ARTISTS AS INVENTORS
INVENTORS AS ARTISTS

The Ludwig Boltzmann Institute for Media Art Research is an institution of the Ludwig Boltzmann Gesellschaft GmbH in cooperation with the Kunstuniversität Linz, Ars Electronica, and the Lentos Kunstmuseum Linz.
Contents

Dieter Daniels / Barbara U. Schmidt

Introduction 7

Barbara U. Schmidt

Dieter Daniels

Artists as Inventors and Invention as Art: A Paradigm Shift from 1840 to 1900 18

Simon Werrett

The Techniques of Innovation: Historical Configurations of Art, Science, and Invention from Galileo to GPS 54

Paul DeMarinis / Dieter Daniels

Working in a Place before Words 70

Wolfgang Hagen

Busoni's Invention: Phantasmagoria and Errancies in Times of Medial Transition 86

Cornelius Borck

Blindness, Seeing, and Envisioning Prosthesis: The Optophone between Science, Technology, and Art 108

Gebhard Sengmüller / Dominik Landwehr

Fictive Media Archeology 130

Simon Penny

Bridging Two Cultures: Towards an Interdisciplinary History of the Artist-Inventor and the Machine-Artwork 142

Sylvie Lacerte

9 Evenings and Experiments in Art and Technology: A Gap to Fill In Art History's Recent Chronicles 158

Billy Klüver / Edward Shanken / ed. Barbara U. Schmidt

I Believed in the Art World as the Only Serious World That Existed 176

Katja Kwastek

The Invention of Interactive Art 182

Karin Harasser

Switched-On Vulnerability: Designability, Gender, and Technology with Laurie Anderson and Wendy Carlos 196

Amy Alexander / Inke Arns

Building Things 208

Kirsten Pieroth / Barbara U. Schmidt

Everyday Inventing 218

Biographies 229

Index 233

Sources 237
Thus one of the purposes of the present book is to make a proper assessment of the individual element in invention and discovery and of the cultural element.

Norbert Wiener, 1954

Thinking of artists as inventors and inventors as artists—that is, scrutinizing the reciprocal interaction of artistic practices and technological developments—is not something we take completely for granted. These domains’ respective epistemological systems, modes of production, and results seem to be too disparate to do so. In the articles collected in this publication, the aim has been to examine the complex interconnections between art, science, and engineering on the basis of historical and contemporary case studies. The focus of these considerations is on the technical and artistic media that have emerged since the nineteenth century.

To do justice to this topic, a wide array of approaches, some of which are to no small extent mutually contradictory and nevertheless equally legitimate, are possible and even necessary. Accordingly, this book contains scholarly articles that employ very diverse methodologies, including:

- the history of science, and in particular the sociology of scientific knowledge and social construction of technology examined across a wide-ranging historical horizon (Simon Werrett);
- media archeology as the basis of an epistemology and a theory of art derived from it (Wolfgang Hagen), supplemented by anthropological aspects of the social studies of medicine (Cornelius Borck);
- art history as media history and vice versa, an essential part of which is a process of reciprocal investigation and cross-fertilization of the methods and themes involved (Dieter Daniels, Katja Kwastek);
- the artistic practice of art, science, and technology as the subject of critical reflection on its current status (Simon Penny), and a no less critical history of how this has been received by the public (Sylvie Lacerte); and gender studies in combination with media art and pop culture theory (Karin Harrasser).

Arranged contrapuntally to the scholarly-theoretical approaches taken in this publication is a series of interviews with protagonists—mostly artists—whose fields of activity are situated at the nexus of art and technology. In these dialogues with experts from different scholarly disciplines, they give an account of the transitory practices they utilize to avoid explicit definitions and
Although the art-science-technology discourse is conducted by an international community in publications, festivals, and symposia, it often remains highly self-referential. Despite a claim to interdisciplinarily, what this discourse frequently lacks is a more profound methodological and epistemological connection to its own three component fields: art, science, and technology. The multiple methods presented here are meant to take this discourse beyond the realm of its own immanence. We want to show it as an exemplary context that provides the opportunity of relating discourses that have revolved around them since the beginning of the twentieth century.

