title Three-dimensional visual analysis (Akner-Koler 1994, see Paper II).

Initially I introduced the geometric-organic (geo-organic) foundation of Reed and Kostellow. (Greet 2002). This was based on law-bound geometric volumes that merged with organic principles in a comprehensive approach. One would assume that aesthetic methods and concepts concerned with developing a foundation for 3-D formgiving were fairly well defined, since industrial designers, traditionally, have seen their main role as shaping products (Buchanan 1995). However, this is not the case. There is, in fact, very little documentation about the active formgiving process. Some reasons for this are that:

1. Documenting 3-D work is inherently problematic
2. The field of design has only recently been offered the opportunity to do research
3. The resources in design research concerned with aesthetics tend to go towards consumer-based aesthetic preferences rather than opening up the formgiving process from a designers position.

This lack of documentation and theoretical development about forming the artifact raises many questions about the identity of the design discipline itself.

In time, I developed a method that involved the students in expanding Reed’s/ Kostellow’s foundation studies of form and space compositions. Many of the form studies in our teaching program at Konstfack referred to similar concepts that could be presented through more comprehensive visualization models, which worked for various form and space studies. These collective efforts
led to the development of a taxonomy of form. Thanks to the educational grant and funding from Artistic Development (in Swedish: Konstnärig Utveckling, KU) at Konstfack, I was able to reformulate and reorganize my teaching material into a comprehensive textbook, which is part of this thesis. I was then given more time and resources to integrate the foundation program with product-oriented courses at the Department of Industrial Design at Konstfack. These courses merged form and gestalt development with semiotics, where I collaborated for more than ten years with Rune Monö (1997) and Bosse Lindström in model making in the second-year program. Later I invited Anna Thies (in semiotics, when Rune Monö retired) and Teo Enlund (in color and gestalt) to join the teaching team. I have also supported and at times co-supervised the examination projects in the final year of the bachelor’s program (see figure 1).

As the field of design joins the research community, we enter with a very fuzzy identity. The traditional and methodological knowledge about the development of artifacts, embedded in the practice of design, is unarticulated. The multidisciplinary and spiraling design culture of today does not seem to create supportive conditions for the profession to do practice-based research about making physical artifacts. To deal with this spiraling nature of design, I place form in the context of formgiving at the hub, giving it a significant role in the first part of my thesis. This emphasizes the roots of industrial design as a profession that makes things in the real world (Dunin-Woyseth and Bruskel and Amundsen 1995).

Christopher Alexander explains the need to use form for its controlling capacity (Alexander 1964). He works with form with the intent to deliver solutions. The tight schedules and economic framework of industrial design often focus the design process on solving particular problems, with very little time to develop coherent knowledge to enrich the field of design. To establish the field, we need to step back and create and document knowledge about form, to understand the explorative capacity of form beyond the needs of industry and the market place, and to question normative forces. My approach to developing exploratory knowledge has been through my role as an artist. I have spent half of my time in education and half on my own solo art or art-based collaborative project. The arts offer a free zone for unconditional exploration, which is explained in the coming section on formlessness.

1.3 Formlessness and art

Constructivism and productivism

A constructivist artist community centered around the gallery Konstruktiv Tendens in Stockholm became an important context for my own artistic development. The artists, gallerist, and collectors at the gallery taught me...
about the Russian constructivist and productivist movements and Central European constructivism with its center at the Bauhaus. I also experienced an enormous variation of expression that pushed the limits of geometry and spatial dimensions. My own art work was supported through the gallery, where I staged several solo exhibitions and took part in many group shows (see Paper III).

I found that the constructivist movement united my work with form in an industrial design culture with my initial sculptural interest of exploring geometric distortion (figure 2). The Russian constructivist and productivist art movement in the beginning of the twentieth century was one of the first art movements that directly collaborated with scientists (Lodder 1987 [1983]). It was also the major art movement that openly worked with industry to create products for society. The artistic roots of industrial design can be found in this movement, as can the methodological approach to aesthetic reasoning presented in this thesis.

Initially my own artistic interests were concerned with concepts of distortion. I limited my elements to hard-edged, planar structures that indirectly defined open constructions enclosing space pockets and creating voids as shown in figure 2. As a counterbalance to the dominant interest in form from the industrial design culture, I chose to emphasize spatial relationships in my art. Gradually I began to question the controlling role that concrete form elements take on and searched for media that prioritized spatial experiences. Rowena Reed had developed teaching methods with straight and curved planes aimed to expand, activate, and enclose space (Greet 2002). To push these methods further, I began to work with translucency and degrees of material density aimed to dissolve the hard edge transitions between concrete form and void.

I joined the St. Erik “Art reservation”, headed by artist Kjartan Slettemark, who supported explorative processes. At that time my interest was in transforming material through combustion that created smoke, ashes (figure 3), and other unstable materials. This change in my art brought up temporal issues and put emphasis on changing events rather than on the stages and sequential reasoning I had developed in my form taxonomy (Paper II).

Slettemark and I produced an exhibition in the Future’s Museum in Borlänge called “transformation” (in Swedish: Förvandling och Omvandling). I refer to my work in this areas with temporal issues and the dissolving of materials into space as included in the search for formlessness.

Collaboration between art/design and physics

My art projects in formlessness were open-ended and explorative. I studied Goethe’s perceptual work on trüben (a German word meaning “cloud”), which involved the embodiment of space and primary colors that arise in fog (Sällström 1979, 109–15). Through my interest in Goethe, I collaborated with physicist Pehr Sällström, who had updated and translated Goethe’s color theory to Swedish. From my studies of smoke and fog, I became involved in a collaborative project on the theme Empty Space with three physicists at Stockholm University: Professor Lars Bergström, Doctor Narendra Yamdagni and Professor P.O. Hulth. This two-year project resulted
in an exhibition and seminar series on cloud chambers, smoke filled prisms, and air-glass, coal and vacuum in the old Orangeri at Bergianska Gardens in Stockholm, supported by a grant from Stockholm Culture Capital 1998 (see figure 4). A short film was produced about this project and broadcast by Swedish Television (see thesis website).

The empty space group was later invited to be part of an art and science festival at Kulturhuset in Stockholm 2002, where we presented an exhibition and program on the theme Infinity. In this project, I worked closely with Lars Bergström and explored complex curvatures in multidimensional space. Both these collaborative experiences focused on developing and producing exhibitions that involved the public in our projects. Again, emphasis was on showing the results of our work rather than presenting our methods about how and why we arrived at these results.

Parallel to my art projects, I also was able to engage industrial design master’s students to take part in exploring formlessness, beginning with a project on ecology (Degerman 1997). We studied how organic materials could be transformed through dehydration and other processes such as heat, electricity, hydration and implosion (see figure 5). We also explored non-visual aesthetic studies of color and substance, which emphasized tactility, haptics, taste, temperature, and interactivity with emphasis on process (see film Non-visual color, on thesis website).

In collaboration with a design firm called No Picnic, I put together a two-day exploratory workshop that exposed the designers (my former students) to the explorative aesthetics of “formlessness” and “material transformation” (see figure 6). The enthusiastic response the No Picnic group gave this workshop strengthened my convictions regarding the importance of explorative aesthetics.

Needing to document and critically discuss what these exploratory aesthetic studies offered, I realized that the student courses and firm workshops could not provide a long-term forum for further development. Some of my former students sometimes found ways to apply these formless experiences in design; however, there was no feedback loop to help me develop knowledge from their products. I later used my experiences from the non-visual color laboration and the material transformation laboration to develop a plan for collaboration with physicists, artists, architects, and designers, called a Cross-disciplinary study in Complexity and Transformation described below.

Cross-disciplinary studies in complexity and transformation

Through funding from the Swedish Research Council, I became project leader of a three-year project to conduct exploratory studies on the theme of Complexity and Transformation (C&T) (see Paper VII). This C&T project gave me the opportunity to explore the ideas I had been working on about formlessness and temporal changes in collaboration with other researchers, professionals,
and teachers. My own drive to start such an explorative project was to counterbalance the structured geometric reasoning with form and materials in an industrial design context. I turned my back on the methods of abstraction that relied on simple geometric, stable materials or a structured spatial 3-D matrix. The C&T project was demanding, since it did not refer to a common discipline, only to a common yet ambiguous theme. The four workshops and 12 laborations introduced concrete examples of phenomena that demonstrated complexity and transformation. We managed to grasp the different interpretations of the theme through playful interaction with phenomena on an aesthetic level, where we could share our different views. The final report of this project is presented as Paper VII in the present thesis. Through this project we created an archive of documentary video films from all four workshops, giving an inside view of the dialogue and concrete laborations we performed. There were also two exhibitions/seminars of our activities; one in the context of SAPS at Art.Platform (URL) and the second at Konstfack.

1.4 Research profile

The design profession is going through fundamental changes that are creating an increasing gap between design and the arts/crafts. I see these human-centered activities of art and crafts being pushed aside rather than integrated with high technology and market strategies. My intention with the present thesis is to create a greater understanding for formgiving that embraces embodied methods of art and crafts within and beyond the industrial design field.

Through the research culture at Chalmers School of Architecture in Göteborg, in collaboration with Konstfack, I found support to conduct practice-based research that opens up aesthetic reasoning in both a mono-disciplinary context of industrial design and in cross-disciplinary projects. Chalmers underlines the importance of developing cross-links between experience, conceptualization, laboration, and problematization.
1.5. Aims

This thesis aims:
1. To generate aesthetic strategies that support skillful formgiving methods of conceptualizing and shaping artifacts in a design culture
2. To create a taxonomy that reciprocally interlaces geometric law-bound reasoning with organic growth principles
3. To develop constructive and critical methods and models that challenge normative trends in design
4. To conduct exploratory, cross-disciplinary studies in complexity and transformation that support the renewal of aesthetic reasoning in both the art/design and scientific communities
5. To generate methods that lift aesthetics into a dynamic mode of reasoning that supports change, transformation and formlessness
6. To support the interaction between the explorative, embodied approach of the arts and the didactic and concrete needs of design education

1.6 How to read the thesis

This thesis on art and design research mixes academic writing with presentation methods and exhibition/works from art and design traditions.

Structure of the research and disposition of thesis

The written material in the present thesis applies three writing styles. Most of the written articles use an academic writing style called the IMRAd structure (Introduction, Methods, Results, and Discussion). This writing style entails separating the background information, the methods used to conduct the study, and the results of the study with an overall discussion at the end. I found that this structure of academic writing helped to open up my work so I could present and discuss it with other researchers. It also set boundaries for the questions I set out to answer so I could easily focus on the different areas within the research project. The remaining written papers use the academic structure of reports as well as an essay form.

Also included in the papers are “works,” such as physical exhibits of artifacts and media productions with accompanying catalog texts, which will be presented on a thesis website. The combined presentation of both papers and works thus reflects ways for both the scientific community and the art and design community to share knowledge and experience. All ten “papers” in the present thesis refer to practice-based experiences centered around aesthetic issues concerning physical form and phenomena.

The Papers have been organized in three parts:

**Part 1:** Developing an aesthetic taxonomy of form  
**Part 2:** Expanding and challenging the *Evolution of Form*-model  
**Part 3:** Formlessness—beyond the aesthetic taxonomy of form

The comprehensive summary (“coat”) of the present thesis is comprised of seven chapters ending with the individual ten papers:

**Chapter 1. Introduction:** Explains the area of investigation, my point of departure, form and formgiving, formlessness, and art, ending with the aims addressed in the thesis.

**Chapter 2. Theoretical framework:**

Presents the theoretical background of the field, limited to the scope of the research. This is done by positioning the research in the field of aesthetics and outlining the main theoretical and practical sources that are relevant for shaping the way I have approached the concepts of form and formlessness.
Chapter 3. Results – summary and discussion:
This chapter is organized around the same three parts as described above. Each part summarizes the results, then provides a general discussion, including strengths and weaknesses.

Chapter 4. Methods and procedures—summary and discussion: This chapter is also organized around the same three parts as described above. Each part summarizes the methods, strategies, and procedures, then presents a general discussion, including strengths and weaknesses.

Chapter 5. Contributions, conclusions and future plans: A summary of the particular methods and models that the present thesis has developed and concluding thoughts about what these methods and models can offer in developing the field of applied aesthetics. This chapter ends with some suggestions for future plans.

Chapter 6. References.

Chapter 7. Summary of Papers.

Regarding referencing
Due to the multi-disciplinary nature of the field of aesthetics and the large amount of internal cross-referencing in the literature from many disciplines and different epochs, I have found it hard to keep track of how I refer to my sources. To make this clear to the reader (and to myself), I have used a system of referencing that looks like this: (Jones 2002, 23 [1927]). The authors last name, a first date that indicates the quoted source and the page number if necessary, then in square brackets the date of the original source. It is my hope that this system will help clarify to the reader: a) that many of the ideas I present come from a different epochs; and b) that the information has been republished, because the sources are still of interest for an audience.
This chapter gives the theoretical background to my work and terminological definitions, presented in four main sections:

- Aesthetics
- Form
- Formgiving
- Formlessness

2.1 Aesthetics

This section presents theoretical support for defining aesthetics within an applied, embodied context that recognizes the importance of immediacy through basic-level experience. It presents the need to develop skills and methods that support a way of reasoning through tangible form, developing aesthetic abstractions, experiencing playfulness, relying on sketching procedures, etc.

Definition

The concept of aesthetics can be traced back to two main movements (Dahlin 2002, 15): 1) Analytical aesthetics, which aims to separate theory from practice as well as to institutionalize aesthetics as belonging only to the fine arts, 2) Pragmatist aesthetics, which regards aesthetics as perceptual experience involved in the everyday world and aims to unify theory and practice. There is, of course, a gray zone between these two schools of thought; however, this research is primarily based on a pragmatist aesthetic approach (Shusterman 2000 [1992]) (see figure 7).

I refer to John Dewey’s work, which outlines the main conditions of what is now considered pragmatist aesthetics. He considers aesthetic experience as such that is immediately felt and has a unifying holistic quality (Dewey 1980, 38–44 [1934]). Dewey is interested in aesthetics from the individual’s everyday experience. He also recognizes the organizational energy that an artist or designer works with during the active process of creating artifacts and events (Dewey 1980, chap. 9 [1934]). Dewey’s view of aesthetics involves a process of events that brings together intellectual and practical experiences through emotions. He states that our emotional, aesthetic reactions are what keep us involved in the immediate situation and embrace the feeling of the gestalt (Dewey 1980, 42 [1934]). I need to make a distinction between analytical and pragmatist aesthetics because the intention of this thesis is to begin to establish a viable academic platform that can support practice-based aesthetic reasoning. A pragmatist aesthetic approach offers such a platform.

Science of sensuous cognition

The German philosopher Alexander Baumgarten’s 1735 definition of aesthetics as the science of sensuous cognition (Shusterman 2000, 263–7 [1992]) is frequently referred to in the field of pragmatist aesthetics. He defined the word sensuous as meaning the “fusion of our senses,” and the word cognition as to “know.” The concept of fusion emphasizes the real-world experience and embodiment of knowledge, which is one of the themes of this research.
According to Richard Shusterman, Baumgarten recognized the importance of aesthetic reasoning to “promote greater knowledge” (Shusterman 2000, 264 [1992]) during scientific studies. Baumgarten understood the value of developing sensory skills that improved an individual’s ability to discern relationships between features, and to develop improvisation and imaginative capacity. Baumgarten suggested that aesthetic reasoning could offer ways to go beyond the established norms of order that scientists often rely on. He also proposed that aesthetic experience prepares individuals to deal with relative values as a useful way of reasoning when one deals with new territories that challenge conventions (Shusterman 2000, 263–7 [1992]).

The presented Fusion of our senses-model in figure 8 (see Paper VIII) further illustrates two concepts regarding fusion: i) The spiraling form emphasizes Baumgarten’s idea of fusing the senses within an embodied real-world context; ii) The scale at the bottom of the figure refers to the sense of equilibrium that continually aims for a dynamic balance of aesthetic values.

The Fusion of our senses-model starts with the concept move at the top, then rotates clockwise through grasp, touch, etc. to underline embodied reasoning, emphasizing Kinaesthetic/haptic activities and placing see last. It is through movement and interaction we can fuse our senses together (Dewey 1980, 118–25 [1934]). Dewey claims that “vision is a spectator,” offering only a passive view of our world. This spectator view has dominated philosophy, aesthetics, and education for centuries (Levin 1999). Today, there is greater awareness of how our conceptual language has been controlled by visual metaphors that reflect a shallow experience (Smith 1999). In line with this reasoning, I have come to question the way vision has previously dominated my theoretical aesthetic approach.

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, 5)

Embodiment is a growing field of study that recognizes the role the body and perception play in developing the way we conceptualize the world. Strong evidence from scientific research is challenging the idea that the mind is separated from the body (Norman 2002 [1988]). Instead, scientists such as neurologist Antonio Damasio (2005 [1994]) state that our ways of reasoning arise from the commonalities between our mind and body immersed in the environment we live in. Through perception and motor activity, we build up a pool of experience that forms our cognitive unconscious (see figure 9). This pool of unconsciousness greatly affects how we act and think. As we shift our understanding of how reason is shaped through embodied experiences, society is changing the way it looks at the fields of art, design, and crafts. These fields have a long history of gaining knowledge through embodied processes and therefore have a wealth of experience to share with the academic world.

Aesthetic reaction

The idea of *immediacy* in aesthetic experience is a concept
that John Dewey (1980, 119 [1934]) argued for and that has been important to the development of this thesis. What Dewey aimed to support was the full force of an experience at the very moment one becomes aesthetically involved. He sees this immediacy as a key experience that builds on emotional involvement and recognizes the holistic features of the gestalt.

_It cannot be asserted too strongly that what is not immediate is not aesthetic._ (Dewey 1980, 119 [1934])

I build on Dewey’s idea of immediacy and use the concept of aesthetic reaction, because I am interested in supporting the action that may arise from the immediate aesthetic experience. In design, we work with a myriad of possibilities as we bring materials and techniques together to create a solution. Most developmental processes face many conflicting concepts or interests to be dealt with. What we need, to keep the process moving forward, is to dare to organized shape despite the turbulence in the process. Embodied aesthetic reactions can inspire the creation of such shape. Rowena Reed studied with Hans Hoffmann in Germany and applied his action painting methods in her teaching of 3-D visual structures. She saw a strong connection between reaction and reasoning through abstractions and creating spontaneous compositions (personal communication). Instead of starting with a white canvas as Hoffmann did, Reed started with movements in physical space and the direct use of sketch materials. John Rajchman (2003) supports an aesthetic reaction that, however question action painting, yet still regards the sensation prior to reflective judgment as vital for new ideas to come.

In defense of the immediate sensuous character of aesthetic experience, art theorist Susanne Langer explained what she called the “direct import” of expressions through form that have no prior activity of interpretation (Langer 1953, 31). Langer points out the difference between language and aesthetics by arguing that the elements of language (words) refer to conventions, while the elements of aesthetics (form) use sensuous qualities that allow the form expression to immediately become a part of our ongoing experience at the moment. Her criticism, from the 1950s, of research in aesthetics is that there is a strong tendency to transfer the structure of language to the field of aesthetics without any deeper understanding of the nature of art and design.

I believe Langer’s main contribution to the field of aesthetics lies in defining aesthetics as a discipline in itself and not as another type of language (Langer 1953, 31). This insight should expand research in applied aesthetics to counterbalance the limitations of semiotics and semantics (both rooted in linguistics), which aim to categorize form through social conventions (see below in this Chaper, Aesthetic abstractions: essential and substantial).

**Basic-level experience**

Dewey stated that in order to understand the nature of aesthetic experience, “one must begin with it in the raw” (Dewey 1980, 4 [1934]). He was referring to phenomena such as the sparks from a glowing fire, a bulldozer digging pits in the earth, or the spiraling cutting edge of a corkscrew. Dewey’s idea of raw aesthetic experience has strong parallels to what Lakoff and Johnson refer to as the basic-level experience, supported by findings in fields such as neurobiology and cognitive/perceptual science.
(Lakoff and Johnson 1999, 27–9). It is a level on which we interact with our environment through what they define as *survival abilities*, dealing with what we sense as real to us. This level is not governed by conventions or cultural interpretations, but rather aims to optimally perceive the world by relying on sensorimotor activities to interact with objects. Lakoff and Johnson define basic-level concepts, such as move, drag, push, pull, lift, and fall. Moreover, they claim that basic-level events involve actions and emotions and are the “source of our most stable knowledge.”

This shift in our understanding of how reasoning is shaped through embodied experience is changing the way we look at the fields of art, design, and crafts. These disciplines have a long history of gaining knowledge through embodied aesthetic processes and therefore have a wealth of experience to share with the academic world.

**Crafting skills**

Skillful engagement is about creating a physical dialogue with materials and space. How one stands (posture) and moves in relation to the physical model strengthens or weakens perceptual awareness. Classic sculptural and crafting working methods train this engagement by keeping the body in motion with the intent of bringing energy to the work. An awareness of the way one holds and uses tools (haptic, Kinaesthetic) directly affects the way the materials of a physical model take shape. Philosopher Richard Shusterman’s research in *somaesthetics* (soma is the Greek word for body) defines a new area in aesthetic research that deals with how the well-being and skill of the artisan’s body affect his or her conceptualization and problem solving abilities (Shusterman 2000, 268 [1992]).

Movements of the body as it is engaged in work develop muscle memory (Sallnäs 2004), which can help guide the use of tools as well as allowing the body to independently make conscious aesthetic decisions on shaping the overall gestalt without language fixed associations (Langer 1953, 31).

Anthropologist Tim Ingold (2005) has researched qualities of *discrete movement* with the aim of understanding “movement as skill building.” He recognizes that engaging creative processes occur when the organization of a studio space or workshop supports a natural sequence of skillful movements. These movements are driven by the need to explore and solve complex problems.

Ingold’s conclusions seem simple to craftsmen and sculptors, yet his research shows how sophisticated the skillful shaping process is in practice (Ingold 2005).

**Beauty and ugliness**

The above definition of aesthetics, based on the work of Alexander Baumgarten and John Dewey, does not actively deal with the concept of beauty. Dewey (1980, 129–31 [1934]) even considered it to be an obstructive term, which he found difficult to handle in a theoretical way. I also find the concept of “beauty” difficult, because it implies aesthetic norms and therefore limits aesthetics to a very narrow area of human experience.

However, for the development of the present thesis I need to briefly present concepts of beauty that I have experienced through Rowena Reed’s teaching and traditional Swedish formgiving culture, as well as in relation to “ugliness.” Rowena Reed clearly advocated beauty in her life and work. On the inside cover of Gail Greet’s (2002) book on Reed’s life and work is the quote: “If you can’t make it
more beautiful, what’s the point?” What this statement implies, I believe, is that Reed felt she had developed a canon of principles that determined what was beautiful. Her early education as a sculptor taught her to judge balance, visual organization, and inner movement, all expressing growth and life. She learned the complexity of the human body through a classic sculptural discipline, which aimed to bridge emotion and perception through the articulation of form. Reed then took this tacit and procedural knowledge further by merging it with an asymmetrical aesthetic approach to the abstract geometric structural knowledge she learned from Alexander Kostelow (Personal communication). Both the human figure and geometry are considered sources that offer insight into beauty. Reed’s sense of beauty and personal interest aimed to push these principles of beauty by creating tension and contrast within the inner structure of the composition and how it activated and expanded space. Her sensitivity to void, which she developed through the Russian sculptor Alexander Archipenko, and her awareness of architectural space were other aesthetic sources that shaped her sense of beauty. Reed was not, however, interested in integrating functional reasoning with her aesthetics (personal communication), which is very problematic in an industrial design profession.

The author and educator Ellen Key (1996 [1913]) was one of Sweden’s most influential scholars in the field of aesthetics at the beginning of the industrial revolution. She argued that beauty was expressed through a “harmonious wholeness in relation to purposefulness” and that the sense of beauty lies in the “true pleasure of lagom (a Swedish word meaning “just enough”) and moderation.” Key’s sense of beauty can be exemplified in the functional and ergonomic shape of the traditional wooden butter knife that every Swede creates as a school project in their childhood (see figure 10).

Swedish architect Sven Hesselgren’s (1954; 54–8) PhD thesis in expressive modes of architecture, is an extensive research project in aesthetics with a critical analysis of earlier aesthetic principles of beauty. He questioned the aesthetic assumptions concerning the golden mean, claiming that they were based on “superstition and numerology,” since there were no experimental studies supporting them. His rigorous aesthetic experimental studies with subjects, gave results that problematized the idea that “pure” geometric forms were aesthetically superior to deviating forms (Hesselgren 1954, 61). He was particularly interested in what he referred to as pregnant forms (Hesselgren 1954, 49–78), which were developed by a gradual transformation of one geometric form into another. This type of form was not “pure” yet was considered by many as aesthetically pleasing.

Art historians Gregor and Nils Paulsson (1956, 25) felt that the main goal of a formgiver was to create “beautiful everyday things”. Their definition of beauty was that a product has a “pure gestalt” and they claimed that only experienced formgivers with taste and an open sensitivity can create. This normative and purist attitude of the beauty concept, controlled through the inherent talents of individual formgivers, confines aesthetics to a select group. This elitist attitude was a way for industry to control its aesthetic profile, but it renders aesthetics nearly useless in explorative processes that go beyond taste and individual conventions. For this reason, the contemporary arts have turned away from aesthetics. Leading design firms in Sweden, aiming to develop innovative products, also see the limits of classic design aesthetics and are searching for alternative paths (personal communication with No picnic and Ergonomidesign).

A book celebrating the 150-year anniversary of Svensk Form (the Swedish Society of Crafts and Design) in 1995 still made strong reference to Gregor Paulsson (Wickman 1995) with few critical voices or opposing scholarly views. Linda Rampell’s PhD thesis (2003), *Designatlas*, offers a critical view on Swedish design, which among other things has helped open up the design community to adopt a more self-critical attitude.

Today, design culture in Sweden is in a state of flux and the aesthetic dogma of Swedish functionalism is being questioned as well as part of the taxonomy presented in part 1 of this thesis that supports this geometric foundation with a focus on solid “pure” form.

The scope of this thesis does not offer the opportunity to pursue this subject in any depth. However, I will conclude this passage concerned with beauty and ugliness with some important insight into aesthetics from two influential Swedish scholars, Tom Sandqvist and Gunnar Berefelt. Sandqvist (1998) has summarized how the terms aesthetic, beauty, sublime, and ugly have changed throughout history. His study from an art theoretical vantage point questions our current understanding of aesthetics, locked within the closed arena of beauty and the sublime. According to Sandqvist, historically the term sublime was meant to represent the opposite of beauty, touching on the formless, unlimited, frightening, beyond the limits of cognition, ugly, and free from conventions. Today the sublime is defined as almost a synonym to beauty, such as elated, revered, spiritual, uplifted, inspiring, awesome, etc. (Sandqvist 1998). The aesthetics of beauty, which reject what is ugly and formless, cannot generate new aesthetic reasoning, because it excludes the untamed and complex world that provides new material for developing aesthetics. Gunnar Berefelt’s (1973) research also questioned the norms of beauty. He considered an aesthetic experience to lie on...
### Fields | Examples of systems of aesthetic abstraction
---|---
Music | Symbol-based notation
| Letter notation
Color | Perception-based color system, e.g. Johann Wolfgang Goethe (Goethe 1979 [1810])
| Natural color system (NCS), e.g. Sven Hesselgren and Anders Hård (URL)
Form | Geometric-based system, e.g. Iakov Chernikhov (Cooke 1989)
| Nature-based system, e.g. Denman Ross (Ross 1901)
Space | Space syntax, e.g. Bill Hillier and Julienne Hanson (URL)
| Curved spatial system, e.g. Mikhail Matiushin (Tillberg 2003)
Dance | Geometric combination, e.g. Rudolph Laban (URL)
| Figurative notation, e.g. Joan and Rudolf Benesh (URL)

Fig. 11 Five examples of different systems of aesthetic abstraction inspired by Pehr Sällström (1991).

A spectrum from indifferent to overwhelming, where the “norms” of beauty lie close to the pole of indifference, while chaos and the ugly are at the overwhelming pole.

**Aesthetic abstractions**
The arts, and particularly aesthetics, have modes of reasoning that can deal with complexity in the real world (Nørretrander 2003). The mode I emphasize in the present thesis is *aesthetic abstractions* (see chapter 6, Conclusions, for a model that puts aesthetic abstractions in context with *linguistic* and *numeric* abstractions). An abstraction can be defined in two opposing ways: 1) a general concept formed by extracting common features from specific examples and 2) a concept or idea not associated with any specific features (www.visualthesaurus.com). In the present thesis I use the concept aesthetic abstraction as a mode of extracting, that is connected with specific features and context. Aesthetic abstractions build on embodied experience in the physical world. They are used to simplify or grasp an experience that attempts to be managed in some way. In a formgiving context, aesthetic abstractions are used to either explore and/or organize a project. The present research project is biased towards abstractions in sculpture and architecture, which are defined through structural features and relationships of form in space. Rowena Reed’s and Alexander Kostellow’s work in *visual abstraction* is my main source of reference here (Greet 2002). I changed their term *visual to aesthetic* abstractions to emphasize a more embodied experience, integrating haptic, kinaesthetic and visual/spatial sensitivities.

In the present thesis two possibilities of developing aesthetic abstractions are presented:

1. **Essential aesthetic abstractions**: Immediately felt structural and proportional expression of elements and forces in a composition that gain their role and identity through their relation to a coherent gestalt. This definition builds in part on Max Wertheimer’s work in gestalt theory (King and Wertheimer 2005, 42) as well as on Kostellow’s and Reed’s visual abstractions and idea of synergy (Greet 2002). Essential aesthetic abstractions are focused on an inner sense of form in space and are expressed through the interdependency between direct and indirect perception of movements, forces and proportions (see chapter 4, Methods Part 1 & 2, for further explanation). They are primarily about uncovering compositional structure for the sake of making constructive and sensuous decisions and do not necessarily lead to aesthetic judgment concerned with beauty.

2. **Substantial aesthetic abstractions**: Immediately felt gestalt experience, yet requires active immersed engagement to pick up on the expressed properties and qualities. Substantial aesthetic abstractions involve haptic and explorative experiences. They are more context-dependent and embodied than essential abstractions and are therefore much more complex to identify. John Rajchman (2003, 64) formulates arguments (that are shared by Gilles Deleuze) supporting this kind of aesthetic “exposure” that originates in experimentation. Substantial abstractions are loose enough to be able to adapt to the transforming event which means refraining from judgments like beauty or ugly.
Here are some examples of essential aesthetic abstractions taught by Reed and Kostellow that are presented in this thesis (Greet 2002):
- Elements: volume, plane, line, point, enclosed space
- Axis
- Axial movement
- Direct, position, tip
- Proportion: extension, massive, superficial
- Geometric volume
- Accent, directional force
- Tensional relationships between directional forces
- Oppositional relations
- Spatial organization: static, dynamic, organic etc.

The above terms for defining essential aesthetic abstractions can also be found in the work of such figures as Rudolf Arnheim (1974 [1954]), Gyorgy Kepes (1944), László Moholy-Nagy (1969), Kandinsky (1979 [1926]), and many more artists and teachers.

The various aesthetic disciplines in the art and design community have developed different types of aesthetic abstractions (see figure 11).

Many artists, authors, and scientists have written about aesthetic abstractions. A few central figures are mentioned below:

Rudolf Arnheim explained aesthetic (visual) abstraction as the art of drawing essential features from an entity. He saw abstractions in relation to the organizing principles of the gestalt (Arnheim 1969, 173), as did Reed and Kostellow (Greet 2002, 136–40). This implies that in order to discern abstractions, one must take into account an awareness of particular and overall qualities of the intent of the composition. Arnheim claims that abstractions are the very “basis of perception and the beginning of cognition” (Arnheim 1969, 161).

In his book Beyond Sculpture, Jack Burnham (1978 3–6 [1968]) explained that the development of visual abstractions gave a means for technology to sidetrack aesthetics and our sensuous relationship to the world. He explained that by creating abstract notations of form, one can manipulate and control, rather than take part in, a sensual experience. Burnham showed that despite this detached way of abstracting form that technology aimed for, sculptors eventually developed a way to use abstract reasoning that stimulates our senses. This thesis supports aesthetic abstractions as sensuously derived experiences, rather than detached and uninvolved activities.

**Anti-aesthetic movement**

Since the seventies there has been very little development in understanding the practical application of aesthetics with regard to form and sculptural procedures. By the 1980s, a postmodern, anti-aesthetic movement began, advocated by the October group with Hal Foster (2002 [1983]), Rosalind Krauss, and others. Their theoretical work has had a strong influence over the art and architectural communities, creating an academic vacuum around aesthetic reasoning. In Sweden, Linda Rampell’s (2003) PhD thesis, Designatlas, marks one of the first academic research projects in Sweden that strongly challenged the modern movement and its inclusive attitude of defining “pure form,” abstractions aiming to define a universal aesthetic. Her arguments were that modernist “purist” aesthetics are removed from the everyday world and therefore treat the product in isolation, separated from its context. In many ways, user-based design roots in Sweden never demonstrated the extreme purist version of modernism that was seen in the United States and many other countries. Besides, Sweden’s first formal industrial design department was founded at Konstfack, as late as 1980, so the academic forum to develop and discuss the pros and cons of industrial design aesthetics and processes has been very limited. It is no longer as relevant to state a postmodern argument today, because this movement is declining internationally (Rajchman 2003).

During the past few years, art theorist John Rajchman (2003) has attacked the post modern French theorists, blaming them for breeding a deep melancholy in the art and architectural communities through their critical view. Rajchman refers to an international recovery period in which artists are becoming indifferent to the impossible demands of the post-modern critics. He and others with him see a movement towards a reinvention and/or renewal of aesthetics through the rediscovery of modernist strategies.
2.2 Form

This section offers a definition of form and its organizational capacity through geometric structures and organic principles in an aesthetic realm. A number of artists and researchers are presented below who have contributed to the development of our knowledge of form, mainly in an educational context.

Definition

The concept of form has to do both with the realization of concrete objects and the organization of ideas. It can be used as both a noun and a verb:

- Noun: This is a form.
  - Referring to the physical/spatial dimensions that form occupies and activates.
- Verb: To form an object/To form a concept.
  - The skillful procedures and craftsmanship necessary to make things.
  - The cognitive processes that develop concepts and images driving the formgiving process or any conceptual process that works through aesthetic methods.

This two-fold way of aesthetic reasoning through form (noun & verb) emphasizes the coinciding physical and conceptual aspects of form.

John Dewey (1980, 134–5 [1934]) refers to form as “relationship” and a means of organizing substance into unified wholes. He explains form as a sensorimotor experience with materials that stimulate aesthetic responses (Dewey 1980, 124–5 [1934]). He finds it impossible to discuss form without referring to the role it plays in an event in life. No matter how minimal the expression of form is, it is always about the “organization of energies” that create a life rhythm (Dewey 1980, 162, [1934]). Dewey attributes this rhythm within form as the energy source that engages our emotions, connecting form with aesthetic experiences.

Dewey’s defense of form as a catalyst for relationships through the organization of energy is similar to the way Reed and Kostellow treated it in their educational program (Greet 2002). They taught the importance of sensing the inner movements and forces through and beyond the positive and negative forms. This inner sense of form is the key to understanding how to build a holistic composition. Concrete examples of such compositional studies can be found in Reed and Kostellow’s visual “problems,” presented in the book Elements of Design (Greet 2002).

Geometric form

Most schools of arts, design and/or crafts deal with the complex nature of form by offering basic design courses that study geometric structures (Steinø 2006). These courses aim to give students an embodied and analytical experience of both the organizing capacity and the concrete properties of geometric form.

Art historian Willy Rottzler (1977, 11) claimed that throughout history, mankind has always used geometry to create an alternative vision that reflects a “primary expression of the shaping will.” There is a long tradition in the arts and architecture of studying geometric structures to step outside of this conditions and explore future alternatives. Art historian Alfred Barr, who was instrumental in establishing the Museum of Modern Art (MOMA) in New York City, categorized modern art into two main movements: geometric abstract art and non-geometric abstract art (Encyclopedia Britannica). The emphasis on geometry and abstraction as a means of understanding the main influences in modern art underlines how important geometric abstractions were to the modern art movement.

Art historian Herbert Read (1992, 14 [1964]) has explained that the geometric movement in constructivism and modernism rejected “the human traditions as such together with their organic criteria, in order to create values of a different kind, the absolute value of “pure form.”” The source of inspiration for creating these absolute values came from the scientific world. According to Herbert Read, the modernist artist’s search for pure abstract form invented “the three-dimensional work,” which was constructed instead of sculpted, and which was understood through sight, not touch (Read 1992, 15 [1964]).

Review of geometric form-references

Below is a brief review of constructivist and modernist artists and architects, as well as perceptual psychologists, who have contributed to developing aesthetic knowledge about composition through the use of geometric structures:

- Russian painter Wassily Kandinsky conducted an aesthetic investigation of 2-D compositional elements. His first book—Concerning the Spiritual in Art, published in 1910—discussed the development of an “inner knowledge” of form through abstraction (Kandinsky 1977 [1914]). Kandinsky aimed to dematerialize objects by mapping out the forces in form, and he used geometric shapes to perform his studies (see “Formlessness” section below for Kandinsky’s further thoughts on dematerialization). This book has a very dogmatic tone and mixed his theosophical beliefs with his aesthetic and psychological studies, which makes it difficult to follow
his line of reasoning. However, his second book, *Point and Line to Plane*, has a more open, explanatory writing style that presents principles and relationships that transferred terminology from music to aesthetic elements in a straightforward and illustrative way (Kandinsky 1979 [1926]). Kandinsky’s three structural categories start with point and then move to line and finally to plane. This arrangement reflects a painter’s approach to investigating composition. However, as a sculptor/form giver, I question his arrangement of categories and suggest a reversed order that starts with volume (which Kandinsky did not analyze) and progresses plane → line → point (see Papers I–II).

- Russian architect Iakov Chernikhov translated basic geometric constructions from mechanical engineering into an aesthetic program for basic design in the late 1920s. He explained the different kinds of unions between form in a strict geometric language of aesthetic abstractions that artists could relate to (Cooke 1989). His program explored organizational principles and demonstrated how simple elements can be combined in a multitude of different ways. Many of Chernikhov’s geometric constructions are similar to the form and space experiments that Reed and Kostellow taught at the Pratt Institute (Greet 2002). However, Reed and Kostellow placed more emphasis on proportional contrasts between elements and an asymmetrical organization that connected the inner structure of the geometric form with a similar spatial matrix.

