MICHAEL SHAMIYEH ‹
and DOM Research Laboratory (Ed.)

DRIVING DESIRED FUTURES

Turning Design Thinking into Real Innovation

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Pictures front cover (from left to right)

Microcomputer display unit and TV display.
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A Kodak research scientist displays an image that was processed using color image processing algorithms developed during the mid-1980s.
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Disassembled camera.
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Steven Sasson and the first portable all electronic still camera. Vintage 1975.
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Pictures back cover (from left to right)

A professional photographer uses a medium-format film camera in the late 1980s.
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In the mid-1980s, a Kodak technician makes adjustments to an early megapixel color camera laboratory prototype, before capturing a photo of the miniature "train" scene behind him.
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This team, from Kodak Research Labs, captured the world's first megapixel color images, using a Kodak CCD image sensor, and created prints which were displayed at Photokina in 1986.
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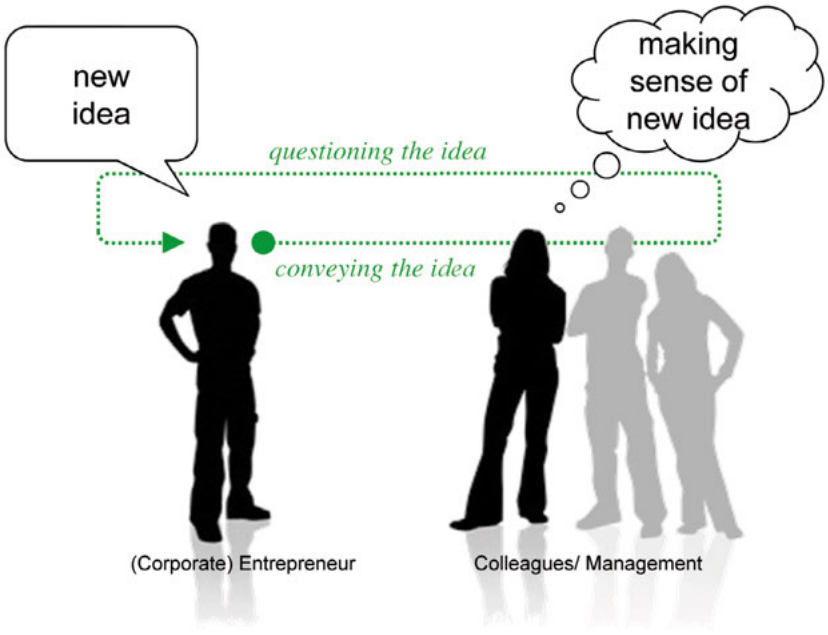

FIGURE 1
Social Exchange and the Process of Sensemaking

FOREWORD ❮ Michael Shamiyeh

In the last decade, we have witnessed the reawakening of a vibrant debate on design methodologies labeled "design thinking." After more than thirty years of being almost forgotten, the topic suddenly went mainstream. Moreover, the topic has left the disciplinary boundaries from which it originated – the design disciplines. There is a great outpouring of interest on the part of corporate executives and management scholars who see in the designer's creative-analytical mode of operation, in his or her way of thinking, a strong and even unique potential for business innovation. As a matter of fact,

DESIGN THINKING HAS BECOME A LIVELY, INTERDISCIPLINARY RESEARCH AREA.

Many different aspects of design thinking have been examined in current research, such as studies on the core phases of the design process (e.g., Cross, 2006, 2007; Dorst & Cross, 2001; Michel, 2007; Plattner, Meinel, & Weinberg, 2009), the importance of visualization in the process of envisioning new opportunities to unleash collective imagination (e.g., Lockwood, 2010; Roam, 2009; Ware, 2010), its potential to boost business innovation (e.g., Brown, 2009; Shamiyeh, 2010; Verganti, 2009), and assets beneficial for strategy formation (e.g., Boland & Collopy, 2004; Liedtka, 2000; Lockwood & Walton, 2008; Martin, 2009).
While extensive literature on design thinking contributes much to our understanding of the particular approach at work in design and its effective application to the generation of new business ideas,

LITTLE ATTENTION HAS BEEN PAID TO WHAT IT TAKES TO TURN THESE NOVEL IDEAS INTO AN ORGANIZATIONAL PROCESS AND HOW THEY BECOME SHARED WITHIN A GROUP:

Moving a new idea into an organizational initiative usually requires additional resources that are not under the control of a single person or an organization's innovation team. To engage in a process of securing various types of resources, a new idea must move out of the realm of the individual or team experience and become part of a collective experience, to become accepted on all levels of the organization. Given the potential of design thinking to bring forth new ideas, it sets the stage for questioning existing assumption and beliefs; that is to say, members of an organization are asked to comprehend new ways of (design) thinking and to explore how their existing capabilities can be redefined, renewed, or replaced in such a way that changes in policies, priorities, and procedures will be accepted and organizational performance is not at risk. The extent of shared understanding and the level of interpersonal trust are central in this process of social exchange and sensemaking. Thus, we believe that existing literature on design thinking leaves several important questions unanswered. How do individuals achieve credibility for new ideas in established social systems? What are the criteria that render comprehension of new ideas more likely within a group of people with diverse sets of beliefs? What triggers management's attention to allocate resources to the development of new ideas among a wide variety of potential organizational agendas? To address these questions, various authors will discuss the structure and dynamics of developing new ideas as a particular form of social construction. The purpose is to specify the individual and sociological processes associated with the exchange and sensemaking of novel ideas in large, complex organizations.

HOW DO WE EXPLAIN THE ABSENCE OF THOROUGH DISCUSSIONS ON HOW NEW WAYS OF (DESIGN) THINKING ENTER ORGANIZATIONAL PROCESSES?

We hypothesize that this shortcoming can be explained by the different perspectives of researchers in design methodology. Though the book aims at closing this gap, we briefly outline this hypothesis in the following:

A SHORT REVIEW OF THE TWO PERSPECTIVES TAKEN ON DESIGN-THINKING RESEARCH

Research on design methods received its first substantial recognition in the in the early 1960s, a time when architects

and designers were facing a deep crisis: No longer could they rely solely on their ability to focus upon the artifact as the center of their task. The postwar area required new production techniques and designs that meet the needs of new clients, the masses of the working class. Jones and Thornley (1963) marked the ground for design methodology as an academic field of study with their *Conference on Design Methods*.

ARCHITECT AND VISIONARY BUCKMINSTER FULLER (1963) CALLED FOR A DESIGN SCIENCE REVOLUTION TO OVERCOME THE HUMAN AND ENVIRONMENTAL PROBLEMS THAT HE BELIEVED COULD NOT BE SOLVED BY POLITICS AND ECONOMICS.

He clearly understood that the application of *scientific* design methods to new social and economic problems could tremendously expand the designer's domain of intervention – an insight, as we will see later, that today again drives the profession to investigate design thinking. Considering the complexity and variety of problems architects and designers were facing in their daily work, it became obvious that the application of prescribed methods or standardized techniques would meet criticism. The big backlash against design methodology came in the early 1970s. Christopher Alexander, whose PhD thesis (1964) in design methodology broke new ground in architecture, criticized simplifications of design techniques, and abruptly abandoned the whole idea of the usefulness of design methodology (1971). Other knowledgeable scholars in the field echoed his rejection (Jones, 1977), which finally led to a kind of unintentional self-elimination of the whole movement. The field of design methodology swiftly fell into oblivion, at least from the perspective of the design disciplines.

Design research continued, but in a different direction and driven by members of other disciplines: Researchers in OR and systems theory tried to adopt design methodology for their own ends. In his seminal writings, Herbert Rittel (1973) called for a paradigm shift in design methodology by discarding the omnipresence of the designer – especially in the case of "wicked problems" – and the recognition of satisfactory or appropriates solution-types. He built his arguments upon Herbert Simon's (1969) earlier insights into the notion of satisficing and the argumentative, participatory processes in which designers are partners with the "problem owners." Although design methodology was temporarily saved, progress in the field remained marginal until recently.

In the face of the increasingly diverse forms of complexities of our world – in which stakeholders with different agendas and worldviews, organizations, economies, and entire societies are extremely interconnected and affected by each other – people running businesses began to understand that the failings of management are most directly attributed to a famine of novel ideas.

THE VERY FOCUS ON BUSINESS ADMINISTRATION, THE EMPHASIS ON CONTROLLING, INTEGRATING, AND COORDINATING, IMPEDES AND UNDERESTIMATES THE VALUE AND NECESSITY TO INNOVATE IN TIMES OF CHANGE

(Shamiyeh, 2010). In this context the use of design methodology apparently showed great promise in devising "courses of action aimed at changing existing situations into preferred ones" (Simon, 1969). Hence, management scholars directed their attention to design methodology to investigate its potential to transform organizations and inspire innovations. Jeane Liedtka's (2000) seminal account of the implications of the design process in strategy-making and Boland and Collopy's (2004) observations on *Managing as Designing* triggered – certainly among other notable contributions – the current energetic research interest in design methods that culminated in a variety of initiatives to integrate design methodologies into MBA curricula, such as those pursued by the pioneering faculties at Stanford University or the Rotman School of Management.