In the early twentieth century, at the high point of the modernist avant-garde, artists turned into inventors for practical reasons. To respond with their aesthetic visions to the impact of technology on the human senses, they needed a new apparatus that was not yet available. One of these artists was the Italian Futurist painter Luigi Russolo. In his manifesto for a new art of noise, he wrote that the sound environment of the industrial city had changed so completely that the traditional instruments could no longer compete with this experience. So he went ahead and built his intonarumori, which imitated the sound of machines, and made it available for his performances of the art of noise. Another example is Walter Ruttmann, a Munich painter who decided to quit the easel and take up film instead. He also wrote a manifesto in which he declared that the static image no longer satisfies our perception, which is changed by the speed of media information. His aim was a painting in time, using the cinema for a new kind of Abstract Art evokes like music. But there was no equipment available to make such a movie, because film only depicts images from reality, not from the inner vision of an artist. Ruttmann had to invent an apparatus that made it possible to capture on film flowing forms moving in time created by paint on a glass surface, and he was ultimately issued a patent for the device. The first example of this new art was Opus 1 (1921), an abstract film hand-colored frame by frame and accompanied by music written expressly for this piece. For these avant-garde artists, the technology of their time was a stimulus of perception and, at the same time, its limitations were a challenge to their search for new artistic media. So technology is both: objective motif and subjective motivation, impression and expression of their art.

A broader methodological debate on the interrelationship of culture, science, and technology has been taking shape since the mid-twentieth century. In his book Invention: The Care and Feeding of Ideas, Norbert Wiener investigated the disparate factors that must first come together in order to lead to an invention or in whose wake one might occur: individual genius and collective consciousness, hard technical and economic facts, as well as a favorable social and intellectual climate. Back in 1954, Wiener conceived a chronological sequence of these factors; as for the accelerated innovation of modern-day technical developments, a simultaneous interaction of these factors can be assumed. Wiener’s general mission statement, even if not shared to an equal extent by all of our contributing authors, might also serve as the motto for this volume: “Thus one of the purposes of the present book is to make a proper assessment of the individual element in invention and discovery and of the cultural element.”

A split between the “two cultures” of arts and humanities on the one hand and the sciences on the other was pronounced in 1959 by English novelist and scientist C. P. Snow. He summarized

POINTS OF REFERENCE
In order to put the articles collected in this volume into their proper historical context, each of these three points can be illustrated by several positions and methods culled from the ongoing discourses that have revolved around them since the beginning of the twentieth century.

2 A fourth question that has not been exhaustively treated here has to do with an astounding phenomenon that has been observed repeatedly in all three fields—art, science, and technology: the simultaneity with which certain inventions and innovations arise independently of one another at different places. The examples range from photography and telegraphy all the way to Abstract Painting and atonal music.

4 Text from The Estate of Walter Ruttmann, untitled, undated, ca. 1919–20; published under the title “Malerei mit Zeit” in Film als Film, 1910 bis heute, ed. Birgit Heim and Wulf Herzogenrath (Stuttgart, 1977), pp. 63–64.
6 Wiener 1993 (see note II, p. 7).
7 Ibid., p. 4. On this subject, also see Dieter Daniels, “Inventing and Re-Inventing Radio,” in Re-Inventing Radio: Aspects of Radio as Art, ed. Heidi Grundmann et al. (Frankfurt, 2008), pp. 27–47.
8 See the original lecture, Snow’s reply to the ensuing controversy, and an account of the subsequent debate in C. P. Snow, The Two Cultures, intro. Stefan Collini (Cambridge, 1993).
his personal experiences in both worlds and concluded that the two cultures were incapable of dialogue or mutual recognition. This address, which received a great deal of attention at the time and is still cited and just as often criticized to this day, targeted the hostility toward progress and technology on the part of what Snow referred to as “literary intellectuals” and called for the acknowledgment of the natural sciences and engineering as intellectual—and thus also cultural—achievements. Later, Paul Feyerabend, the enfant terrible of the philosophy of science, came out in opposition to precisely this absolutization of the positivist concept of progress in the natural sciences and, in Wissenschaft als Kunst (Science as Art), armed himself methodologically for this intellectual fray with Alois Riegl’s theory of art as a sequence of stylistic forms of equal rank.9