- Russian constructivist Kazimir Malevich taught geometric composition in relation to architecture, urban planning, and painting at VKhUTEMAS in Moscow (Higher State art Technical school that trained artist for the benefit of national economy (Willett 1978)). His concern regarding 3-D composition was about how to cluster rectangular blocks that expressed innovative ways for planning cities. Some of these combinations were vertical stacks resembling skyscrapers, whereas others were spread out and incorporated negative space (Martin 1980). Malevich also used the minimal expression of geometric shapes in his spiritual studies of suprematism. The essential qualities of geometry had parallels with Russian icon painting, which most Russian artists were trained in (Lodder 1987, [1983]). Malevich’s spiritual search through minimal geometric composition was therefore not as radical as it may seem.

- The artists and architects teaching at the Bauhaus were all more or less involved in exploring basic form problems through geometry (Wick 2000 [1982]). The institution’s founding dean, Walter Gropius, explained geometry as a *common denominator* that would offer a foundation for all of the arts (Gropius 1974 [1943]). This search for a new aesthetic way of reasoning attempted to merge art and architecture closer to science and technology, without losing a dynamic rhythm that engaged individual sensitivity.

- Swedish architect Sven Hesselgren’s (1954) thesis on expression of architecture is an extensive research project in aesthetics and semiotics. He explored the perception of form through empirical and theoretical studies of the visual, audio, tactile, and haptic senses. His research included proportional studies of form and space, methods of transformation with continual and discontinual form, open and closed form, comparative proportions, and tone of textural surfaces, as well as color, ornament, and pattern. His systematic studies provide a strong foundation for applied aesthetics. The strength of his studies is that he shows there is no common agreement concerning forms that are inherently “beautiful,” and he has proven that pure geometric forms do not awake a universal feeling of beauty. Hesselgren thus defines applied aesthetics as a discipline that can deal with ambiguity, properties of pregnant form, degrees of articulation in relation to the development of gestalt, etc. (Hesselgren 1954, 60–6, 100). His method was to set up controlled studies of, for example, one form sequentially transforming into another (e.g. a square to a circle) and ask subjects to specify where roundness and squareness are equally expressed. I question some of Hesselgren’s value judgment studies, especially some of his assumptions regarding 2-D outlined forms and photographs of products and architecture in reference to perception of 3-D physical forms.

- Since the 1970s, perceptual psychologist James Gibson has argued against this mixing of 2-D and 3-D perceptual findings (Gibson 1979, 83), which has confused research in 3-D form perception for centuries. In some schools of perceptual psychology, there is an assumption that the sharp contour of a 3-D form or a 2-D illustration of a form projected on the retina is the first feature that is detected, followed by the perception of depth. Based on empirical experiments that studied foreshortening of form as it moves back in space, Gibson claimed that we perceive form through a “direct pick-up of solidity,” telling us an object “is in fact voluminous” (Gibson 1979, 83). Gibson offers a way to understand form that is based on volume perception instead of silhouette and contours, matching the sculptural approach Rowena Reed relied on (Greet 2002, 106).
2. THEORETICAL FRAMEWORK

- Francis D.K. Ching (1979) also developed a system for ordering form and space within an architectural context. His aim was to present a “morphological study of the essential elements” through drawing skills. He covered a wide range of visual principles that showed how different elements may be organized into unified architectural structures. He recognizes Rudolf Arnheim’s visual perception, gestalt theory, and the building traditions of Vitruvius.

- İlihan Koman worked through a practice-based method that started with a 2-D geometric form that developed into hyperforms through twisting, folding, and curving the surfaces (Koman 1994). Koman used the tensile structure in the material to strengthen the form, which added curvatures, giving a very organic quality to his work.

- Wong Wucius (1993) developed a visual grammar of 3-D and 2-D form. His approach to 3-D form was through a complex method of folding, which resulted in constructed planar volumes made up of repetitive patterns.

Many other important artists and architects have contributed to developing knowledge about geometric structures and how they interact in space. To mention a few:
- Donald Judd: repetition of positive and negative volumes (Zelevansky 2004)
- George Rickey: kinaesthetic sculptures of lines at oblique angles (Rickey 1995 [1967])

**Geometric and organic form**

There are strong traditions in art and design of merging geometric structural analysis with organic principles of growth and tension. Two main paths of organic reasoning are presented here:

1. *Human figure studies* based on classic artistic training through drawing and sculpting with roots in the work of Michelangelo and Rodin. These teaching methods prioritized touch and have survived over thousands of years (Read 1992, 11–7 [1964]).
2. *Nature studies* of living organisms and phenomena based on learning how forms are generated and degenerated in nature. The Sydney Opera house, designed by Jørn Utzon, applies this type of organic thinking (Thompson 1961, Weston 2001).

**Review of geometric-organic form references**

Below is a brief review of some artists and scientists who have contributed to uniting geometric and organic aesthetic reasoning:

- Sculptor Rowena Reed and painter/psychologist Alexander Kostellow merged geometric abstractions with organic principles of growth and tension, mainly based on human figure studies (Greet 2002). In the present thesis, Reed and Kostellow’s vision of merging geometry with organic principles will be referred to as geo/organic vision. They developed their theoretical framework and their geo-organic vision through teaching and curriculum development. Each course explored a number of principles that were embodied in 3-D models and successively built on the experience of the prior course. Their geo-organic vision of form was, in my opinion, their major contribution to applied aesthetics. The present thesis is strongly influenced by this vision.

  The 3-D principles, developed from assumed principles of beauty and growth, were inspired by classic sculptural traditions that Reed acquired through her many years of training in sculpture (Greet 2002, 104–7). She did not refer directly to the body, but rather abstracted the convexities and concavities from figure studies and allowed for a more plastic composition.

  Reed’s way of working with form opposed the superficial focus on the outline of form, which is common in design. She applied organic principles built on the experience of form from the inside out and all-roundness. Her argument for this inner and under-the-surface approach was that if you design the outline first, then the volume will be subordinate to the outline, which may force the volumes into spatial positions that are contorted and insensitive to the 3-D qualities of the all-round form. She taught the logic of her reasoning by starting with general rough volumes and organizing them in space with attention to the inner axis and the proportions of the volumes. The shapes of the major surfaces are secondary and express the inner movement, which controls the outer contours (Greet 2002).

  Reed’s main influence came from Russian sculptor Alexander Archipenko (personal communication Reed 1978), who was known for his work with both geometric abstraction of the figure and studies of convexities and concavities (Karshan 1989). Archipenko was one of the first sculptors who worked with void, treating it as if it were positive form (Archipenko URL). Similar ideas about inner movement through volumes can be found in the work of sculptor Henry Moore (Read 1992 [1964]), sculptor Anish Kapoor (McEvilley 1990), and architect Jørn Utzon (Weston 2001).
Reed and Kostellow deconstructed visual abstraction from geometry into forms, movements, and relationships in order to integrate them with organic principles of growth, movement, tension, gesture, asymmetrical composition, etc. Reed then developed this spatial reasoning further and the last two to three decades of her life were devoted to expanding and activating space. She even classified space into three categories; static, dynamic, and organic (Greet 2002).

It was this open approach to geometry, figure studies, and void/space that gave a unique coherency to Reed and Kostellow’s educational program, distinguishing it from the different approaches developed at such institutions as the Bauhaus School, Germany (Wick 2000 [1982]) and the VKhUTEEMAS in Moscow, Russia (Lodder 1987 [1983]).

Oskar Schlemmer developed what he called *anthropocentric constructivism* in 1915, which was a synthesis of geometric form and the human figure (Wick 2000, 259 [1982]). He applied geometric abstraction to the body by translating the ribcage to a square, the neck to a cylinder, the head to a circle, etc. Schlemmer emphasized the importance of studying the human body, because the abstractions, laws, and rhythm one learns through the body are much different than those learned through pure, abstract, geometric composition (Wick 2000, 260 [1982]). Schlemmer’s choreographic work for dance was built on forces expressed through dynamic rhythm. He brought attention to the movement of the human body in relation to the 3-D cubic room (Hopsch 2002).

Vladimir Tatlin and Mikhail Matiushin (Lodder 1987, Chapter 7 [1983]) became interested in studies of nature and living organisms to inspire and enrich their methods of working with law-bound geometric pattern. These growth principles gave life to their compositions and tempered the mechanical, systematic, geometric approach that engineers used to control form. Tatlin and Matiushin began to question the way art was becoming mechanized and advocated for a more artistic way of reasoning and a return to organic principles that could inspire technology. They attempted to start a movement called *organic constructivism* in 1923 (Lodder 1987, 212 [1983]), which developed first from curvilinear geometric structures. Later the movement took on tensile structures of materials, all-round spatial perception, referred to as zorved.

Tatlin and Matiushin were also involved in studies of the efficiency and energy-conserving qualities of the anatomy of animals, what today might be called a “bionic” approach. They were interested in expanding perception through all of our senses. Matiushin did extensive work in vision to include tactility and hearing (Tillberg 2003, 148–60) as well as “vision without eyes”, which dealt with visualizing a work of art before it was painted. However, their organic constructivism movement never gained any attention and was eventually ignored. Matiushin developed visualization models and manuals outlining his work in aesthetic reasoning of color, form and space (Tillberg 2003). Tatlin and Matiushin were central figures in the foundation of constructivism, which prioritized geometry and
questioned mechanistic thinking in the constructivism/productivism movement that worked with industry (Lodder 1987, 223 [1983]).

- Naum Gabo played an important role in establishing the Russian Constructivist movement and was instrumental in introducing a geometric-organic approach. Gabo’s geo-organic interpretation was based on tensile structures and spherical curvatures (Nash & Merket 1985). Although Gabo, Tatlin and Matishun were all involved in expanding constructivism beyond the limits of geometry, the theoretical and educational implications of their organic reasoning did not gain popularity within the movement.

- Robert G. Scott (1951) has presented a comprehensive approach to basic design principles. He started by defining form through contrast, rhythm, and figure organization, which refers to principles of gestalt psychology. His work uses both geometric form and plastic organization.

- Stephen Luecking’s (2002) work has roots in sculptural traditions combined with the logistics of engineering. He merged 3-D form with meaningful compositions and utilitarian functions in relation to simple elements of form as well as to complex classical sculptural work.

- In Mine Öskar’s (2004) PhD thesis in basic design education, based on the work of Denman Ross and Arthur Dow, she argues that training in the rearrangement of geometric elements improves designers’ ability to both recognize emerging compositions and develop desired strategies that optimize limitations. Through reasoning with simple forms, one can create a composition that has the potential to be recomposed in different ways, creating an array of compositions that express different qualities.

- Perceptual researchers Irvine Biederman and David Marr show that we intuitively understand the physical world through geometric abstractions. The structure of geometric volumes is easily understood, because the straight symmetrical axis in the volume and different shapes (e.g. cylinder, cone, sphere, rectangular volume, etc.) are easily discernable even in rough models. Irvine Biederman’s (1987) research on geons (figure 12) and David Marr’s (1982, 305–20) 3-D models explain our inherent ability to recognize geometric 3-D volumes (figure 13). Geometry helps to limit the possibilities of how to interpret the situation. Geometric volumes are built up around axes that define a simplified structural framework of the volume. An axis is an imaginary line within a form that elemental parts may be referred to. Still life studies and human figure studies apply such axial analysis (Hoppsch 2002).

Defining the inner axial movement and structure of a form or enclosed space is a classic method from painting and sculpture for dealing with complex compositions. David Marr has done extensive research concerning shape recognition through the awareness of axes. These axes, “determined by salient geometrical characteristics of the shape,” define what he called an “object-centered coordinate system” (Marr 1982, 298–320). According to Marr, actively perceiving and conceptualizing the coordinating role of axial structures is the most efficient, stable, and sensitive way of understanding shape (1982, 301). Marr’s reasoning about axes is very similar to their way Reed/Kostellow built up their visual structure (Greet 2002).

- Neurobiologist Semir Zeki (1999) also conducted empirical research that attempted to explain the drive behind aesthetic abstraction and the use of geometric structures in compositional development. Zeki’s research involved studying how the brain responds to different stimuli, such as the orientation of elements and their movements and contrasts. He also studied the work of artists such as Paul Cézanne, Piet Mondrian, Kazimir Malevich, and Ben Nicholson to learn about the way artists sacrifice information in order to express essential qualities that rely on geometric structures. Zeki’s own interpretation was that the artist’s use of geometry implies that the brain responds optimally to geometric form, because large groups of brain cells respond selectively to simple organized form (Zeki 1999, 112–3).

Form defined through 3-D computer modeling

3-D computer modeling technology has been extremely useful for developing software that builds up complex forms by transforming geometric volumes or changing topological points. The toolbars in modeling programs are organized into a variety of geometric primitives, such as sphere, cube, torus, and cylinder. These primitives can then be modeled through transformations, intersections, deformations, etc., in an X, Y, Z matrix (O’Rourke 1993/2003). The software programmers tutor the user in a sophisticated understanding of form, structure, space, texture, light, and so on. Before 3-D computer modeling technology was available, our first-year ID students at Konstfack had little active knowledge of geometric form. Today, designers are much more knowledgeable about geometric form, constructions, nanostructures, and more.
However, there is still a lack of aesthetic awareness and discussions concerning virtual and physical form and material development.

I recognize how potent this virtual world is for changing both our understanding of form and the formgiving/industrial process. Computer technology is one of the strongest drivers of research development in the field of form. However, I question the one-sidedness of a design process that relies too heavily on pure retinal input and ignores the other senses.

### 3-D printers

This thesis does not go into the way computers have affected form, mainly because my own experience is very limited, since Konstfack has a human-centered, model-making profile with little support from computers. We are waiting for 3-D printer technology to support the formgiving process by easily and economically making virtual models physical. Jan Capjon’s (2005) recent PhD thesis in industrial design presents empirical projects that skillfully alternate between the virtual and real worlds through rapid prototyping technology/3-D printing. Capjon’s research is very promising because his empirical studies underline the importance of bringing a number of virtual forms into the physical world to be tested and manually transformed at many phases within the formgiving process. In his laboratories at the Oslo School of Architecture, he uses technology in a very human-centered way. Eva-Lotta Saltnäs’ (2004) recent PhD thesis in human-computer interaction also presents evidence calling for a more embodied experience in innovative design processes that are developed in design teams working together around the world. Her findings state that the design process does not develop well if the team members do not have haptic and face-to-face experiences throughout the product development.

### 2.3 Formgiving

Although the papers presented in this thesis have only slightly touched on the design and formgiving process, my understanding of form and abstractions is directly related to these processes. I therefore introduce the concept formgiving and some theoretical background to the activity of creating concrete artifacts.

**Definition**

The concept of formgiving is briefly explained in the introduction of the present thesis. It is derived from the Swedish and German words formgivning and formgeben, meaning to give form as well as color, texture, sound, etc. to concepts, needs, and desires of contemporary society. It has roots in the collaboration between arts/crafts and technology that is involved in serial production. Historically, the Swedish word formgivning referred to a gestalt process assumed to rely on unique artistic talent alone and which could therefore only be carried out by chosen talented individuals in a solitary activity (Paulsson and Paulsson 1956, 98).

This idea of formgiving as an inborn personal talent reflects the attitude in the first part of the twentieth century when the identity of an artist and artisan was a person who skillfully expressed themselves through a medium. Today, designers work in collective situations with many other disciplines that aim to mix the skills and sensitivities of individuals to express the intent of the project. The expression of the unique individual character or profile of an artist or formgiver can be very submerged in one project, and yet be a central focus in another. In this thesis, I argue that there is always an element of individual expression in the formgiving process, because it actively engages value judgments and aesthetic sensitivities that are essential for the development of holistic imagery. These sensitivities have to do with an individual’s ability to discern contrasts, tensions, proportions, coherency, balance, etc. The important issue today is that we are much more capable of coordinating and engaging the individual sensitivities of designers and artists, as well as other professionals, in collective problem-solving processes.

From the beginning of the industrial revolution until the 1970s, the central task of the formgiver/industrial designer in Sweden was to integrate user needs with function and technological requirements in an aesthetically unified artifact (Paulsson and Paulsson 1956). Designers were therefore able to concentrate on the formgiving process.

In Sweden, formgivning was considered synonymous for the concept of design up until the 1970s. By the 1980s the word formgivning was replaced with the international term industrial design and the identity of a designer was no longer linked to the arts and aesthetics. Today, design is a multidisciplinary process involving much more than the realization of tangible products and the shaping of artifacts. The formgiving process can therefore be considered an activity that works within a design process. However, the design process today does not necessarily have to include a physical product and can be systematically carried out without relying on aesthetic or visual inductive reasoning (Goldsmith 2001). When a formgiving process is applied, there are no clear boundaries between the formgiving level and the design/planning level, because aesthetic reasoning in formgiving activities can be used to solve conceptual problems that do not have direct links to the shaping of a physical object.

Psychologist Edith Ackermann (2006) argues for inductive
reasoning and the use of physical forms to enhance our way of “making ideas tangible.” She suggests that tangible forms offer the chance to negotiate meaning, as well as to discover meaning through our embodied experience.

**Gestalt**

Gestalt is a central concept for understanding applied aesthetics and the formgiving process. Gestalt originally stems from German and refers to the forming capacity of our senses to recognize holistic structures through the interdependency of the role the parts play in the composition. The word gestalt can be found in many English dictionaries, but is not commonly used.

To further explain this concept, I summarized the early work of Christian von Ehrenfel and Max Wertheimer, who renewed the concept and brought it into an aesthetic realm. Von Ehrenfel's experience in music led him to describe gestalt qualities in 1890 (Behrens 1998). In this paper, he proposed to redefine the German word gestalt by explaining that the elements gain their character through their role in the “compelling power of the composition that holds our attention over time.” In the same paper, Ehrenfel brought up the commonalities between 1) Objects that activate space and 2) Audio melodies that are expressed over time (Behrens 1998). He saw these two experiences of space and time as inseparable and explained their unifying character through gestalt. Max Wertheimer, a student of Ehrenfel, collaborated with him on the further development of the gestalt concept based on conducting studies in visual perception. These studies involved what he called hidden forces, which are inferred through indirect perception. In 1912, Wertheimer published Experimental Studies on Seeing of Motion (King & Wertheimer 2005, 75). This work involved identifying apparent motion between two blinking lights that were placed apart from each other. His studies showed that test subjects perceived the light as moving from one position in space to the other and then oscillating back again, despite the fact that the light sources were stationary. The scientific community considered these findings, which did not correspond with the physical facts, as illusions or misperceptions. Wertheimer, however, insisted that perception can be based on more than the measurable physical stimulus and how it is represented on the retina. He wrote about hidden forces and invisible activities (Wertheimer 1997 [1924]) that are part of our perceptual experience, and included Kinaesthetic forces that create a deeper structural organization going beyond the physical features. Wertheimer attributes this deeper structure to the intentions of the composer or participant. Experiencing a gestalt therefore includes the physical properties of an event and the emotional state and cognitive intention of the individual. Wertheimer collaborated with Kurt Kaffka and Wolfgang Köhler, forming a group referred to as gestalt psychologists. Their visual research on part, motion, and interrelationships between elements across space (King & Wertheimer 2005, 155) was performed by arranging dots, straight and curved lines, lights, and a variety of geometric 2-D figures. These compositional studies resulted in a definition of the “laws of organization in perception of forms” (Wertheimer 1997 [1924]). Each law is correlated to a specific perceptual study such as similarity, proximity, closure, and continuity, as shown in figure 14.

The empirical research of the gestalt psychologists brought attention to the interrelationship between tangible and intangible properties, as well as to how the intentions of the composer drive the development of a gestalt.
Many of the visual laws from gestalt psychologists primarily apply to 2-D flat pattern recognition. The fixed view of a 2-D image makes it easy to recognize the overall figure and see how the hidden forces move between points. The reference to geometric, graphic surfaces and smooth, continual lines also reduces complexity and strengthens legibility. The relevance of these 2-D laws to the aesthetic experience of 3-D artifacts is an issue I take up in the present thesis. It is important to deal with the multiple dimensions that physical artifacts offer. This includes many different viewpoints as well as an embodied experience, all of which greatly affect how the gestalt is developed and perceived. Physical all-round 3-D perception involves a much more embodied experience than 2-D pattern recognition. Nevertheless, the conceptual idea of gestalt is a very useful concept in aesthetic reasoning. What I find important in the work of the gestalt psychologists is that their initial discoveries were made through the arts; first in music and later applied to the visual perception of graphic shapes. Wertheimer’s passion for music and his aesthetic sensitivities for discerning tone and compositional features led him to write his first article about the interconnected organizing structure of gestalt (King & Wertheimer 2005, 80–1).

Application of gestalt laws of perception

Rudolf Arnheim is a central figure in American art education who applied the gestalt laws of perception to how we visually perceive art. Arnheim studied with the gestalt psychologists in Berlin and did his PhD thesis in perceptual psychology. His book, Art and Visual Perception (Arnheim 1974 [1954]), is one of the most influential books in art education today. His work is focused on visual abstractions and gives detailed explanations of how to analyze compositions through perception of inner axial structures and the interrelationship between direct and indirect perception. Arnheim (1969, 153-87) argues that we have an inborn capacity to comprehend and perceive abstractions. He explains that visual abstractions take place in perception and are not divorced from context or invented by the mind alone. Visual abstractions are always discerned in direct relationship to the holistic gestalt (Arnheim 1969, 161). Arnheim also reversed this statement, claiming that a holistic gestalt presupposes abstractions. An individual’s ability to perceive abstractions is therefore directly correlated with how a holistic image develops (see section Aesthetic abstractions above).

Gyorgy Kepes (1944) compiled visual principles in a comprehensive book about painting composition entitled Language of Vision. Kepes acknowledges the work of gestalt psychologists, who inspired him in his development of illustrations and explanations of the aesthetic laws of visual organization. Kepes was instrumental in what he called the “visual re-education” of artists by teaching systems of abstractions that he claimed would “mobilize the creative imagination for positive social action.” Kepes (1965) edited a series of books on Values and Vision as well founding MIT’s Advanced Center for Visual Studies, which brought artists and scientists together in collaborative projects.

The whole idea of gestalt was to understand and support the creative process of performance and compositional work. Arnhein and Kepes show a particular way to understand the relationship between form and gestalt through application.

Gestalt/haptic and Kinaesthetic

Although gestalt implies a holistic experience that engages our human capacities from intellect through emotions to all our senses (King and Wertheimer 2005, 41–4), today we associate it with the visual principles of form from Wertheimer’s research with dots and indirect perception (King & Wertheimer 2005, 155). The present thesis emphasizes form in relation to the active, embodied process of creating a holistic gestalt that begins with an inner sense of form (see section 2.2, “Form”), which is more than a visual experience. Formgiving is performed through an engaged and interactive contact with form and material. The results of the formgiving process also include color, sound, taste, and smell; however, my experience from teaching industrial designers is limited to experiencing form through sight and the use of our body movements (kinaesthetic sense) with particular emphasis on how our hands test and shape materials.

Perceptual psychologist David Katz (1989 [1925]) was also an advocate of the gestalt movement. His research in tactile, Kinaesthetic, and haptic senses concerned how our bodies respond to direct stimuli imposed on us from the outer world, as well as how we use our bodies to explore and intentionally feel our way through the complex world (Katz 1989, 83 [1925]). Katz emphasized our need for movement of our bodies and putting our hands on and around a form or material (figure 15) in order to create an impression of its properties, proportions, pronouncedness, density, weight, etc.

Katz (1989, 79–84 [1925]) explained that the intentional movement of our limbs, purposive touch, carries a creative force, which I feel is important for the development of our understanding of the formgiving process. Through Katz’s work, we can find theoretical and empirical support for the need to experience direct contact with form and substance through our hands and bodies.

Active formgiving process
There is very little research and documentation of the active formgiving process showing the skillful aesthetic reasoning applied in shaping artifacts. This is a dilemma for the field of design, because the concrete product mediates decisions of the design process; yet we know so little about what is going on within the formgiving process. One obvious reason for this lack of research in understanding form and the formgiving process is partly related to the problem of documentation. To be able to transfer the first-hand haptic, Kinaesthetic and visual/spatial experiences that are linked to the dialogue within the formgiving process requires documentation from an insider’s vantage point that can record knowledge in action (Molander 1996, Chapter 10). The scope of the present research does not include detailed documentation of the formgiving process.

Anders Warell’s (2001) PhD thesis aims to bridge active applied aesthetics with technology through a model referred to as form syntactics modeling. His research defined form elements and form entities of a product, aiming to draw attention to the wholeness of the form. He looked for ways to deal with alternative visual form solutions, mainly through 2-D sketching methods. Warell’s process is only applicable in the late or final phase of the formgiving process, after the main gestalt process has been developed.

In a recent PhD thesis on branding, market researcher Toni-Matti Karjalainen (2004, 30) addresses a lack of knowledge of the formgiving process:

In the same breath, three-dimensional product characteristics are those that largely dictate the interaction between the company’s product and the customer. In this sense, it is surprising how little research exists on the relationship between three-dimensional product design and brand.

(Karjalainen 2004, 30)

Karjalainen’s research focused on how visible form language and design cues communicate brand identity. The interviews he conducted are very useful for the present thesis, because they include comments about the design process that explain the need for a balance between the degree of novelty and the consistency of product profile (Karjalainen 2004, 176–8, 204). I am interested in how this balance is achieved and the unpredictable and contrasting nature of creating a combined vision of a gestalt.

Jan Capjon’s (2005) research on the formgiving process involves combining rapid prototyping technology and manual skills for shaping products. Capjon (2005, 166–88, Chapter 10) has further developed David Kolb’s “experiential learning model” into the presented “Plant of Emerging Materiality” model (PoEM), which gives technology and the embodied aesthetic process equal roles in defining the physicalities of the product. Capjon deals with form through an aesthetic awareness and play in collaboration.
with Erik Lerdahl (2001). He argues that the interpretive aspects defined in research in semiotics, do not deal with the form parameters in the early making process (2005, 202–3). Capjon states that there is an unnecessary tension today between the semiotic aim to interpret and the aesthetic aim to sensuously perceive form. He is against such dualism and offers the PoEM model to unite the verbal and perceptual experiences. I see Capjon’s research as pioneering, because it offers a method of bringing human aesthetic perception of users and designers together with high technology that explores 3-D physicalities of form.

**Play**

Fredrik Schiller’s (1995, 82 [1795]) letters on Aesthetics from 1795 advocated that play catalyzes aesthetic experiences and expressions. He regarded spontaneous play as a means of emancipating our senses and bringing one in touch with a richer awareness of the perceptual world. Play, he claimed, is a necessary activity to expand our consciousness and bring life to the development of the gestalt.

The design process is often dependent on the playful activities of designers, and we consider play as a counterbalance to the systematic and rational demands during the design process. Through the unconditional and explorative process of play, people get involved and interact spontaneously, relying more on their senses than on their rational mindsets. Barbara Marie Stafford (1994) regards exploratory play as a means of educating, because it helps develop the ability to synthesize, which is of vital importance to the design process.

Using aesthetic reasoning that involves play is part of our design educational traditions as well as of the practice of design. Erik Lerdahl’s (2001, 21–9) PhD thesis defines play as a means of developing creative collaboration in design teams. Play has also been used as a catalyst for discovery in a newly developed master’s course, “Research by Design,” at Chalmers School of Architecture, Sweden (Dyressen and Billger 2005). This course gives a holistic experience to the students that takes them through 1) a playful discovery process; 2) the development of methods and procedures; 3) the articulation of hypotheses; 4) the development of visualization models; 5) academic writing skills in formulating an abstract for a conference; 6) the design of a scientific poster; and 7) preparation for a short conference presentation. By directly involving students in a playful and provocative discovery process, they efficiently learn the formalities of the research process. (Dyressen and Billger 2005).

**From aesthetics to communication**

The Swedish industrial designer Rune Monö (1997), with whom I have collaborated for more than a decade, presented what he considered a holistic view on the product design process through a theoretical model shown in figure 16. This model consists of a triangle with the three sides labeled communicative, ergonomic, and technical. Two rings representing ecology and economy encircle the triangle.

I argue that if Monö’s model aims to be holistic, he needs to include aesthetic reasoning that goes beyond the conventions of semiotics. In his theoretical work in the aesthetics of design from a semiotic approach, he strived to “read” products through their visual signs and codes (Monö 1997, 117). Monö’s overriding aim was to support an understanding of products that was as unambiguous as possible. His quest for meaningful visual communication ignored the aesthetic relationships that hold the holistic gestalt together. Monö also presented a
dismantled mechanical device (a regulator) (Monö 1997, 32–3) as an example of a gestalt supporting an atomistic, mechanistic and reductionistic scientific approach, which is entirely opposite to the holistic gestalt that Wertheimer advocates. As a matter of fact, Wertheimer and von Ehrenfel specifically stated that a holistic gestalt can be transposed into a different set of elements, which are independent of the isolated qualities of the separate elements (King and Wertheimer 2005, 42–3). Gestalt is thus about emerging properties that are unpredictable in relation to the parts. I need to make it clear that gestalt and aesthetics are not meant to be treated through a reductionistic, mechanical approach. Through my years of teaching with Rune Monö, I know he was open to a more aesthetic and inclusive approach to support the formgiving process of our ID students; however, his applied theoretical work in his book “Design for Product Understanding” (Monö 1997) does not reveal his aesthetic reasoning or the interdependency between semiotics and aesthetics.

Finnish industrial designer and design theorist Susan Vihma (1995, 151–68) has studied the relationship between aesthetics and semiotics; however, the scope of her doctoral research restricted her to the representational qualities of products, which made it difficult to defend many aspects of aesthetic experience. Vihma clearly states that the intentions and aesthetic preferences of designers play a significant role in product development. Her creative way of mapping out the steam iron demonstrates her awareness of the role art and aesthetics have had on industrial product development (Vihma 1995, 101–22).

A recent article about the history of aesthetics in design in France explained the gradual shift from aesthetic exploration to communication and information (Le Boeuf 2006) as outlined in figure 17.

Replacing aesthetic reasoning with communicative reasoning has had a profound effect on the design profession. In the foreword to Klaus Krippendorff’s (2006) book, “The Semantic Turn”, Bruce Archer summarizes Krippendorff’s contribution in the following axiom:

*Humans do not respond to the physical properties of things to their form, structure and function but to their individual and cultural meanings.*

Bruce Archer (Krippendorff 2006, foreword)

Krippendorff (2006, 283) endorses this axiom in his book and explains that semantics takes a distinctly different route, turning away from aesthetics and towards a sociolinguistic view. He argues that we cannot experience attributes that we have not verbalized. This statement goes against research in embodiment (Damasio 2005 [1994]), which says that most of our reasoning is not on a conscious level and that sense perception, emotions, and feeling play a central role in how we reason. What worries me about Krippendorff’s need to place language and cultural meanings first is that he puts design in the intellectual/social world and gives less emphasis to the aesthetic/sensory world.

What is vital about aesthetic reactions and reasoning is their capacity to explore and organize phenomena and situations that have not gained the attention of society at large. Antonio Damasio’s (2005 [1994]) research states that sensuous experience is extremely important for decision making, because we can rely on our sensitivities to emphasize certain alternatives over others. Without these somatic mechanisms we would be overwhelmed by our pluralistic and complex society. One way to understand what this embodied aesthetic experience involves is to work with processes that are strange and formless and thereby not easily understood in terms of social meaning.

### 2.4 Formlessness

In keeping with Reed and Kostellow’s support of the arts and my own search to understand form through negative-form void and material breakdown, I embarked on explorative studies of formlessness (see figure 18).

**Paradox**

The following passage embarks on a paradoxical task, which defies the very nature of formlessness. My plan is to place the theme of formlessness within the walls of academia, attempting to define the concept from different vantage points that I have found relevant. Since this is an empirical, rather than theoretical, thesis, I have not attempted to cover the theme formlessness in depth. My mapping of formlessness has developed in an ad hoc way, because my drive to explore it was intuitive, not theoretical. The longer I worked with form and formgiving in the industrial design educational community, the more claustrophobic I felt. Working with formlessness brought me back to an immediate, improvisational and embodied working method that I was loosing in the design world. Moving theory and methods of formlessness through an academic process has intensified the discovery process, because I was able to share laborations with other researchers. Yet, the academic writing phase has forced me to retreat from the immediate experience and return to reflection and disembodied, theoretical working methods, which are contrary to formlessness. Nevertheless, I defend this academic process, because it has been the only way to put these conflicting experiences on the same table.

This section on formlessness aims to give theoretical support that can reorient aesthetic reasoning in order...
to deal with change and uncertainties. It involves an inclusive, open attitude that embraces emerging and transforming phenomena. Some sources of inspiration for the conceptual development of this section is found in the field of complexity (Gell-Man 2003), since it is concerned with studies of chaos and order in relation to disorder. I also refer to theoretical and practice-based work in the arts concerning the theme formlessness (in French, “informe”) (Bois and Krauss 1997) and John Rajchman’s work in relation to Gilles Deleuze concerning transforming aesthetics and the “science of the sensible” based on unconditional experimentation. A last source comes from the contributions from perceptual psychology that study blur, blobs, and gradation.

The question this section addresses is: how do we develop aesthetic reasoning that can follow the emergence of new structures as well as the breakdown of old structures? What abstract principles (if any) can we formulate that can offer a means of orientation as materials change and transform? Or, perhaps even more importantly, what concepts of reality do we need to help us deal with formlessness? Can a form-based taxonomy expand to include events and changing phenomena? Or is there, as suggested by George Bataille, a way to make a “taxonomy of disorder” (Bois and Krauss 1997, 18)?

Context, change, and event

A physicist looks upon the world as energy, matter, and forces operating in space—an isolated, stable object in space does not exist in the physicist’s view of the universe (Greene 2000, 79). The contemporary world of art has shifted its attention from isolated art objects to the contextual conditions that generate and underline a work of art or an installation (Bourriaud 2001). In effect, like physics, art has cultivated an approach in which genesis is more important than a concrete expression in space. This shift to context, change, and event has challenged the limits of object-based aesthetics. My goal in this section is to find theoretical and practice-based sources that expose the strengths and weaknesses of investigating formlessness.

Art historians Yve-Alain Bois and Rosalind Krauss (1997, 18) charted and reconceptualized the field of formless as an alternative way to approach the unknown and avant-garde. A central figure in this field is George Bataille, who explored the formless to find freedom from conventions.
of representation. He refused to define the word formless (informe) (Bois and Krauss 1997) and declared that formless is understood through the immediate experience. The formless takes on different shapes and conjures up unexpected happenings that can not be repeated. Due to this constant transformation, the formless has no sharp contours or stable structures, making it difficult to literally grasp and control. Bataille started the informe movement with the aim of sabotaging the academic world and its need to categorize and organize. Bataille saw formlessness as a means of provoking an embodied, erotic response through the “impurity” of substance and the amorphous nature of material (Bois and Krauss 1997). Although my exploration of formlessness through my work in art and complexity does not reach the depth of Bataille’s experience, I have approached it to problematize the field of aesthetics and go beyond social conventions and essential aesthetic abstractions. The concepts formless and formlessness are very pluralistic, which can be shown in the map of synonyms in figure 18, inspired by Thinkmap Visual Thesaurus (URL). The synonyms are clustered without any hierarchy.

The material in this section is presented through five different areas that link to various laborations, courses, works of art, and literature references that have inspired the development of the thesis.

Five areas of formlessness:

- **Void**
  - Empty space,
  - Blur
- **Transformation**
  - Distortion
  - Irregularities
  - Asymmetry
- **Amorphous phenomena**
  - Blob
  - Decomposition and breakdown
- **Haptic and kineasthetic**
  - Movement and intention
- **Emerging properties**
  - Conflicting forces
  - Context dependency

**Void**

Kazimir Malevich and Alexander Archipenko were both challenged by the mathematical concept of zero and explored ways to transfer this concept into their art. Malevich used geometric shapes to express his interpretation, and his famous Black Square was part of the “Zero, ten” exhibition in 1915 (Kovtun 1989, 157). Alexander Archipenko’s interest in the concept zero was inspired by
his father, who was a mathematician. His aim was to give void (zero) a predominant role in his sculptural composition (see figure 19).

Reed and Kostellow emulated Archipenko’s way of materializing void through the direct and indirect properties of form into their educational program.

Sculptor Anish Kapoor’s work is also devoted to exploring what he calls void fields, offering a hidden space for the unconscious (McEvilley 1990). Kapoor’s work with form is very much about negating form by expressing forces through and beyond material.

Empty space
Wolfgang Goethe studied the polarity between empty space and matter. His method for conducting his studies was to observe “truben” or fog/cloudiness, which fills space (see figure 20). He saw the particles of clouds as a “primary phenomenon” (in Swedish: “ur-fenomen”) in nature, because they make up the first step towards the embodiment of space/room (Sällström 1993, 106–11). He considered clouds as a medium for the further development of color theory in relation to light and darkness. Goethe emphasized human perception, which connected him with art more than science (at that time). His observations showed that yellow is the first color that is expressed in clouds in relation to light, and bluish/violet in relation to darkness (see figure 21).

Blur
Visual psychologist David Marr (1982, 56) stated that perception is all about the detection of intensity changes. His research involved studying blurred images to emphasize contrast and to fuzz the physical boundaries and edges (figure 22). Marr believed that the “heart of perception” is to grasp the structure of things in the real world and that blurring their images is a means of understanding this structure. This method of blurring is also common in the arts. See also blob below.

Transformation
Transformation involves the act of changing from one form or state to another. Material transformation can occur as a gradual modification, so that the original form can be observed more or less throughout the process or as a radical change, where the material is transformed at the root. These changes can come from internal or external processes or forces. One example of radical change is defined by philosopher Manuel de Landa (2000, 60) as a transformation process that changes between scale entities. He uses an example of a loose collection of pebbles that transform through sedimentation into large-scale rock. Delanda refers in turn to Deleuze and Guattari, who call this scale-to-scale transformation “double articulation.”
**Distortion**

To distort means to alter the original shape of form by introducing forces that expand, contract, twist, turn, and so on, changing the structure of the form. Despite distortion, the identity of the original form is still expressed. To distort implies a process that refers back to the recognizable shape in order to grasp the features of the distorted form (see figure 23). Malevitch used distortion of rectangles and squares, as well as diagonal placement of elements to develop a sense of floating and fading away, which were the aesthetic aims of dynamic suprmatism (Moszynska 1990, 60–2).

In computer technology, distortion usually refers to the increase or decrease of space between designated points (Ware 2004, 340). Distortion relies heavily on indirect perception, because the distorting forces move within and beyond the form.

**Irregularities**

Irregularities are what give life to a system. When unexpected features take the place of expected features, this is what makes something stand out and gain identity; see figure 24. Learning to prioritize regularities and ignore irregularities may inhibit one’s appreciation of complex relationships and events. Physicist Murray Gell-Mann (2003) has observed such problems with the way scientists tend to work. His years of experience in research into complexity have brought him to the conclusion that if we focus too much energy on learning to see order, we tend to see order where it is not. Gell-Mann explains that since the universe is a dynamic, changing system, there is a need for alternative methodologies that support studies in irregularities.