From the perspective of the designers, there had been little contributions to the field. There was a forward-looking paper on "Designing for Business" (1999) by IDEO

co-founder Tom Kelley; however, by and large the design profession took notice of the issue quite late, either for reasons of ignorance or defensiveness inspired by the motives we mentioned above.[1] Today, a decade after economists have rediscovered the issue, members of both disciplines are deeply involved in design thinking research. However, points of departure and motivation to pursue research in the field vary tremendously, which may have caused the absence of a thorough discussion on how new ways of (design) thinking enter organizational processes: For managers and managements scholars, design thinking is a knowledge-creation tool among many other analytical or creative tools for innovating business and strategy. Innovation is a key form of organizational knowledge creation. It includes processes by which the organization creates and defines problems and then actively develops new knowledge to solve them (Nonaka, 1994). New knowledge can be developed in many forms, particularly in a problem domain as open-ended as design (Akin, 1986). Design, the ability to combine empathy for the context of a problem, creativity in the generation of insights and solutions, and rationality to analyze and fit solutions to the context, has its own distinct "things to know, ways of knowing them, and ways of finding out about them" (Cross, 2006).

Corporate Entrepreneurship (CE), a specific research stream in the field of management, is concerned with various forms of innovation (e.g., establishing new ventures or strategic renewal). In the past two decades, both management scholars and practitioners have remained heavily interested in studying and better understanding CE processes and their consequences for organizational survival, growth, and performance. (For an overview of key issues related to the field, please refer to, e.g., Dess et al. (2003)). In particular, researchers have been highlighting the role of CE in inducing and cultivating organizational learning – which is a key source of new knowledge – the role of leadership, and social exchange. Thus,

THERE IS QUITE AN EXTENSIVE UNDERSTANDING ABOUT ORGANIZATIONAL PROCESSES THROUGH WHICH KNOWLEDGE IS CREATED AND MEDIATED INTO COLLECTIVE ACTIONS.

In other words, for management scholars there is no need to engage in a parallel discussion on how new ways of (design) thinking enter organizational processes.

For design scholars and professionals, on the contrary, CE is a foreign domain: A central concern of design is the conception of new artifacts (e.g., buildings or consumables). It encompasses the appreciation for a material practice in which key competences are related to planning, inventing, as well as making and doing. Competences related to the abstract development of new businesses within ongoing organizations, as achieved through innovation (product, process, or administrative), diversification, joint ventures, acquisitions, or strategic renewal are completely foreign to the field of design. It is one thing to understand and practice design methodologies in the context of constructing concrete artifacts, another to translate this capability into the domain of new venture creation and strategic renewal. It is for this very reason that design-thinking literature generally centers around the particular design processes (knowledge-creation process) rather than on the determining factors (e.g., the role of leadership and social exchange) that render its application in business contexts successful.

There is another striking difference between the two disciplines in their approach to investigation of design thinking, which becomes evident in the current literature.

1 At this point a personal note may illustrate the situation at that time: The DOM Research Laboratory quite early pushed the discussion on design thinking. In 2005 we dedicated our annual international conference to this subject. We invited knowledgeable people from the field of management, e.g., Fifth-Discipline author Peter Senge, to investigate, with leading architectural theoreticians and practitioners, the virtues of design thinking for other domains (Shamiyeh, 2007). We had been surprised to notice that internationally known and knowledgeable members of the design profession were wondering about our ambition. Still in 2007/08, when I joined the prestigious Architectural Association in London to pursue a two-year research project on design methodology and its application in other domains, I was confronted with strong resentments. In 2009, the context suddenly changed decisively, and design thinking achieved broad recognition beyond management schools. To our surprise at DOM, it then became fairly easy to invite design and management scholars and practitioners to debate the viability of design methodology in the context of business innovation. Representatives from companies such as Shell Innovation Research, Nike, IDEO, and Arup followed up our invitation (Shamiyeh, 2010).

FOR GOOD REASONS, MANAGEMENT SCHOLARS AND PRACTITIONERS TEND TO ADOPT A PERSPECTIVE FROM WITHIN THE ORGANIZATION IN LOOKING AT DESIGN THINKING AS AN EFFECTIVE MEANS FOR BUSINESS INNOVATION;

designers, on the contrary, by and large adopt an external point of view:

From CE research, we know that an organization may develop its knowledge base either by acquisition or experimentation (Zahra, Nielsen, & Bogner, 1999).