In the mid-1950s, just as these positions on the theory of science were taking shape, the artistic practices that are today subsumed under the heading of media art began to develop. From origins in electronic music, media-based poetry, expanded cinema, and electronic visual arts there emerged a new form of artistic expression beyond the bounds of all established genres, one that does not merely take technology as its subject but rather uses it as a medium, and one that, in a way that is both experimental as well as exemplary, lets interdisciplinarity and intermediality become a process of self-reflection that can at the same time be a sensory experience. Accordingly, two of the inventor-artists in this book also emphasize that working with technology has to be personal and hands-on, since a collaborative process in cooperation with technicians does not permit an intuitive “working before words” approach.10

Today, these fields of knowledge and particularly the value systems inherent in art, science, and technology have diverged so far from one another that we are no longer even cognizant of the split that was conjured up in the 1950s. In his foreword to a new edition of C. P. Snow’s Two Cultures, Stefan Collini wrote in 1993: “Reflection on this point should do more than simply soften Snow’s original polarity into a more continuous spectrum. . . . We need, rather, something like multidimensional graph paper in which all the complex parameters which describe the interconnections and contrasts can be plotted simultaneously.”11 The theory of cybernetics, which was likewise developed by Norbert Wiener in the 1950s, and its subsequent popularization as the “third culture” correspond today to the widespread propagation of digital phenomena in the culture of everyday life.12 The new proliferation of technologies throughout all spheres and aspects of life and the way this hardware and software increasingly shape creative work processes and cultural practices have given rise to aesthetic-technical hybridization. This manifests itself both in the digital and

viral culture of everyday life as well as in contemporary media art as an experimental outpost of high culture. The utopias of an across-the-board reconciliation or even synthesis of these fields—concepts that, for example, provided the political justification well into the 1990s for the necessity of establishing specialized institutions of media art—have by now lost a good deal of their seductive power.13 Nevertheless, the central question raised by media art regarding the interrelationship among art, technology, and society remains as current as it ever was. And this is the frame of reference of the Ludwig Boltzmann Institute Media.Art.Research., for which this book delineates an expanded theoretical background.

METHODOLOGIES OF HISTORY

Popular conceptions of technology and art are still characterized by the belief in a linear narrative of progress featuring an extensive canon of inventors and their machines, or of artists and their works. This book seeks to counter this linear mode of thinking by calling attention to elements of upheaval, transitional zones, and paradigm shifts. These resist conceptualization as logical, inevitable continuations of a causal chain of events and instead mark points of crisis or interference, and sometimes even failure. This methodology has outlived its usefulness in the field of art history, though it is hanging on a bit more doggedly in the history of technology. The latest research in this field is characterized by controversies surrounding two major points: the myth of the absolute novelty of the individual invention and its personification by a singular genius-inventor.

This can be illustrated by two recent publications. The classic approach to the history of technology usually seeks to establish a sequence of singular inventors and their apparatuses. Indeed, John H. Lienhard warns against uncritically mythologizing individual inventions as innovation ex nihilo; nonetheless, he insists that, “like any of our myths, they are based on essential truths.” In his view, these inventor-heroes personify precisely those points of crisis that he calls tipping points and also points of no return, although a variety of “multigenia” have prepared the field as a complex pattern of interdependent technologies.14 Most approaches in the field of cultural studies, on the other hand, emphasize that innovation is embedded in a social and economic context. Lisa Gitelman, for instance, has come out against today’s prevailing “tendency to naturalize or essentialize media,” which she has identified in the work of a number of scholars, including Friedrich Kittler.15 Her objective, “to cut across the technological determinism of popular accounts,” thus calls for seeing media inventions in a dual historicity—as both evidence of history as well as producer of it—so “that they share some of the conventional attributes of both art historical objects and scientific ones.”16 For this reason, she also defends their inevitable personification in the form