In the arts, we explore the irregularities and deviating characters of individuals, society, and world events. We applaud the artists who expose our dysfunctional behavior and deviations. As philosopher Fredrika Spindler (2004, 19) states (in reference to Deleuze), to really work at the “extreme point,” where the known meets the unknown, we need to force ourselves to deal with unconventional and strange conditions. Spindler goes further by explaining that meeting the strange means confronting a conceptual violence that is fueled by overwhelming our senses with input that is too complex. The force we gain out of the violent shock can help articulate an immediate understanding of the situation.

Spindler and Gell-Mann both see the same problem. Gell-Mann warns of the complacency that science exhibits when confronting the strange, while Spindler warns of the risk one takes in the immediate interaction with the strange. The focus of my investigation with regard to irregularities and the strange is to confront them and develop aesthetic methods that use the overwhelming feeling and clash that new experiences cause.
Asymmetry
Poincaré associated truth in mathematics with beauty, order, harmony, and symmetry. His view reflects a long tradition of western thinking starting with Plato (Lorand 2003–4). It is a view that aims to define a higher, ideal order that does not exist in the mundane world. It seems art and design are more interested in learning from asymmetric movement and composition, prioritizing contrast and tension between elements expressing more dynamics.

Ruth Lorand (2003–4) challenges the classic idea that order and symmetry are the same. Her argument is that order relies on a combination of symmetry and asymmetry, because breaking symmetry creates distinction, which increases the level of complexity and creates a more vitalized order. Lorand’s theoretical work in aesthetics has a very practice-based reasoning that uses examples from domestic life to prove her point. Her arguments about the interdependency between symmetry and asymmetry have helped to problematize the way I treat the concepts of symmetry, asymmetry, and dissymmetry in the present thesis. Further support for the interdependency of symmetry and asymmetry is given by Vera and Francois Molnár (2005) in their definition of controlled disorder and hidden symmetry—which lies behind the structures of many asymmetrical compositions.

Amorphous phenomena
Amorphous phenomena are made of unstable materials that can change shape over time and are therefore difficult to recognize, categorize, and classify. Art theorist Tom Sandqvist (1998, 51) explains that substances that do not have clear boundaries (i.e. are sticky, leaky, slimy, liquid, etc.) are considered repulsive, because the separation between the amorphous material and our bodies is vague. This vagueness seems to threaten our identity, according to Sandqvist. Bataille was also interested in how formlessness can be absorbed into other substances and break down barriers (Bois and Krauss 1997). There are, however, amorphous solids that do not change over time, yet have vague and uneven contours, such as wax, clay, etc. These formless volumes are easier to grasp, both physically and conceptually.

Blob
A simple clump of clay, as shown in figure 25, expresses a spontaneous 3-D raw shape that captures a sense of the volume, proportion, and axial movement that lies beneath the surface qualities and the contours or form. Learning to work through this unpolished phase supports a deeper perceptual experience that involves volume. The research of visual psychologist James Gibson (1986, 83 [1979]) supports our inherent ability to sense volume. He states that we experience “a direct pick-up of solidity”
that is continuous through the volume and does not rely on silhouette. Visual psychologist David Marr (1982, 52) has also studied how we perceive these voluminous clumps, which he termed “blobs”. His research confirms that we perceive rough position, length, width, and orientation in spatial context, rather than contours. Marr also emphasized our ability to prioritize spatial localities, while the edges and contours are controlled by these spatial structures. Both Marr and Gibson question the research results on shape recognition through contours and outlines presented by researchers such as da Fontura Costa and Cesar (2001). Rowena Reed also stated that the perception of mass dominates over the perception of contours, edge, and silhouette (Greet 2002, 106).

Decomposition and breakdown
Decomposition refers to the breakdown of organic material through various stages or phases. Through these stages, materials may change, for example, by releasing gas and odor at one stage and changing from firm material to liquid at another. Eventually the material that is left dries out and is either preserved or dissipated. Bataille compared the ideal form of matter in opposition to dead matter (Bois and Krauss 1997, 29).

He considered formlessness as demonstrated through phenomena such as death/decomposition or trauma/sores, offering a state of unity between form and content. He explained that when an insect is squashed, it is no longer an image or object that can be abstracted and analyzed. The squashed insect does not represent anything; it becomes real and immediate in the momentary state. The processes that break down materials create a great deal of disorder, which frees the material from the role it plays in society. Bataille suggested the need for a science of what is entirely disordered, which he called “scatology”. Scatology refers to “feces” or “waste” products, which have no articulated place in society. Bataille was looking for a “taxonomy of disorder of base material” so that we might learn to understand the degradation of material and energy.

Physicist Brian Greene (2004, 174) provided an elaborate explanation of an egg falling off the edge of a countertop and splattering on the floor. His message is that we need to experience the unfolding of disorder in order to understand processes of expansion of the universe. In a sense, Greene is also saying we need to complement today’s science with a science of disorder. James Crutchfield (2003, 35) also points to a need to understand the mechanisms underlying what he calls a deterministic chaos.

Haptic and kinaesthetic
David Katz’s (1989 [1925]) research in haptics, which included kinaesthetic and tactile experiences, emphasized the need to explore complex phenomena rather than isolated specific sensations that focus on individual sensory modalities, such as vibration or temperature. His research also supported the immediate felt experience and the role of “active intentionality”, which is an important part of
2. THEORETICAL FRAMEWORK

Material under the fingertips, and 2) the active hand that intentionally explores material by moving fingertips over it. Katz advocated that the active hand has a greater sensitivity, because sensation from muscle movement (Kinaesthetic) enters into the experience. He referred to the intentional movement of our hands as extremely important in forming our understanding of a tactile phenomenon, and he connected a creative force to the active hand (Katz 1989, 75, 79–84 [1925]). Figure 27a–27b shows how dominant the hands are for sensuous cognition through movement.

Emergent properties
Physicist Paul Davies (1995, 21–3 [1987]) considers the universe as a continually changing and creative system. He states that in nature, there are physical processes that show a kind of spontaneous creativity, giving rise to unique “emerging" formations. He argues that our universe started in a featureless state and continually increases in complexity so that new forms and structures are constantly coming into being.

Emergent properties arise out of contextual conditions that support the development of a distinctly new system. The emergent properties have no similarities to the properties from which they arose, so they cannot be reduced to elements (Davis 1995, 114–5 [1987]).

Conflicting forces
In the 1950s, Gordon Pask conducted research in learning theory through empirical studies of dendritic crystal structure growth (Cariani 1993). One of his research issues
aimed to explain the development of “reward mechanisms” for adapting to problems in the environment. The crystals “learned” to construct and reconstruct branching structures due to local changes in surrounding conditions. Useful structures were rewarded by the allocation of more energy, thus attracting more material to areas “fighting” to maintain intended growth. Feedback systems developed that affected the entire system in unpredictable ways. One of Pask’s conclusions was that conflicts stimulate growth processes.

From a formless substance, a very defined system can arise. Figure 28 shows crystal structures emerging from a transparent copper sulfate fluid solution (see Paper VIII).

**Context dependency**

Formlessness implies the ability to adapt and change in response to the environment. A formless system is therefore considered context-dependent, because its shape depends on external conditions such as temperature and movement. Figure 29 shows how smoke patterns change from linear to non-linear behavior due to surrounding conditions.

Vassily Kandinsky stated that “every form is as sensitive as a puff of smoke; the slightest breath will alter it completely” (Kandinsky 1977, 32 [1914]).
This chapter is divided into 3 parts. Each part presents a summary of results in relation to aims followed by a discussion of strengths and weaknesses.

Part 1: Developing an aesthetic taxonomy of form (Papers I–II)

Part 2: Expanding and challenging the Evolution of Form-model (Papers III–VI)

Part 3: Formlessness—Beyond the aesthetic taxonomy of form (Papers VII–X)

Each part begins with a brief outline of how the results relate to the aims, followed by a summary of results, which are then discussed in terms of strengths and weaknesses.

Part 1: Developing an aesthetic taxonomy of form

I refer here to my experiences from:
- Work and studies with Rowena Reed in New York City
- Developing an educational program for form theory and practice for industrial designer at Konstfack
- The Swedish cultural context

Results in relation to aims

The results presented below attempt to address aims 1–3 and aim 6 defined in the Introduction:

Aim 1: To generate aesthetic strategies that support skillful formgiving methods of conceptualizing and shaping artifacts in a design culture.
- The present thesis offers an aesthetic taxonomy of form, which supports the organizational needs of formgivers in developing a gestaltgestalt (Paper II).

Aim 2: To create a model that integrates geometrical law-bound, aesthetic reasoning with organic growth principles.
- The present thesis offers the Evolution of Form (EoF) model as a way to support the reciprocal weaving-together of geometric and organic form principles (based on human figure studies) (Papers I–II).

Aim 3: To develop constructive and critical methods and models that challenge normative trends in design aesthetics.
- The present thesis uses a bipolar spectrum in the Evolution of Form-model, which provides possibilities to work outside the norms of beauty along the negative pole, yet still included in the same aesthetic taxonomy that supports these norms (Paper I).

Aim 6: To support the interaction between the explorative, embodied approach of the arts and the didactic and concrete need of design education.
- The present thesis offers didactic teaching material in the aesthetic taxonomy of form including the EoF model that relies on creative and skillful embodied procedures to bring conceptual and perceptual reasoning together (Paper II).
Summary of results – Part 1

Aesthetic taxonomy of form in five levels
The term taxonomy originally referred to classifying living phenomena into sets, relationships, and principles, but today it can apply to anything. The aesthetic taxonomy of form presented in this thesis was developed by defining 3-D essential aesthetic abstractions of form and space that compactify properties, movements, relationships, and organizations. The aesthetic abstractions are derived from geometric structures and organic principles of growth and tension, founded by Rowena Reed and Alexander Kostellow at Pratt Institute (Greet 2002). The taxonomy grew within the context of a Swedish formgiving culture and an industrial design educational institution at Konstfack rooted in Arts, Crafts and Design.

Paper II is a textbook originally published in 1994 outlining four levels that organize the taxonomy and its nomenclature, conceptual models, illustrations and photographs of 3-D physical models. The four levels are: I. Elements and their properties, II. Movements and forces, III. Relationships and IV. Organization. This research develops arguments and theoretical support that expand the taxonomy to also include an additional fifth level, Intention involving the formgiver’s individual sensitivities applied during the gestalt process (see figure 30). However, the scope of this research does not include a detailed revision of the entire taxonomy, see Future plans.

During this research project many revisions of the taxonomy outlined in paper II have been considered, such as: i) problematizing the concept visual, ii) questioning the theoretical implications of adding a bipolar spectrum, especially regarding the negative pole, iii) improving the graphic layout, photographs and illustrations and iv) adding examples of products that apply this taxonomy.

The Evolution of Form-model in figure 31 and the expanded Evolution of Form-model in figure 33, show examples of revised models.
Evolution of Form (EoF) model

The EoF model, as shown in paper II and figure 31, has a 7-stage horizontal axis that reciprocally interlaces geometrical law-bound reasoning with organic principles from simple to complex. Each stage has a vertical axis with a bipolar spectrum.

Horizontal axis
The 7 stages start with join at the left end and progress through increasing complexity ending in the organic stage at the right. The 7 stages are:
1. **Join**—cutting away a part of one geometric volume to exactly fit with another geometric volume
2. **Intersection**—the common mass within the joint of two geometric volumes, defined by the geometric properties of the surfaces of the joined forms
3. **Divide**—cutting through geometric forms, creating two or more parts
4. **Adapt**—fitting a compliant geometric form up against or around another form that is stable
5. **Merge**—blending two or more geometric forms into a combined figure
6. **Distort**—exposing a geometric form to forces that affect its inner structure and elemental parts
7. **Organic**—beginning with formlessness (clay) and creating complex movements and tensions in the form expressed through convexities and concavities having no geometric reference.

Bipolar spectrum
The bipolar spectrum moves vertically across the horizontal axis at each stage in the EoF-model (see figure 31). The spectrum introduces a positive and a negative pole that expand the practical and theoretical dimensions of this evolutionary model. This spectrum both supports and challenges the classic aesthetic aims of achieving beauty and expansion. It gives equal weight to activities that build up and break down the geometric structure.

The top half of the model represents the positive pole of the spectrum, which supports congruency with the original geometric structure. The terms **accordance**, **assimilate**, **converge**, and **conform** indicate support for the geometric structure or identity of the original forms. The bottom half of the spectrum represents the negative pole, which supports incongruence with the original geometric structure. The terms **discordance**, **dissimilate**, **diverge**, and **deform** are meant to disturb, take away and work against the geometric structure or identity of the original forms.
3. RESULTS

10-step Concept-Translation-Form-method

The ten steps are:
1. Lecture on concept
2. Translation/interpretation
3. Experimental 3-D modeling
4. Individual support
5. Gathering the work
6. Perception and reflection
7. Exploring aesthetic reasoning
8. Bipolar spectrum
9. Summary
10. Feedback

This method developed over many years within an industrial design educational program that aimed to generate new concepts and conditions for organizing and shaping form. The method was based on working back and forth between conceptual development and physical experimentation with 3-D form. A major goal was to develop concepts and forms, eventually resulting in the EoF-model (figure 31). A cooperative inquiry method was applied, using students as co-researchers.

The 10-step method is considered both a method and a result in the present thesis and is presented in detail in Paper I-II.

Discussion of results - Part 1

Strengths

Five strengths concerning the aesthetic taxonomy of form are discussed below:

1. Five levels and coherent nomenclature supporting the creation of the gestalt
2. Blending geometric/organic structures and principles
3. Bipolar spectrum problematizing “beauty”
4. 3-D sketching and crafting skills
5. Designers as problems solvers

A first strength of the present taxonomy, including its revisions, is that it offers a coherent way to understand form in space. The concepts, principles, and graphic models are organized into five levels (figure 30) that correspond to different levels of complexity and to gestalt reasoning. These five levels reinforce the interrelationship between the way the elements and their movements/forces make up and/or reflect a meaningful organization. The concentric order of the five levels as shown in figure 30 therefore supports ways of analyzing aesthetic abstractions of a 3-D composition as it emerges. It also indicates the increasing contextualization and complexity one is faced with when moving from description of properties to artistic intention.

The way to use and understand an applied aesthetic taxonomy is not like anatomy or a map. An aesthetic taxonomy is calibrated through the sensitivities of the individuals involved in the formgiving process. It is about aesthetic abstractions that must be discerned in relation to the whole to help clarify options and choices.

Through research in perceptual science, starting with Max Wertheimer (King and Wertheimer 2005, 4), there has been a strong commitment to developing knowledge about how we perceive both measurable physicalities and non-measurable experiences.

The non-measurable experiences are about:

- Indirect perception referring to how properties, movements, and forces relate through mass and over space, derived from the physical and contextual situation.
- The intentions, sensitivities, and experiences of the involved individual in the interaction with the gestalt

The nomenclature of this aesthetic taxonomy (Paper I) is based on aesthetic abstractions that are derived from geometric structures and organic principles. The concepts are defined, and the visual images and physical models are specifically developed in parallel with the development of the concepts. There is therefore a direct correlation between concepts and aesthetic abstractions with physical features and perceived expressions.

A second strength found in the EoF-model (figure 31) applies to the sequential and reciprocal reasoning that blends geometric structures and organic principles in the same model. It is common in basic design courses to present one way to understand and analyze the construction of geometric forms and another way to understand and sculpt organic forms and figures (Read 1992 [1964]). The 3 stage geometric-organic (geo-organic) “vision” conceived by Rowena Reed strived to weave together the geometric and organic ways of working and reasoning (Greet 2002, 106–16). The proposed EoF-model, derived from Reed’s vision, offers the first comprehensive visualized diagram over her geo-organic reasoning and present 7 stages (including the 3 stages from Reed) that explicitly shows the stage for stage link between geometric and organic qualities and principles.

A third strength is the bipolar spectrum, which includes a negative pole that supports concepts of breakdown, discordance, etc. It is the negative pole that expands the EoF-model and challenges the normative principles
concerned with “beauty” from which Reed’s early geo-
organic vision developed. Reed was strongly committed
to supporting “beauty” in product design (Greet 2002).
Her sensitivities, procedural knowledge and critiques
were tempered by her attempts to develop beautiful solu-
tions, which also underlines how the principles developed
and were interpreted by students. By adding the bipolar
spectrum at the different stages of the EoF-model, I was
able to step out of Reed’s “principles of beauty” through
the negative pole. Thus, through this bipolar reasoning,
I could both a) problematize the EoF-model by making
it much more inclusive, and b) impose a regeneration
of the definition of concepts at the positive pole by their
relationship to the negative pole.

A fourth strength is that the 10-step method relies heavily
on the 3-D crafting skills of the students/participants. The
discrete and skillful movements (Ingold 2000) that students
employ to create clay models over the years is a key pro-
cedure for the development of this research. Interesting,
sensitive, and creative solutions stimulated intellectual
involvement and moved the research forward. Gabriella
Goldsmit’s (2001) research explains the importance
of the sketching process when dealing with complex problem
solving, and is equally important in this research for the
development of a taxonomy of form.

A fifth strength is that this research was developed
within the educational framework of industrial design,
because designers are problem-solvers with an interest
in understanding how people perceive their products.
Their willingness to materialize possible solutions for a
problem has kept this theory and vision in touch with the
concrete world. Without this willingness to “just do it,”
the taxonomy of form and the Evolution of Form-model
would not have developed. In Henrik Gedennyd’s (1998,
9) PhD thesis in cognitive science on How designers
work, he points out the vital importance of “practical skills
and authentic activity” in the development of the design
profession. He even states that recent cognitive research
sees “cognition as fundamentally practical by nature.” This
statement is also supported and further developed by Edith
Ackermann’s research, which concludes that cognition
is greatly enhanced by fusing concrete experience with
abstract analysis (Ackermann 1996).

Weaknesses
These 5 points were raised concerning the weaknesses
of the aesthetic taxonomy of form:
1. Geometry and aesthetic abstractions
   play a normative role.
2. No application.
4. Lack of historical roots in aesthetic judgment.
5. Innovative vs. didactic solutions.

A first weakness is voiced by the Swedish postmodernist
critic Linda Rampell (2003, 373–6) in her recent PhD thesis
Designatlas. Rampell considers geometric references for
developing aesthetic abstractions as a means of separat-
ing designers from becoming contextually grounded. She
bases her criticism on a number of established postmodern
critics such as Evgenii Kovev, who explains that the use
of geometry entails a reductionism that excludes and
“washes away” contact with the real world. To an extent,
I agree with postmodern critics about geometry offering
ways to step back from the immediate context, however,
I do not agree with the critic of losing contact with the
real world. If the design process was always embedded
in context and refrained from using abstractions, it would
not have been able to produce solutions and products
for society. Being able to apply geometrically derived
aesthetic abstractions allows the individual to step back
and aesthetically summarize the complex context without
loosing contact with the physical world. Rotzley (1977)
states that throughout history we have used geometry to
develop something different from the present. He says
that geometry and abstractions are directly linked to hu-
man perception and our drive to create. Rudolf Arnheim
(1979) and Christopher Alexander (1964) also defend the
organizing capacity of geometric form and abstractions
as central to the creative process.

In a user-based culture like Sweden, the industrial
design process is often contextualized in relation to i) the
human body through ergonomics, and ii) the complexity
of the particular problem in focus from a human perspec-
tive. Industrial design is one of the most contextualized
professions in our society (Thackara 2005) daring to
take on problems in the real world. I argue that aest-
thetic abstractions supporting visual imagery and physical
model making have helped create the development of this
problem-solving profession. However, we need to better
explain our methods to gain support for further in-depth
documentation of these contextualized procedures, to
show the role aesthetic abstractions and geometry play
in the process of planning and formgiving.

Given the “ill defined/wicked problems” (Rittel 1972)
that industrial designers take on, the nature of geometric
composition offers ways to gain holistic control over the process (Alexander 1964, 27). The design process usually involves developing solutions for conflicting concepts and desires in a competitive market. Geometry can catalyze ways to organize the “infinite variabilities” (Deleuze and Guattari 2003, 201 [1994]) that design activities bring forth. As long as we use geometry as a way to explore possibilities, geometry can act as a way to bring conflicting forces into balance. What often happens in the design culture is that superficial aesthetic experience of geometry hinders the explorative process and “geometric clichés” (Deleuze and Guattari 2003, 204 [1994]) are applied. Using geometry in the design process begins with using its organizing capacity on a structural and proportional level. Geometric reasoning in the design process does not dictate however, a geometric solution.

I urge the aesthetic disciplines to regenerate knowledge about geometry by challenging geometric principles in relation to different modes of aesthetic reasoning. As mentioned above, Rowena Reed (Greet 2002) created a geo-organic vision that brought the principles of growth, tension, and expansion to geometry and the law-bound order of geometry to organic composition. The 7-stage *Evolution of Form*-model (Papers I & II) further developed Reed’s geometric-organic vision and set up an opposing bipolar dimension that runs perpendicular to each of the original stages. This model confronts the cliché use of geometry as well as the normative concept of beauty by introducing possibilities of exploring geometric breakdown, deformity, discordance, etc., through a bipolar spectrum.

A second weakness points out that the taxonomy presented here does not directly show how it is applied in art, design, or architectural work. The criticism is that the taxonomy is too abstract and loses relevance through the lack of application. To my knowledge, the majority of books published in this area of applied aesthetics and foundation design courses present and discuss the work of established artists, architects, and designers who apply aesthetic concepts and principles (Stephan Luecking 2002; Jonathan Block & Jerry Leisure 1987; Francis D.K. Chung 1979; Moholy Nagy 1969; Robert Gillam Scott 1951).

My argument is that I deliberately excluded applications of the aesthetic taxonomy because they would influence and restrict the way an aesthetic abstract principle is expressed. I am following the traditions of Reed and Kostellow (Greet 2002), which are rooted in a scientific attitude and a commitment to developing original and innovative products. By working with essential aesthetic abstractions within the context of a real problem, one can develop solutions that do not necessarily have strong prior references to other work. Materials, techniques, functional problems, ergonomics, etc., contextualize the aesthetic abstractions; thus, analogies are not necessary. The proposed taxonomy was developed in a context supporting the education of industrial designers in learning to deal with an active formgiving process in product development. Students see the work of other students in the advanced classes and eventually develop their own applications of the taxonomy. Through conversations with former students, I found that there are strong educational benefits to working with the aesthetic through abstract models rather then applied directly in products. The benefit is that the students can recall the experience of the taxonomy and the *EoF*-stages, making it easier to discern form in the formgiving process.

The present thesis does not present how our curriculum integrates the proposed aesthetic taxonomy of form with semiotics, user needs, marketing, technology, function and sustainability that reflect the Swedish formgiving culture. However, it is important to validate this taxonomy through application. It was my intention to explain more of the formgiving process and how aesthetics work within the process, but the scope of the present thesis could not include this material. A few applications of students’ work are found in the introduction and included on the thesis website.

A third weakness is that 80 percent of the nomenclature presented in paper II is rooted in modernistic terminology. This aesthetic nomenclature was influenced by science (particularly physics) and some examples are force, space, axis, movement, mass, position, and expansion (Wick 2000). By putting emphasis on the essential abstract structures of form in space, the non-structural properties, such as color, texture, smell, sound, and ornamentation, are assumed to have little effect on the structural organization. This assumption is something I have questioned over the years, and I suggest a more inclusive approach that brings together all other aesthetic disciplines to create an overall aesthetic field of knowledge. Part 3 in this chapter opens up aesthetics beyond essential abstractions.

In 1983, philosopher Jürgen Habermas explained that “the spirit of aesthetic modernity has recently begun to age” and that modernism was “dominant but dead.” I agree with Habermas, because I see very little energy within the design field to develop knowledge about aesthetics that push the limits of modernism. Since there has not been any other coherent aesthetic movement in modernism, it is still the language used by active designers who create artifacts. My hope lies in John Rajchman’s (2003) recent prediction about a renewed interest in modernist aesthetics fueled by a loss of interest in the anti-aesthetic and highly critical postmodern movement. In this renewal period, we
can aim to bring all the aesthetic disciplines together to compare, interweave, and oppose each other.

A fourth weakness has to do with Klaus Krippendorff’s (2006, 159) critique about the aesthetics of modernism being unable to deal with the “cultural roots of aesthetic judgment”. I agree with Krippendorff, since dealing with cultural roots is one of the most difficult issues in the design process. Our aesthetic discipline within the design process is underdeveloped and does not have the methods or principles for dealing with deep cultural roots. Cultural differences are slowly being swept away as more and more nations become industrialized and product designers ride on this wave. Krippendorff sidetracks aesthetics and points to a “semantic turn,” which, he argues, will support cultural expression. I argue that the active formgiving/design process concerned with cultural issues needs aesthetic reasoning. Semantics (without aesthetics), as Krippendorff suggests, has no formative methods for developing products and services that explore contemporary ways of expressing culture. Besides, if we are to deal with cultural historical roots, then historically aesthetics, art, and culture are inseparable.

Part 2: Expanding and challenging the Evolution of Form-model

I refer here to my experiences from:
- My art within a constructivist community of artists
- Art/physics collaboration projects
- Exploratory laborations with industrial design students

Results in relation to aims
The results presented below attempt to address aims 3, 5, & 6 defined in the Introduction:

Aim 3: To develop constructive and critical methods and models that challenge normative trends in design aesthetics.
- The present thesis shows how art is a method for aesthetic development. An art–physics project developed collaborative methods, procedures and techniques to explore aesthetic issues concerning complex curvatures and transparencies (e.g., point-cloud volume) in the physical and virtual world that challenge the aesthetic taxonomy of solid forms in the EoF-model in part 1 (Papers III–V)
- The present thesis has developed procedures to study material breakdown, which also challenges the usual ways of transforming solid form as defined in the EoF model in part 1 (Paper VI)
Aim 5: To generate methods that lift aesthetics into a dynamic mode of reasoning that supports change, transformation, and formlessness.

- The present thesis introduces procedures that show how the particular physical context around an “organic cube” affects material change over time. The material transformed into a somewhat formless mass (Paper VI).

Aim 6: To support the interaction between the explorative, embodied approach of the arts and the didactic and concrete need of design education.

- The present thesis presents a new model that expands the EoF-model from Part 1 (Paper VI).

Summary of results – Part 2

Art as a method for aesthetic development

Another question concerning the whole idea of creating or expanding any sort of aesthetic taxonomy and nomenclature is whether the arts are interested in supporting such a movement. Since the mid-1980s, mainstream postmodern art has “repudiated” modernism and the field of aesthetics to celebrate the social context and a changing culture (Foster 2002 [1983]). As I see it, what happened in the vacuum of this anti-aesthetic movement is that the design world was left on its own to develop applied aesthetics in isolated communities.

However, in art and architecture today, there are signs of a renewed interest in aesthetics. John Rajchman (2003) explains that postmodernism is no longer attracting interest and that there is a growing interest today in becoming more “sensible,” as he puts it, and to begin to develop the field of aesthetics. Since the proposed form taxonomy has roots in the arts, it seems imperative to keep a relationship with the arts as the field of aesthetics undergoes change. The arts were vital for the development of the visual structure, principles, and terminology that Kostellow and Reed founded, as well as the aesthetic taxonomy and EoF-model presented in the present thesis. The arts have also been instrumental in finding ways of going beyond the taxonomy to generate and regenerate knowledge of contextualized form.

In paper III, I give a brief summary of my work as an artist in a constructivist community centered on the “Konstruktivist Tendens” gallery (URL) in Stockholm. I refer to a number of exhibits and projects that I developed over a period of ten years. My work involved distortion of geometric triangular forms composed with enclosed space and eventually exploring transparency and material breakdown inspired by Goethe’s color theory. Goethe’s scientific approach supported a productive critical attitude (Sällström 1993), which bases the development of knowledge on individual interests, experiences, and sensitivities. Both constructivism and Goethe were two important sources of inspiration in part 2, because they were both centered on the value of aesthetic experiences.
The scope of this thesis does not include an extensive presentation of my work in the arts. However, without the possibilities of free exploration supported by the art community at large, I would probably not have found ways to develop, expand, and go beyond the taxonomy of form and the EoF model.

**Expanding the Evolution of Form-model**

The expansion of the EoF (conceptual) model was accomplished through the following two methods leading to 3-D (physical) models: i) Complex curvatures and ii) Material breakdown, described below.

**Complex curvatures—“point-cloud volume”**

Papers IV–V offer methods, procedures and results from an art/physics collaborative project on the theme *infinity* between astro-particle physicist Lars Bergström and me.

Our approach to the theme was to explore complex curvatures that moved between dimensions in a cyclical process. Bergström applied the multi-dimensions of the Calabi-Yau model from string theory and I developed a hypertwist of convex and concave surfaces based on the “Möbius strip” (URL), creating a “point-cloud volume” (see figure 32a). The study extended the horizontal axis of the EoF-model, pushing the limits of the 7th stage—“organic” into an 8th stage (see figure 33 and Paper VI). The method for developing the models was in a dialogue, where we shared ideas and materials in preparation for the coming exhibition. We were both interested in explorative methods that transformed the original models into an alternative expression, hoping to uncover new properties. The exploration of our respective models met in a study of transparency as a way to transpose and overlap dimensions as well as blend points with the surrounding space. During an art–science festival in 2002, the project was presented in an exhibition combined with a lecture series at Kulturhuset in Stockholm.

**Material breakdown**

This study involved ecological issues related to material transformation and breakdown in courses offered to both bachelor and masters students in industrial design, briefly presented in paper VI. The course was inspired by an ecology theme at Konstfack in 1995. At the time I developed the course, I did not see any relationship between it and the EoF-model presented in Papers I & II. The course aimed to study how organic materials (potatoes, ginger, pear, apple, etc.) cut into cubes change through different processes such as heat, pressure, dehydration, etc. (see figure 32b). The aim was to observe the transformation process and record changes. This very intuitively planned course gave many important results, see below.

**Discussion of results - Part 2**

Before I explain the way the EoF model expands, it is important to discuss why this model should expand, or if indeed an aesthetic taxonomy should exist at all.

In the introduction, I refer to John Dewey as a source of inspiration; yet Dewey was very much against the idea of creating categories and terms, because they reduced the total holistic experience and “tie[d] the material down to rigid immobility” (Shusterman 2000, 16 [1992]). If the present thesis refers to Dewey’s ideas of art as experience, then perhaps creating terms and categories may create an incompatible factor.

My interpretation of Dewey’s critical view of categorization and terminology comes from his worry over the “discursive way” art theorists and philosophers develop theory and terminology. Dewey would perhaps have agreed on categorizations that involved the particular perceptual experience of things. As Richard Shusterman (2000, 58 [1992]) points out, however, the main criticism of Dewey’s aesthetic thesis is that it is hopelessly impractical. It offers no applied methods that unfold the procedures of working with pragmatist aesthetics from a creative position. The scope of the present thesis was not to tailor an aesthetic taxonomy to suit Dewey’s intentions, but rather to see parallels between what Dewey aimed for and what supports a formgiving process.

I argue that the creation of an aesthetic taxonomy and nomenclature deriving from the practice of art and design creates a different kind of structure than an aesthetic one defined from an art theorist’s or philosophical vantage point. An aesthetic taxonomy should be structured experientially, and nomenclature should be directly understood and also invite a continuing renewal process. An aesthetic taxonomy aims to support the development of knowledge that will enrich the process and result in more sensuous products. Alexander Kostellow, the founder of the visual approach on which the present thesis builds, emphasized the importance of visual concepts that are defined through the language of today. Kostellow strived to convert moods to terms and develop abstract conceptions driven by inner compulsions (Greet 2002, 26). If this sensuous link between concept and experience is supported in the abstractions and nomenclature of a taxonomy, then Dewey’s (1980 [1934]) holistic approach could gain an applied profile. Again, it is important to remind the reader that the present thesis only presents an aesthetic taxonomy of form.
3. RESULTS

Strengths

Five strengths concerning the expansion of the EoF-model are discussed below:

1. Expansion of the EoF-model along the horizontal axis
2. Visual links between the virtual (high-tech) and physical (low-tech) models
3. Expansion of the EoF-model along the vertical axis
4. Process-based aesthetics
5. Unifying form with color, texture, material, and shape in a holistic process

A first strength is the revision of the EoF model along the horizontal axis, where the concavo-convex volume (at stage 7) was translated into a transparent point-cloud volume, creating a possible stage 8. This point cloud or transparent stage 8, in the revised model in figure 33, marks a move away from the law-bound structure of geometry and from stable solid objects in space. Point clouds introduce amorphic characteristics with a vague spatial position pushing the limits of the concrete expression of form. These cloud images bring up concepts of density, overlap, and all-roundness. The unexpected results of this scanning experiment were that the majority of the 2-D images that were produced were not easily recognized as originating from the same sculpture. Although I know this sculpture (as a solid form) from all angles, I was not able to easily locate the particular view from which each scanned image was taken. This shows that although we are able to grasp a coherent, holistic, and complex 3-D volume by fusing all the different views of the form together, it is much more difficult to grasp the superimposed, transparent “point-cloud image” that shows the back and front through the same picture plane.

A second strength is about finding visual links between
i) the virtual Calabi-Yau multidimensional model based on string theory (see Paper V), and II) the physical sculpture entitled “complex curvatures” and its virtual counterpart, the scanned point-cloud volume. An important issue in the art–physics collaboration was the combination of low technology—sculptural craftsmanship with clay and metal casting—and high technology—3-D digital scanning and computer-generated hypermodels (Hanson 1994).

This combination of hand craftsmanship and high technology is a central issue in merging embodied reasoning with the challenges of the visual expression of the digital world. The industrial design process is becoming increasingly dependant on digital information and new media. An important question is: Are we able to support aesthetic reactions and reasoning through these primarily visual/virtual media? Malcolm McCullough’s (1996, 48–9) practical and theoretical work in digital craftsmanship highlights this question. He praises the hands and haptic experience, while at the same time predicting the decline of physical objects as we offer more and more virtual solutions to problems. McCullough presents the situation of the “de-materialized artifact” and the changes in professions and technology that will bring new forms of visual knowledge in the virtual and real worlds. These point-cloud images are a product of virtual technology that literally dematerialized the solid physical sculpture by merging physical “points” with spatial distance. At the same time, this virtual technology “re-materialized” the complex curvatures of the sculpture into an unpredictable sequence of images. How to follow the development of a physical form that is transformed into new imagery is one of the areas of development that form theory will need to include. How these new visual images relate to our embodied and haptic experiences is yet another question.

A third strength is the expansion of the EoF-model at the 6th stage—“distort”—along the vertical axis of the bipolar spectrum. The dehydrated organic shapes express a distortion of the original cubes through cracked and dried surfaces as well as color and texture distortion. The EoF-model was expanded along the negative pole towards “deform” (see figure 33 and Paper VI). Discussions with students regarding the different organic cubes uncovered the following issues:

- The changes of the organic cubes were context-dependent, sensitive to climate, position, and the unique transforming effects these conditions had on the various organic materials.
- A gradual, temporal process controlled the transformation.
- The transformation of organic materials was partially determined by the geometric structure of a cube. The sharp edges and corners of the cubes were retained throughout the entire dehydration process, and the concavities and surface deformation were framed by the six separate surfaces of the cube.
- The study introduces complex forms that cannot be separated from the properties of the material.

This particular material breakdown study mixes amorphous substances with geometric form and introduces aesthetic reasoning that contrasts with traditional sculptural and industrial design aesthetics. It challenges the tensional surfaces and highly polished shapes established through traditions such as car design. By setting up explorative studies of non-traditional and organic materials that change
3. RESULTS

Over time, we can problematize aesthetics by asking questions such as: 1) How do highly polished products defy aging or wear and tear? 2) How can organic spontaneous processes be introduced into product development?

A fourth strength lies in exploring process-based aesthetics as an alternative or complement to object-based aesthetics, through material transformation. The ecological issues concerned with dehydration (such as the dried pear cube shown in figure 33) aimed to present alternative concepts such as life cycle, decomposition, and context dependency into an aesthetic realm.

A fifth strength lies in unifying form with color, texture, material, and shape through a holistic transformation process. The dehydration study demonstrated how context dependency and time are factors for transformation. The study also supported an awareness of the difference between the materials traditionally used in industrial design, which are chosen because they do not easily change, and organic materials that are in a constant process of transformation.

Weaknesses

Two weaknesses concerning the expansion of the EoF-model are discussed below:

1. Expansion of the EoF-model creates “unbalance”
2. Spontaneous and contextualized process

A first weakness in the expansion of the EoF-model is that the model loses its symmetrical legibility and becomes “unbalanced” as it expands. In general, all models represent an oversimplification of the problem and are not easy to transform when a deeper understanding of a structure or principle is developed. Often, a totally new model is needed to accommodate the changes. One may argue, though, that expanding the model not only provides an ordered structure, but also allows contextualization and adaptation, thereby generating a way to use it for explorative purposes.

A second weakness involves material transformation driven by a spontaneous contextualized process that changes form, color, texture, and smell, controlled by the properties of the materials. This process introduces a very different kind of procedure for changing the properties of form than the traditional sculptural craftsmanship applied in the other stages of the EoF model. Thus, a formgiver can only influence the transformation by shaping the surfaces cut on the material and placing the organic cube within a context. To combine the active formgiving process that this aesthetic taxonomy and the EoF model build on with an autopoiesis process is perhaps too great a shift. A completely new model might be needed—which again points out the merit of expanding the model. I argue that this is not a normative action, but a mode of exploring its possibilities and limits to inspire the further development of aesthetic reasoning.
Part 3: Formlessness – Beyond the aesthetic taxonomy of form

I refer here to experiences from:
- My art beyond constructivism
- The Complexity and Transformation (C&T) project supported by the Swedish Research Council (see also chapter 4, Methods)

Results in relation to aims
The results presented below attempt to address aims 3–5 defined in the introduction.

Aim 3: To develop constructive and critical methods and models that challenge normative trends in design aesthetics.
- The present thesis has developed methods to conduct the cross-disciplinary Complexity and Transformation project. A major method was laboratories involving applied explorative procedures of formlessness and contrasting the normative structures of geometry (Paper VII).

Aim 4: To conduct exploratory, cross-disciplinary studies in complexity and transformation that support the renewal of aesthetic reasoning in both the art/design and scientific communities.
- The present thesis applies a cooperative inquiry method involving individuals from different disciplines as co-researchers in the explorative procedures (Papers VII–X).