10 Cf. the essay by Simon Penny, pp. 162–157, the section entitled “Individualism and Collaboration,” and the interview with Paul DeMarinis, pp. 70–85, in this volume.
11 Snow 1993 (see note 8), pp. 16.
13 Examples of such institutions are the Center for Advanced Visual Studies (CAVS) at MIT in Boston, the ZKM Center for Art and Media Karlsruhe, and the Ars Electronica Center Linz (AEC).
16 Ibid., pp. 18 and 4.
of inventor-heroes usually spotlighted by the classical history of technology. In the attempt to
differentiate between causal necessity and personified individuality of technological inventions,
both positions—that of the history of technology and that of cultural studies—run up against the
limits imposed by their methodological point of departure.

The papers presented in this book pursue related methodological questions, and their concep-
tual models range from focusing on specific subject positions in their sociohistorical context
(Daniels, Harrasser) to a structural objectification of media technologies as “incarnated knowl-
edge” (Hagen). What all authors have in common, though, is that they avoid the popular generali-
izations operating via a cult of genius or an essentialization of technology and make their readers
cognizant of the complex, contradictory, non-linear sequences that make up the history of art and
technology.

The fields of a possible convergence and interference of art, science, and technology can only
de be described scientifically when their utmost separation remains consistently visible to the mind
and eye. Here, especially artistic and technical media can assume the role of a “boundary object”
between different intellectual cultures.” Another model is that of the “missing link and material
linkage” by Cornelius Borch: “Often, art and science are seen or stylized as two oppositional
approaches in a binary world of two cultures, rehashing the contrast of facts and fiction, determi-
nation and meaning, or laws and values. Instead of calling for a cooperation between art and sci-
ence for their mutual apotheosis, I want to start at the other end, namely investigating the existing
overlap between both practices, where I see communicating vessels. Technology is the commu-
nicator, the missing link and material linkage between the art and science. Again, doing science
and producing art remain different practices but they may share important procedural steps.”

**INVENTORS AS ARTISTS**

The “artist as inventor” occupies the focal point of this book; nevertheless, the “communicating
vessels” metaphor chosen by Cornelius Borch functions only if the inversion into “inventor as artist”
also remains open. This transition is, no doubt, more difficult to state precisely in terms of
methodology; after all, as Billy Klüver put it: “But if a person says he or she is an artist, one can’t
to say to that person: ‘You are not an artist.’ You are not allowed to say that.” This popular under-
standing of the term means that being an artist resists external definition, whereas the label “inven-
tor,” though indeed not the designation of a profession per se, can nevertheless be substantiated
by means of objective criteria such as patents. Thus, there exists no mirror-image symmetry
between the social roles of the artist and the inventor. Maintaining that such symmetry did indeed
exist would mean falling into the generalization trap. As a result, this bidirectional relation is dealt
with in a wide variety of ways in the articles contained in this book. Simon Werrett looks at the
early stages of certain devices, when their application and categorization are still the subject of
negotiations among the spheres of culture and science, entertainment, and engineering, a process
that is reversible in both directions. In light of today’s highly differentiated knowledge hierarchies
and specialized cultural disciplines, this mutability of an invention into a work of art has become
increasingly improbable, examples of which are often under suspicion of being techno-kitsch, and
justifiably so.