Aim 5: To generate methods that lift aesthetics into a dynamic mode of reasoning that supports change, transformation, and formlessness.
- The present thesis has developed the Transformation-model (figure 35) and the Framing the Dialogue-model (figure 36), which were used to interact, document, and discuss change and transformation through bipolar reasoning (Paper VIII). The Aesthetic Phase Transition-model (figure 37) was used to contextualize object-centered, aesthetic reasoning in an event (Paper IX).

Summary of Results – Part 3

Background
To orient the discussion I present a provisional figure 34, Embedding Form in Formlessness that offers conceptual orientation in how formlessness is dealt with in the present thesis as well as how parts 1, 2 and 3 are related.

The illustration in figure 34 shows a “form” as a conical funnel that contains the properties, principles, and tacit knowledge of aesthetics supporting a normative order of beauty. The positive pole of the bipolar spectrum in the EoF-model lies within the form cone, including the geometric, joined stage at the tip of the cone and the organic stage at the opening. The negative pole of the
bipolar spectrum can lie within or outside the cone. The form cone is then embedded in a sphere of formlessness within the real world. Formlessness contains the unpredictable, chaotic, ugly, and complex real world. The arrows that move between the open base of the cone and the outside formless world support a continual flow of new charged material and matter that can circulate within the cone. This flow gives rise to turbulence and conflicts with the established structures within the form cone, as well as offers potential material for developing new aesthetic abstractions. By working with contrasting concepts/features in the same event, we can learn to recognize transformation as a common happening, rather than as a paradox or dilemma.

Framing the Dialogue-model
The Framing the Dialogue-model in paper VIII and figure 36 may be used to stimulate discussions of complex and changing phenomena that include contrasting, bipolar features. This model further develops the Transformation-model in figure 35 above. The purpose of the model is to support a cross-disciplinary dialogue, in which our individualized views of an event could be more easily expressed. The model demonstrates contrasting features, which offer the opportunity for individuals to express opposing and conflicting ideas. Since a specific, coherent phenomenon can embody two or more very different, opposing features, one can learn to accept that things can change in a radical (a Latin word meaning at the root) way over time. This model also offers a way to better deal with the participants’ pluralistic interpretations and to eventually explore emerging concepts, framed within the two opposing poles.

The educational field of art and design deals with opposition and contrast in aesthetic compositions. Students work with problems that include different values and conflicting forces that need to be unified into one coherent composition. Some examples are the work of Wassily Kandinsky (1979, 9 [1926]), who explored the idea of counterpoint; Rowena Reed, who referred to tensional relationships (Greet 2002, 94); and Gyorgy Kepes (1944, 29), who ex-
explained the dynamic interrelationship of opposing forces. From an art/design experience of developing a gestalt, it is crucial to work with oppositions. It was easy to transfer this need for opposition to conceptual reasoning, particularly in developing innovative ideas.

Aesthetic Phase Transition-model
The Aesthetic Phase Transition-model was developed to map out sequential changes as material undergoes transformation (Paper IX). Both abrupt and gradual material changes were easy to recognize on a visual level and therefore gave concrete, shared experiences for the cross-disciplinary participants. The purpose of the C&T laborations was to lift aesthetic reasoning into a dynamic and inclusive way of working that got the participants involved. The Aesthetic Phase Transition-model focused on the process of transformation by examining phenomena on the periphery of or beyond the current, established aesthetic boundaries. The chronological event framed in figure 37 shows the material transformation of an eggplant wedge as it was exposed to heat from a gas torch.

Spatial staging-method
Spatial staging brought together diverse activities and viewpoints within the cross-disciplinary project, primarily for the sake of the participants/co-researchers in the project, and secondarily for an interested audience. Paper VII describes the aesthetic strategy of spatial staging as an alternative to traditional art and design “exhibitions” for the evaluation of the C&T project. Spatial staging offers a holistic way of sharing first-hand experiences of key laborations from the workshops, interwoven with the lectures and discussions (figure 38).

Work/Paper X presents a film showing the exhibition space and the ongoing activities. The film material is a documentation of the exhibition. However, it was the first-hand interaction with the participants in the space and the exploration of the laborations that offered insight into the value of spatial staging.

Discussion of results – Part 3
This discussion was developed in response to the weaknesses presented above in parts 1 and 2 concerning the aesthetic taxonomy of form and its geometric foundation. “Formlessness” is an antonym to “form,” implying an opposing approach to aesthetic reasoning, problematizing the concept of “form.” However, it is not part of an anti-aesthetic postmodern approach aiming to sacrifice the modernists’ aesthetic knowledge of form (Foster 2002 [1983]). Instead, the results and concepts presented here question the normative tendencies and the concern for beauty generated by the taxonomy. The discussion here strives to open up the field of aesthetics beyond the boundaries of predictable form and applied principles towards a process-based aesthetic reasoning, which has the potential to reorient the field of aesthetics.

Since the proposed aesthetic taxonomy of form developed within a design paradigm (as outlined in part 1), I began to recognize the risk of creating an exclusive system that ignored the chaotic and complex nature of form and formlessness in the real world. A taxonomy might confine form within a very narrow field of aesthetic concepts and principles for designers, which could easily become dogmatic, as was the fate of the aesthetic studies at the Bauhaus (Fitzgerald 2002).

Part 3 was developed through empirical investigations...
conducted during the Cross-Disciplinary Studies in Complexity and Transformation project. The methods used in this study are described in chapter 4 of the present thesis, and in Papers VII–IX. The aim of the C&T study was to support the renewal of aesthetic reasoning in both the art/design and the scientific communities.

**Formlessness and the field of complexity**

Two main sources of inspiration for the conceptual development of part 3 are:

- Theoretical and practice-based work in the arts on the theme “formless” (in French, *informe*) (Bois & Krauss 1997)

- The multidisciplinary field of complexity, which is concerned with studies of chaos and emerging and transforming phenomena

The questions I discuss here in part 3 concern the following: How can we develop aesthetic reasoning that follows the emergence of new structures as well as the breakdown of old ones? What abstract principles (if any) can be formulated that offer a means for orientation as materials change and transform? Or, perhaps even more importantly, what concepts of reality could be helpful in finding ways to deal with formlessness? Finally, a short discussion is presented around George Bataille’s suggestion of a “taxonomic disorder” (Bois and Krauss 1997, 18).

Aesthetic reasoning that embraces formlessness and ugliness has offered me a way to step out of the restricted aesthetic paradigm of design. As mentioned in chapter 2, George Bataille declared that the formless is understood through an immediate experience (Bois and Krauss 1997). An awareness of the immediate is also an important issue in Dewey’s (1980, 119 [1934]) aesthetic approach. Since formlessness has no simple organized contours or stable structures, one cannot easily classify it in the same way as we classify stable structures such as chair, apple, nail, etc. Formlessness therefore provokes an aesthetic reaction that engages our biases and individual sensitivities. Understanding formlessness requires risk-taking, because it challenges the aesthetic threshold of what we can tolerate or appreciate. By accepting formlessness in an aesthetic approach, we go beyond beauty, geometry, and the well-known curvature of the body (which is the foundation of the taxonomy of form in part 1 & 2).

The constructivists and modernists radically questioned aesthetic norms, which were established within an elite culture. Their approach for a renewal of aesthetics was to turn to science for concepts and models. Throughout the first two decades of the constructivist and modern movements, their aesthetic reasoning was considered provocative, challenging the norms of beauty (Krauss 1981, 53 [1977]). Today, the aesthetic contributions of these movements have become the dominant aesthetic norms (Habermas 1998 [1983]).

Even though designers need to work with norms in order to easily communicate semiotic attributes, it is also vital for the design profession to develop unconventional approaches that break and go beyond the norms. I argue
that the return to the arts and the active acceptance of formlessness—which includes the ugly—is an important step towards aesthetic renewal. The Transformation- and Framing the Dialogue-models, presented here, provide support for this step toward renewal.

It is becoming apparent in the design community that survival in the marketplace today cannot rely simply on following norms. New expressions must be uncovered through interaction with the real, complex world. I argue that to develop aesthetics, we need to connect the normalizing and exclusive aims of form/beauty with the chaotic openness of formlessness/ugliness.

**Strengths**
The strength of the C&T project was the opportunity to explore a common theme from different, contrasting disciplines: art/design and physics. Four strengths concerning formlessness are discussed below:

1. **Process-based aesthetic reasoning**
2. **Bipolar reasoning**
3. **Conflict and reward**
4. **Spatial summary**

**A first strength** is found in the three models: The Transformation-model, the Framing the Dialogue-model and the Aesthetic Phase Transition-model, which all attempt to bring aesthetics into a process-based reasoning that changes over time and grasps the unpredictable qualities of formlessness. According to Pehr Sällström (1999, 15–6), our senses have evolved to deal with long-term changes. He states that we easily learn to select relevant relationships and properties in continuous processes. Only since the industrial revolution have we been surrounded with artifacts about which we have little or no comprehension of the particular process that produced them. Formgiving and explorative studies of complexity are about taking part of transformation processes—including generative and degenerative processes—that show predictable and unpredictable changes.

**A second strength** is the bipolar reasoning in the Transformation- and Framing the Dialogue-models, which promotes an awareness of differences through contrasting concepts and features. Bipolarity is different than a dichotomy, because it is not necessarily about creating poles that mutually exclude the qualities at the opposite pole. Bipolar reasoning involves more of a sense of mutual dependency; each pole needs the other to embrace complex reasoning. Edith Ackermann’s (1991) research supports the need for “differences,” because they provide a framework for studying new ideas. She connects our ability to deal with differences with our ability to develop rich and diverse individuality, which can challenge formalized thinking. Christopher Alexander (1964) refers to studying the “misfit” as a method for learning about what the problem is and is not. Deleuze also explains the need to meet the radically unknown and foreign, if we are to learn something new. According to Fredrika Spindler, Deleuze considers the meeting of the unknown as initiating a kind of “conceptual violence,” because the unknown usually opposes the known, which shocks our view of the world (Spindler 2004).

To summarize, if our goal is to renew our aesthetic reasoning, we need to be prepared to confront the unknown and question the foundation and biases that make up our present aesthetic knowledge. It is therefore important to develop models that expose us to this confrontation, if we truly wish to generate and regenerate aesthetic knowledge.

**A third strength** centers on supporting a constructive discussion and our ability to deal with conflicting relationships. The Framing the Dialogue-model relies on a bipolar spectrum to stimulate an exchange of ideas between participants. A bipolar spectrum works by pointing out “conflicting” concepts within the same coherent phenomenon, supporting a sharp discussion climate. Gordon Pask’s (1976) theory of conversation supports the positive effect of conflict as a means of learning and “a source of cognitive energy.” His empirical work with dendritic crystals (which also inspired a C&T laboration; see paper VIII) gave evidence showing how conflict and perturbation could enhance growth through a reward system (Cariani 1993). The crystal branches at the area of “conflict” were rewarded with more energy flow, which led to the formation of more crystal structures. These crystals would have to find alternative connecting structures to overcome the conflict in the area, thereby increasing structural variation and demonstrating an ability to adapt. The other branches, outside of the conflict area, might receive less energy, causing their growth pattern to stagnate.

**A fourth strength** lies in summarizing a controversial project, like the C&T project, by spatially organizing the methods and results. The Spatial staging method uses the exhibition hall as a 3-D model to navigate through the project. By placing laborations together simultaneously in the same space, one could walk between them and begin to draw parallels that would not be possible in the traditional way of summarizing a report. What spatial staging offers is an experiential opening that may stimulate the participants’ involvement. Its strength lies in the demonstration of real phenomena, which stimulate immediate aesthetic reactions and invite individual interpretation.
Spatial staging differs from a traditional exhibition, because the focus is on continuing the development of knowledge for the active participants in the project by reliving and reexamining moments and concepts within the project. Spatial staging supports a way of summarizing our diverse interpretations of the theme and gaining better insight into our differences and similarities through a spatial medium. Just as a written report offers a means of gaining a better understanding of a project, a “spatial report” may offer a means of seeing connections between ideas and artifacts, thereby enhancing understanding.

**Weaknesses**
Three weaknesses of embedding form in formlessness are discussed below:

1. Inclusive and boundless
2. Art as intrinsically open
3. The theme of Complexity and Transformation was not easy to define

**A first weakness** lies in the inclusive and boundless nature of formlessness. Dealing with formlessness requires a very different way of reasoning than the aesthetic reasoning through essential abstraction of form in space presented in part 1 and 2. The EoF-model has a foundation in geometry, which makes it much easier to focus on the differences and similarities of each stage within the model. Since there is no easy way to abstract qualities of formlessness, each phenomenon is treated more or less in a unique way. Formlessness is therefore boundless in two ways: i) It offers no simple system (like geometry) to compare to, in order to judge the level of complexity, and ii) an infinite number of possible situations are formless. There is no real overall model that provides a sense of aesthetic orientation in the infinite field of formlessness.

**A second weakness** could be rooted in what art theorist Morris Weitz (1996 [1956]) defines as the “intrinsically open” and “mutating” nature of the arts. The arts, as we know them today, are unwilling to offer well-formulated theories, methods, or models. This unwillingness to define a common ground makes it impossible to structure nomenclature or agree on procedures and working methods. The arts, according to Weitz, want to maintain a free attitude to methodology in order to develop a unique individual and contextualized approach. I argue in favor of this intrinsically open and free relationship at the cost of strong methods at different phases within the creative process, because I believe designers need to engage their unique sensitivities in the formgiving process on which mutating methodological development relies. This sense of openness is what makes it possible to see unpredictable relationships, which is still very much a part of an innovative design process.

**A third weakness** is that the cross-disciplinary approach did not evolve into a transdisciplinary project that could focus our collective energy on an innovative design project. This would have required resources to free the core group from other commitments. If the core group was able to spend time creatively planning a number of laborations that were contextualized in a landscape, culture, and territory, we would be able to test the methods and models developed in the C&T project integrated into a design process. Future plans for the C&T group would be to reapply for trans-disciplinary funding, focusing our efforts on a project that is more contextualized.
4. METHODS AND PROCEDURES: SUMMARY AND DISCUSSION

This chapter is divided into 3 parts. Each part presents a summary of methods followed by a discussion.

Part 1 Form—Developing an aesthetic taxonomy of form (Papers I–II)
Part 2 Expanding and challenging the Evolution of Form-model (Papers III–VI)
Part 3 Formlessness—Beyond the aesthetic taxonomy of form (Papers VII–X)
Concluding discussion of methods

Background to methods and procedures
Until recently, research resources have not been available for art and the art-oriented design/architectural field, leaving a weak collective understanding of methodology. Now that the academic community is developing a growing interest in the art-oriented methodological development of the practicing design/architectural world, we can begin to open up the process. However, in order to create a supportive research atmosphere, the academic community at large needs to re-examine its criteria of what a “method” is. In the early 1900s, perceptual gestalt scientist Max Wertheimer found scientific methodology too insensitive to the field he was studying.

We go from the world of everyday events to that of science and not unnaturally assume that in making this transition we shall gain a deeper and more precise understanding of essentials. The transition should mark an advance. And yet, though one may have learned a great deal, one is poorer than before. It is the same in psychology. Here too we find science intent upon a systematic collection of data, yet often excluding through that very activity precisely that which is most vivid and real in the living phenomena it studies. Somehow the thing that matters has eluded us.
(Wertheimer 1997 [1924])

Today, science is much more open to alternative methods that can deal with living phenomena, as well as direct and indirect human perception, thanks to the efforts of scientists like Max Wertheimer.

Search for alternative scientific methods
In 2001, the Swedish Parliament passed “Government Bill 2000/2001:3,” giving research status to the arts and encouraging the development of networks between art schools and other universities offering research experience, as well as the initiation of art/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 developing knowledge. Another argument stated in the bill was that the government needed to stimulate alternative methodologies that deal with “creative subjective values” as opposed to traditional scientific activities. In the wake of this bill, the Swedish Research Council offered funding for artistic research and development and gave the arts a place on its research board.

What is a method?
When I began to pursue my formalized research education in collaboration with Chalmers, the first task I was given by my supervisor, Dr. Monica Billger, was to explain the methods, strategies, and procedures I had used to develop the educational material that served as the starting point of my research. At that time, I could not clearly explain how I integrated my teaching practice with research in form theory. My course plans did not go into detail about the procedures in the studio, focusing rather on the learning outcome for the student. All my previous art and educational projects prior to doing research focused on presenting the results through sculptures, 3-D models, exhibitions, graphic illustrations, and concise texts. It took a lot of effort for me to begin to outline my educational methods and to define the underlying theoretical basis guiding the
particular way I approached the aesthetic field of form and space. Although I build heavily on my experience with Rowena Reed, she never documented the methodology she and Alexander Kostellow developed through their teaching. So I had no literature to refer to that explained the methods and procedural traditions I had inherited and those I planned to develop.

Procedural knowledge
Donald Norman (1988, 57–8) explains that we use two different types of knowledge: “knowledge of,” which involves facts and rules that are easy to document, and “knowledge how,” which deals with procedural knowledge that is almost impossible to write down and is taught by demonstration and through practice. Most of the methods I have used to conduct the present research project concern procedural knowledge. Since art, design, and architecture rely heavily on such procedural knowledge, this may explain why it has been so difficult for these disciplines to define research methods. Victor Margolin (1984) refers to this lack of “self-definition” of methods from inside the active design field as one of the major problems in design research today.

Part 1: Form – Developing an aesthetic taxonomy of form

The five main methods and procedures developed and applied in part 1 are:

- Pedagogically framed research
- Cooperative inquiry
- Essential aesthetic abstractions
- 10-step Concept-Translation-Form-method
- Sculptural working procedures

Pedagogically framed research
Using pedagogically framed research methods, I engaged students in the development of aesthetic knowledge of form and space (Paper I). Traditionally, art and design schools have had little academic structure or funding for doing research, especially if the research was not “contract research” geared to areas that are sponsored and controlled by industry. One way of doing more “self-defined,” practice-based, explorative research is to combine it with teaching, a method referred to here as pedagogically framed research. Reed, Kostellow, and the artists/teachers at the Bauhaus and at the VKhUTEMAS in Moscow all developed their ideas through teaching, as well as through their art (Greet 2002, Lodder 1987[1983], Wick 2000 [1982]). My work continues and expands this pedagogically framed research tradition.

Cooperative inquiry
Peter Reason’s (2003) research in cooperative inquiry has strong parallels with how teaching and research have merged as a method during the development of the present thesis. The epistemological grounds of the “cooperative inquiry” method are to engage the participants (students) as “co-researchers” in a joint venture with the researcher to develop new knowledge (see Paper I). These co-researchers participate in the project by relying on their experiences and ability to react and reason about the way the project progresses. As defined by Reason, the four interwoven activities that support cooperative inquiry are face-to-face encounter, presentational knowledge, propositional knowing, and practical knowing. As the industrial design program at Konstfack is based on these four activities, it was easy to apply this method in my research.

Essential aesthetic abstractions
The development of the aesthetic taxonomy of form, presented in paper II and in chapter 3, builds on methods that emphasize essential aesthetic abstractions of form in space. Essential aesthetic abstractions are immediately felt and relate to the overall gestalt. The term “essential” is defined in the perceptual and neurological sciences as meaning the vital properties of a composition or body. It is about the inner essence of objects and how they occupy space (Zeki 1999, 10–2). Perceiving essential aesthetic abstractions has to do with direct and indirect perception and is similar to visual studies in experimental gestalt research (King and Werthiemer 2005, 343). It is about the capacity to sacrifice superficial qualities and properties in order to grasp three-dimensional, inner movements and structures (see chapter 2). Essential abstractions, as presented in the present thesis, are synonymous with Reed and Kostellow’s concept of 3-D “visual abstractions,” defined in their structure of visual relationships (Greet 2002, 32–42). I chose to use the term essential aesthetic abstraction in the present thesis instead of visual abstraction because my practice-based, embodied methods question the dominant role of our visual senses. Examples of essential aesthetic abstractions are inner axis, directional forces, tensions, spatial dimensions, expansion, and matrix. Wassily Kandinsky (1979 [1926], Rudolf Arnheim (1969, 48) and others also worked with essential abstractions.
10 step Concept-Translation-Form-method

Through close collaboration with industrial design students, a pedagogically framed 10-step Concept-Translation-Form-method (see figure 39) was developed within a practice-based, art-oriented, formgiving culture at the Department of Industrial design at Konstfack in Stockholm. The method is explained in detail in Paper I.

The 10 steps are:
1. Lecture on concepts
2. Translation
3. Experimental 3-D modeling
4. Individual support
5. Gathering the work
6. Perception and reflection
7. Exploring aesthetic reasoning
8. Bipolar spectrum
9. Summary
10. Feedback

This method alternates between developing concepts concerning aesthetic abstractions and developing 3-D physical models, aiming to merge analytical reasoning with embodied reasoning. Since I work in a practice-based culture, we rely on developing knowledge-through-action (Molander 1996). I therefore purposefully start by presenting concepts to underline the importance of developing a nomenclature and broaden the possibilities of how form can take shape. The steps in the method reflect a) sculptural procedures and techniques from my own education with Rowena Reed; b) the students’ need for translating aesthetic concepts into Swedish; c) the students’ interest in advancing 3-D aesthetic knowledge and procedures; and d) my own need to develop teaching material and further explore the field of applied aesthetics. This method is also presented as a result in chapter 3.

Translation

Living in Sweden imposed the need for me to translate the terminology I brought from my education with Rowena Reed and the new terms that were emerging through the development of the Evolution of Form-model. The students and I re-examined the visual vocabulary systematically, moving back and forth between English and Swedish. We discussed domestic and professional terms, concepts and words in an open dialogue, exposing the differences in our cultures, as well as our individual backgrounds. The translation process made me keenly aware of the semantic problems all terms impose (see paper I). The important issue I found was that the aesthetic definitions of form are vague and cannot be understood until embodied in a perceptual, physical form. The entire procedure developed to deal with cross-cultural terminology was intuitive. Today, I continue to apply this process of translation even though I speak fluent Swedish. Due to the abstract nature of the terminology I use, it is important to spend time examining a concept from different cultural and semantic vantage points and expressing its meaning through form.

Sculptural working procedures

In the 10-step model, we have worked with certain inherited sculptural principles, procedures and techniques (see figure 39).

Here I list only a few that stem from my practice-based studies with Rowena Reed and her former student, Dr. William Fogler:

- Sensing the immediate responses first, followed by aesthetic analysis.
- Making quick sketches to catch the immediacy of an impression (based on Hans Hoffman’s “action painting”).
- Perceiving the inner sense of form expressed beyond and beneath the surface.
• Experiencing form in relationship to void and space.
• Using a turntable as a method for grasping a gestalt. When an object is rotated on a turntable, the details are blurred and it is easier to grasp the totality of the experience (see figure 40). Learning to deal with the all-roundness of a 3-D model from an infinite number of angles is a tradition developed in the arts.

The hands-on procedures we applied in the 10-step model to develop the EoF model were supported by the set-up of tools, materials, and work spaces in the studios and workshops at Konstfack. The procedures were, as Donald Norman explains, articulated "in the world" (Norman 1988, 56–8), but they were not formulated in words at the start of the research project (see Paper I). My understanding of procedural methods progressively developed as the project advanced. This is in part due to the demand I had from my research education and from the academic writing process. I eventually found ways to communicate aspects of our procedures, though the majority of methods are still hidden within the process.

**Discussion of methods – Part 1**

The methods for developing the taxonomy of form and the EoF model are based on working with essential aesthetic abstractions (see above) that prioritize 3-D structural compositions as well as supporting the development of a 3-D gestalt process (see chapter 3, Results). It is important to examine how this essential gestalt approach prioritizes properties, relationships, movements, and the like, because these directly shape the way the taxonomy developed. It is equally important to examine what is excluded by this essential-gestalt approach in order to determine the limitations of the taxonomy. The more I develop the present taxonomy of form, the clearer it becomes to me how other means of aesthetic abstractions are excluded, such as texture, color, and sound (see Part 3 Formlessness for a more inclusive approach to aesthetics).

**Uniting concepts with percepts through form**

The 10-step method can be further discussed in more specific ways through perception psychologist Edith Ackermann's (1996) work in "situated knowledge", that involves formgiving activities. She has studied the way individuals “give form to their ideas, and how these forms, once built, inform back their ideas.” Her work both questions and supports Jean Piaget's “stage the-
ory,“ which claimed that separating abstract concepts from context represents a higher level of cognitive skills. Seymour Papert, Edith Ackermann and other scholars in the learning sciences have focused attention on the importance of the artifact in reasoning and have founded a “constructionist learning theory” (URL) based on learning-through-making. Constructionist research findings suggest that working back and forth between concrete experiences and abstractions enhances cognitive activities. My research, contextualized in the arts and crafts-oriented design traditions in Sweden, is also grounded in this type of physical–perceptual–conceptual method of reasoning. The difference between a constructionist perspective and the approach I present in the present thesis is that we emphasize the actual formgiving process, which is grounded in the intentions of the individual creating a gestalt (see figure 41). What we can bring to the learning sciences is insight into learning through developing tangible forms. This important area for research development has gained recognition the past few years; however, there is very little research available, since the field is so young and few practical formgivers have managed to find funding and supervision that support research from inside the process.

Questioning object-based scientific methodology

According to Barbara Stafford (1994, 138–40), historically there has been a very negative attitude toward research in object-based methodological development. She traces this skepticism toward experimentalists and artisans to a fear from scholars of uncovering evidence that questions theoretical dogma. She goes on to say that stereotypes were fostered depicting people from the art and crafts traditions as “impulsive-ridden” (Stafford 1994, 284) and “hedonistic” in order to keep art and artisans on the outside of the academic walls. My own experience in trying to establish research in applied aesthetics and formgiving processes has been very difficult. The majority of researchers in the academic and science world considered this field either too chaotic or too trivial and ostensive. I argue the contrary and claim that it is through interaction with tangible forms that one can learn to a) recognize the organizing capacity of form and b) develop values and skills relating to the aesthetic processes that help artists and designers deal with a high level of complexity and find order in chaos.

Both original and didactic

I end this part of the discussion with some comments concerning advantages and disadvantages of pedagogically framed research methods in an art-based design school. To a large extent, my research has relied on creative energy, aesthetic reasoning, and the skills of industrial design (ID) students to develop the EoF-model. However, the students’ original and novel forms did not always serve the purpose of my research. For example, to illustrate a spectrum between two contrasting poles on the bipolar axis of the EoF-model, I needed a sequence of didactic 3-D models that were based on the same geometric forms and included at least one very predictable solution at the positive pole (see Paper I). ID-students at art-based schools are usually more interested in new and unfamiliar solutions, which reflect the traditions of the arts (Weitz 1996 [1956]). However, this need for originality, makes it difficult to develop didactic, physical forms. In the past few years, I have found ways to motivate students to create more logical, sequential
solutions, thus improving the *EoF*-model. Therefore, in comparison with the early version of the *EoF*-model in Paper I, the version presented in Paper II is easier to understand.

**Part 2: Expanding and challenging the Evolution of Form-model**

The three main methods and procedures developed and applied in part 2 are:
- Technology and natural processes
- Exhibition, lectures and writing as a methods for exchanging ideas between disciplines
- Witnessing transformation through similarities and differences

**Technology and natural processes**

The procedures and techniques described in papers V–VI, expanding on the *EoF*-model, were:
- Low-technology sand-casting aluminum of a convex and concave clay sculpture
- High-technology digital scanning, which produced a point-cloud volume
- Natural autopoiesis process of dehydration
- Drawing techniques that generate analogies

**Exhibition, lectures, and writing as methods for exchanging ideas between disciplines**

The *Infinity project* was developed around planning for an exhibition and a public lecture program (see Paper V and figures 42–43). This method of using spatial dimensions, physical artifacts, and oral/visual presentations for organizing ideas offers a very productive approach to support the exchange of ideas between different disciplines (Molander 1996, 220). The objects, events, instruments, and images materializing the content of the exhibition emphasized our different intentions within the theme early in the process. In the planning procedure, we were able to grasp our different approaches and find where our ideas overlapped. During the ongoing exhibition, we gave lectures and took part in sofa discussions about the exhibition in an aula linked to the exhibition space, helping us articulate and confront our differences and similarities. It became very apparent how we alternated between verbal expression and embodied experimentation (Dyrsen 2006).

After the Infinity exhibition, Lars Bergström and I collaborated on writing a scientific article entitled *Complex curvatures in form theory and string theory* (Paper V). The writing process we undertook helped us visualize our different ways of thinking for each other and made it easier to push our ideas further (Björk and Räissänen 1996, 16). We developed a strong conceptual understanding of how transparency fused materials with space in an overlapping depth dimension. By formulating questions about the particular transparent impressions that both our models expressed (figure 44–45), we could discuss transparency in a very real way that altered our understanding of the models.

This method of exhibition, lecture, and writing was further developed later in the cross-disciplinary study of complexity and transformation (see papers VII - X).
Witnessing transformation through similarities and differences

The transforming process that occurred as the pear cube dehydrated (see paper VI) was a temporal event that was witnessed in real time over about three months. The students were asked to draw or paint the different stages of change in order to:

- improve their own observation of the changes
- become involved in the transformation process through active visualization

Each drawing or image showed the particular features the student had singled out from the change process. The sequence of drawing can be considered “visual analogies” (Goldschmidt 2001) that build on similarities and differences between the transforming stages of a physical object. The final stage of the dehydration process, as shown in figure 32b, shows an object (pear cube) that transformed over a long event into a stable object. The event that produced the object is as important as the object itself.

Discussion of methods – Part 2

Both the point-cloud volume (figure 45) and the dehydrated pear (figure 32b) and apple cubes were developed as explorative projects/studies that were not initially planned to expand the EoF-model. The transparent point-cloud volume is the result of digital scanning of a clay sculpture, which involved a different technique than the solid forms that make up the stages and spectrum in the EoF-model. The idea of transparency introduces a radically different aesthetic experience opening up the EoF-model (see figure 33 in chapter 3). The aesthetic abstractions presented in the taxonomy of form apply to solid forms and may not easily adapt to issues of transparency. If we include the point-cloud volume and the organic cubes in the expanded EoF-model, a renewal of the entire aesthetic taxonomy of form is needed in order to deal with transparency and the changing qualities of such characteristics as color, texture, deformations, and translucency. However, such a renewal is not included in the scope of the present thesis.

Drawing/painting as a way to develop analogies

The sequence of drawings that captured the dehydration process of an organic cube (see Paper VI) stimulated students to single out the particular features that they recognized as important. According to Gabriela Goldschmidt (2001), the act of drawing generates analogies that improve cognitive skills by stimulating “mental imagery.” Her conclusions are similar to those of Ackermann (1995) and the constructionists. Learning to create mental imagery is very
instrumental in the design problem-solving process. The more we study transformation processes, such as those involved in the material breakdown study (Paper VI), the greater chance we have of developing the mental imagery that helps us understand life-cycle processes that include material breakdown. These images can act as a counterbalance to the aesthetic traditions of industrial design, rooted as they are in car design, whose aim is highly polished fixed surfaces that withstand degenerative forces.

Exhibitions and the writing process
Presenting the results of our Infinity project in an exhibition space and developing parallel lectures on the exhibited work gave us the opportunity to bring out our own personal and collective experiences. The experience we shared through building the exhibition helped us structure the article we wrote about our collaboration (Paper V).

Referring to the models and concepts presented in the exhibition gave us a common problem to explore. The combined experience of creating an exhibition and collaborating on writing a scientific article made this collective project very valuable. This approach of combining experience from exhibitions with academic writing processes is a well-developed research method at the University of Art and Design in Helsinki, Finland (UdA) under the leadership of Susan Vihma (URL).

Dehydrated pear cube
Part 2 represents a long transitional process that mainly developed through questions in my art, culminating in the material breakdown study embodied in the pear cube (Paper VI). This study marks an important shift in my way of approaching aesthetics, making me realize the limitations of essential, aesthetic abstractions and inspiring me to initiate an explorative process for finding other means of abstracting (see the first workshop in the C&T study, which developed this material breakdown study further as presented in Papers VII - IX).

Part 3: Formlessness – Beyond the aesthetic taxonomy of form
The three procedures and strategies developed and applied in part 3 are:

- Laborations as multidisciplinary and art-based explorative methods
- Cooperative inquiry
- Non-geometric and substantial aesthetic abstractions

Papers VII–X in part 3 describe and visualize methods of the Cross-disciplinary study of complexity and transformation (C&T) project. This project was funded by the Swedish Research Council for three years, 2003–2005 and was summarized in both an exhibition and a final report of the entire project. The C&T study involved a group of artists, designers, architects, and researchers from different branches of physics. It was planned around hands-on laborations (see below) that demonstrated transforming and complex phenomena. The C&T study offered four workshops with twelve lab sessions representing ten individual interpretations of the theme complexity and transformation.

Laborations as multidisciplinary and art-based explorative methods
The word laboration is used as an alternative word to “lab session” in the C&T papers VII–X. It is a Swedish word meaning experimental work in a laboratory, though here the meaning is changed somewhat, as well as contextualized. I would like to introduce the term laboration as an international word used in an art-based context meaning:

Laboration: Interactive, embodied experiment performed in a collective, where the participants are free to explore many different approaches within and beyond the broad interpretation of the intentions of the laboration as such. Laborations invite aesthetic reactions and reasoning, as well as creating a forum for dialogue and playful impulses. They were developed for multidisciplinary collaboration, but is suitable for any group constellation.
How the laborations were planned

Through a number of meetings with the workshop leaders, project leader, and one or two members from the core group, we discussed a theme and procedures for the laborations. The workshop leaders were asked to create a laboration as follows:

- Exemplify complexity and transformation
- Introduce an unexplored area/question in relation to your work/research field
- Stimulate perception
- Support open experimentation
- Inspire playful interaction

The workshop leaders introduced the laborations through an oral/visual performance (Stafford 1994, 1) explaining their own background and their intentions with each laboration (figure 46).

The laborations were not to be regulated through strict protocols. Rather, the workshop leaders were asked to supply materials, provide a general setup and formulate somewhat “ambiguous” directives so the participants had to use their intuition and experience to develop the procedures of the laboration. Insight from game theory shows that individuals tend to become engaged in playing when they must make choices that determine certain pathways and give unique outcomes (Graver et al 2003).

Play and skill

The particular development of each laboration emerged through playfulness entwined with the skillful discipline of the participants. Friedrich Schiller (1995, 76–80 [1795]) advocated that the drive for an aesthetic experience and the drive to play are one and the same. He found that unconditional play overcomes egotistic behavior, which stimulates interest for others and urges a drive to create (see figure 47a-c). Bringing highly disciplined professionals together in a situation that supports play with relevance for a common project is an art-based method that is very valuable in multidisciplinary projects.

Haptic and intentional movement

All laborations in the C&T project supported various degrees of haptic/embodied experiences. By stimulating hands-on interactivity, the participants were easily engaged in exploring the complex phenomena presented in the laboration (see figure 48 a-e and papers VII–X).
Cooperative inquiry

Peter Reason’s (2003) research in cooperative inquiry describes methods that involve the participants as co-researchers in projects. In the C&T project, the participants helped to plan and carry out the laborations. This method was expanded to encourage explorative, immediate and playful interaction during the concrete laborations, supporting a relaxed dialogue of everyday reasoning, mixed with professional insight.

Non-geometric and substantial aesthetic abstractions

The development of the Aesthetic Phase Transition-model (see chapter 3 and Paper IX) was based on strategies challenging the use of geometric references and essential aesthetic abstractions, as defined in part 1. My interest in formlessness has led me to try and find explorative methods for developing substantial abstractions that treat material as substance in a physical context and engage more haptic experience. This includes eg. regular and irregular outer properties as well as color and texture on a surface in relation to the inner properties of density and viscosity (figure 48e). I am also concerned with the aesthetic experience connected with how material changes over time, which places aesthetic reasoning in a more temporal and context-sensitive mode that even includes the negative pole of aesthetic experiences such as “ugliness”. Gathering samples is one means of developing substantial abstractions.

Discussion of methods – Part 3

Stimulating explorative experimentation

The present thesis introduces the art-based multidisciplinary laboration method that enables participants to engage in embodied explorative experiences. The laborations are set up with the intent to stimulate an aesthetic exchange between participants in the ongoing experiments. I argue that the laboration method introduced in the present thesis is a valuable, and perhaps necessary, complement to rigorous monodisciplinary methods. Innovative researchers and teachers seldom have time to play together and allow their immediate reactions to guide an explorative project. Tapping into these more embodied reactions of skilled individuals from different disciplines is, I believe, an important art-based scientific method to stimulate discovery and change. Similar types of laborative procedures are also used in the Masters introductory research course, “Research by design,” at Chalmers (Billger and Dyrssen 2005).

Art historian Barbara Maria Stafford’s (1994, 190) book on “Artful science” supports this laboration method, implying the importance of play, aesthetics and sensuous experience in experimentation and knowledge development. However, she points out that the scientific community, residing within its academic walls, discourages this kind of aesthetic playfulness (Stafford 1994, 140). She argues that qualitative methods of playful exploration of phenomena do not easily translate into quantitative methods that offer measurable results.
No common methods or definition
A weakness of the open explorative methods used in the cross-disciplinary C&T study could frustrate those participants who were goal-oriented problem solvers. Since the theme complexity and transformation was a controversial theme in the scientific community and an ambiguous one in the art/design community, we had no common ground to stand on. Therefore, we did not offer a definition of the theme or suggest methods at the start of the project. Instead, the purpose of the project was to experience different interpretations of the C&T theme and broaden one’s own direct experience.

Cross-disciplinary studies are difficult in themselves, so perhaps a theme like complexity and transformation makes it even more difficult to understand each other. Halfway through the project, I felt overwhelmed and at times wished for a more focused theme. However, now that the project is completed, I feel that the complexity theme is exactly what the project was about, on both a meta and a concrete laboration level. The theme complexity enhanced an open dialogue because no one was an expert in the field. Sometimes the physicists offered insights into the mechanisms of heat shock or crystal growth that helped sharpen our focus and benefited the development of the laboration. At other times, the inspired formulation of how to disturb a system could motivate interaction with the phenomena. Since most of the participants felt uncertain about the definition of the theme, we needed the various individual interpretations embodied in the laborations to grasp what complexity and transformation could mean.

Beyond essential abstractions and regularities
Regarding the need to go beyond essential abstractions and explore new methods that can deal with complex phenomena and formlessness, I found inspiration in the theoretical work of Gilles Deleuze as described by architect Fredrik Nilsson (2004, 109–11) in his recent doctoral thesis. According to Nilsson, Deleuze strongly questions the idea of essential abstractions of modernism. Deleuze recognizes the need for “impure” abstractions that are embodied in the material world and come directly from empirical, pragmatic and experimental activities. Instead of striving for universal abstractions, he contextualizes them. The C&T project that was planned around laborations of complex phenomena has many parallels with how Nilsson interprets Deleuze’s way of reasoning. In my view, the challenge is to show practically how substantial, meaning “unpure”, aesthetic abstractions may be used to enrich the formgiving process and in turn broaden our applied aesthetic knowledge.