Nevertheless, both Katja Kwastek and Simon Penny call the cybernetic toys of Grey Walter and
Claude Shannon apparatuses whose self-reflection and meta-irony clearly enable them to hold
their own up against any work of media art. Accordingly, the two authors are quite correct in
raising the question of whether the self-definition of a maker/author is decisive for the reception
accorded to his/her artifacts, or, on the other hand, whether it is the reception itself that codeter-
mines when and how the status of “art” or “technology” is attributed to them. Even more far-
reaching is the significance of this bidirectional relation when it is not personified but rather
comprehended as an exchange of paradigms. As Dieter Daniels shows using the examples of
photography and telegraphy, media technologies assume the role of the arts with respect to social
context, audience reception, and production aesthetics. Since the second half of the nineteenth
century, inventors such as Thomas Edison and Nikola Tesla therefore have also embodied the
social understanding of the role of the mythical genius who creates that which is absolutely new
and never before seen or conceived, which until then was reserved for the artist.

**LEONARDO: A PERSON BECOMES A PARADIGM**

Among the above-mentioned generalizations and mythifications driven more by spiritual longing
than intellectual reflection, there has long been one particular one of unmatched fascination and
seduction: the life and work of Leonardo da Vinci.20 Here, the history of the debates about the roles
of artist, inventor, and scholar cumulate in exemplary form; after all, here we have the only eminent
figure in Western culture to whom a key role in the history of both art and technology can be
assigned. The currency of his utopian and anticipatory dimensions is revealed by the inflationary
use of the name “Leonardo” for software, cultural subsidies, magazines, and institutions.

17 The now-widESPread term “boundary objects” originated in the social studies of science and was introduced by Susan Leigh Star
and James R. Griesemer: “They have different meanings in different social worlds but their structure is common enough to more than
one world to make them recognizable, a means of translation.” These “boundary objects” can have in common with technical media
that they are “versatile, plastic, reconfigurable [programmable] objects that each world can mould to its purposes locally.” Susan
Leigh Star and James R. Griesemer: “Institutional Ecology, Translations and Boundary Objects: Amateurs and Professionals in
18 Cornelius Borch: Spaces of Intervention: Towards an Epidemiology of Artistic Experimentation, Lecture given at the symposium
for Art, Science and Technology, on September 28, 2007.
19 Cf. the interview with Billy Klüver, pp. 176–181, in this volume.
21 For example, the closing remarks delivered by Manfred Schröter at Die Künste im technischen Zeitalter, a 1953 conference whose
list of speakers included Martin Heidegger and Werner Heisenberg: “Like a symbol and a sign of promise, Leonardo’s superhuman
figure towers over the portal to our modern European culture. The three realms of mentality—art, science, and technology—whose
overlap we have been discussing were unified in equal measure and in supreme creative abundance in this greatest genius of them all.”
(Die Künste im technischen Zeitalter, publ. Bayerische Akademie of Fine Arts [Darmstadt, 1956], pp. 134f. A present-day example is the
promotion mail by the Leonardo/GA’ST Network of February 21, 2008: “Join the New Leonardo Working on the Burning Issues of Our
Times: The Leonardo organization promotes the work of the New Leonardo—artists who are transforming science and technology
as well as scientists and engineers whose innovative work is changing our cultural imagery.”
In art historiography, Leonardo, along with his forerunners and contemporaries Masaccio, Filippo Brunelleschi, Leon Battista Alberti, and Piero della Francesca, is considered to have paved the way for a new conception of the artist’s role, one that takes leave of aspects of handicrafts, of medieval workshop manuals full of specifications on how to produce undercoats, paints, and glues, and develops in the direction of scientifically systematized design procedures. Leonardo’s uniqueness among Renaissance artists, however, is not based on his work as a painter, but rather on his extensive manuscripts, including his studies of the work by thinkers from antiquity and the Middle Ages and his descriptions and drawings of his own technical experiments and inventions as well as a wide array of natural phenomena. From a modern-day perspective, it is quite difficult to assess Leonardo’s motivation for this detailed and comprehensive scientific-technical portion of his life’s work (of which only a fraction has been preserved). This is still a point of discussion in present-day scholarship on Leonardo.