George Bataille uses the concept “formless” to create complex methodology that looks for heterogeneity and aims at declassifying and emancipating objects from simple categories. Bataille was against the creation of categories and abstractions. However, he toyed with the idea of creating a “taxonomy of disorder” (Bois and Krauss 1997, 18). According to Yve-Alain Bois (1997, 53–62), formlessness means to appreciate matter for what it is and not for what it might “resemble” or “should be”.

In the book Art and Complexity, physicist Murry Gell-Man (2003) also argues for the need to prepare scientists to recognize and expect impure and “irregular structures.” Gell-Man reached this conclusion through his research in complex and adapting systems, as well as in how irregularities mark complex systems. Yet, according to Gell-Man, a natural science education seldom provides students with methods for studying irregularities. I argue that art-related research exploring impurities and irregularities through formlessness may improve our methods of understanding complex phenomena.

Concluding discussion of methods
The most valuable method I have used throughout my research, as described in the present thesis, is the cooperative inquiry method, which engaged students and experienced professionals as co-researches in explorative studies to develop aesthetic knowledge.

In the monodisciplinary, pedagogically framed studies with ID students, a common nomenclature was used and a workspace set up that placed physical and conceptual boundaries around the questions to be explored. In the multidisciplinary, open-ended studies of complexity and transformation with experienced professionals, however, we shared no common nomenclature and worked in a variety of situations.

Both of these approaches gave very different results that complemented each other. By going between a focused and a fuzzy approach, the inquiry of aesthetics may become vivid as form at one level and elude us through formlessness at another. Both vivid and elusive impressions are part of an aesthetic experience.

Art is a quality of doing and of what is done.
John Dewey (1980, 214 [1934])

...art as intrinsically open and mutating.
Morris Weitz (1996 [1956])
5. CONTRIBUTIONS, CONCLUSIONS AND FUTURE PLANS

5.1 Contributions

Part 1: Developing an aesthetic taxonomy of form

- Documented and further developed a four level taxonomy of form in space including a nomenclature, building on essential aesthetic abstractions (Paper I-II).
- Created and visualized the Evolution of Form (EoF)-model (Paper I-II).
  - Developed four of the seven stages along the horizontal axis of the EoF-model, i.e. intersection/merge/distort.
  - Developed the bipolar spectrum along the vertical axis of the EoF-model including the following eight concepts: accordance/discordance, assimilate/dissimilate, converge/diverge, conform/deform.
- Developed a 10-step Concept-translation-form-method encouraging students to participate in the conceptual and practical development of the EoF-model (Paper I).
- Established the concepts formgiving and formgiver.

Part 2: Expanding & challenging the Evolution of form-model

- Expanded the Evolution of form-model (Paper VI)
  - Developed concepts of material breakdown, transparency and point-cloud volumes in the expanded version of the EoF-model.
- Developed exhibitions, lectures, artifacts and writing as methods for driving trans-disciplinary, collaborative projects (Paper IV, VII and X).

Part 3: Formlessness – beyond the aesthetic taxonomy of form

- Developed art-based, explorative laboration-methods (Paper VII-IX, chapter 3 in coat)
- Developed Aesthetic phase transition-model (Paper IX)
- Developed Transformation-model (Paper VIII)
- Developed Framing the dialogue-model (Paper VIII)
- Developed Spatial staging-method (Paper VII and X)

Concluding contribution

- Presenting the provisional illustration: Three modes of abstraction – to support a discussion of what aesthetics can offer (figure 49 and section 5.2)
5.2 Concluding remarks

The present thesis has developed alternative methods engaging students and experienced professionals from different disciplines in active formgiving procedures and explorative laborations, attempting to develop and renew applied aesthetic knowledge. Aesthetic abstractions, of both essential and substantial character, may offer theoretical and procedural knowledge about the structure of form as well as grasp a deeper contextual understanding of the theme complexity and transformation.

Modes of aesthetic abstraction

I would like to suggest a provisional mode of abstraction, designated aesthetic abstraction, which contextualizes reasoning by supporting the unique background, sensitivities and experience of individuals. It is about sensuous cognition relying on immediacy, playful interaction and engagement in order to “charge” the process with energy to create a gestalt. This aesthetic mode of reacting and reasoning needs to operate in authentic situations that offer a sense of coherency and motivate gestalt processes.

Aesthetic abstractions, driven through our embodied experiences, complement numeric mode = measurable units of abstraction, and linguistic mode = words of abstraction. All three modes of abstraction are interdependent on each other, and although the present thesis attempts to zoom in on aesthetic abstractions, they should all be integrated when applied. The art, design and architectural disciplines are known to actively use aesthetic reasoning within their professions (Karls-son 2002), thus clearly marking the difference between prioritizing numerical abstractions, in eg. engineering, and linguistic abstractions, in the humanities.

Figure 49 shows a provisional Three modes of abstraction-model, which was initially developed in response to a questionnaire from the Swedish Research Council for the evaluation of the Cross-disciplinary study of Complexity and Transformation. The questions focused on explaining the results of our project on a meta-level and the issue of who/whom might have practical use of art-based research. I argue for aesthetic abstractions as an embodied kind of “meta-level” and through collaboration with other disciplines I have found that aesthetic modes of reasoning are important for the development of knowledge in any field. I believe the field of applied aesthetics can benefit the research community by offering ways to open up a sensuous cognition that is inclusive and not restricted to the norms of beauty. The intentions, sensitivities and experiences of individuals need to be respected as a vital driving force for the research process since they often play a part in determining how research results may be interpreted.

Figure 49 shows three overlapping cones of different heights, with their shared base surrounding the upper half of a sphere. The tip of the largest cone is aligned with the concept separation and the base of the cone, surrounding the sphere, is aligned with the concept contextualization. The three modes of abstraction are defined as numeric, linguistic and aesthetic, and are placed in relation to the spectrum between separation and contextualization. Aesthetic abstractions are grounded in context at the base, while linguistic are in the middle and
numeric abstractions are at the tip of the largest cone.

Finally, as I consider my experiences in developing the present thesis, I feel ambivalent about how I have prioritized linguistic abstractions to argue for the importance of aesthetics. I would have felt more comfortable by arguing more through different types of aesthetic abstractions in the creation of forms, photos, diagrams, illustrations etc. In the future it is my hope that the scientific community will include aesthetic abstractions as a mode of reasoning so that research in the field of aesthetics (and any field) could actually be structured through aesthetic arguments, using linguistic and/ or numeric abstractions only to support the aesthetic reasoning. If science aims to deal more closely with contextualized knowledge development, we must give the field of applied aesthetics a chance to prove its validity.

5.3 Future plans
Here are a number of suggestions for future plans that aim to generate and regenerate aesthetic abstractions:

1. Elaborating within and beyond the aesthetic taxonomy of form
   a. Develop a masters course at the Dept. of Industrial Design at Konstfack
      This course should problematize the modernistic foundation of the original work presented in the book *Three Dimensional Visual Analysis* and involve a collaboration with students and experienced professionals by:
      - Re-examining the ways of reasoning that essential aesthetic abstractions are built on.
      - Re-conceptualizing the taxonomy of form in relation to the 6th stage, distort, and the 7th stage, organic, in the Evolution of form (EoF)-model. The approach to distort needs to be defined in depth. The approach to organic, based on human figure studies, could e.g. be developed to include more specific aesthetic knowledge of aging during our life span. Emphasis could be placed on comparing generative and degenerative processes in both the distort- and organic stages.
      - Exploring possibilities of integrating haptic, kinesthetic and tactile qualities within or beyond the taxonomy of form, with the aim to develop a more embodied approach to applied aesthetics.
      - Pushing the limits of the negative pole in the bipolar spectrum of the EoF-model at all stages.
   b. Revise the aesthetic taxonomy of form
      Improving photographic material, format/ graphic layout and the original text in the book *Three dimensional visual analysis*.

2. Investigating the formgiving process as a method to develop knowledge
I would like to organize a trans-disciplinary project that uses the industrial design process, including formgiving activities, developed at our ID department. The proposed project could aim to develop both aesthetic knowledge and offer tangible and intangible product solutions. The steps for the development of the project might be:
   - Formulate an applied design project attempting to solve a particular authentic problem within a defined context.
   - Interface the formgiving process within the design process, with an academic ambition to develop and document aesthetic knowledge. This entails oscillating back and forth between problem solving and studying relevant aesthetic issues, unfolded within the design process.
   - Set up a number of laborations parallel with the design process that further explore, organize and document relevant aesthetic issues. Many of the methods and models presented in the present thesis could be applied.
   - Develop innovative design solutions aiming to both generate new aesthetic abstractions and regenerate established aesthetic procedures within and beyond the presented taxonomy of form.
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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. 

The two major aims of this empirical study were: i) to investigate ways for creating a visualization model outlining 3-D form that reciprocally merges geometric and organic structures, ii) to find a way to expand aesthetic reasoning to include incongruency in reference to geometry.

An educationally framed research approach was developed applying a cooperative inquiry method engaging industrial design students at Konstfack (Stockholm Sweden) as co-researchers with feedback and feed-forward loops. A practice-based, 10-step Concept-Translation-Form-method was developed. The different steps developed from the following sources: a) sculptural working method from my own education with Rowena Reed, b) students’ need for translation of aesthetic concepts from English to Swedish, c) students’ participation in practical / analytical studies that advanced their 3-D aesthetic knowledge and d) creating teaching material based on a comprehensive analytical structure.

The main result was the development of the 7-stage Evolution of form-model including a bipolar spectrum at each stage. The visualization model presents an aesthetic nomenclature with a dozen specifically defined terms illustrated by physical forms. Furthermore, the practice-based, 10-step method is also presented as a result.

PAPER II
Three dimensional visual analysis. 

The aim of this paper was to create an aesthetic taxonomy and nomenclature of principles, concepts and models presented through 3-D physical forms and/or 2-D illustrations. The methods to develop this system were: i) the 10-step method outlined in Paper I combined with informal discussions with students about translation of general aesthetic concepts, ii) my own sculptural/design experiences with Rowena Reed, iii) literature studies in the cross-disciplinary field of art, design, architecture, learning sciences, engineering and physics and iv) my own artistic experience within a contemporary constructivist artists community in Stockholm.

The result was the development of a taxonomy of form in space organized around four major sections:

I. Elements and their properties
II. Movements and forces
III. Relationships (including the Evolution of form-model, mentioned in Paper I)
IV. Organization

The material in this text book has been partially revised during the present research project resulting in e.g. a new version of the Evolution of form-model presented in Paper VI and in an enclosed poster in the thesis.
PART 2
EXPANDING & CHALLENGING THE EVOLUTION OF FORM-MODEL

PAPER III

This article summarizes my early work with hard edge geometric compositions up to a recent project, Point cloud volumes. It briefly presents my different exhibitions at the Gallery from 1986-2006 and the turning point from distorted geometric reasoning to transparency and formlessness.

WORK/PAPER IV

This Work/Paper IV is primarily presented by photographic documentation of the exhibition, (see Paper V for an in-depth description of the collaboration that drove the project). The final exhibition was designed to express our collaborative approach emphasizing our different views concerning the theme Infinity and complex curvatures. The final goal of this study was to present material from an exhibition on Infinity at the Art and Science Festival: Spelplan Stockholm in September 2002 (see Paper V).

PAPER V

The aims of this collaborative art/science study were to develop aesthetic criteria concerning complex curvatures moving between dimensions in conceptual and perceptual space.

The methods used were open explorative meetings for nine months to prepare the content of an exhibition and program for an art/science festival at Kulturhuset in 2002. Physical Lars Bergström and artist Cheryl Akner-Koler developed a theme around complex curvatures, twisting and curving within an unending cyclical path with no separation between inside and out. Bergström’s background in theoretical physics and his interest in string theory inspired him to further develop his conceptual and perceptual awareness of the digital model of a Calabi-Yau manifold. Akner-Koler sculpted a compound twisted sculpture that explored variations of density, width and a shift of accents, based on the construction of a Möbius strip. A practice-based aesthetic study of transparency was a central part of this project by using 3-D digital scanning technology and digital tools for 3-D transparency.

The results were: 1) a final sculpture, Twisting curvature, produced in aluminum through a lost-wax method and then plotted through a 3-D digital scanner, which translated the aluminum sculpture into a translucent “point cloud” volume, 2) a transparent digital model of the Calabi-Yau was developed creating a manifold that blended into the surrounding space giving a better expression of the multi-spatial dimensions of the Calabi-Yau.

PAPER VI

The aim of this paper was to challenge and expand the foundation for aesthetic reasoning in the general field of industrial design, and specifically the Evolution of form-model described in Papers I & II. The project addressed two major questions: How can we gain new aesthetic awareness through art/science collaborative projects concerning the theme Infinity and cyclical processes? How can ecological issues inspire aesthetic reasoning?

Two empirical methods were applied: 1) Complex curvatures/transparency: Sculpting procedures and 3-D digital techniques were used to explore complex curvatures in multi-dimensional space through collaboration between art and physics, 2) Ecology/Material breakdown: Pedagogically framed experiments where students were asked to cut organic material in geometric shapes (cubes) and allow the cubes to dehydrate.

The results offered new form examples that expanded the Evolution of form-model in two different ways:

1) Complex curvatures extended the horizontal axis after the organic stage towards transparency and amorphic properties
2) Ecology/Break-down expanded the vertical, bipolar axis at the stage, Distort, towards the negative pole, Deform.
PART 3
FORMLESSNESS - BEYOND THE AESTHETIC TAXONOMY OF FORM

PAPER VII

Through the support of a three year grant from the Swedish Research Council, a diverse art/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 cross-disciplinary network of individuals represented a balance between gender as well as different cultures and ages. Some of the questions this study aimed to answer were:

1) How can aesthetic reasoning embrace a more temporal and context-sensitive awareness?
2) How can exploratory laboratories 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?

The empirical methods for driving the project were to involve participants as co-researchers in the project. Four embodied workshops with 12 interactive laboratories were planned and performed playfully exploring complex and transforming phenomena. Video documentation from a participant’s vantage point created a C&T video archive that exposed the meaningful dialogue and working process conducted during the laboratories.

Some results were: 1) Spatial staging as an evaluation method and model to share the content of the project; 2) Three models were developed: Aesthetic phase-transition-model, Transformation-model and Framing the dialogue-model. These models are presented in Papers VIII and IX. The project was concluded by formulating a manifest attempting to unfold the aesthetics of complexity.

PAPER VIII

The aim of this study was to generate and regenerate aesthetic concepts in a cross-disciplinary study of complex and transforming phenomena over time.

The methods were to set up an explorative, interactive laboratories on dendritic crystal growth for the C&T participants. The laboration was video documented and the films were edited after the laboration. This particular laboration set up by an architect and artist, involved an electro-chemical process producing branching crystal structures called dendrites. This scientific experimental study from the 1950s, inspired by the work of Gordon Pask, was re-introduced because it offered a physical real time experience of generative processes. The intention of the laboration was to show how a self-organizing structure could emerge from a simple salt solution. The generative pattern is a fractal structure, which means that it grows by following similar local rules at all levels of growth. The dendritic growth laboration was selected because it presents complex behavior over time in the following ways: i) exhibits growth and deterioration of patterns, ii) builds up and breaks down symmetry, iii) is context sensitive, iv) shows emerging properties.

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PAPER IX

The aim of the study was to investigate changing processes over time and develop a way to study the aesthetic changes expressed within an event. The methods used here were similar to the Ecology/Material breakdown study described in Paper VII. Four groups of C&T participants were created to experiment in the Material degeneration-laboration, which was set up with four stations to expose organic materials (e.g. eggplant, parsnip, potato etc.) to radiation, microwaves, gas and steam. The groups documented their activities on video films and edited the films at the end of the laboration based on aesthetic reactions and reasoning. The films were then reviewed and discussed. From these observations and discussions we developed the following results. 1) The concept process-based aesthetics, which is about exploring both time-related events and isolated embedded objects within the event, 2) The Aesthetic phase-transition-model, which is about aesthetically recognizing a number of gradual and radical changes in an event. By comparing the patterns, structures, textures, colors etc., one could discern substantial abstractions. The Aesthetic phase transition model presented here introduces the interdependency between event and object.
WORK/PAPER X

Akner-Koler, Cheryl (project leader and producer), Norberg, Björn (co-producer)
Kajres, 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)

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.
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 II
  Three dimensional visual analysis.

PART 2
Expanding & challenging the Evolution of form-model

- Paper III
  Akner-Koler, Cheryl. 2006.
  Twisting, blurring and dissolving the hard edges of constructivism.

- Work/ Paper IV
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  “Infinity” (exhibition and program) shown September 17-29 at Kulturhuset, in Stockholm, Sweden. (www.formandformlessness.com)

- Paper V

- Paper VI
  Akner-Koler, Cheryl. 2006.

PART 3
Formlessness - opposing the aesthetic taxonomy of form

- Paper VII
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- Paper VIII
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Expanding the boundaries of form theory
Developing the model *Evolution of Form*

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**Introduction**
There is an increasing awareness in the design community to recognize the organizing capacity of form and space as an scientific method of its own right. The past decade of design-oriented research as well as research in embodiment has put focus on how the physical qualities expressed through form directly reflect and affect our way of reasoning (Lakoff and Johnson 1999). Since the qualities of form can be directly imported to us through our senses there is an experience of immediacy that can be shared over disciplines and cultures at a very basic level (Langer 1953, 31). Learning to differentiate form and spatial activities within and around form is therefore a fundamental skill for designers (Akner-Koler 1994, Greet 2002).

Form is pluralistic in nature: The physical 3-D form-sketches and mockups created during the design process bring concepts into reality. Form offers *basic level experience* that integrates parts into a holistic expression (Lakoff and Johnson 1999, 28-30). Form supports the structure and function of a product. It gives substance to intangible emotional ideas making them tangible. Form defines the boundaries of the prototype. Form carries the pragmatic semiotic signs and symbols of the product (Monó 1997).

Recent research in strategic brand identity also points to *three-dimensional product characteristics* as the central method to communicate brand identity (Karjalainen 2004). Industrial designer Jan Capjon’s (2004) thesis *Trial and Error Based Innovation*, explores how creating a rich spectrum of 3-D form (through rapid prototyping) offers scientific methods for perceptual reasoning that improves complex problem solving.

**Aesthetical domain**
The key to understanding this pluralistic nature and organizing capacity of form lies in the realm of aesthetics with roots in the active process of experiencing the real world. In this paper the concept of aesthetics concerns the active involvement of our senses through direct and indirect perception which inspires emotional involvement (Dewey 1980, 4-5), play (Schiller 1995) and aesthetical abstraction (Akner-Koler 1994).
Historical background

The present paper builds on a form and space theory that was initially developed by the painter Alexander Kostellow and sculptor Rowena Reed. Kostellow and Reed founded the first industrial design education in USA in 1934 at Pratt Institute, New York City. Their teaching approach, according to Kostellow, “drew on modern scientific methods” that supported self-expression as well as design for industry (Greet 2002).

Kostellow’s early education in psychology and linguistics at the University of Berlin, Germany, taught him analytical methods that he transferred and greatly expanded to artistic activities (Reed and Adele Kostellow, personal communication). There is, however, no literature that documents how he linked scientific methodology to art and design. I find connections to the early work of Max Wertheimer in the development of Gestalt theory and indirect perception (King & Wertheimer 2006). Kostellow’s and Reed’s close collaborative working relationship created a comprehensive system of aesthetical reasoning. This system was applied in an educational program that successively introduced different levels of visual complexity through concrete experiences in a variety of different 2-D and 3-D media. Their program offered a system of concepts, abstract terms and principles that supported perceptual and conceptual involvement of the active designer and artist under the different phases of the design education process (Greet 2002). They referred to their program as the structure of visual relationships. The terminology was consistent throughout the program and reinforced at each level.

One of their many contributions was an analytical approach for discerning 3-D properties of form and space that started with geometric form in a static, spatial framework and gradually deviated from the law-bound geometric properties to dynamic and organic principles of tension and expansion. This geo-organic vision was based on assumed principles of beauty and growth inspired by classic sculpture through Alexander Archipenko (Michaelsen & Jánszky, 1986) and Rowena Reed (Greet 2002), which gave a unique coherency to their educational program distinguishing it from the modernistic approach developed at the Bauhaus and through the Russian Constructivist movement.

Kostellow and Reed sympathized with the growing needs from industry that asked for creative methods to define and integrate aesthetical activities throughout product development. They became very instrumental in shaping the roots of the profession of Industrial Design in the USA.

My relationship with Rowena Reed developed as I worked as her personal teaching assistant and private student for two years between 1976-1978. It is through these two years of working and studying with Reed that I build my fundamental understanding of 3-D abstract aesthetics.

Terminology

In the different professions of design, art and architecture there is little consensus regarding 3-D form- and space terminology or definitions. Although the abstract aesthetical language of modernism from the early twentieth century is fairly established in the art and design world today, the exact definitions of the modernist vocabulary are not agreed upon. Modernist artists correlated scientific thinking with their artistic development.
Terminology was therefore strongly linked to the sciences such as physics, biology, mathematics, psychology, engineering etc (Lodder 1983, Wick 2000). Examples of such terms are: forces, movements, spatial activities, elements, properties, orientation, position, point, mass, negative, positive, static, dynamic etc. The aesthetical vocabulary of modernism and constructivism was therefore to a large extent, both directly and indirectly inspired by the definitions formulated by the sciences. The vocabulary used in this paper further develops and expands this modernistic language and the visual language of Alexander Kostellow and Rowena Reed.

The word form in the present paper refers to both the cognitive activity of thinking in abstract form and the transfer of abstract form to the concrete properties, structures and relationships of form elements in space (the limits of this paper does not allow for an in-depth presentation of spatial reasoning). Form involves the haptic and kinesthetic senses as well as the direct and indirect visual perception that is stimulated through physical features. Form is the manifestation of the gestalt. The aesthetical involvement needed to organize concrete form for product development is referred to here as the formgiving process, which is derived from the Swedish word formgivning, meaning to create the physical form that reflects the goals of the product.

Aim and questions
My particular aim is to define an embodied analytical method for the development of a visual/conceptual model showing a sequential development of form from the geometric to the organic. Some questions raised in this paper are:
1) What is the value of developing aesthetical knowledge based on geometric structures sequentially developing into organic properties?
2) How can reasoning through dichotomies and void expand knowledge of form?
3) How does the organizing capacity of form and space handle complex problem solving?

Methods
Pedagogically framed art/design research
Traditionally art and design educational institutions have had little academic structure or funding for doing research, especially if the research was not “contract research” geared to areas that are sponsored and controlled by industry. One way of doing more practice-based, theoretical and explorative research is to combine teaching with research which is referred to here as pedagogically framed research. The artists/teachers at the Bauhaus and at the VKhUTEMAS in Moscow as well as Reed, Kostellow, all developed their ideas through teaching (Lodder 1987, Wick 2000, Greet 2002). My work continues and expands this pedagogical framed research tradition.

Translation
Most of my teaching has been conducted in a bilingual atmosphere of Swedish and English. During my early years of teaching it was imperative for me to learn to understand Swedish. I therefore spent a great deal of time discussing with the students the general definitions and the subtle nuances of terms. This culturally imposed struggle with translating the visual language into Swedish and then using both English and Swedish
(or any other language spoken in the group) to further develop the terminology has proven to be a very vitalizing process. To constantly re-examine the concept veiled in a term has made me keenly aware of the semantic problems all perceptual terms impose. The concept defined through the term(s) is never wholly understood until embodied in a perceptual/physical solution. Today I apply this process of translation even though I speak fluent Swedish. Due to the abstract nature of the terminology I use, it is important to spend time examining the concept and expressing its meaning through form. This is why I continue to use this translation in the method below.

10 step Concept-Translation-Form method

Through close collaboration with industrial design students the following practice-based, 10-step “Concept-Translation-Form” method was developed. The different steps reflect a) sculptural methods from my own education with Rowena Reed, b) the students’ need for translation of aesthetical concepts, c) students’ participation in practical/analytical studies that advanced 3-D aesthetical knowledge and d) my need to create teaching material that was based on a comprehensive analytical structure rather than teaching material that was defined for each isolated form study. The below described participatory action research method (Reason 1994) has been applied since the mid 1980ies in numerous case studies involving 10-12 participants/students from the first and second year classes in the Dept. of Industrial Design at Konstfack as well as in other design schools in Scandinavia, see figure 1. The students applied a qualitative investigation through creative problem solving that produced form compositions uniting theory and practice (Merriam 1988).

The method is outlined in the following 10 steps:

1. Lecture on abstract concepts
   A short lecture in English is given to the students introducing the general concept underpinning a geo-organic sequential reasoning. One selected abstract concept and its definition is then presented, eg: “adapt - to fit one geometric form up against or around another geometric form without subtracting or reducing either of the forms”. The concept is further defined by discerning two contrasting poles such as: “assimilate - willing to adapt” and “dissimilate - unwilling to adapt”.

2. Translation/interpretation of concepts
   The students are asked to translate the abstract concepts from English to Swedish or to any language spoken by the students. All suggested translations and interpretations are recorded on a white board. We discuss the list of suggested concepts and arrange them in order that best match the present understanding of the concepts. Some words may be crossed out if they are either not specific enough, too specific or defined a different problem (which could be used later). Through an iterative feed-back process each successive student group questions and critically analyzes both the previous Swedish translations and the original English concepts.

3. Experimental 3-D modeling
   The students begin an open experimental sketching period of quick 3-D models (Kolb clay:
http://www.kolb-technology.com/ showing spontaneous creative solutions that aim to embody the abstract concepts.

4. Individual support
Individual support is given to the students concerning specific properties of their sketches and craftsmanship.

5. Gathering the work
The 3-D models are gathered for evaluation.

6. All-round perception
Each model is slowly rotated on a turntable and the students are asked to quietly perceive and reflect on the 3-D clay sketches to experience the all-around, holistic gestalt. They are also asked to abstract the composition in terms of: axis, proportions, properties of form, orientation, tensions and the direct and indirect relationships between elemental properties and movement and forces. (These concepts of abstractions were introduced earlier in the introductory lectures and studies.)

7. Articulate critique of aesthetical abstractions
The students are encouraged to give suggestions about coherent ways to group the different models together and develop perceptually related form sequences. These groups or sequences of form could suggest aesthetical abstract reasoning beyond the limits of the initial concept (adapt, divide etc.).

The students are then asked to give critique of a single composition and articulate their all-round aesthetical response with respect to the holistic gestalt of the composition. The traditional way to give aesthetical critique in art and design is to create a dialogue with the creator in connection to the composition itself. The questions are presented to the composer so as to gain insight into the organizing concepts that are expressed through the composition. Particular views are pointed out to bring attention to the strengths or weaknesses of the composition. A marker is placed on the turntable indicating the focus of attention. The turntable is then rotated so that everyone can see the particular view that is being discussed in relationship to the overall image. Asking carefully formulated questions, that correlate to specific direct and indirect properties in the composition, will open up possibilities for further development. The composer is asked to motivate her/his own formgiving decisions and subjective thoughts that inspired their forms as well as to point to problem areas that the group could help resolve. This phase aims to develop aesthetical consciousness, a method for collective aesthetical exchange and personal involvement on the part of the person who gives a critique. For the continual education of the students I introduce many other aesthetical principles and ways of reasoning expressed through the models (Akner-Koler 1994, Greet 2002).

8. Bipolar spectrum – supporting and questioning beauty
Selected models were grouped in a bipolar spectrum that clearly exemplify the initial abstract concept, eg. adapt: “assimilate - dissimilate”. Different interpretations of the spectrum are set-up by the students, focusing on different qualities that illustrate the pluralistic nature of form. We also discuss the excluded models in order to determine if there are any qualities of interest that might further inspire a new area of exploration.
9. Summary

Notes on the conclusions from the group are summarized and the selected models are stored for further reference.

10. Feed-back loop

I then re-examine the results of each case study, photograph key models and again look for ways to change the prior concept or add a new abstract concept. This dynamic process modifies the material offered to the next group of students.

Throughout this whole 10 step method we always renew our understanding of the initial problem in an iterative process relying on continuous interaction between abstract reasoning and concrete work.

Figure 1a-c. The figure shows the studio situation in which the 10-step Concept-Translation-Form method was developed. We used Kolb industrial design light-grey clay, which was developed through a recent collaboration with Kolb Technology.

Results

A theoretical and practical model: “Evolution of form”

The 10-step Concept-Translation-Form method gradually gave rise to a seven-stage, bipolar visualization model called “Evolution of form”, see figure 2-3. The model consists of two axes: one horizontal “evolutionary” axis and one vertical “bipolar” axis. Here I present a general summary of the model and refer the reader to a more detailed description in my book “Three Dimensional Visual Analysis” (Akner-Koler 1994).
Evolution of form – horizontal axis

Figure 2. The figure shows the horizontal axis of the model Evolution of form, that bridges geometric and organic properties.

Horizontal axis

On the horizontal axis in figure 2, there is a logical sequence of seven stages; from compositions of geometric forms to organic form. The stages are:

1. JOIN - cutting away part of one geometric volume to exactly fit with another geometric volume
2. INTERSECTION - the common mass within the joint of two geometric volumes, defined by the geometric properties of the surfaces of the joined forms
3. DIVIDE - to cut through geometric forms creating two or more parts
4. ADAPT - to fit a compliant geometric form up against or around another form that is stable
5. MERGE - to blend two or more geometric forms into a combined figure
6. DISTORT - to expose a geometric form to a force(s) affecting its inner structure and elemental parts
7. ORGANIC - to begin with formlessness (clay) and create complex movements and tensions in the form that are expressed through convexities and concavities having no geometric reference

The sequence moves from simple to complex by introducing properties altering the structure and symmetry of the original geometric form towards organic properties. See also “Contribution” below.

Vertical axis

The added dimension to this evolutionary model is the bipolar spectrum that moves vertically crossing the horizontal axis of the evolutionary model at each stage, see figure 3.
**Evolution of form** – horizontal and vertical axis

![Bipolar spectrum diagram](image)

Figure 3. The figure shows the full version of the model *Evolution of form*, including both the horizontal- and the added vertical axis of the bipolar spectrum at each stage.

**Bipolar spectrum**

The bipolar spectrum in figure 3 moves vertically at each stage along the horizontal axis in the model “Evolution of form” that introduces a dichotomy between a positive and a negative pole which expands the practical and theoretical dimension of this evolutionary model. This spectrum both supports and challenges the classic aesthetical aims of achieving beauty and expansion. It gives equal weight to activities that build up and break down the geometric structure.

The top half of the model represents the positive pole which supports *congruency* with the original geometric structure. The terms *conform*, *assimilate*, *converge* and *concordance* indicate support for the geometric structure or identity of the original form. The bottom half of the spectrum represents the negative pole, which supports incongruency with the original geometric structure. The terms *discordance*, *disassimilate*, *diverge* and *deform* are meant to disturb, take away and work against the geometric structure or identity of the original forms. It is this negative pole that expands the evolutionary model and challenges the concept of beauty.

Furthermore, the negative pole of this spectrum offers a way to include negative form (void) as equally important as positive form, i.e. concavity is place toward the negative pole. This sculptural concept of *equating positive and negative* originates from the work of the Russian sculptor Alexander Archipenko ([http://www.archipenko.org/aa_chron_1967.html](http://www.archipenko.org/aa_chron_1967.html)) and was transferred to the field of industrial design through Rowena Reed (Greet 2002).
Example of bipolar spectrum

A more detailed description of the bipolar spectrum can be found in *Three Dimensional Visual Analysis* (Akner-Koler 1994).

![Image](image.jpg)

**Fig 4.** The figure shows the bipolar spectrum conform-deform at the stage distort.

Figure 4a-b shows a closer analysis of the vertical axis in the model at the stage distort and the bipolar concepts *conform*, meaning to work with the structure of the geometric form and *deform*, meaning to work against the structure of the form. Figure 4a, *conform*, was originally a circular solid cylinder that has been symmetrically squeezed at the two base surfaces and twisted in two opposing directions around its rotational axis. The result of these forces expanded the properties of the form. Figure 4b, *deform*, was originally also a circular cylinder. The forces contracted the original structure by asymmetrically pressing against the two base surfaces resulting in the collapse of the form, which contorted axial movement. Contraction and contortion together constitute criteria for deformation.

**Dichotomy**

Theoretical support for this line of thinking in dichotomies, that the bipolar spectrum (+ and -) represents, is found in Håkan Edeholt’s (2004) recent thesis on *Design Innovation*. He recognizes the need to work with dichotomies in the design process in order to more openly deal with complex problem solving. By considering the opposite standpoint in relation to the preferred standpoint, new knowledge can arise that gives depth and stability to the area of study.

**Abstractions of form and space**

The presented model “Evolution of form” is an integrated part of a perceptual system of analysis and aesthetical terminology that were initially structured by Kostellow and Reed. This system and terminology was organized by the author into four major sections (Akner-Koler 1994):
I. Elements and their properties – involve proportions and the inherent relationships between the positive and negative volumetric parts: plane, line and point in reference to geometric law-bound structures.

II. Movements and Forces – involve indirect perception that is expressed through the axial activities and tensions within and beyond the physical elements.

III. Relationships – deal with the communication between the positive and negative elements and their movements and forces from all views and over time. The model Evolution of Form presented here belongs to this section.

IV. Organization – deals with putting everything in a three-dimensional spatial context. The organization strives to arrange the properties, movements, forces and relationships in three general spatial frameworks: static, dynamic and organic.

Each of these four sections presents a combination of definitions, concepts and principles which were derived from a) my sculptural experiences with Rowena Reed, b) literature in this cross-disciplinary field of aesthetics and perception, c) my own teaching, which added new models and concepts as well as formulated basic aesthetical terminology.

Contributions

The above described model, “Evolution of form”, visualizes how to unite, within one model, both geometric and organic properties. From the 1930s Kostellow/Reed began developing form exercises that united on the one hand the law-bound structures of geometry and on the other hand the balance of tensions and forces from organic growth processes and the traditions of sculpture. They developed the visual discipline and analytical approach that exemplified how these very different form worlds, could be bridged together. However, they did not develop any teaching material that mapped out a comprehensive overview of this bridge.

My contribution to further develop this visual/analytical methodology are:

1) Created the Evolution of Form (EoF)-visualization model
2) Developed four stages along the horizontal axis of the EoF-model, ex. intersection, adapt, merge and distort. (Reeds defined three stages: Join, Fragment (where Fragment is changed to Divide) and Organic.)
3) Developed the bipolar spectrum on the vertical axis of the EoF-model including the following eight concepts: accordance / discordance, assimilate / dissimilate, converge / diverge, conform / deform.
4) Expanded the conceptual limits of the EoF-model to work through a dichotomy of positive and negative features that build up and break down geometry, thereby questioning beauty.
5) Emphasized perception which involves all of our senses and questions the dominant role of visual perception.
6) Developed a 10-step concept-translation-form method that encourages students to participate in the conceptual and practical development of the EoF-model.
Discussion

The active formgiving process

The “Evolution of form” model offers a way to differentiate form through activities that modify the fundamental structure of geometric form in space. The model is developed to support the active formgiving process of creating a gestalt. It involves innovative reasoning that aims to create form compositions that may or may not already exist. By understanding and perceiving the potential expressions of form that are embraced in the “Evolution of form”-model, a broad aesthetic attitude to formgiving can be developed. Formgiving is an ongoing process that is affected by a continual flow of input from ergonomics, technology, marketing, culture etc. Since the design process requires the ability to handle a vast amount of information that can be conflicting, contradictory, ambiguous etc, there is no single method that can rationally organize all the input (Margolin & Buchanan 2002). The organisational capacity that is represented through form and space offers this pluralistic structure that can create coherency out of seemingly disparate demands.

Experiencing the pluralistic nature of form through the 10 step Concept-Translation-Form method gives insight into the complexity of form and how to understand form through a continual process of change rather than as a fixed object.

Pluralism refers to diversity and contrast. The pluralistic nature of form comes from its complex role in our perception of both the abstract and concrete real world (Arnheim 1969, 153-159). Form can be perceived as an abstract geometric structure (see below) and as a concrete complex expression in the physical world that engages all our senses. Because form exists in the physical world it has the potential to fuse our senses together and involve our emotional response (Dewey 1980, Norman 2004). By involving emotions, form becomes open to subjective interpretations that invites pluralism.

Inner sense of form

Product designers are trained to offer a stream of form suggestions. The organization of the demands, desires and specifications for product development can be channeled through aesthetic abstraction, which offers a way to grasp the essential 3-D composition aiming to solve the problem. The roots of the aesthetic abstraction I apply come from sculptural traditions that rely on an inner sense of form as taught by Reed (Akner-Koler 1994, Greet 2002). This inner sense puts primary emphasis on the indirect perception of axial movement, proportional relationships as well as relationships of forces and orientation in a spatial framework. The outer contours and surfaces that delineate shape are subordinate to these 3-D compositional structures. This priority of perceiving the inner qualities of form tends to reduce the dominance of pure visual perception and shifts to a kinesthetic sense that relies on a feeling of balance and equilibrium within a spatial framework.

Since form is constantly changing throughout the design process this sculptural approach of inner 3-D perception helps product designers simplify the compositional properties in order to explore a variety of solutions for complex problem solving. By touching and working with the forms, using proportions of the
body as an embodied way to measure and blurring the superficial properties through rotation on a turntable you can improve your ability to experience the synthesis of the all-round composition. This interaction greatly increases consciousness by thinking with your body (Damasio 2005).

The limitation of this model and its aesthetical references is that it is strongly oriented toward sculptural traditions and 3-D abstractions. It does not include sound, texture, color, ornamentation, smell, taste etc. A future plan is to collaborate with artists / designers and researchers who work with aesthetical abstractions from the other areas in aesthetics in order to encompass a inclusive model for embodied aesthetical abstraction.

Pedagogically framed research method
An important aspect of doing pedagogically framed research through the 10-step translation method in an art- and design educational program is that the students assume they can creatively and aesthetically challenge the limits of the problem. They give energy to defining their own individual interpretations of the problem rather then trying to develop the most general interpretation. This explains why the forms I use to exemplify the different stages in the model for Evolution of form (figure 2-3) are not standardized and uniform.

The physical environment at the Department of Industrial Design at Konstfack has been optimal for conducting this practice-based research. Access to materials, studio spaces and workshops are generous and the industrial design students are trained as creative problem-solvers; they can easily take abstract ideas and create physical models that embody these ideas. Collaboration with industrial design students has kept this theory closely linked to “practical skills and authentic activity” referred to as a practical cognitive view (Gedenryd, 1998).