On one hand, there are pragmatic reasons related to the status of practitioners of the plastic arts at this time. This inclusion of elements from the exact sciences, the acquisition of proportion and geometry, was meant to emancipate the plastic arts and elevate them to the rank of the artes liberales. In his investigation of Leonardo, Frank Zöllner points out that the plastic arts were regarded “by the literary scholars of the Quattrocento almost without exception as ‘ars mechanica,’ as not ‘free’ art but rather as art arrested in the artisanal stage.” He identifies the reasons for Leonardo’s specific interest in elevating its status in the paragone of poetry and visual arts, which reached its first high point around 1492, and with regard to orders for his work around 1490. He sees here as well the background factors before which “in all probability Leonardo’s efforts in connection with the ‘scientificity’ of the plastic arts are to be understood.”

Nevertheless, there is absolutely no doubt that Leonardo received no recognition for his scholarly and technical studies during his lifetime. And even around 1500, after he had completed The Last Supper and became a famous and sought-after artist, he continued his studies. In fact, they were even grounds for criticism of him by his patrons, because they kept him from his artistic work. Accordingly, this gives rise to the supposition that it was not only the social status of the paragone but also Leonardo’s self-definition as an artist that played an important role here.

Perhaps Leonardo’s artifacts—his inventions, constructions, and works of art—are less interesting with regard to present-day issues than several elements of his methodological approach. From this perspective, the current relevance of Leonardo da Vinci as a person is not that he embodied a new ideal of the artist, but rather that he came along during a historic transitional phase in which elements that had previously been separate were set in relation to each other and in which there was profound empirical exploration of procedures and processes of design and creation, investigation of the diversity of available possibilities and potential solutions to problems, reinterpretation of traditional wisdom, and elaboration of alternative rules. For example, an examination of his notebooks raises the question of differentiating between purely documentary observations (of nature) and what he developed further on his own, between what he recorded using language and what he registered visually. Equally ambivalent is the way Leonardo dealt with theoretical prescriptions; he frequently ordered them according to empirical exactitude, as he did in an entry written in around 1490 in which he remarked that “rules will enable you to possess a free and good judgment; since good judgment is born of understanding well and understanding well derives from causes (fragione) taken from good rules and good rules are the daughters of good experience: the common mother of all sciences and arts.” On the other hand, somewhat later (between 1493 and 1495), he wrote about his preference for acting in accordance with rules: “Effect of my rules/If you said to me what do your rules bring? To whom are they useful? I [would] reply to you that they serve as reins for engineers and investigators to not let them promise to themselves or to others impossible things and make fools and cheats of themselves.”

Therefore, there does not exist one single method applied by Leonardo, the understanding of which would completely resolve his complexity and contradictoriness, since, in all of his writings about art and in the scientific experiments conducted throughout his career, he tested a wide variety of theoretical and empirical approaches. And even though what he ultimately remains in the field of science as well as in art is a great Unfinished Work who left behind more fragments than completed treatates, some of his inventions have been invested with overarching significance in a number of different scientific disciplines. And then there are his creations that remain in the utopian realm—for instance, on the subject of Leonardo’s flying machines, British aviation historian Charles Gibbs-Smith wrote that some “are feasible, a few of them possible, but many of them quite fantastic and outside all realms of possibility.” Nevertheless, just like Leonardo’s artworks, 24 Codex Atlanticus 221vb, cited in Kim, H. Veltman, Studies on Leonardo da Vinci: I. Linear Perspective and the Visual Dimensions of Science and Art (Munich, 1986), p. 64.

25 Ibid.

26 Kim Veltman describes the scientific systematization of Leonardo’s writings as correspondingly difficult: “There is a vast literature on Leonardo da Vinci. Nonetheless, his ca. 4,500 pages of extant notes and drawings . . . still await detailed, systematic study.” Ibid., p. 10. Veltman cites three basic reasons for this: Firstly, access to all these writings is hindered by the fact that the manuscripts, which are located in Milan, Paris, London, Windsor, Madrid, Holkham Hall, and Turin, were not published until around 1870 and then only in limited editions, so that the texts are not completely accessible even to this day. Furthermore, there are still no complete translations into one of the widely-spoken languages. Secondly, up to the end of the eighteenth century, effort was made to put Leonardo’s uncataloged writings into a thematic sequence, the upshot of which was the destruction of Leonardo’s own system. It was not until 1797, when J.-B. Venturi developed a new method of systematizing that took Leonardo’s own system into account, that other scholars who worked with this material could be sensitized to this problem. Thirdly, Veltman criticizes the fact that, in all editions of Leonardo’s work, his visual statements are neglected in favor of his writings, even though, according to Veltman, Leonardo’s verbal and visual lines of argumentation complement one another and must therefore be analyzed together. Ibid., pp. 10–12.

27 The “pyramidal law” that Leonardo developed in his studies on perspective, for example, is of such fundamental importance that it can be applied to other entities. As Veltman points out, “He went on . . . to apply the same principles of linear perspective to his four powers of nature: percussion (light, heat etc.), gravity, force and motion. Perspective thus became a cornerstone of his physics.” Ibid., p. 240.

If one liberates Leonardo from the spiritual longings for a great synthesis, what remains as the core of his artistic-scientific method is a topic of great current relevance: visual, or even manual, practice and that is not conducive to translation into directives or descriptions is also cited by several of the artist-inventors presented in this book as the central method they use. In this context, Martin Kemp wrote in his latest examination of Leonardo’s manuscripts: “He was a supreme visualizer, a master manipulator of mental ‘sculpture,’ and almost everything he wrote was ultimately based on acts of observation and cerebral picturing.” The bidirectional relationship of artist and inventor established in the title of this book applies just as well to the question of the visualization and vanity of aesthetic, technical, and scientific thinking that has only recently entered into the consciousness of the general public. Perhaps this approach also does more justice to Leonardo than the overstrained efforts to make him personify a synthesis of art and technology. From this point of view, Leonardo’s counterpart as “visualizer” would be Galileo Galilei. According to Horst Bredekamp’s new investigative study entitled Galilei der Künstler (Galileo the Artist), his drawings of the moon created with the help of the telescope are among the “great instances of the use of visual forms of thinking,” and even “of the stylistic forms of manual thinking,” and thus “among the precursors of the early modern period’s process of determining science.”

The origins of visual thinking, which today have been buried by the separation of science and art, is thus also characterized by a bidirectional relation: artist as scientist, scientist as artist.”

29 Cf. Martin Kemp: “The engineer learnt how nature designed its forms to fit functions, respecting her principles and the absolute sovereignty of her natural law, in order to become what he called a ‘second nature’ in the world. In this, the artist and the engineer are at one. They make new things on the basis of the inner workings of nature rather than simply imitating what nature has already done.” Martin Kemp, Leonardo (Oxford, 2004), p. 113.
30 Cf. the essay by Paul DeMarinis, pp. 70–85, in this volume.
31 Kemp 2004 (see note 29), pp. 681.
32 The Ludwig Boltzmann Institute Media Art Research will explore the field of knowledge representation and visual interfaces in relation to media art.
33 Horst Bredekamp, Galilei der Künstler: Die Zeichnung, der Mensch, die Sonne (Berlin, 2007), pp. 6, 340, and 337.

* Acknowledgments
We wish to express our gratitude to the organizers of Refresh! The 1st International Conference on the Histories of Media Art, Science and Technology in 2005 at the Banff New Media Institute, where the modified papers by Cornelius Börck and Simon Penny were originally delivered at the Art as Research/Artists as Inventors panel. Thanks are also due to all those who have supported this publication through their inspiration and collaboration.

Dieter Daniels / Barbara U. Schmidt

Introduction