Validity the “Evolution of form” model
The validation and application of my methodology can be argued by the fact that I have conducted these qualitative case studies for more than fifteen years at Konstfack as well as in workshops in departments of Industrial Design throughout Sweden, Denmark and Norway. A textbook that summarizes the results of this research was published in 1994, “Three Dimensional Visual Analysis” (Akner-Koler, 1994) and a second edition was recently reprinted. In 2000 a revised edition was translated to Korean and printed 2000 (Akner-Koler 2000). I have also collaborated in product-oriented courses since the late 1980’s with industrial designer Rune Monö (Monö 1997). Monö’s pragmatic semiotic theory deals with the development of signs and symbols carried by form. Through our many years of working together on product oriented courses that begins with weaving together basic form, color and semiotic courses we have explored the boundaries and common territory between semiotics and aesthetics as we confront the work of our students. The curriculum that has developed through our collaboration is now a fulcrum for our formgiving culture at the Department of Industrial Design at Konstfack. Another important validation is that the form experiences the students receive through working with the “Evolution of form” model are later applied to product development in established design firms started by our students. I am presently planing to make a survey that will offer insight into design application of this model.
Post-modern criticism
Since the fall of high modernism in the 1960s there has been little effort from the art and design community to renew or replace the modernist aesthetic language. Hal Foster refers to this period as “non-aesthetical paradigm” (Foster 2002). Post-modern criticism points to the limitations of the modernist discourse with its aspiration of defining universal principles, genotypes and the search for “pure form” (Rampell, 2003). This search for pure form created an elite attitude aimed to define criteria for “good” design, thereby excluding deviations from a “norm” and discriminating against alternative individual expressions.

I definitely agree with some of the post-modern critics, especially in their criticism of establishing an aesthetical norm for design. The organizational principles for this norm come from geometric reasoning and concepts in engineering such as what is a “good” or “corrupt” curve. The lack of interest that designers show in problematizing and renewing the field of aesthetics is a major problem today as design enters many new arenas.

There is a deep wealth of knowledge that has developed from collective efforts the modernists’ devoted in order to understand form. We need to recognize this knowledge and integrate it back into the sensuous world it came from to learn more about form through non-geometric approaches.

The model Evolution of form (EoF-model) to a great extent still resides within modernistic, aesthetical boundaries and discourse, mainly because it is introduced through geometric structures. However, the bipolar spectrum invites deviation from the “norm” by breaking down and disturbing geometry. Also the sixth stage in the EoF-model, distort, provides possibilities to explore distortion through organic material focusing on processes of disintegration, dehydration, decay, decomposition etc. Figures 5-6 show two organic studies starting with a geometric cube made from potato and ginger root, respectively, that demonstrate the effects of dehydration. This particular study of geometric form made in organic material opens up many possibilities for form theory to include ecological processes that greatly expand the EoF-model. (Akner-Koler 2006) This ecological form study was inspired by my work in the arts (Törner M 1997).

Since I published Three Dimensional Visual Analysis (Akner-Koler 1994) I have began to see the limitations of the discipline, language and methods I work with. Through my own art projects I have studied complex, non-
geometric phenomena as a counterbalance to the geometric and optimised world of industrial design I teach in. My previous projects such as “Degree of transparency and material disintegration” (Degerman 1997), Empty space (Cornell 1998) and Cyclical processes (Akner-Koler and Bergström 2005) all represent this quest. I have also recently headed a 3-year art-science collaborative project called “Cross-Disciplinary Studies in Complexity and Transformation” with the aim to find methods and concepts of abstraction that challenge geometric reasoning and aesthetics (Akner-Koler et al. 2005, Norberg et al 2005) (www.complexityandtransformation.com).

Conclusions
The participatory 10 step method presented here gave the students a strong role in affecting the conceptual and concrete development of aesthetical knowledge. Working with concrete form and embodied methods aimed to unite practical and theoretical experience. The experiential aesthetical approach recognizes how logical thinking, perceptual awareness, abstract reasoning and personal involvement are intertwined together.

The experiences students gained through the development of the “Evolution of form” model prepared them to recognize sequential stages, work with dichotomies, handle transitions that are radical or predictable, deal with pluralism, as well as determine coherent relationships. These types of cognitive skills that go back and forth between parts that are connected to holistic organizational frameworks are especially necessary in the multidisciplinary field of product development as well as any complex problem solving field.

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PART 1
Developing an aesthetic taxonomy of form

- **Paper I**

- **Paper II**

PART 2
Expanding & challenging the Evolution of form-model

- **Paper III**

- **Work/ Paper IV**

- **Paper V**

- **Paper VI**

PART 3
Formlessness - opposing the aesthetic taxonomy of form

- **Paper VII**

- **Paper VIII**

- **Paper IX**

- **Work/ Paper X**
THREE-DIMENSIONAL VISUAL ANALYSIS

DEPARTMENT OF INDUSTRIAL DESIGN
UNIVERSITY COLLEGE OF ARTS, CRAFTS AND DESIGN

INSTITUTIONEN FÖR INDUSTRIDESIGN
KONSTFACK

CHERYL AKNER-KOLER
To Gunnar, Corina and Malcolm

Correspondence
I hope this book is constructively criticized with respect for Rowena Reed’s intentions and that suggestions for improvement will come my way.

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THREE-DIMENSIONAL VISUAL ANALYSIS

DEPARTMENT OF INDUSTRIAL DESIGN
UNIVERSITY COLLEGE OF ARTS, CRAFTS AND DESIGN

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"It is not exactly the presence of a thing but rather the absence of it that becomes the cause and impulse for creative motivation"

Alexander Archipenko
This book aims to strengthen an understanding of the sculptural possibilities of form and space through developing a visual language and structure that recognizes and gives priority to 3-dimensional visual perception. It is written so as to apply to both the active process of shaping 3-D form and space and analyzing any existing visual situation.

Foundation

The foundation of this language is derived from the inspiring courses conducted by professor Rowena Reed at Pratt Institute in New York City and also in private Soho classes. Rowena Reed’s method of visual analysis taught her students to “think with their eyes” and to translate an inner vision into concrete experiences. Her challenging way of teaching combined creative exploration with an analytical search for the “Principles of visual relationships”.

The last pages of this book are dedicated to summarizing her background, philosophy and educational vision. Moreover, in order to gain a historical perspective, a map is included that outlines the relevant art movements in the beginning of this century and some of the major events in the early work of Rowena Reed and her husband Alexander Kostellow. As illustrated in this map, the Russian constructivist movement is the point of origin for the artistic tendencies and formal language developed by Reed and Kostellow.

Teaching in Sweden

Under the leadership of Professor Lars Lallerstedt at the Department of Industrial Design (ID) at the University College of Arts Crafts and Design (Konstfack) in Stockholm Sweden, I have been given great opportunities to further develop and document this visual study program. The visual problems taken on by the first and second year Industrial Design students provide the substance of this book. Using clay and paper models the students creatively question the “established terminology” and develop solutions which strengthen and/or add new concepts to the program. Regrettably, this interactive exchange of ideas with the ID students as they strive to bring visual thoughts into the 3-dimensional world could not be communicated within the scope of this book.

Although this book is written in English, most of my teaching has been in Swedish and therefore many ideas have been discovered and discussed in the Swedish language. This culturally imposed struggle with translating the visual language into Swedish and then using both English and Swedish to further develop the terminology has proven to be a very vitalizing process. To constantly re-examine the concept vailed by a term has made me keenly aware of the shortcomings of both languages. This inherent problem in communication has helped me see the need to create strong “visual images” of each form and space concept logically connected within an overall framework.
Framework
Through working and teaching within this constructivist tradition I have felt the need to document and organize this visual 3-dimensional (3-D) terminology into a comprehensive framework which demonstrates the strength of visual analysis. The following four sections (I - IV) constitute the backbone of my teaching as well as outline the content of this book:

I. Elements and their properties
II. Movements and forces
III. Relationships
IV. Organization

Within this framework there are several underlying principles that are central for this 3-dimensional visual approach: 1) recognizing an interdependence between form, movement and space; 2) visualizing the inner movement and structure of form; 3) prioritizing asymmetry; 4) deconstructing a composition in a logical sequence from inner structure → movement → volume → plane → line → point; 5) perceiving 3-D compositions from a number of different views in order to grasp their all-aroundness.

Intent
My intent with writing this book is to prepare the reader for a dialogue with the 3-dimensional world. I believe that deeper concern for our 3-D visual reality may be awakened through learning to discern form and spatial qualities in our environment. It is my hope that the methodology outlined in the pages of this book will give a starting point for discerning the different levels of complexity inherent in each visual situation and that general principles can be made concrete through each individual work. The concepts presented here can all be greatly expanded upon since each visual solution/situation in itself is unique and demonstrates specific relationships which challenge abstract definitions.

I have tried to emphasize volume, inner movement, depth, space and all-aroundness as much as possible in order to stress 3-D thinking. However, there is no way to simulate these qualities in 2-D illustrations and photos. As a result the characteristics of the outer configuration of the positive forms override the less tangible, spatial and volumetric qualities. Issues such as light-shadow, color, texture, transparency-nontransparency, which are an intrinsic part of creating and experiencing form and space, have not been brought up here because of the limits of this documentational media and time. I hope to devote energy in the future to prepare and develop effective ways of documenting experiments which focus on these issues.

Methods of Documentation
This book is written on a Macintosh LC computer using Pagemaker® layout program. All photographic images show 3-D models made by ID students at Konstfack. The models have been photographed by a Canon ION digital camera and mounted into the computer using Macvision® software. The low resolution of the digital photographs was considered acceptable within the limits of the budget at the onset of the project in 1990. Some of the illustrations are created through Superpaint® program while others are derived from an Intergraph® CAD (computer aided design)-system and then scanned into the computer. The CAD-technology made it possible to recreate some of the student’s geometrically derived 3-D models through a solid geometry computer program. This technique allowed us to deconstruct these models into their elemental parts.

The original material has been printed through a Hewlett-Packard Laserjet 4M printer.
This chapter on Elements and their properties deals with defining the basic visual elements and their elemental parts, dimensions and proportions. For the sake of simplicity, the cube and rectangular volume are used to exemplify principles and ideas in this chapter. The concepts here, however, apply to the entire spectrum of forms from geometric to organic and from positive to negative.

The primary geometric forms are described at the end of this chapter. The basic visual structure defined through these primary forms provides an important visual reference for the proceeding chapters.
Volume is a 3-dimensional element expressing height, width and depth. The boundaries of the volume are defined by surfaces. The properties of the inner mass is reflected in the movement and shape of the surfaces. These surfaces can be divided by hard transitions creating the boundaries of the planes. The boundaries/edges represent the lines of the volume and the corners on the volume are the points.

Plane is defined as an elemental part of a volume. When the surfaces on a volume have clearly defined edges so you can discern its shape and contours, a plane is delineated. Plane has lines and points as its elemental parts. A plane can also exist independantly in space and is a 2-dimensional element expressing width and length.

Line is used to delineate the shape of a plane and the hard transitions between surfaces as they form the edges on a volume. Line has points as its elemental parts. An independant line in space articulates 1-dimension expressing length.

Point is an elemental part of a line. It can be visualized as the start and end of a linear element and the corner points of a volume. Point has no elemental parts and no dimensional movement, yet it expresses position.

Any 3-dimensional visual situation can be broken down into its different elements to gain an understanding of what the whole is made up of. The four basic elements are introduced in relation to the 3-D volume. Deconstructing the volume into its elemental parts stresses the importance of thinking 3-dimensionally even when working with 2-D or 1-D elements and, thus, focus on the 3-dimensional origin of visual elements.
Spacial enclosures can be considered basic visual elements of 3-dimensions if the positive elements limiting a space define a clearly recognizable shape. Negative elements are defined within the space between any of the positive elements: the surfaces on volumes or independent planes, lines and points in space. The description of the different positive elements can also be applied to the negative elements, yet perceived spacially.

The elemental parts of spacial enclosures are, however, more varied than the positive elements. The sequence of (-) volumes in figure 2b illustrates this variation: the first volume is a closed volume using five planes to define its boundaries, the second is partially open, using three planes and the third is an open volume outlined by one plane and one line.

The limits of spacial enclosures are dependent on the strength of spacial articulation of the surrounding positive forms. This involves perceiving movements and forces (see chapter II) and relationships (see chapter III) that are expressed from positive elements into space. Spacial elements can therefore be interpreted differently depending on the view-point of observation and the spacial awareness and experience of the observers. The concept of negative elements is more difficult to comprehend and perceive than positive elements because we are trained to see and discern objects rather than the space between them.
There are a number of different terms that are used when referring to the dimensions of elements: length, height, width, breadth, depth, thickness etc. Some of these terms imply a spacial orientation. Height implies a vertical direction in space starting from the base of an element and moving to the top. Width and breadth imply movement from side to side. Depth means the direction backwards or inwards. Thickness and length have no spacial correlation. Thickness is usually the smallest measurement of an element, whereas length refers to how long an element is and implies measurement. The less dimensions an element occupies, the less correlated the terms are to specific spacial orientation.

In theory, the concept of independent 2-D planes having only length and width can not exist in a 3-D world. Yet, they are part of our visual vocabulary used to describe a figure whose predominant visual qualities expresses 2-D. The definitions have been abstracted in order to use the idea of plane, line and point in a 3-dimensional visual context. When referring to planes in space you disregard the thickness of the material that the plane is made of, as implying an articulation of the third dimension. Thickness of a plane is seen as a visual detail subordinate to the two predominant dimensions of a plane. A similar explanation is applied to line and point.

A volume has 3-dimensions:
- Height = 1-D
- Width = 2-D
- Depth = 3-D

The limits of the first and second dimension. There is an inherent problem in defining 1- and 2-dimensional elements as independent elements in space, because of the added thickness of the material the element is made up of.
Inherent proportions involve the direct correlation of one elemental part to another. For example, the measurements of the length and width of a plane determine the exact length of the lines which border it. If the proportions of the plane are changed, then the length of the lines will be altered in correspondence to the plane.

A cube uses the elemental parts (Fig. 4): planes, lines and points to limit its total mass and to delinate and punctuate the transitions between surfaces. All the six square planes on the cube are identical in size and all the lines on the planes are therefore the same length.

Geometric forms are strictly bound by the laws of geometry. Figure 5 shows that the change of the width of plane 1 directly affects the proportions of three other planes including their edges (lines) as well as the relative inherent proportions of the entire volume. The concept of inherent proportions also applies to organic form, however, the elemental parts are not as interdependant as geometric forms. It is possible to change the shape of a plane on one side of an organic volume and not affect the proportions of the entire volume.

INHERENT PROPORTIONS
Fig. 6

General Proportions Circle

The primary proportions (shown in black in figure 6) are extensional, superficial and massive. Three secondary proportions (shown in grey in figure 6) combine 50% of two primary proportions: extensional / superficial (E/S), superficial / massive (S/M) and massive / extensional (M/E). The middle volume (shown in white) is a combination of all three primary proportions: extensional, superficial and massive (E/S/M).

GENERAL PROPORTIONS

The concept of General Proportions summarizes the essential proportional features of an element rather than gives an exact elemental description. The three primary proportions a form can assume involves the following features:

- **Extensional** - expresses length. A line illustrates the most extreme expression of extension.
- **Superficial** - expresses flatness. A square plane is the most extreme example of superficial proportions.
- **Massive** - expresses volume. A cube is the most extreme example of massive proportions having no extensional or superficial qualities.

General Proportions Circle

The primary proportions (shown in black in figure 6) are extensional, superficial and massive. Three secondary proportions (shown in grey in figure 6) combine 50% of two primary proportions: extensional / superficial (E/S), superficial / massive (S/M) and massive / extensional (M/E). The middle volume (shown in white) is a combination of all three primary proportions: extensional, superficial and massive (E/S/M).
To see the complete visual make-up of the 3-D elements and their properties is a spacial- as well as a form-experience. It is of equal importance to be aware of the variation of proportions of each solid volume as the model turns, as well as the fluctuating spacial proportions between the volumes.

By seeing the model from different views visual information can be obtained to judge the dimensions and general proportions of each volume.

The study model of “Three Rectangular Volumes” in space shown from three different view-points in figures 8-10 is the first exercise in this visual program. It applies the visual structure and vocabulary introduced in this chapter as well as some of the principles in chapters 2-4.

GENERAL PROPORTIONS

This model of three volumes clearly expresses three different general proportions.

In figure 10 the horizontal extension of each positive (a, b, c) and negative (d) volume is marked by a line (black or white) in order to illustrate the contrast in measurement between the planes on the different positive and negative volumes from this view. Throughout the entire composition there is as little repetition of measurement as possible.

This view shows the “O” joint between the massive volume (b) and the superficial volume (a). (see “Joints”).

The distance between the volumes (c) and (a) and between the base and (b) defines the boundary of the spacial enclosure (d) (Fig. 10).
The three families of curved primary geometric volumes are:

- Ellipsoid sphere
- Cylinder
- Cone

The basic curved primary geometric volumes are illustrated on the first horizontal row in figure 13 (dark grey background). These three massive volumes all have equal parameters for height and diameter. The other volumes in the same figure show how primary volumes can vary in general proportions: massive-extensional-superficial. Geometric planes can be derived from all these primary geometric volumes by cutting them in three sections oriented horizontally, vertically and in depth (Fig. 11). Figure 12 summarizes the various geometric planes resulting from these three sections. The planes derived from the ellipsoid family are circles/ellipses, planes from the cylindrical family are circles/ellipses and squares/rectangles and planes form the conical family are circles/ellipses and triangles.
PRIMARY GEOMETRIC VOLUMES – STRAIGHT

The four families of straight primary geometric volumes are:

- Rectangular volumes/cube
- Triangular prism
- Pyramid
- Tetrahedron

The basic straight primary geometric volumes are illustrated on the first horizontal row in figure 14 (dark grey background). The first four massive volumes all have equal parameters for height and base. The other volumes in the same figure show how these primary volumes can vary in general proportions: massive - extensional - superficial. These volumes have also been cut horizontally, vertically and in depth as illustrated in figure 11.

The planes derived from the rectangular volumes family are squares/rectangles, planes from the triangular prism family and the pyramid family are triangles and squares/rectangles and planes from the tetrahedron family are regular or irregular triangles. Figure 15 summarises the cut planes from figure 14.
The circular cone is a very dynamic volume because of the diagonal contour of the form due to the changing diameter of the curved surface. The elemental parts of a cone include one simple curved surface that wraps around the volume, one flat surface with a circular contour and one vertex point. The movement of the curved surface creates the circular edge on the flat base. At the top of the volume where the curved surface comes together at a single point the vertex is created.

The simplest way to change the proportions of a cone is to extend it along its primary, rotational axis. However other proportional variations that vary the width or depth, requires that the curved surface follows an elliptical curve and that the base plane of the cone changes to an elliptical plane.

### Description of 7 PRIMARY GEOMETRIC FORM FAMILIES

<table>
<thead>
<tr>
<th>Ellipsoid / Sphere</th>
<th>Cylinder</th>
<th>Cone</th>
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<tbody>
<tr>
<td>A sphere is classified within the ellipsoid geometric family, yet it has special conditions which governs its structure. The sphere is visually the simplest form because it is perfectly symmetrical from all views. The single continuous surface that covers the volume is a double curved surface which is at an equal distance from the center creating circular contours and no articulated axes. Ellipsoids, like the sphere, are defined by one continuous double curved surface, but the distance from the center gradually changes through elliptical curvatures. An ellipsoid can change its proportions along one, two or three axes, but the sphere can only change in size.</td>
<td>A circular cylinder is symmetrical around the rotational axis and from top to bottom. The elemental parts are a simple curved surface and two flat circular surfaces that are parallel to each other. The simple curved surface meets the two flat planes at a right angle and outlines their circular edges. The cylinder can change its general proportions through extension or contraction along its rotational axis. It can also alter its proportions by changing the neutral (circular) simple curved surface to an accented elliptically curved surface. The outline of the two base surfaces then change from circular to elliptical.</td>
<td>The circular cone is a very dynamic volume because of the diagonal contour of the form due to the changing diameter of the curved surface. The elemental parts of a cone include one simple curved surface that wraps around the volume, one flat surface with a circular contour and one vertex point. The movement of the curved surface creates the circular edge on the flat base. At the top of the volume where the curved surface comes together at a single point the vertex is created. The simplest way to change the proportions of a cone is to extend it along its primary, rotational axis. However other proportional variations that vary the width or depth, requires that the curved surface follows an elliptical curve and that the base plane of the cone changes to an elliptical plane.</td>
</tr>
</tbody>
</table>
A pyramid has similar features as the cone, such as the diagonal contour of the form and the vertex point at the top. The elemental parts of a pyramid are four planes with triangular outlines and a fifth plane which is square or rectangular. The triangular planes meet at a vertex at the top and form the sides of the pyramid. The square or rectangular plane form the base. The straight pyramid with the tip of the pyramid in line with the center of a the base implies that the opposing triangular planes are identical. Proportional changes are determined by the rectangular proportions of the base and the height of the vertex.

A triangular prism is similar to a cylinder in that it is symmetrical between the two parallel triangular planes and out from the primary axis. The elemental parts include three rectangular or square planes and two parallel triangular planes. The three rectangular or square planes are at an acute or obtuse angled relationship to each other. The degree of the angle between the rectangular planes defines the shape of the two triangular planes. Changing the general proportions of a triangular prism by varying the distance between the triangular end planes involves no structural changes in the angles between the elements. However, changing proportions that vary the length of the sides of the base triangles introduces new angular relationships between the sides of the triangles and the rectangular surfaces.

The tetrahedron is the simplest 3-D closed volume that can be constructed of flat planes, just as the triangle is the simplest 2-D plane made of straight lines. The tetrahedron is also the most structurally stable form of all the primary geometric forms, yet visually it emphasizes the dynamic edges and the opposing movement between the pointed corners of the form. The equilateral tetrahedron is made of four identical equilateral triangular flat planes and has structural similarities with the cube. Proportional changes are made by varying the angular relationship between bordering surfaces which directly changes the degree of each angle on the triangle as well as the length of the sides of the triangular planes.

<table>
<thead>
<tr>
<th>RECTANGULAR volume / CUBE</th>
<th>TRIANGULAR prism</th>
<th>PYRAMID</th>
<th>TETRAHEDRON</th>
</tr>
</thead>
<tbody>
<tr>
<td>A cube is defined by the same properties as a rectangular volume, however, it has special conditions governing its proportions. The cube is visually the simplest straight geometric volume, because its elemental parts are all identical and the composition of the elements involve right angles and parallel relationships. The 6 flat elemental planes of the cube are all squares of equal size, which fixes the inherent proportions and allows no variation in width, depth or height. The only changes that can occur are in scale. A rectangular volume is constructed of 6 flat rectangular or square planes in right angled relationships to the bordering planes. There are three sets of parallel planes which have an inherent proportional relationship to each other. Variations of the proportions of a rectangular volume can occur along all three axes.</td>
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The first step in analyzing a concrete 3-D composition is to perceive the inner- and spacial activity of the elements. These "activities" encompass the combined effect of movements and forces. The movement of an axis and the forces that act upon it, can only be indirectly perceived through the visual clues from positive forms. It requires a kind of "x-ray vision" which visualizes the paths of visual energy that interacts with the proportions and shapes of the elemental parts.

The nature of sculptural experiences are rooted in the perception of the energy and inner structure of a form or composition. The general path of movement through major proportions of the positive and negative elements governs the surface/plane activity. The transitions between surfaces in turn control the position, shape and sharpness of the edges (lines) as surfaces come together on the form. The position of corners/points are the last visual details of sculptural articulation.
**AXIS**

The general definition of an axis is an imaginary line within an element which is the fundamental structure that all elemental parts refer to (Fig. 16).

1. **Primary axis** - the central structural line in an element which expresses the major movement of the form. It is also often the longest axis within the form.

2. **Secondary axis** - lies in oppositional angle to the primary axis and gives a structural line that represents the movement outward from the primary axis. It is often the second longest axis within the form.

3. **Tertiary axis** - the structural movement that is subordinate to the primary and secondary axes. It is the shortest axis and usually expresses less movement than the other two.

**AXIAL MOVEMENT**

The movement of an axis can only be indirectly perceived through the visual clues from positive forms. It requires a kind of “x-ray vision” in the mind’s eye which visualizes the paths on inner activities that interacts with the proportions and shapes of the elemental parts.

**INNER AXIAL MOVEMENT** is the motion expressed **WITHIN** the form (Fig. 17), through the length of the primary axis. The movement can range from a simple straight axis to a compound curved axis.

**DIRECTIONAL MOVEMENT** is the general direction in which the whole form moves. The triangle’s directional movement is upwards. A rectangle has no specific directional movement along its primary axis, but it can gain direction indirectly after the axial movement of the form (Fig. 18). The continual visual movement of the elements strengthen the articulation of a dimension in space as well as allows for potential relationships to arise between forms across space.

**THREE AXES**

1. **Primary**
2. **Secondary**
3. **Tertiary**
Elements with straight axes have a uniform inner movement that is often reflected in outer symmetrical shape and restricted spacial activity. Forces can be introduced to increase visual complexity both within and beyond an element.

A force(s) can induce structural asymmetry which is expressed in bending or curving the inner axis of a form and some of its elemental parts. Forces themselves can not be seen, but may be perceived by how they affect positive forms. The energy from the force is absorbed by the positive element and then projected outward through the form and into space. The force-induced changes in form are the results of the power the force has over the integrity and strength of the elements.

Forces encompass the following features:

An axis can express three general conditions:

- A straight axis (Fig. 21a) involves a 1-dimensional movement, without any forces acting upon it.
- A bent axis (Fig. 21b) incorporates two activities from different dimensions: the movement of the axis and the force that abruptly changes the course of the axial movement creating a sharp bent angle.
- A curved axis (Fig. 21c) can express two or more activities from different dimensions: the axial movement and the force(s) that gradually change the course of the axis.

Curves

A curve is a smooth and continual change in direction (Fig. 22 and curve chart on p. 20).

The three ex. of curved planes /surfaces in figure 22 illustrate the correlation between the axial movement & the shape of the edges/transitions of each surface.
ACCENTED:
The degree of curvature changes throughout the curve. The accent is the most expanded area of the curve.

NEUTRAL:
The curve has the same radius throughout the entire curvature. A segment of a circle is neutral.

The chart in figure 25 shows examples of a variety of different curves. The purpose of this chart is to offer a selection of curves which illustrate subtle differences in how the curve expands, due to the strength, scope and angle of each force(s) (see Fig. 20). The shape of a curve can assume two general features: neutral or accented (Fig. 23-24). Three of the curves on the chart are neutral: circular segment, spiral and reverse (even) and the remaining curves are accented.
Figures 28 and 29 are fragments of the divided ellipsoid (see chapter III).

Figure 28 (fragment 1) shows the straight silhouette of one of the simple curved dividing surfaces through the ellipsoid and also the accented surface on the outer contour of the ellipsoid. The movement of the axis is a compromise between the straight silhouette and the accented surface.

The curved surface (a) in figure 29 (fragment 2) shows a neutral curve that comes from the circular contour of the ellipsoid. Surface (b) is a simple curved surface that divides the ellipsoid. Directional forces radiate from the accent on surface (b) through the form and out into space.

The DIRECTIONAL FORCE is the energy channelled out from the accent through the form and into space. The directional forces radiate from both the convex and concave sides of the accented area (Fig. 26). The specific shape of the curvature controls the path of the directional force. The concave side of the curve has a more focused force than the convex side, since the force is more enclosed as it moves out from the accent. On the convex side, however, it is more

Directional forces add visual activity to the composition that can compete with the inner axial movement of the elements. The organization of the elements should include coordinating the axial movement and position with the directional forces. The concept of balance (see chapter IV) relies greatly on how the directional forces work to complement the other movements and structures within the composition.
### RELATIONSHIPS

<table>
<thead>
<tr>
<th>ORDER</th>
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<tbody>
<tr>
<td>DOMINANT</td>
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<tr>
<td>SUBDOMINANT</td>
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<tr>
<td>SUBORDINATE</td>
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</table>

| AXIAL RELATIONSHIPS |

| COMPARATIVE RELATIONSHIPS |

| JOINED FORMS |
| INTERSECTIONAL FORMS |

| TRANSITIONAL FORMS |
| DIVIDE |
| ADAPT |
| MERGE |
| DISTORT |

| FORCES in RELATIONSHIPS |
| TENSIONAL |
| ORGANIC |

| EVOLUTION of FORM |

Relationships are created between the properties of the elements (chapter I) and their movements and forces (chapter II). These interrelationships create a network of visual connections that make up the overall visual statement. Each relationship, no matter how subtle, becomes an important compositional link so that even the smallest detail can influence the originality and quality of the entire visual image.

This chapter on relationships also includes ideas of how to combine and reshape geometric forms based on principles of division, adaption, distortion etc. These ideas are presented under their own section called "Transitional forms". Following this section is an introduction to structural principles and interrelationships of forces concerning organic forms. A chart over the different geometrically derived forms and organically shaped forms is presented at the end of this chapter. The theme of this chart is to illustrate an "Evolution of Form" from geometric to organic. The sequence of "evolution" shows two different 3-D models that exemplify two ends of a spectrum at each stage.
The idea of hierarchy of order is implicit when working within an asymmetrical organization. Since the principles of asymmetry prioritize contrasting properties and non-repetition, there will always be elements and qualities that dominate and others that are subordinate (Fig. 30).

A method for deciding which visual qualities/forms are more important than others is to first cover up or “think away” one quality/form at a time (Fig. 31-33) and ask the following questions:

Which form seems to give the entire composition its identity? Which is the most visible from all views and is perhaps largest? This is the dominant. Which one has a clear and vital interrelationship with the dominant, yet has a less interesting shape and is smaller? This is the subdominant. Which is dependent on the dominant and subdominant forms, yet is smaller in size and is a complementary form? This is the subordinate.
ORDER cont.

The idea that something dominates over another can be relative to the view of observation. At some viewpoint a subordinate form can gain more visual attention because it is closer to the observer or partially overlaps a more dominant form as in figures 34a and 34b.

However, certain features and forms will be remembered as having overall dominance. This accumulated allround impression, which our visual memory and 3-D experiences are built on, gives the basis for judgement of the work and a sense of order can be interpreted.

GROUPING

Each level of the hierarchy can be represented by a single positive (Fig. 30) or negative element (Fig. 36) or by a group of elements. Grouping elements or features together involves recognizing similarities, e.g.: shape, movement, position, size, proportion, color.

Negative elements are also recognized when determining the hierarchy of order. This model has a clearly outlined spatial enclosure (x).

The idea of order is easy to understand when it comes to the example above and on the prior page, since each form is a separate unit. When analyzing a complex object that is highly differentiated and does not easily break down into separate units, it is more difficult to specify what the visual order is. None the less, it is important to seek a visual hierarchy to gain an awareness as to which features are essential in communicating the visual message.

Throughout the development of a composition, experimental studies can be undertaken to see if the message can be made stronger. The non-essential features can therefore be reshaped in order to reinforce the major idea.

Figure 35 shows that the forms a & b are identical in shape, movement and proportion (but not orientation). Together they form a group which has a subdominant roll in the composition. The relationship between grouped elements/features can occur in a specific area or across the entire composition. The shared qualities that define a group must have visual strengths that overrides other form/space interruptions.

Figure 34a

Fig. 34b

Fig. 35

Fig. 36
Since the axes represent the individual visual structure within each element, then axial relationships created within and between elements reveal the essential framework of the composition. Some basic axial relationships are:

Oppositional Relationships - The axial movement of one element lies in an opposite dimension to another. The forms pull away from each other, moving out in different dimensions and are considered independent visual components. Figure 37 shows oppositional relationships: adjacent and across space.

Parallel Relationships - The axial movement of one element runs parallel to that of another. Figure 38 shows parallel relationships: adjacent and across space. Figure 35 on the prior page shows a parallel axial relationship across space between (a) & (b) which also forms a group.

Continual Relationships - The axial movement of one element flows directly into another. Figure 39 shows two continual relationships: adjacent and across space.

**Gesture**

A gesture is a special condition for curved elements in a continual relationship. It deals with guiding the axial movement of forms so they gradually group together to make a continual complex movement.

The change in position, direction and distance between each line in figure 40 depends on the shape and strength of the continual movement (see page 18) from one to the next. If the gesture involves 3-D volumes, then the proportions and outer shape should complement each other so that some of the contours of the forms continue from one to another.
In figure 41a, a black circular plane and a black rectangular plane are compared to each other and to the surrounding outlining frame. Together they visually activate the space within the frame. The circle is lifted slightly from the bottom line of the frame activating the space underneath. The rectangle and the circle express contrasting comparative relationships between the roundness of the circle and the straightness of the rectangle. The frame itself has a primary vertical movement, which reinforces the vertical movement of the black rectangle. The solitary circle in figure 41b loses some of its contextual identity since it is isolated from other elements. Its roundness is no longer compared to the long rectangular qualities of the other plane and without the frame its position and scale seems vague.

Figure 42 shows a cube divided by a simple neutral curved surface that cuts through the cube in two opposing directions. This model demonstrates several comparative relationships, e.g. between the negative and positive parts, between the curved surface and the straight edge / right angled corners.

The visual information concerning elements and their movements and forces can be subjected to comparative relationships; to examine in order to note the similarities or differences. The figures 41-42 give examples of some comparative relationships.
JOINED FORMS

Joining elements together provides a structural quality between the elements. The relative proportions and the 3-D orientation of each volume determines the type of joint, i.e., orientation in the vertical, horizontal and depth dimension, as shown in figure 43.

There are three basic joints that can occur between rectangular volumes in a static organisation (see chapter IV): "L" = 2-sided, "U" = 3-sided, "O" = 4-sided.

The above three joints can be made as partial or complete joints as illustrated in figure 44.

ACTIVE and PASSIVE: When forms are joined together there is usually an active form, that retains its entire volume and a passive form that is cut to make the joint.
The composition in figures 45 - 46 is made up of an ellipsoid and two cylinders. The two joints applied here are both complete "U" joints.

The following features are added to the volumes due to the joints:

* elliptical curved lines around the joints
* induced axial movement through the flat cylinder between the two joints

The following features are subtracted from the volumes due to the joints:

* the elliptical cylinder (active) cuts into the flat circular cylinder (passive) - joint 1.
* the flat cylinder (active) cuts into the ellipsoid (passive) - joint 2

Since the volumes intersect each other at dynamic angles the two joints are asymmetrical.

From the accent of joint 2 an axial movement is induced through the surface of the flat cylinder upward toward joint 1.

In joint 2 (Fig. 46c) the passive ellipsoid is joined to the "active" flat cylinder on "three sides" creating a "U"-joint. A section of the "passive" ellipsoid is cut away to construct the joint. The elliptical hard edges introduced through joint 2 adds strong details to the composition.
JOINED FORMS - three rectangular volumes

Joining volumes together so that all three or more volumes intersect each other builds a compound joint. The three geometric rectangular volumes in figure 47 have oppositional relationships to each other that lock the volumes into place. There are two different types of joints applied here, "O" and "U", illustrated in figure 48. The new parameters introduced through the joints create asymmetrical qualities on the volumes. The orientation of the joints subdivide the rectangular volumes and introduces new edges.

Analysis of a compound joint
The brake-down of the compound joined volumes illustrates three joints (Fig. 48):
The first is a complete "U"-joint showing the massive volume deeply joined on three sides within the superficial volume; the second is an "O"-joint where the extensional volume moves completely through the massive volume; the third is another complete "U"-joint showing the extensional volume cutting down the superficial volume.
The sequence of intersectional forms are:

**COMPOUND INTERSECTIONAL FORM**
requires at least three volumes that intersect each other and create an interlocking joint. A compound form encompasses the entire differentiated form that is confined within the limits of the shared joints.

**CORE INTERSECTIONAL FORM**
is the minimum common body within the intersectional forms which is shared by each of the joined forms.

The concept of intersectional forms is by definition restricted to the joints between basic geometric volumes. The surfaces that "cut out" the intersectional forms are therefore completely geometrical.

None of these cut-surfaces on the intersectional forms can be seen on the exterior of the joined volumes. The intersectional forms therefore must be derived indirectly from the different inherent proportions and structure of each of the volumes. The hard lines at the joints between the volumes define some of the contours/edges of the intersectional forms (see Fig. 49-50). Yet, to visualize the proportions and contours of the compound intersectional form(s) takes a great deal of concentration, because the properties of the joined geometric volumes influence your visual interpretation of the intersectional form.
The two joined volumes in figure 51 are illustrated with different values of gray to separate the volumes from each other and to easily identify the origin of the cutting surfaces that define the intersectional form. The cylinder is light gray and the sphere is dark. Correlating these gray surfaces to the core form shows that the spherical surface (dark gray) defines the top surface and the cylindrical mantle surface (light gray) defines the bottom surface.

Another example of two joined curved volumes is shown in figure 52a. The composition is that of a cylinder piercing through a cone; the corresponding intersectional form is shown in figure 52b. Figure 52c shows an intersectional core form derived from a joint between a cone and a sphere.
This separate section on transitional forms within chapter III describes how geometric volumes can be altered through introducing new form relationships between elemental parts, forms or forces. The concepts divide, adapt, merge and distort (presented in the following pages) are grouped together under the heading transitional forms. By using primary geometric volumes as a starting point for development, new features which deviate from geometry can evolve.

The form exercises based on the above concepts are developed to explore transitional properties and are conducted under visually controlled conditions which help to isolate the specific qualities in question. It is the resulting variation in shape that is the focus of interest in this section as well as finding ways to communicate the new "transitional properties" that arise.

The method used to structure the transitional properties that each solution embodies, is to set up a bipolar spectrum that marks out two extreme qualities. As an example, divided forms (p. 34) are related to each other in a spectrum from accordance (features that are similar to the original form) to discordance (features that are different from the original form). Some of the transitional form concepts were easier to analyze by this spectral method than others. Nevertheless, there is a great deal of visual experience to be won in the process of defining the general theme for the spectrum as well as the extreme situation that exemplify each spectral end.
To **DIVIDE** means to cut through a geometric form creating two or more parts. The relationship of parts to the whole and the direct correlation between shared cut surfaces gives an inherent logic and visual order to divided forms. The 3-D movement of the dividing surface(s) and its orientation through the form can introduce unique qualities to the parts that can be similar or different to the original form. The shape and size of these parts are confined within the properties and proportions of the original geometric form. The visual analysis here deals with the similarities and differences between the properties of the original geometric form and:

- the dividing surface(s)
- the inherent proportions and shape of the parts
- the overall organization of the parts

When the above features are similar to the original form they are in **accordance**. When the above features are different from the original form they are in **discordance**.

The sequence illustrated in figure 53 of divided rectangular volumes, is based on the movement and orientation of the dividing surface. The dividing surface gradually changes from straight to compound curved and from a vertical to diagonal/curved orientation. The first volume to the left has been cut into two parts by a straight surface moving perpendicular through the volume (a). The new cut planes/surfaces that appear on the two parts are identical to each other and to the end planes on the original volume. These two planes are therefore both in total accordance. Progressing through the sequence from left to right, the straight surface first changes orientation. By tipping the surface at a diagonal, angled in one dimension, the two cut planes retain a rectangular shape (b).

The next change in orientation is tilting the plane dynamically backwards, angling the plane in two dimensions (c). None of the corners are right angled and thus, the cut planes have become rhomboids. Since all these planes are flat with straight edges they are more or less in accordance with the planes on the original volume. The next step in the sequence is that the surface movement changes from flat to simple curved (d). This curved movement introduces features that are not derived from the original rectangular volume. The curved cutting surface becomes more complex changing from mono-axial (simple curved) to tri-axial curved as it moves to the right. The last three divided volumes (d-f) express varying degrees of discordance.
Figures 54 - 57 show the division and reassembly of a sphere. The organizational concept for this model is based on 3 flat dividing surfaces that cut through the sphere. The cuts are made in a specific sequence (Fig. 55), which are followed by shifting or rotating the parts on the dividing surfaces.

The spherical-like quality of the original form is retained.

The following features are in Accordance; similar to the original form:
* circular contour on the flat cut planes
* crescent shaped planes
* retaining the spherical-like quality in the overall gestalt
* sliding and/or rotating the parts on the cut planes

The following features are in Discordance; different from the original form:
* flatness of the dividing surface
* straight lines and sharp corners that appear at the intersection of two cutting surfaces
**ADAPT**

To **ADAPT** means to fit one geometric form up against or around another geometric form without subtracting or reducing either of the forms. In the process of adaptation one form is defined as stable (unchanged) and the other, the compliant (pliable or changed).

The compliant form is reshaped at the area of contact to comply with the properties of the stable form. The edges of the adapted (compliant) form are hard so that there is a clear border line between the forms.

The visual analysis here starts with examining the:

- orientation of the forms to each other
- elemental parts of the compliant form to find a starting point for adaptation

There should be a sense of control over the adapted area on the compliant form so that it seems consciously manipulated to fit the stable form, instead of forced or deformed.

Figure 58 defines the two extremes within the spectrum for adaption, e.g. **assimilate**: to adjust the compliant form so as to encompass the stable form and **dissimilate**: to disengage or segregate the compliant form from the stable form.

The method of adapting the compliant form to the stable form can be separated into two types: To manipulate the entire compliant form around the stable form (a) or to make an incision in the compliant form at the edges of the elemental parts of the volume or in a “visually logical” area (b).

Adaptation of one form to another involves developing features that are similar to joined forms (p. 28-30). Joined forms have a defined border between the forms at the joined area, just as the compliant form retains a distinct border as it adapts to the stable form. Joined forms express passive and active qualities within the joint, which can be compared to the compliant and stable qualities of adapted forms. The adaptation of the compliant form also expresses controlled distortion based on the shape of the stable geometric form.
Figures 59a-c show different views of an elliptical cylinder adapted to a cube. The elliptical cylinder is compliant and the cube is stable. The sharp edges and corners of the cube have cut through one of the flat elliptical surfaces and the simple curved mantle surface. The volume of the cylinder has been adapted to the shape of the cube by creating distorted corners (Fig 59b) on the cylindrical volume.

The organization of the two volumes is dynamic (see chapter IV) and the adaption involves one of the accented areas of the elliptical cylinder (Fig. 59a-c) and four hard edges of the cube.

The simple curved mantle surface is divided and pressed outward to partially encompass the massive body of the cube. Two hard edges are introduced on the mantle surface as well as two non-geometric double curved surfaces (Fig. 59b-c).

The following features are **Assimilated;** involved in complying to the stable form:

* four straight edges on elliptical cylinder induced by the cube
* non-geometric double curved and simple curved surfaces
* the outer elliptical edge stretches to accommodate for the cube
* distorted corners introduced on the cylinder
* asymmetrical qualities on the original symmetrical cylinder

The following features are **Dissimilated;** uninvolved in complying to the stable form:

* more than half of the elliptical cylinder is unchanged
* main straight axis in the cylinder is intact
* the top elliptical surface retained its original geometric properties
* the shape of the cube is easily discernible
To **MERGE** means to blend two or more geometric forms into a combined figure. Merging of forms can occur gradually throughout the entire composition or abruptly within an isolated area where the two forms come together. The overall figure can appear to unite or to separate the original forms depending on:

- orientation, movement & relationship of the axes of the original forms toward each other
- variation in properties, size and elemental parts between forms
- how gradual or abrupt the transition between surfaces are

Figure 60 defines the two extremes within the spectrum of merging forms: **Converge** involves unifying forms as well as creating transitional surfaces that gradually change from the properties of one form into the properties of another. **Diverge** involves separating forms as well as creating transitional surfaces that abruptly change from one form to another.

Figure 61 shows a sequence of four forms from converge to diverge. The order is determined in reference to the transitional surfaces and how gradual or abrupt these surfaces merge the forms together. If the sequence was based on showing unity - separation, then form (b) would change places with form (c) since the overall proportion and contour of form (c) expresses a more unified merged form.

**CONVERGE**
Features that express unity between forms. The transitions are gradual.

**DIVERGE**
Features that express separation between forms. The transitions are abrupt.

---

**Fig. 60**

rectangular volume + triangular prism
sphere + triangular prism
pyramid + circular cone
elliptical cone + tetrahedron

---

**Fig. 61**
Figure 61 shows a merged forms that express some visual properties of a joined forms. Surface(s) on the triangular prism is not a transitional surface but rather a surface that cut into the ellipsoid. This shows an example of how the different form stages overlap with each other.
The following features

Converge; unity between forms gradual transitions

* The two original forms are totally united with each other
* The main straight axial movement in both volumes have merged together and express a single curved axis
* All of the surfaces parallel to the main axis of the original forms have merged together and transformed from straight to curved
* One of the 4-sided surfaces on the rectangular volume has been transformed into a 3-sided surface

Diverge; separation between forms abrupt transitions

* The top triangular surface from the triangular prism is unchanged
* The bottom rectangular surface from the rectangular volume is unchanged

The only two surfaces that are unchanged from the original geometric forms are the triangular surface shown in figure 62d and the rectangular base shown in figure 62e.

MERGED FORMS applied to triangular prism and rectangular volume
To DISTORT means to expose a geometric form to a force(s) affecting its inner structure and elemental parts. The act of distorting can be a direct result of forces that affect the qualities and inherent properties of the material in which the forms are made, e.g., throwing a block of clay against the wall. Another way is to interpret how a force should affect a form under controlled conditions, given a defined material. This method of distorting is on a more abstract level since the materials used to make the model can differ from the intended material. Some different direct, physical forces are: twist, squeeze, roll, pull, push, bend, hit, erode, etc. Examples of interpreted forces are: optical distortion, implosion, explosion etc.

Figure 63 shows different ways of distorting geometric forms within a spectrum. The position of each form within the spectrum shown here is relative and not absolute. On the one end of the spectrum is conform, the form expands the inner mass which stretches the surfaces. Conform also means that force(s) work with the properties of the elemental parts and the inner structure of the original form. On the other end is deform, the form contracts and the force(s) work against the properties of the elemental parts and the inner structure of the original form.

The way the force(s) work with or against the structure of a geometric form depends upon the:

- type
- movement
- magnitude
- orientation

The position of the above selected forms within the spectrum (Fig. 63 a-c) is based on expansion and contraction. The properties of the surfaces on all the forms have been more or less changed as well as the edges and contours. Distorted forms often express tensional relationships between expanded and contracted areas. The visual changes that occur on distorted geometric forms are often of an organic nature, i.e. transitional surfaces, expansion and contraction, convexities and concavities etc. (see Chapter IV).
To DISTORT means to expose a geometric form to a force(s) affecting its inner structure and elemental parts. The act of distorting can be a direct result of forces that affect the qualities and inherent properties of the material in which the forms are made, e.g. throwing a block of clay against the wall. Another way is to interpret how a force should affect a form under controlled conditions, given a defined material. This method of distorting is on a more abstract level since the materials used to make the model can differ from the intended material. Some different direct, physical forces are: twist, squeeze, roll, pull, push, bend, hit, erode, etc. Examples of interpreted forces are: optical distortion, implosion, explosion etc.

Figure 63 shows different ways of distorting geometric forms within a spectrum. The position of each form within the spectrum shown here is relative and not absolute.

On the one end of the spectrum is CONFORM, the form expands the inner mass which stretches the surfaces. Conform also means that force(s) work with the properties of the elemental parts and the inner structure of the original form. On the other end is DEFORM, the form contracts and the force(s) work against the properties of the elemental parts and the inner structure of the original form.

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The way the force(s) work with or against the structure of a geometric form depends upon the:

- **type**
- **movement**
- **magnitude**
- **orientation**

**CONFORM**
Features that expand the form and work with the structure of the form.

**DEFORM**
Features that contract the form and work against the structure of the form.

**DISTORTED FORMS** applied to circular cylinder

By taking hold of the two ends of the original cylinder and twisting the form around its own axis (Fig. 64) the simple curved surfaces of the original form change to double curved surfaces with two strong asymmetrical accented areas (b and c in Fig. 65). This axial twist work with the structure of the original form. A tensional relationship between these two accents (Fig. 65) expands the form diagonally and changes the movement in the mass of the original cylinder. The grip used to hold the cylinder squeezed the circular ends and created oval, simple curved surfaces (a in Fig. 64).

The overall proportion, structure and movement have expanded and the form no longer retains strict geometric properties, yet a geometric heritage can be deciphered.

Figure 66 shows a straighter silhouette due to the more simple curved quality of the surface at the oval accents of the form.

The following features **Conform;** expand and work with the original form:
- The mass and mantel surfaces expand outward
- Twisting the cylinder around the primary axis
- The hard edges of the original circular ends of the cylinder are retained as they change to oval
- The more or less straight silhouette as seen in figure 66

The following features **Deform;** contract and work against the original form:
- Introducing double-curved surfaces with asymmetrical accents
- The end-surfaces contract inward and are simple-curved with oval contours
- The tensional relationship occurs through the mass, changing the movement of the axes within the form

The original form was a circular cylinder.
FORCES IN RELATIONSHIPS

Forces express visual activity within and beyond the positive and negative elements. As mentioned in chapter II, forces are not visible in themselves, however, their paths can be discerned and controlled through the shapes of the positive forms in the composition. The visible embodiment of a force can be seen at the accent of curved surfaces or at angled corners within and at the edges of volumes.

TENSIOINAL RELATIONSHIPS

deals with the energy that radiates from directional forces (Fig. 68).

The two illustrations below in (Fig. 69a-b) show two examples of tensional relationships. In figure 69a the directional forces on the concave side of the two curved lines channel their energy out from the accent towards each other.

In figure 69b the force from the convex side of one curve relates to the force from the concave side of the other curve.

The distorted cylinder in figure 70 shows a tensional relationship through the mass. An inner energy and tension is embraced between the two accented areas, (a) and (b). The arrows represent the directional forces that channel this interaction. The tensional relationship moves at a diagonal through the form.

In figure 71 the rectangular volume is distorted (see p.40) through expanding inner forces. The accented compound curve at the top interacts with the front and with part of the underside of the volume. The axial movement of the form runs horizontally through the longest proportion and is affected by the organic (see p. 43) inner activity of the forces in tensional relationships.
A general definition of organic is to have properties associated with living organisms. The approach in this handbook for describing organic form is to find links from the organic world to the geometric world. Unlike geometric forms, which have a clearly defined mathematical structure that dictates and restricts the properties of the elemental parts, abstract organic forms are in general “amorphous”. However, the simplest organic form = the egg, and the simplest geometric form = the sphere/ellipsoid have a great deal in common (Fig. 72).

Organic concepts presented here do not involve the mapping of shapes and forms from nature, but rather aims to find abstract general principles of growth and diminishment. The interaction between movements and forces is the most essential concept in organic form. Through these subtle inner activities organic forms express expansion and contraction. The visual elemental parts of organic forms are curved surfaces that are either convex or concave with varying degrees of transitions between the surfaces.

**Convexity:** growth and expansion

**Concavity:** diminishment and contraction

The hen’s egg has rotational symmetry around its primary axis. This rotational symmetry is exemplified through the circular section of a plane that cuts at right angles to the primary axis. The different sections mapped out below illustrate the similarities and differences between a hen’s egg (Fig. 73a) and a geometric ellipsoid (Fig. 73b). The dark circle on the inside of the egg sections is the yolk. Since the yolk is perfectly spherical any flat section through it results in circles of different sizes.

All eggs exhibit total convexity and can be regarded as the visual evolutionary link between geometric and organic forms. Perfectly spherical eggs, such as fish eggs, are during certain stages of development identical with the geometric sphere. This implies that the geometric and the organic form world may be considered to have a “visual ancestral origin”.

Eggs can also resemble different members in the ellipsoid family (chapter I). The classic hen’s egg is similar to an ellipsoid, however, it is asymmetrical from top to bottom. The bottom curvature in figure 72 takes on the shape of a sphere which slowly transforms to different degrees of elliptical curvature as it moves upwards.
The neutral curved line below in figure 74 gives a simple illustration of convexity and concavity. The curved line implies that convexity and concavity are the direct opposite of each other, where the convexity is the outside and the concavity is the inside of the same curve.

Convexity - form pushing outwards
Concavity - space pushing inwards

3-D convexities and concavities are expressed as organically shaped positive and negative volumes and are much more complicated than a curved line. There is no direct match between the inner and outer shapes of convexities and concavities on volumes due to how the entire mass of the form interacts with the forces.

The organic form shown from four different views in figures 75 - 78 express various shapes of convexity and concavity. The organic features are non-geometric and therefore each convexity and concavity is made up of a number of different surfaces that define the limits of the positive or negative volumes (see “central concavity” in figure 75). Tensional relationships across the enclosed space of the central concavity can be seen between the accents (a) & (b). Tensional relationships between accent (a) within the concavity and through the form to accent (c) on the convexity can also be noted. The transitions between the active surfaces on the convexity and concavity are important visual expressions of the form. In figure 75 the convex surface (d) has a harder transitional edge on one side and a soft transitional surface on the other side.

These three different views of the above sculpture show various qualities of convexities and concavities.
The sculpture in figures 79a-e is made up of concavities and convexities and is similar to the model on the prior page, however, the concavity has a more dominant roll in the composition. The larger and deeper the concavity pushes its way into the mass, the more it influences the inner structure and thereby develops a visual dominance. The positive volume is diminished while the negative concave volume grows. The model illustrated here is built around a piercing concavity, which is the most extreme example of concavities. A piercing concavity can be compared to a tunnel. The two openings of the tunnel allow light to move through the form and an integration of convex and concave surfaces from one side to another. The openings as well as the inner “tunnel” are composed of a vast number of oval/organic surfaces and contours that blend and intertwine with each other.

Figure 80 shows a simplified example of this blend of contours as they progress from one opening through the tunnel to the other opening.

CONCAVITY and CONVEXITY

These five views of the same model show the diversity of oval and organic shaped surfaces defining this compound concavo-convex form. In figures 79b-d the opening and the piercing concavity are illustrated by drawings.

The piercing concavity moves in depth through the organic form in figure 79b.

The directional movement of the oval opening is angled to the vertical in figure 79d.

Only a part of the piercing concavity can be seen in figure 79c.

front view Fig. 80
The "evolutionary" progression of form begins with the outline of the structure of primary geometric forms. Each stage progresses from this geometric base to a higher level of visual complexity. The sequence illustrated in figure 81 depicts seven stages of evolutionary development where each stage has its own bipolar spectrum (e.g. the divided spectrum ranges from accordance and discordance) as defined earlier in this chapter. The figure shows one example from each side of each spectrum.

The first stage of evolution, shown at the far left in figure 81, begins with joining primary geometric forms together. Demarcated within the joints are intersectional forms which are completely defined by geometric surfaces, yet allow for asymmetry.

The four following stages, i.e. divided, adapted, merged and distorted can be considered transitional forms because they progressively introduce transitional properties of non-geometric and/or organic nature and link geometric forms with "amorphous" organic forms. The last stage in development is organic, which emphasizes non-symmetrical convexo-concave features and is defined as having no initial geometric structure.
The gradual stages of form "evolution" begins with the outline of the structure of primary geometric forms. Each stage progresses from this geometric base to a higher level of visual complexity. The sequence illustrated in figure 81 depicts seven stages of evolutionary development where each stage has its own bipolar spectrum (e.g. the divided spectrum ranges from accordance and discordance) as defined earlier in this chapter. The figure shows one example from each side of each spectrum.

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Fig. 81 does not show all the different phases form can undergo. The aim is to find logical links that connects and overlaps one form spectrum with another.
IV ORGANIZATION

3-D SPACIAL MATRIX
- VERTICAL
- HORIZONTAL
- DEPTH

ORGANIZATIONAL FRAMEWORK
- STATIC
- DYNAMIC
- ORGANIC

SYMMETRY and ASYMMETRY

BALANCE

STRUCTURAL
- VISUAL

ORIENTATION
- DIRECTION
- POSITION
- TIP

OVERALL PROPORTION

In this section on organization ideas and principles will be presented that pertain to pure visual compositional structure for 3-D asymmetry.

An organization can be seen as a “master plan” that maps out the routes and interactions between all visual aspects of the composition (i.e. elements, movements & forces and relationships). An organization can also be seen as the “accumulated structure” that each element can give to the total expression of the work. In other words, there is a direct correlation between the visual integrity of the individual elements and the overall organization.

The message that is meant to be communicated through the overall “gestalt” has strong bearing on the organization and character of the work. However, the scope of this handbook is to focus on the concrete descriptive visual information that can be observed more or less independent of the interpretation of the work. It may seem counterproductive to isolate form from content, since the goal in any visual work is to synthesize these two worlds. Yet, developing the ability to abstract the 3-D visual structure that is inherent in anything that exists in our 3-D world, adds objective viewpoints to the creative process of “shaping” new ideas.
The 3-D spacial matrix (Fig. 82) constitutes the fundamental context in which visual components interact. The three different dimensions of the matrix are: vertical, horizontal and depth, which give the basic reference of orientation for all positive and negative elements and their inner structure and spatial activity.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st dimension</td>
<td>vertical moves - up / down</td>
</tr>
<tr>
<td>2nd dimension</td>
<td>horizontal moves - side / side</td>
</tr>
<tr>
<td>3rd dimension</td>
<td>depth moves - front / back</td>
</tr>
</tbody>
</table>

**3-D SPACIAL MATRIX**

To determine the orientation of an object within a 3-D matrix requires an active participation from the observer. Visual information must be gathered from different view points, at different distances. 3-D spacial perception demands a stereoscopic vision, i.e. to observe with both eyes, as well as a high level of concentration because the different views must be fused together to give an integrated spacial interpretation. In comparison, the orientation of an element on a 2-D picture plane can be determined with one eye closed and from one fixed view.

**Depth perception**

All three dimensions, vertical, horizontal and depth are implicit in the 3-D matrix, however, the third dimension, depth, is the key to experiencing space. The depth dimension embodies a 3-dimensional quality in itself, unlike the 2-D more graphic representation of vertical and horizontal. A vertical dimension can be defined without relating it to the other dimensions; it is parallel to the the plumb line that is governed by the laws of gravity. The horizontal dimension does not need to be defined in relation to the vertical or depth dimensions; it is parallel to the horizon. We are extremely sensitive to any deviation from the vertical and horizontal dimensions, which at times can be a source of irritation (like a picture hanging askew).

However, we are not as conscious of the phenomenon of depth despite its fundamental role in the 3-D world. Our perception of depth is nevertheless an inborn function that is integrated together with the other two dimensions within our sense of balance (E.J. Gibson).
The three organizational frameworks are:

- **Static**: The elements are aligned with the 3-D spatial matrix.
- **Dynamic**: The elements are angled to the 3-D spatial matrix.
- **Organic**: The elements are curved within the 3-D spatial matrix.

The above frameworks outline three distinct ways to organize elements in space (Fig. 83a-c). The static framework organizes the elements parallel to the 3-dimensions and is therefore the most rigid framework. In the dynamic and organic frameworks, there are an infinite number of degrees of angles and curvatures that deviate from the vertical, horizontal, and depth dimensions. The position of each element is defined in reference to the 3-dimensions. The organizational framework should correlate to the shape and character of the elements as well as their interrelationships applied within the framework. This correlation implies a logical hierarchy from the smallest detail to the overall composition.

**STATIC** - Three straight lines parallel with the vertical, horizontal, and depth dimensions, respectively.

**DYNAMIC** - Three uneven triangles are placed at an angle to the vertical, horizontal, and depth dimensions, respectively. The diagonal properties of these triangular planes are reinforced and strengthened within a dynamic framework.

**ORGANIC** - Three curved lines curve to the vertical, horizontal, and depth dimensions, respectively. An element with an inner axial curvature is a prerequisite for the organic framework.
The concepts of symmetry and asymmetry apply either to the organization of elements in a composition and/or to the internal structure of a single form.

**SYMMETRY**
Strives to maintain regularity and creates an equilibrium through repetition and the cancellation of movements and forces by identical opposing elements and forces. A sphere is the only perfectly symmetrical form since it is identical from all views.

An egg has bilateral symmetry, i.e. identical qualities on both sides of a vertical dividing line, however, the composition is asymmetrical from top to bottom.

**ASYMMETRY**
Strives to maintain diversity and aims to counterbalance elements, movements and forces so as to compensate for opposing strengths and weaknesses, yet does not lead to repetition.

Symmetry and asymmetry can also be seen as two extreme poles within a spectrum. A composition can involve a combination of symmetrical and asymmetrical qualities. Figure 85a-c shows three different compositions that exemplify the symmetry/asymmetry spectrum.

The visual method presented throughout this book emphasizes asymmetry in order to create visual challenges from each view with respect to the 3-D visual statement.
The concepts of symmetry and asymmetry apply either to the organization of elements in a composition and/or to the internal structure of a single form.

**Symmetry**

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The visual method presented throughout this book emphasizes asymmetry in order to create visual challenges from each view with respect to the 3-D visual statement.

The tensional relationship between accents (a) and (b) in figure 86 counterbalance directional forces. Figure 87 illustrates the tensional relationships in figure 86.

Surface qualities and visual contrasts, such as sharp edges or silhouettes, usually dominate visual perception. If these more superficial stimuli are strongly integrated with the activity of movement and forces within and beyond the elements then a clear 3-dimensional visual balance can be developed (Fig. 86).

**Balance**

Balance involves the interaction between the properties of the elements and their movements/forces so as to establish an equilibrium or counterbalance throughout the composition. Balance can be thought of in terms of:

**Structural balance** - deals with the physical ability of a composition to "stand on its own". The distribution of weight and the combined structural features such as joints, supportive elements, strength of transitional areas between forms etc. determine the structural balance of the composition.

**Visual balance** - deals with perceptual dynamics of the composition, taking into account the visual potential of both positive and negative elements. The first step is to visualize an equilibrium or counterbalance between the axial movements and the visual forces within and beyond the elements. To develop such an "all-around mental image" of how the movements and forces interact within a 3-D spatial context is a very abstract experience. It is, however, the "scaffolding" on which elemental properties and relationships are built and therefore is essential for perceiving or developing visual balance. The next step it to see how the proportions of the elements are distributed within the composition and how they are correlated to the specific configuration the composition takes on from different views.

Symmetry/asymmetry and frameworks

The perception of visual balance must take into account whether the composition is based on symmetry or asymmetry (see p. 52). The organizational framework, i.e. static, dynamic or organic, also set the conditions for visual balance. Figure 88 shows three curved geometric volumes in an asymmetrical, dynamic framework.

The concept of balance is constantly challenged within the visual field. The tolerance for accepting asymmetrical balance varies from person to person, since the perception of balance has to do with relating the proportions and activities within a composition to how we sense equilibrium within our body and our previous visual experiences.
Orientation specifies the location of each element in relation to the spatial matrix. Figure 89 illustrates the terms used in orienting the elements, i.e., direction, position and tip/rotation.

**Direction** - the general movement of the primary axis in reference to the 3-dimensions of space, e.g. angled to the vertical.

**Position** - to shift the position of the element up or down along the defined directional movement.

**Tip / Rotation** - to turn the element around its primary axis.

Figure 90 shows how the above terms of orientation are applied. The direction of the plane moves parallel to the depth dimension and is rotated 90 degrees.
The first structural features to be considered within the organizational framework is the orientation of the primary axis of each element. In figure 92 the three rectangular planes are organized so that the primary axis of one plane moves vertically (a), another plane moves horizontally (b) and the third plane moves in depth (c).

In figure 93 a 90 degree rotation of each plane around its primary axis has been performed (a→a’, b→b’, c→c’). This rotation is meant to illustrate the six different possible orientations of planes within a static framework. Since there are only three different dimensions, the primary axis of two planes must share the same dimension, i.e. the primary axis of (a) and (a’) share the vertical dimension, (b) and (b’) share the horizontal dimension and (c) and (c’) share the dimension of depth.

The principle difference in each of these pair of planes is that the secondary axis of the two planes move in an opposing dimension (Fig. 91).
This model in figure 94a-b applies some of the terms presented in all four chapters. The following features are incorporated in this model:

* A static organizational framework governs the position of the positive and negative elements.
* The entire composition is asymmetrical.
* The spacial enclosures (x), (y) and (z) are open negative volumes.
* Due to the compatibility between the rectangular shape of the planes and the static organizational framework, the shape of the spacial enclosures are also rectangular and of contrasting proportions.
* The inherent proportions of the planes and the spacial enclosures are all different from each other.
* There is a hierarchy of order of the planes, which is dependant on an inner relationship of comparative size and proportion, position and role in creating spacial qualities. Plane A appears to have a dominant role, plane D a subdominant and plane B a subordinate role in relation to A and D.

The purpose of this exercise is to define at least 3 different spacial enclosures within an asymmetrical static organization of planes. The positive and negative elements (see chapter I, p. 7) all have varied proportions and spacial orientation. Each element moves as 3-dimensionally as possible within the spacial matrix.

The spacial enclosures marked (x), (y) and (z) in figure 94a-b are open from at least three sides and are therefore all open negative volumes.

All 6 planes in the model can be seen in both figure 94a and b, however, in figure 94b the vertical plane D overlaps plane C and F which visually interrupts the surfaces C and F which changes the visual proportions.
Figure 95 maps out the direction, position and rotation of each of the six planes (A-F). The dotted lines on the planes mark the primary axis = 1 and secondary axis = 2 as well as the dimensional direction of the two axes; vertical = v, horizontal = h, depth = d. As an example, plane A shows that the primary axis moves vertically (v1) and the secondary axis moves horizontally (h2).
The **overall proportion** has to do with the entire shape of the composition and summarizes the proportions of the positive and negative elements. A way to perceive the overall proportion is to observe the composition "out of focus" (e.g. by squinting). This allows the details and the sharp silhouette to fade as you see the object from all sides so that the entire composition is generalized into pure movements and proportions.

Figure 96 shows three curved geometric forms joined together in a dynamic framework. The gray-shaded surface in figure 98 is meant to illustrate the overall proportions of the model in fig 96. The illustration can not represent the 3-D volumetric qualities of the overall proportion, but it does show that the main directional movement is angled to the vertical dimension and that the composition is asymmetrical.

A comparison of the principally different ways of seeing form and space is shown in figure 97 and 98. Figure 97 zooms in on details within the model while figure 98 "shadows" these superficial qualities.

The "U"-joint in figure 97 illustrates how the lines around the joint are shaped in comparison to the overall proportions in figure 97 (a more complete joint analysis can be found on page 29).
Professor Rowena Reed was a sculptor and teacher, who was born at the turn of this century. She belonged to the generation of artists that took on the challenges of introducing the principles of the modern movement into art and design education in America. Through her close working relationship with her husband, painter Alexander Kostellow, she collaborated in the development of a logically structured foundation for the visual arts. Together Reed and Kostellow worked out a visual foundation program that introduced the different levels of visual complexity through concrete experiences in 2-D and 3-D mediums. The terminology was consistent throughout the program and reinforced at each level. The exercises were intended for artists as well as designers, since the ideas explored in the foundation courses were “meant to apply to all forms of visual expression” (2).

Alexander Kostellow outlined the first stages of this visual program through his teaching positions in the painting departments at Kansas City Art Institute in Missouri and at Carnegie Institute in Pittsburgh, Pennsylvania. He began to formulate “definitions for the elements of visual experience and to identify the principles underlying the organization of these elements into significant form.” (2). The program was established at Pratt Institute in NYC 1936 as the “foundation program” for all first year students in the Art and Design Departments. Rowena Reed had responsibility for developing and teaching the 3-D courses. When Reed was invited to Pratt, together with Alexander Kostellow, she joined the teaching staff that established one of the first Industrial Design (ID) Departments in the USA. She brought her background and working methods as a sculptor into the education of an industrial designer and used her more intuitive visual approach and 3D-teaching methods with the structured visual foundation. The Industrial Design Department, under the leadership of Kostellow, integrated the foundation program into its own curriculum. Rowena Reed was therefore able to develop and teach advanced studies of form and space at the ID department, as well as lead and/or collaborate in practical/functional design projects that applied the visual foundation.

After the early death of Alexander Kostellow in 1954, Rowena Reed continued to teach for more than thirty years and developed new directions within the visual program. Her devotion to explore the fundamental issues of 3-dimensional visual phenomena assured that her comments and criticism were unaffected of trends and “isms” that superficially shape the art and design world.
Reed’s teaching methods

Rowena Reed’s 3-dimensional sensitivities were intimately linked with her ability to abstractly analyze and discern visual complexity. Reed’s method of teaching encouraged a creative process that gave her students freedom of expression and ensured 3-D visual thinking. Through a spontaneous confrontation with 3-D sketching, a variety of visual expressions would begin to take form. The power, identity and idiosyncrasies of each sketch could potentially contribute to the final “visual statement”, either directly or indirectly. The development of a gestalt/image progressed through different phases that interweave this spontaneous method with an analytical approach which involved determining the inner structure and abstract organization of a composition.

The source of inspiration for Rowena Reed’s dynamic sketching process presumably stems from her experiences with German-American painter Hans Hofman. Hofman’s painting and teaching methods “initiated the transformation of abstract art from the invention of images, drawn before they were coloured, to their creation in the process, or action, of painting” (3). Rowena Reed brought that abstract spontaneity from painting into developmental methods of sculptural work without reducing 3-dimensional complexity. She was very clear about distinguishing between the 2-D vision and tools of a painter and those of sculptor. Students were usually discouraged from working out ideas in a 2-D media in her courses, because line, surface quality, shading, color and fixed viewpoints were stressed when working 2-dimensionally. In contrast, working solely in a 3-D media, emphasis is placed on volume, space, depth and all-roundness, which is vital in communicating sculptural experiences.

Toward the last part of her teaching career, Reed became involved in architectural problems and art installations where spatial articulation was imperative. She worked out ways to explore static, dynamic and organic space where expansion of the “total negative volume” was a central concept. These space studies were a further development of her understanding of convexity and concavity which the Russian-American sculptor Alexander Archipenko initially introduced to Reed. Archipenko was Reed’s most important link to the modern development within the sculptural arts. The controversial ideas of shaping space as a “tangible” element as well as the constructivist attitude that Archipenko fostered through his teaching helped to build the platform on which Rowena Reed founded her teaching. The following citations of Alexander Archipenko (1) gives insight into his view of convexities/concavities and the creative process:

“It is evident that in sculpture each point of the surface would have meaning and be related to millions of other points of the surface. Likewise, relief and concave are reciprocally integrated. It is exactly as in music; each note has its psychological significance while it is related to every other note and pause in the composition”.

Alexander Archipenko was considered one of the first truly modern sculptors of the 20th century (5). His classic training gave him the technical working methods of a traditional sculptor and his inner artistic vision freed him from the conservative bonds with materials and representational imagery. Archipenko left Russia around the onset of the revolution and was therefore not engulfed in the Russian constructivist movement. His unique 3-dimensional organic methodology was based on abstraction of the figure and did not share the dogmatic geometric grounds nor the social/political connections to art.
Previous documentation
Neither Rowena Reed nor Alexander Kostellow documented their educational program or the theoretical framework that structured their visual vocabulary and principles. Many of the concepts Alexander Kostellow integrated into the comprehensive visual structure came from contemporary artists that were active in New York City in the beginning of this century, many of which had emigrated to the US from Europe.

There is little documentation by others concerning Reed’s or Kostellow’s methods of teaching and educational material within the visual field. Arthur Pulos writes about Alexander Kostellow’s role in establishing educational requirements for industrial design programs as well as heading committees that worked to strengthen the profile for the industrial design profession. These issues demanded all Kostellow’s time outside of the Department.

Research is needed to trace the individual artists that Alexander Kostellow studied and worked with, who influenced and supported him during the initial phase in creating an objective base for the visual arts and design as well as Kostellow’s and Reed’s step by step development of their principles of visual relationships.

The structure I have attempted to document in this book is therefore my interpretation and further development of Rowena Reed’s 3-D foundation.

References regarding Background Rowena Reed
The chart on this page is derived from the chart “Art streams of the 20s” in John Willett’s book “The new sobriety - art and politics in the Weimar Period 1917-33.” This chart has been adapted to put Reed and Kostellow in a historical context and points to some schools/movements that share a common source of inspiration.

The dark grey blocks mark the initial events of Reed’s and Kostellow’s development. The light grey blocks outline the movements and schools that contributed to establishing the bases of artistic expression that stem from the visual arts themselves and the creative process.

Alexander Kostellow 1896 - 1954
Rowena Reed-Kostellow 1900 - 1988
First I wish to acknowledge Rowena Reed, my teacher and friend, for her never-ending enthusiasm in sharing her experiences and knowledge. I am forever indebted to her for the generosity and concern she showed me as I struggled to understand the significance of the visual concepts and principles she taught.

I would like to sincerely thank Professor Lars Lallestedt, the head of the Department of Industrial Design at the National College of Art Craft and Design in Stockholm, Sweden, for his deep belief in a common foundation for the fine arts and applied arts. Without his support and open-mindedness to the long-term educational benefits our students receive through fundamental 3-D training, I would never have been able to develop the teaching materials and experiences needed to create this book. Warmest thanks to you, Lars!

I wish to express my gratitude to the students at the Department of Industrial Design. Their enthusiasm and explorative attitude has given me the motivation to start and complete this project. Their inspired work and thoughts have been a continuous contribution to the entire content of this book. Keep in touch!

I am also very grateful for the positive atmosphere and support I have felt from the entire ID-faculty and our secretary. Tack!

Through funding from Estrid Ericsson’s Stiftelse of a joint project together with the computer expertise of Sven Ringmar, we were able to prepare teaching materials that stimulated the development and documentation of “Transitional forms”. Sune Sundahl’s expert advice in setting up a uniform method for photographing 3-D models was also included in this project. Thank you Sven and Sune for being so generous with your professional insight. Special thanks to Kerstin Wickman on the board of Estrid Ericsson for believing in my pedagogical ideas and giving me the crucial support I needed in the beginning of this project.

Through Konstfack’s Artistic Funding program (Konstnärlig Utveckling = KU) I continued to explore different methods of computer documentation in collaboration with Sven Ringmar using Macintosh and ION digital camera and Mikael E. Widman from the Royal Institute of Technology, using Integraph CAD. The CAD illustrations in chapter III and IV were created by Mikael Widman. Songping Lee who heads our Computer Department has also been very helpful.

Thanks to Rune Monö for his concern for visual terminology and his active support of my method of teaching.

Thanks also to Dr. William Fogler for guiding me through many visual experiences.

To Monica Unna-Thunwall and my constructivist colleagues: Thanks for the continual inspiration in working with constructivistic principles. I would also like to express my thanks to sculptor Gert Marcus for the insight my students gained through his exhibition at the Museum of Modern Art in Stockholm.

Furthermore, I would like to thank the following schools for arranging workshops that have contributed to the development of illustrations and terminology: Poul Östergaard / Marianne Stockholm and the ID students at Arkitekt-skolan i Aarhus in Denmark; P.O. Wikström and the students at the Art Industry School at the University of Göteborg; Bengt Palmgren, Sven-Eric Juhlin and the students at the Design School at Umeå University.

Funding by the National Department of Education (UHÄ) made it possible for me to compile my teaching material into this book. I would again like to thank Lars Lallestedt for initiating and following this project.

Finally, to my husband Gunnar - Thank you for your constant love and encouragement as I developed my art and teaching in Sweden and for acting as my editor as we worked to put the pieces for this book together.
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For references regarding the background of professor Rowena Reed, see also p. 61.
Development of the curriculum at the Department of Industrial Design (ID) at the University College of Arts, Crafts and Design in Stockholm has been carried out during a three year project. The purpose has been to produce teaching materials for our own educational program within the Department, but also for exchange with other design schools in Sweden where similar curriculum developmental projects are under way. The focus has been on the following areas:

Designmetodik (Design Methodology). Vilda idéer och djuplodande analyser; om designmetodikens grunder, belyser hur designarbetet planeras och genomförs i sina olika faser där funktionsanalyser utgör en central del av arbetstiden hos en designer.

Three-Dimensional Visual Analysis (Form- och Rumsstudier), shows how form may be created, influenced and perceived in a structured manner. These visual studies constitute a link between fine and applied arts by developing a "form grammar" which supports both application and education.

Modellbyggnadsteknik (Model Making), introducerar material och tekniker för modellframställning i olika ambitionsnivåer. Skilda materials förutsättningar och begränsningar samt bearbetningstekniker presenteras med råd och anvisningar om hur ett gott resultat ska uppnås och misstag undvikas.

Industrial Design is a young education with a great need for curriculum development. The future intention with this series of books is that other subjects will be added as the basic teaching program progresses.

Lars Lallerstedt
Professor and Head of the Department of Industrial Design
University College of Arts, Crafts and Design
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Stockholm, Sweden
PAPER III

PART 1
Developing an aesthetic taxonomy of form

• Paper I

• Paper II

PART 2
Expanding & challenging the Evolution of form-model

• Paper III

• Work/ Paper IV

• Paper V

• Paper VI

PART 3
Formlessness - opposing the aesthetic taxonomy of form

• Paper VII

• Paper VIII

• Paper IX

• Work/ Paper X
This text attempts to briefly summarize the transformation of my earlier work with hard-edge black triangles into amorphic point-cloud images that dissolve in space. I would also like to celebrate the many exhibition opportunities that were generously offered to me by Monica Urwitz. Through Monica and the local and international artists and collectors at the Konstruktiv Tendens gallery, I was introduced to the Russian-European constructivist movement, which complemented and gave historical roots to my art/design education in New York. To now return for the 25th anniversary of Konstruktiv Tendens reconnects me with an important passage in my life, for which I am deeply thankful.

My debut exhibition at Konstruktiv Tendens in 1986 was based on emancipating the enclosed void captured between the hard edges and sharp contours of dynamic black triangles. The underlying aim was to distort and twist geometry through compositional experiments, without distorting the geometric elements themselves. The distortion emerged through the movement between diagonal surfaces and dynamic dimensions. My next show, in 1989, was planned around rotating distorted, triangular constructions that slightly blurred the details, bringing attention to oscillating silhouettes. The added temporal quality of rotation and movement strengthened an experience of the plurality of form in space. My last attempt to activate the gallery’s space, in 1992, was to work with varied degrees of translucency and shadows transforming my triangular sculptures into an array of blurred points, light, and color.

My work with translucency and shadows progressed through experimentation with embodied color in clouds of smoke. The unstable pile of ashes resulting from my pyro-studies offered me new means of expression and I began to embed different shapes and materials in ashes framed by glass containers. This shift to unstable materials and dissipating particles marked a change in the way I approached my work. The control that triangular geometric forms gave my earlier work was no longer attainable. Even though my attention in these three exhibitions was on void, blur, transparencies, and shadows, I was still able to sharply define the relationships between the geometric elements and treat these constructed compositions as objects in space.

Through my growing interest in clouded volumes, turbulence, and unstable particles, I began to question the hard edges of my constructed objects as well as my methods, use of technologies, and lack of interaction with other disciplines. A major change occurred when I contacted physicist Per Sällström concerning my experiments on translucency to discuss Goethe’s color theory with him. Our informal meetings at Stockholm University (SU) and at my studio resulted in a work on color expression in clouded volume. I prepared a short report about the findings of our exchange1. This in turn led to a new art and science project concerning empty space2, which was conducted in collaboration with three other physicists from SU: Lars Bergström, Narendra Yamdagni, and P.O. Hulth, and was planned around our common interest in cloud chambers and turbulence in space. We finalized the project in a cross-parallel exhibition at Bergianska Gardens. Later, all four of us were invited to prepare a new exhibition in an art/science festival in Stockholm. This exhibition explored the concepts of infinity and cyclical processes, in
which the three point-cloud images presented here were developed. These digitally plotted images all originate from the scanned points of the same sculpture, twisted curvatures. The images express a transformation from a solid form curving through space to a 2.5-dimensional image projecting all 3-D points on one plane.

I sometimes ask myself if I have crossed a line. Did my transformation phase from constructing geometric objects to working with unstable materials and clouded images mark a radical move that challenges the conceptual boundaries of constructivism? Or did I just make a gradual move that still embraces the spirit of the constructivists, showing more of a shift in materials, collaborative methods, and new technology?

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2. Film interview from the “Empty Space” exhibition from the TV News (in Swedish: TV-Aktuellt, March 21, 1998) (order film: cheryl.akner.koler@konstfack.se).
Fig. 2 Triangular prism in color airglass by Cheryl Akner-Koier.
Photo: Åke Sandström
**WORK/PAPER IV**

**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 II**

**PART 2**

**Expanding & challenging the Evolution of form-model**

- **Paper III**

- **Work/ Paper IV**

- **Paper V**

- **Paper VI**

**PART 3**

**Formlessness - opposing the aesthetic taxonomy of form**

- **Paper VII**

- **Paper VIII**

- **Paper IX**

- **Work/ Paper X**
STOCKHOLMS SCIENCE & ART FESTIVAL 2002
KULTURHUSET, STOCKHOLM

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

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

The final exhibition was designed to express our collaborative approach emphasizing our different views concerning the theme Infinity and complex curvatures. The final goal of this study was to present material from an exhibition on Infinity at the Art and Science Festival: Spielplan Stockholm, at Kulturhuset in September 2002 (see Paper V).
Fig. 2 Overall view of two rooms in the exhibition at Kulturhuset in September 2002. Cheryl Akner-Koler’s installation is on the left, and Lars Bergström’s installation is on the right. Photo: Åke Sandström.
\[ G - \Lambda \phi^2 = 8\pi G T \]

\[ z_1^2 + z_2^2 + z_3^2 + z_4^2 + z_5^2 = 0 \]
Fig. 3 The Twisted curvature-sculpture by Åker-Koler surrounded by point-cloud images. Photo: Åke Sandström.
Fig. 4 Three charcoal drawings of infinite curvatures and sculpture Crude curvature by Akner-Koler. Photo: Åke Sandström.
Calabi–Yau

Fig. 5a–d Calabi–Yau manifold by Lars Bergström.

**a-b** Two views of the same mathematical model of Calabi-Yau manifold.

**c-d** Two experiments using texture and transparency of figure 5a and 5b, respectively (see paper V).
Fig. 6a–f A six step demonstration of making a Möbius strip exhibiting one continual edge and one continual surface. Photo: Cheryl Aikner-Koler
PAPER V

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 II
Three dimensional visual analysis.

PART 2
Expanding & challenging the Evolution of form-model

• Paper III
Akner-Koler, Cheryl. 2006.

• Work/ Paper IV
“Infinity” (exhibition and program) shown September 17-29 at Kulturhuset, in Stockholm, Sweden. (www.formandformlessness.com)

• Paper V

• Paper VI
Akner-Koler, Cheryl. 2006.

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.

• Paper IX
Akner-Koler, Cheryl, Bliger, Monica and Catharina Dyrsen. 2005.

• Work/ Paper X


Complex Curvatures in Form Theory and String Theory

Cheryl Akner Koler and Lars Bergström

Physicist Lars Bergström and sculptor Cheryl Akner Koler have worked together on a number of art-science projects over the past 6 years. Their exhibition at the Stockholm Art and Science Festival in September 2002 (together with two other physicists, Narendra Yamdagni and Per Olaf Hulth), entitled “Infinity,” focused on the concept of infinite cyclical processes and extra dimensions (Fig 1). Bergström comes from the field of theoretical astroparticle physics and is an expert in dark matter [1]. Akner Koler is a sculptor with a background in constructivist art and is working on a theoretical model that strives to renew 3D compositional theory [2].

As a physicist one sees the world in terms of energy, matter, attracting forces, transformation, spatial dimensions, etc. This interest in an abstract descriptive language of movements and forces in spatial context is shared by artists working within a constructivist discipline. Our collaboration is based on a common interest in expanding this descriptive aesthetic language in order to explain complexities in physical phenomena. Support for this need for an art-science aesthetic language is given by physicist Brian Greene:

“...deep down, the universe has a less elegant structure than our experience has led us to believe, or perhaps we will find out that our current aesthetic criteria need significant refining when applied to ever less familiar contexts [3].”

Our art-science collaboration inspired a dialogue in a cross-disciplinary context that focused on questions that otherwise would not have been explored. We presented for each other our different views on the same or parallel phenomena and worked to bring these ideas into the perceptual world. An interesting area that developed during the 9 months we spent preparing for the 2002 festival involved exploring complex curvatures and hypersurfaces in space. Through a variety of different media—3D form, smoke, CAD models, drawings and kinesthetic movements—we studied conceptual and embodied ways to approach our common theme. This article is limited to the specific study of twisted sculptural curvatures and the Calabi-Yau manifold from string theory.

SYMMETRY CONFERENCE

We also presented our work in complex curvatures at the Symmetry Festival in Budapest, Hungary, 16–22 August 2003. The conference, “Symmetry and Dis-Symmetry: A Synthesis of Constancy and Change” [4], was a cross-disciplinary forum for those who work with morphological studies of symmetry, asymmetry, broken symmetry, antisymmetry, etc. The International Society for the Interdisciplinary Study of Symmetry (ISIS-Symmetry), which hosted the conference, supports work that goes beyond the traditional boundaries of disciplines and professions. Its members are from art, science, design and engineering.

A SHORT HISTORY OF STRING THEORY AND THE CALABI-YAU

In the micro world we are getting used to the idea of employing more than the usual three spatial dimensions plus time—considered by physicists to be the fourth dimension. In string theory and its underlying models it is held that there may be six or seven extra dimensions; these are usually believed to be curved into themselves. The step out of 3D and into something more complex was a very important one, first taken by a German, Theodore Kaluza, and a Swede, Oskar Klein, in the 1920s. This step is a cornerstone of contemporary particle theory and string theory. The existence of the extra dimensions, if proven scientifically, would mean a resolution in the way we consider space and time, a revolution even greater than the one brought by relativity and quantum mechanics. The lowest energy state of string theory (the vacuum state) does not seem to be unique, or at least we have not found the guiding principle to select the ground state of the theory. Therefore we can only play with low energy state (vacuum) models that seem to have the right amount of symmetry and broken symmetry to encompass the standard model of particle physics. One such type of vacuum model is the Calabi-Yau manifold, given by a simple homogeneous equation in five complex variables. Despite the mathematical simplicity of the defining equation, the properties of the manifold are complex, yet symmetrical in an interesting way.
Properties of 3D Compound Curvatures: Current Models in String Theory

In string theory, there is great uncertainty about the "true" vacuum, particularly the one that causes the universe to expand and even accelerate. Mathematical models built up of strings compactified in certain coordinates, called compact extra dimensions (hypersurfaces), have led us to appreciate the significance of extra dimensions. The Möbius strip [5] (Fig. 2) shows that what is locally a flat surface may globally be very complex, because its orientation in space is undetermined. The twist from inside out gives this area its peculiarity, expressing only one continual single surface and one continual edge.

An algorithm by Andrew Hanson of Indiana University, U.S.A. [6], has integrated hypersurfaces into the fascinating Calabi-Yau manifold. Bergström has used this algorithm to produce a number of different views and interpretations; an example is shown in Fig. 3. This model regards the compactified dimensions of that manifold as the true space where strings roam. This means that in every point in our universe, there is such a manifold—of an incredibly small size. Close to the time of the Big Bang the characteristic radius of our universe was of the order of the Calabi-Yau radius (or Planck radius).

Twisted Curvature

Akner Koler’s concave-convex aluminum sculpture, Twisted Curvature (see Article Frontpiece and Color Plate C No. 2, sculpture on center podium), expresses a twist from the inner to the outer sur-

Fig. 1. Overall view of two rooms in the exhibition at the Stockholm Culture House in September 2002. (Photo © Åke Sandström) Cheryl Akner Koler’s installation is on the left, and Lars Bergström’s installation is on the right.

Fig. 2. Mathematical computer model of a Möbius strip. (© Lars Bergström)

Fig. 3. Calabi-Yau manifold computer visualization model. (© Lars Bergström)
faces and vice versa. This type of complex curvature is a traditional sculptural phenomenon that can be found in figurative and non-figurative sculptures throughout history, such as Michelangelo’s The Dying Slave [7], Henry Moore’s Reclining Figure, Barbara Hepworth’s Plastered Form [8], and Alexander Archipenko’s Walking Woman [9]. The fact that the volumes and surfaces of Twisted Curvature make a cyclical loop intensifies this spatial twist and expresses the paradox of the Möbius strip. Max Bill, Helaman Ferguson and Brent Collins have worked in this area and have given both sculptural and theoretical insight into the mathematical parallels of the Möbius strip and similar structures [10]. Twisted Curvature was not intended to express a mathematical concept; there is only an “implicit” mathematical correlation. The aim of creating this twisted sculpture was to explore organic sculptural traditions in parallel with models of curvatures in string theory as well as to bring digital technology into this sculptural area.

Transforming the simple curved movement of a Möbius strip curvature into a volume that embodies 3D compound curvatures brings out a more complex organic sculptural experience. Rowena Reed explains this organic experience in detail in her descriptive analysis of convexity and concavity [11].

The variation of volume thickness, material density and added compound curves that are accentuated within the twist brings out organic double-curved features that blend together with the mathematical features explored by Möbius. The visual model of the Calabi-Yau (Fig. 4) implies this paradox at a high level of complexity in extra dimensions. One of the main purposes in our collaboration is to gain perceptual experience of these twisting paradoxical forces in the 3D world. Michael Biggs has stated the importance of learning through perceptual experience for the purpose of guiding our thought processes:

I am interested in investigations in which aesthetic judgements are made in relation to sensory objects and one might argue that this process as well as having an empirical basis, that could be examined through experimentation, actually arises through the experience of being confronted with these judgements and that therefore the identification of the initial problem, as well as its conduct through experimentation arises in the realm of experience rather than in the realm of cognition [12].

Fig. 4. Close-up of a twisted area on Lars Bergström’s computer visualization model of the Calabi-Yau manifold, using the algorithm of [4]. (© Lars Bergström)

Fig. 5. Five different point cloud projections of the sculpture Twisted Curvature, developed through scanning digital technology at Nufoparts in Sweden, 2002. (© Cheryl Akner Koler)

**Transparent Dimensions of Form**

Twisted Curvature was plotted through a 3D digital scanning as a “point cloud” volume, shown in Figs 5–6 and in Color Plate C No. 2. A point cloud volume is made by correlating points on the surface of a physical object with points on a digital mesh that map the spatial coordinates in a 3D virtual matrix [13]. To visualize this digital information, a selection of points is made by defining maximal distance and ± variance between points. Sixteen transparent projections of this point cloud were chosen, five of which are shown in Fig. 5. In the exhibition, these transparent projections were mounted on curved white surfaces, hanging from the ceiling and surrounding the sculpture (see Color Plate C No. 2). Each projection is unique because the sculpture is totally non-symmetrical and the projections are all taken from different viewpoints. The phenomena of transparency and the twisted, continual surfaces of the form allow the point coordinates to become superimposed, and the spatial positions of each point are obscured in depth.

To fully experience the properties of the point cloud volume through these pictures, it helps if one avoids focusing on the outer and inner contours and lines of the form. Instead a relaxed perception of depth, movement and volume should be explored, one that allows the inner concave surfaces to transpose into the outer convex surfaces simultaneously. This transposition suggests the undulating change of material density that moves through curvatures between dimensions. Finding ways to understand how to move between dimensions is one common experience we have shared throughout this project. Perhaps hidden somewhere in this transparent hypertwist lie the organizing conditions that give electrons, light particles, photons, etc. their unique properties.

Seeing “solid” form as made up of points or particles in space is a concep-
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natural model physicists use to explain the laws of nature. This scientific concept has been difficult to understand, because our perceptual awareness and visual rhetoric has traditionally reinforced solidity and stability, which is the opposite of moving particles in space. Today digital technology has made it possible to virtually and physically observe forms being composed of points or particles. Through theories from physics and advancements in technology we are slowly reorienting our ways of conceiving, perceiving and aesthetically judging form, space and content. This reorientation can be done without divorcing the historical traditions of sculptural aesthetic knowledge.

REASSESSING THE PROPERTIES OF THE SPACE SURROUNDING HYPERSURFACES

There is a problem in visualizing the hypersurfaces of a Calabi-Yau, which exists at each point in our conventional 3D space. Is it like a sphere contained within itself? Or could it be that there are changes in density, or other properties within the hypersurfaces, that allow some sort of integration with the surrounding space? A transfer of properties happens around the hypersurfaces, which allows the “form” (or rather, mass, color, charge and other physical properties) to dissipate into other dimensions. We have tried to invoke a feeling for these mechanisms by making the Calabi-Yau model transparent and thereby smoothly connected to our space-time.

Transparent Calabi-Yau

The Calabi-Yau manifold is interesting as a model for the compactification of string theory from 10 dimensions to four dimensions (counting time as a dimension). Bergström has taken a 6D algorithmic model of the Calabi-Yau manifold and transformed it into a transparent version (Fig. 7) in which the integration with real space appears vague. This is meant to express the unity of all these 10 dimensional spaces and the fact that the compact extra dimensions are everywhere, influencing all the properties of matter as we know it.

Both the Calabi-Yau manifold and the Twisted Curvature sculpture were presented as transparent images through computer technology. The role transparency played in the Calabi-Yau image was to dissolve the boundaries between the object and the surrounding space. Aesthetically this implies the transformation of properties of matter merged with space. In the case of the point cloud images, the transparency intensifies the depth dimension and sense of volume by showing the “hidden” rear surfaces through the front.

The art critic Jan Butterfield addresses issues of artists collaborating with science and technology in search of instability, transparency and the seeming immateriality of materials [14]. She traces this search back to the 1960s when artists such as James Turrell, Robert Irwin and Maria Nordman began to introduce their works of “Light and Space” to the art community. Butterfield’s critical and supportive analysis of the development of immaterial aesthetics lends a background to the cross-disciplinary nature of our work.

CONCLUSION

Compound curvatures and transparency have inherent properties that move “between” dimensions, yet they are still physical phenomena that can be experienced in the perceptual world as well as the virtual world. We suggest that current research in theoretical astroparticle physics...
and development of the renewal of constructivist aesthetics have a great potential in working together because of their shared interest in aesthetic experience in the physical and the abstract world. Through such art-science collaborations we can open up the field of aesthetics to include questions from disciplines beyond the traditional fields of philosophy, art and design. In time aesthetic criteria can better reflect the conceptual and perceptual dynamics of our time and begin to play a more vital role in shaping our intellectual, emotional and physical environment.

References
4. See <http://www.conferences.hu/symmetry2005/>
5. See <http://mathforum.org/sum95/math_art/ moebius/moebius.html>

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Glossary
Calabi-Yau—a theoretical model that concerns the geometry of the universe. Eugenio Calabi and Shing-Tung Yau developed the theory for this 10D space–time concept, which has greatly influenced string theory. The main application of Calabi-Yau spaces is in theoretical physics, which is presented in purely mathematical terms. There are also attempts to visualize this theory through computer generated models that are referred to as Calabi-Yau manifolds or Calabi-Yau varieties.

 hypersurface—the generalization of the concept of a surface to more than 3D. Various aspects of a hypersurface can be visualized by projecting down to two or three dimensions.

Möbius strip—a form that can be made by taking a rectangular strip of paper and joining the ends of the strip together so that it has a 180˚ twist. This twist brings out the paradoxical property of a twisted surface with only one surface and one edge. The Möbius strip was discovered in 1858 by August Möbius.

point cloud—a digital technology based on scanning physical models and translating the information derived from the surface of the model to points in a virtual spatial matrix. Each point correlates directly to a coordinate on the model. The digital image looks like a white cloud.

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Lars Bergström is a professor of theoretical physics, specializing in astroparticle physics, at Stockholm University. He is involved in several international research projects, such as AMANDA and GLAST, the Gamma Ray Large Area Space Telescope, which is a collaborative project between researchers in the U.S.A., Italy, France, Japan and Sweden. Bergström is one of the first astrophysicists in Sweden and has played a major role in describing the theoretical aspects of this field. He is also the scientific secretary of the Nobel Committee for Physics.
PART 1
Developing an aesthetic taxonomy of form

- **Paper I**
  Akner-Koler, Cheryl. 2006.

- **Paper II**

PART 2
Expanding & challenging the Evolution of form-model

- **Paper III**
  Akner-Koler, Cheryl. 2006.

- **Work/ Paper IV**
  “Infinity” (exhibition and program) shown September 17-29 at Kulturhuset, in Stockholm, Sweden. (www.formandformlessness.com)

- **Paper V**

- **Paper VI**
  Akner-Koler, Cheryl. 2006.

PART 3
Formlessness - opposing the aesthetic taxonomy of form

- **Paper VII**
  Akner-Koler, Cheryl. 2007 (revised version).
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- **Paper VIII**
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- **Paper IX**
  Akner-Koler, Cheryl, Bilger, Monica and Catharina Dyrsen. 2005.

- **Work/ Paper X**
  Akner-Koler, Cheryl (project leader and producer), Norberg, Björn (co-producer) Kojee, Anjana and Ebba Matz (exhibition concept) 2005.
Abstract

Two studies in transparency and material breakdown are presented that expand the Evolution of Form (EoF)-model along two axes. The transparency study using 3-D scanning technology that transform the twisted curvature sculpture into a transparent point cloud volume. A new stage, Transparency, is introduced expanding the EoF-model along the horizontal axis. The model is further expanded along the vertical axis to include material breakdown that introduces a natural process of dehydration as a means to distort and deform. Color, texture, density, smell etc. are introduced as new properties that are included in the process of deformation. Issues of ecology and string theory play a role in the development of these two studies, as well as combining low and high technology.

The revised model aims to integrate relevant contemporary issues in the EoF-model. The concluding remarks present a skeptical attitude to the revised EoF-model, especially in reference to the material breakdown study. Comparing the original model with the revised model does, however, provide a way to highlight both strengths and limitations of the original model.

Introduction

The foundation for aesthetic reasoning in the field of industrial design was established during the first part of the Industrial Revolution. The core of this aesthetic reasoning for shaping form was based on four major factors. The first is perceptual awareness of geometric structures and spatial abstraction (Greet 2002, Wick 2000). The second is traditional craftsmanship through the drawing and sculpting of figures and nature studies (Wick 2000, 382 [1982]). The third is learning about scientific methods to develop the field of design (Cross 2002), and the fourth is the possibilities and limitations that technology and the manufacturing process offered (Chernikov 1989). In this paper I aim to show that these four factors continue to expand and challenge the aesthetic paradigm for industrial design.

The article builds on both previous work I have done in form theory and practice developed within an industrial design educational framework. The issues here deal specifically with further development of a model that reciprocally merges geometric properties with organic properties, referred to as Evolution of Form (EoF)-model. For a background of the EoF model, I refer the reader to the article “Expanding the Boundaries of Form Theory"
(Akner-Koler 2006). The article explains a 10-step Concept-Translation-Form method resulting in the development of the geo-organic Evolution of Form-model as shown in figure 1. Briefly, this model consists of two axes. The horizontal axis presents a sequence of seven stages that are geometrically derived forms gradually taking on organic qualities of convexities and concavities. The seven stages are: join, intersect, divide, adapt, merge, distort and organic. The second axis expands the model in a vertical dimension to include a bipolar spectrum (±) at all stages. This vertical dimension opens up a spectrum between congruent and incongruent properties in relation to features of the original geometric form. The bipolar concepts are: +accordance – discordance, +assimilate – dissociate, +converge – diverge, +conform – deform, +convexity – concavity.

The negative pole in the bipolar spectrum introduces a way to consider the aesthetic properties dealing with breakdown, which questions the overriding principle of beauty usually associated with the organizing capacity of geometry. The negative pole also supports the sculptural qualities concerned with void/ concavity.

Model development

Two studies will be presented here: Complex curvatures and Ecology/ Material breakdown. The specific questions these two projects deal with are, respectively:

1) How can we gain new aesthetic awareness by studying twisted cyclical curvatures using advancements in 3-D digital scanning technology?

2) How can environmental questions inspire aesthetic reasoning? Methods, results and discussion are presented separately for each study. Both projects challenge and expand the EoF-model in figure 1.

Study 1: Complex curvatures - transparency

The Complex curvatures study emerged during an art-science collaborative project concerning the theme Infinity. Over a nine-month period, three physicists - Lars Bergström, Narendra Yamdagni, and P.O. Hulth - and one artist, Cheryl Akner-Koler, met regularly to explore aspects of the theme Infinity and to prepare the content of an exhibition and program for an art/ science festival at Kulturhuset in Stockholm in 2002 (Akner-Koler and Bergström 2005).
Methods

Early in the project, Bergström and Akner-Koler recognized a common interest in non-trivial curvatures that twist and curve within an infinite cyclical path having no beginning or end, as well as no separation between the inside and outside. Bergström’s background in theoretical physics and his interest in string theory inspired him to further develop his conceptual and perceptual awareness of the digital model of a Calabi-Yau manifold, as shown in figure 2. I created a compound twisted sculpture that explored variations of density, width, and a shift of accents based on the construction of a Möbius’ strip, as shown in figure 3. The convexities and concavities of this sculpture were developed through sculpting aesthetic principles rooted in the work of the Russian sculptor Alexander Archipenko, and the American sculptor, designer and educator, Rowena Reed (Greet 2002). The sketching process was done using Kolb (URL) ID clay. The final sculpture, Twisted curvature (figure 6), was cast in aluminum through a lost-wax method and then scanned by a 3-D digital scanner into a point cloud volume.

The article Complex curvatures in form theory and string theory, published in 2005, gives a detailed account of your collaboration, results and the exhibition (Akner-Koler and Bergström 2005).

Results

The results of this project came about through a combination of low-technology, sculptural craftsmanship with clay and high-technology with 3-D digital scanning. The translation of the physical sculpture through the 3-D scanner into a virtual point-cloud volume introduced properties of transparency. Sixteen point-cloud 2.5-D images were selected, printed and mounted on three curved, white, translucent acrylic surfaces that surrounded the sculpture in the exhibition at Kulturhuset (see figure 4).

We explored conceptual advantages of transparency inspired by the point cloud images. Bergström’s work with transparency created a new interpretations of the Calabi-Yau manifold that better represented the ideas of multiple curvatures in string theory.

Discussion

The virtual point cloud volume marks a further move away from both the law-bound physical structure of geometry and stable objects in space that the first 6 stages of the EoF model build on. Point cloud volumes introduce amorphous characteristics with a vague spatial position, pushing the limits of the concrete expression of form exposing phenomena of density, overlap and multi-dimensions. This study also challenged our understanding of 2-D images of 3-D forms. Point cloud volumes expressed from one fixed viewpoint show the back and front of the volume in one view which expresses a 2.5-D image that compactifies dimensions into one frame. Since the point cloud complex curvatures move through virtual space there is no clear sense of depth. The surface therefore can be easily transposed.

An unexpected result of this scanning experiment was that more than half of the 2.5-D point cloud images were not easily recognized as originating from the same sculpture. Although I know this form from all angles and from all stages of development, I was not able to locate the vantage point from which each image was taken. This experience posed questions as to our ability to grasp complex, transparent forms. Although we are able to
To grasp a coherent and holistic 3-D image fusing together all different views of a solid form, it is much more difficult to grasp the superimposed, transparent point cloud images that show the back and front through the same view (i.e., 2.5-D).

This combination of hand craftsmanship and high technology is a very central issue in merging embodied aesthetic experience with the visual abstractions of the digital world. The industrial design process is becoming increasingly dependent on digital images. We need to keep track of wireframe forms and polygonal surfaces that are complicated. An important question is: are we able to support aesthetic reactions and reasoning through these primarily visual media? Malcolm McCullough’s (1996, 48–9) practical and theoretical work in digital craftsmanship brings up this issue. He both praises the hands and haptic experience and at the same time predicts the decline of physical objects as we offer more and more virtual solutions for solving problems. McCullough presents the situation of the “dematerialized artifact” and the changes in professions and technology that will bring new forms of visual knowledge in the virtual and real worlds. The point-cloud images presented here are a product of virtual technology that literally dematerialized the physical, solid sculpture by merging material points with spatial dimensions. At the same time, this virtual technology can “rematerialize” the complex curvatures of the sculpture through 3-D or 2-D printer technology. Following the development of a physical form as it is transformed into new imagery is one of the areas of development that form theory will need to include.

**Study 2: Ecology/ Material breakdown**

This study involved dehydration of organic materials, inspired by an ecological theme at Konstfack in 1995–1996 (Svensson and M6 group 1996). The theme involved the entire school in finding ways to integrate ecological reasoning in the educational curriculum. Since ecology focuses on life cycle processes and decomposition of materials, I chose to problematize the aesthetic traditions of industrial design (which I teach in the first year) and developed a course on Ecology/ Material breakdown.

**Method**

A pedagogically framed study was developed at Dept. of Industrial Design (ID) at Konstfack for second-year ID-students. The study was run parallel with lectures and seminars on the theme ecology that were arranged by the M6 group for the entire school.

We began by selecting organic materials, such as zucchini, pumpkin, potato, ginger, red beet and pear, and cutting the material into cubes of similar size. The cubes were left to dehydrate over three summer months. The students were asked to record the changes in a journal with drawings, photos, and descriptive text that discerned color, texture, form, smell, density etc. (figure 5)

**Results**

After the summer vacation, the organic cubes and student journals were compared. We discussed the experience of observing a gradual transformation of form and substance over time in relation to prior form studies in clay. A list of aesthetic concepts were recorded, such as crack, collapse, transparent, rough, slimy, etc.
The three photos of organic cubes—the figures 6a–c show the final stages of a potato-cube, ginger-root-cube and a pear-cube.

Figure 6a shows a potato-cube in the last stage of its dehydration process. The cube rested on a porcelain plate during dehydration (not shown in photo), which retained moisture at the base where the potato was in contact with the plate. This uneven rate of dehydration between the top and bottom of the potato cube caused a deep concavity at the top in comparison to the slightly raised concavity at the base. It is interesting to note that the distorted edges and corners of the cube are still sharp.

Figure 6b shows a ginger root-cube mounted on a wooden dowel during the drying phase, allowing the air to circulate around the whole cube. The twisted concavities are all very different on each surface in comparison to the potato cube. Some deep concavities emerged by adjoining surfaces twisting around each other, whereas others have more shallow concavities that move from slightly concave surfaces to convex. The ginger cube is strongly influenced by the way the long fibers run through the root.

Figure 6c shows a pear-cube that was transformed into a glowing translucent material with subtle color variations. The pear cube was dried on the tip of a toothpick, creating even conditions for dehydration. The concavities on four sides show collapsed and sunken surfaces that are also partly controlled by the edges of the cube. The two remaining parallel surfaces show a cracked and distorted star-shaped void with sharp negative points. All three organic cubes in figure 6 exhibited sharp edges and corners that were retained throughout the entire dehydration process. The concavities and surface deformation were controlled by the six separate surfaces of the cube.

Through discussions with students, the following conditions were highlighted:

- Context-dependency
- Temporal process
- Autopoiesis (i.e., not controlled by the designer)
- Partial control by geometric structure
- Perceptual experience of the interrelationship between color, texture, smell, density, shape, etc.
- Complex features cannot be separated from the properties of the material.

Discussion

The ecology/material breakdown study explored the amorphic characteristics of organic material. Using the structural features of a geometric cube to discern change and behavior of dehydration supported a comparative study, both as the cube changed over time and between the different materials. Material transformation controlled by geometry has previously been explored by artists such as Lucio Fontana in his “Ceramica spaziale” 1949 and Jean Dubuffet in his work with “Art informel”, as shown in his “La vie interne du mineral” 1959 (Bois and Krauss 1999), and recently in a large-scale object, “Bitumenkub” 1998 by Mikael Lundberg (Valjakka 2001). According to Dubuffet, this interest in material breakdown and texture was to oppose methods of compositional abstraction and to expose the formless nature of substance. These artists used unstable material transformation because they offer means for expressing time, process and entropy that go beyond the concrete form itself.
The present study introduced an aesthetic approach which challenged traditional industrial design aesthetics that emphasizes positive gradual curves, tensional surfaces and highly polished shapes. By setting up explorative studies of non-traditional materials that change over time, we were able to problematize aesthetics by asking such question as: i) How do highly polished products defy aging or wear and tear? ii) How can spontaneous organic processes be introduced into product development? iii) Can ecological concepts, such as the cyclical processes of buildup and breakdown, inspire a different approach to aesthetic reasoning in product development and the field of aesthetics?

Educational relevance: The educational relevance of this ecology/ material breakdown study lies in exploring alternative ways of reasoning that can bring cyclical and process-based thinking into the design process at any level. Studying the dehydration of a pear may seem trivial, because it is part of our mundane everyday world. Yet, it is precisely this everyday world that can help us improve our traditional aesthetic reasoning in design. Tor Norretrander (2003) points out that artists are able to “study the world itself”, such as the flow of water or chaos in the kitchen, while science has a long tradition of ignoring the everyday world. He sees the artist’s process-based working strategies as very valuable to the sciences, because they offer ways to go beyond the general laws of nature. I argue that design also needs to reclaim its roots with the arts and an awareness of natural processes. This ecological breakdown study supports a way to renew aesthetic reasoning so that both the logic of geometry and the unpredictable changes of the real complex world are included in our aesthetic consciousness. The pear-cube embodies the merge of these two worlds.

A majority of our ID students were unclear about the purpose of this study, because it did not seem to have direct relevance for designing products. To stimulate a stronger connection to product development, the students were assigned a project that linked these aesthetic ecological studies to product development. Two examples of the products developed by the students were: a) a computer mouse pad that was designed to show traces of the movements of the mouse and b) a bottle cap that glowed in different hues reflecting the age of the fluids within. An ad-hoc exhibition at the Future Museum in Borlänge, Sweden 1997, was arranged in connection with an exhibition Kjartan Slettemark and I had together called Omvandla – Förvandla (Metamorphose/ Transformation) (Degerman 1997). Both the material breakdown studies where exhibited as well as the suggested products. The material breakdown study has been given to students in our bachelor’s and master’s courses at the Dept. of Industrial Design at Konstfack in different ways over the years. Its main purpose has been to remind ID students of the vast aesthetic experiences that ecology and material breakdown include. It also stimulates a constructive and critical attitude towards the classic geometrically derived form theory and practice I teach at Konstfack. Two workshops were later arranged based on this theme ecology/ material breakdown: one in 1999 for the No Picnic design group and the other for a laboration in material transformation in a Cross-disciplinary studies of Complexity and Transformation 2003–2005 (Akner-Koler 2005) (URL).

Concluding discussion

Provisional revised Evolution of Form-model

The two studies above challenged and expanded the EoF-model as shown in figure 7 and represent an important conceptual phase in development of the model. The studies were designed to challenge the controlling power of geometry and to move beyond solid form into complex curvatures and topological points in space. My point here is that some of the traditional methods of geometric abstraction and sculptural craftsmanship can be interwoven with new areas of exploration in the real world as well as in the virtual world. Because the original EoF-model merged geometry and organic principles of growth, it was not a rigid model to begin with.

The EoF-model was revised along both the horizontal and vertical axes through the phenomena transparency and material breakdown as shown in figure 7.

- Transparency expands the EoF-model next to the last stage “organic” along the horizontal axis. The concept transparency is suggested as an 8th stage to introduce a possible continuation of forms and concepts that go beyond solid volumes. In figure 7, a transparent point cloud volume has been derived from the concavity volume at the organic stage, thereby making up a transparency stage.

- Material breakdown expands the EoF-model along both the horizontal and the vertical axes to introduce more complex ways of organic deformation. First horizontally by stretching the axis between distort and organic (figure 7a), and second vertically at the negative pole deform of the bipolar spectrum, which shows a dehydrated organic cube as a means for deformation (figure 7d).
Strength: The strength of the revised model in figure 7 is to show ways to connect the aesthetic reasoning of the EoF-model that is strongly influenced by values from the early part of the industrial revolution with concepts (e.g., ecology) and technology (e.g., 3-D scanning) that are highly relevant today.

Weakness: The weakness of the revised EoF-model is that it becomes fuzzy when it moves into new modes of aesthetic abstractions. I am especially skeptical of the way the material breakdown study expands the model, since it introduces color, texture, smell etc., which the model cannot properly deal with.

Conclusions

The revised EoF-model exposes new areas of aesthetic abstraction and generates new ways to understand the principles and norms that build up the previous model. I feel that the revised model presented in figure 7 will not survive or replace the old model in figure 1, because of its inconsistencies. However, it is relevant to use the model in an educational context to test the limits of model development. The two studies, transparency and material breakdown, have merits of their own, aside from how they relate to the EoF-model.

Acknowledgments

Thanks to Leif Thies from the Mi6 group who encouraged me to introduce an ecological awareness into aesthetics. Kjartan Slettemark helped me take on the challenge of aesthetic breakdown. I would also like to thank Lars Bergström for his open-minded and curiosity as we worked through the theoretical and practical advantages of transparency. Thanks also to the Industrial Design students at Konstfack, who allowed me to explore aesthetic questions that pushed the limits of traditional industrial design aesthetics.
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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
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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.
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.
12. Gustaf Mårtensson, PhD in fluid mechanics at KTH
13. Fredrik Berefelt, mathematician and astrophysics researcher in nonlinear systems.

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.
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 2005i), 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 dis-/reflect 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
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. 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 zinc 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.
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,
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 laboratories based on our theme of complex and changing phenomena. The 9th laboratory, *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 Anjana 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.
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.
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
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’ 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
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
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.
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...
from literature in the field of complexity. The five first 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 need 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 losing 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 laughter and joking around.
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.
5. Discussion

5.1 Comparing aesthetic strategies with rule-based mechanisms

The following discussion compares the 12 laboratories 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...
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 the C&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:
   o Aesthetic phase transition-model
   o Transformation-model
   o 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
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
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 (Deluze 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.
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

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
6.4 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.

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PART 1
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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


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.

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 an 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 pragmaticist 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
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 the laboratories themselves with minimal help from the leaders. Experimentation was encouraged. The model in figure 2 graphically maps out the stages of one of the laboratories.

**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 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...
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 (Dyrrsen, 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
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 (Deluzé 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...
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 adapt-
ing 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 fea-
tures 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
(arrow) 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 dis-
symmetry 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 ambigu-
ous term for both groups. The art and design group saw
breaking symmetry as having a positive connotation,
while the physics group attached more negative con-
notations 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 discus-
sions 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
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. Saddekh 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 example (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
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 than 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 than 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 exemplar, 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. Deleuze 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 Lordan (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

- Paper II

PART 2
Expanding & challenging the Evolution of form-model

- Paper III

- Work/ Paper IV

- Paper V

- Paper VI

PART 3
Formlessness - opposing the aesthetic taxonomy of form

- Paper VII

- Paper VIII

- Paper IX

- Work/ Paper X
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
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](image1)  
![Fig. 2a. Eggplant](image2)  
![Fig. 2b. Lard](image3)  
![Fig. 2c. Black pudding](image4)  
![Fig. 2d. Parsnip](image5)

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).

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.

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](image)
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.

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 Slettemark’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).
PARTICIPANTS

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Thomas Burgess and Christina Burgess, assistants, physicist, PhD students, AMANDA. SU.

REFERENCES


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 II
  Three dimensional visual analysis.

PART 2
Expanding & challenging the Evolution of form-model

- Paper III
  Akner-Koler, Cheryl. 2006.
  Twisting, blurring and dissolving the hard edges of constructivism.

- Work/ Paper IV
  “Infinity” (exhibition and program) shown September 17-29 at Kulturhuset, in Stockholm, Sweden. (www.complexityandtransformation.com)

- Paper V

- Paper VI
  Akner-Koler, Cheryl. 2006.

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.

- Paper IX
  Akner-Koler, Cheryl, Bilger, Monica and Catharina Dyrsen. 2005.

- Work/ Paper X
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.

Photo: Fig. 1-3 Marcus Öhrn

Fig. 3a–b Material transformation.

Fig. 3b
Fig. 4 Smoke. Photo: Bengt Alm.

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