The acquisition of knowledge takes place when an organization gains access to and subsequently internalizes preexisting knowledge from its environment; in contrast, experimental knowledge evolves from experiments within the organization and generates knowledge that is distinctive to it (Matusik, 2002). Significantly, only the latter form of knowledge development is able to sustain an organization's competitive advantage, because it is the product of an organization-specific knowledge that may be valuable, rare, and imperfectly imitable. Acquisition of knowledge is rarely the source of the uniqueness that organizations require to form a sustainable competitive advantage, because preexisting knowledge resides in the public domain, outside an organization's boundaries, and any organization could take advantage of the knowledge. Thus, experimentally gained knowledge maintains a premium relative to acquisitive knowledge when it comes to the emphasis on innovation as a source of successful competition (Zahra & Garvis, 2000). For this very reason, management scholars and practitioners tend to see and discuss design thinking as a process deeply embedded in the organization's innovation culture assisting its members in their quest to explore new solutions to problems. Acquiring design-thinking services would represent a possible but insufficient condition for competitive success though it is rarely unique.

Design professionals, on the contrary, usually operate as service providers external to contractors. Unless we are talking about art, architecture and design are about meeting particular needs (Loos, 1931); that is to say, design firms are goal directed in the sense that they are driven by the quest to meet the goals of their clients, and they usually work outside the commissioning organization. From a management perspective, we could argue that design services maintain a particular activity in the organization's value chain, among many others, but are executed remotely from the particular structural and strategic context of the organization. Having been trained in this context,

DESIGN SCHOLARS AND PROFESSIONALS TEND TO LOOK AT DESIGN THINKING FOR BUSINESS INNOVATION AS AN ACQUIRABLE SERVICE THAT EXPANDS THEIR ORIGINAL DOMAIN OF ACTIVITY.

Design-thinking literature authored by design-affiliated writers reveals this perspective for the most part (see, e.g., Lockwood, 2010; Lockwood & Walton, 2008). This view suggests that business innovation is possible from outside the organization. New knowledge is created in isolation, well communicated, and then carried into the organization like lost luggage waiting to be found.

We may identify the following problems with this latter approach: First, as outlined above, a perspective taken externally to the organization ignores the fact that acquired knowledge (or an acquired service) is rarely the source of the uniqueness necessary to form a sustainable advantage; moreover, the isolated nature of the service makes it less likely that a resulting initiative will harmonize with the needs of the core business, which, in turn, reduces the likelihood that ideas generated by external design thinkers will receive the support and acceptance necessary to become commercially viable. Second, for designers, moving design methods into the domain of management to create a new market certainly means stretching their core competences beyond the boundaries of a material practice. Although such an ambition takes advantage of the designer's existing capabilities, it may result in poor performance due to the lack of a wider range of competences necessary to successfully pursue this new activity.

THE STRUCTURE OF THE BOOK

To address the issue of how new ways of (design) thinking enter organizational processes, we decided to structure the book into four thematic blocks. We then invited authors with different disciplinary backgrounds to address the topic from their perspective. The structure of the book is as follows: First, we propose to look at innovation as a particular form of social construction, rather than something that is created in an individual's mind and then taken to a collective; cognitive scientists, psychologists, and sociologists will illuminate the construction process of social reality in relation to the emergence of the new. Second, key to social constructions of something new, we believe, is to direct the attention of those involved in the innovation process and to enhance social interactions among them, rather than to set up better or more transactional models of communication; here, interaction designers, management experts, and organizational theoreticians extend the cognitive perspective on social construction discussed in the previous section, by focusing on forms of interactions in social systems. The aim of this section is to apprehend how organizations and their members try to make sense of new stimuli. Third, in organizations, we argue, the collaborative effort to create new ventures requires role-sensitive modes of interaction on all managerial levels, because unlike in other human groupings, in organizations, social interactions are defined on the premises of particular roles people play – roles that entail certain expectations because they are associated with particular functions. Finally, fourth, we suggest that the creation of new ventures calls for ambiguity in social arrangements to modify or redefine competence, while the execution of current business plans requires systems of control and routines to deploy competence efficiently. Management scholars will highlight the fundamental challenge of organizations to manage the conflict between the new and the old and to overcome the inevitable tensions that such conflict produces for management.

Besides the idea of structuring the book according to four thematic blocks, we had been searching for opportunities to allow readers to assess key issues in more practical terms. In this regard, we decided to look for a real case that we could cover in a very pragmatic and comprehensible way.

FIGURE 2
Steven Sasson holding the first digital camera, developed in 1975.
© Eastman Kodak Company

THE STORY OF THE BREAKTHROUGH INNOVATION OF THE WORLD'S FIRST DIGITAL CAMERA, AT A TIME OF ANALOG TECHNOLOGY, SHOWED GREAT PROMISE FOR THIS ENDEAVOR.

In a personal interview we asked inventor and former Kodak employee Steve Sasson to recall for us the process of making digital photography a reality. In the mid-1970s, when Steve developed his invention, Kodak was a large corporation of 50-60,000 employees, with a clear focus on chemical film; hence, looking into his efforts to move forward with his radical idea promised many valid findings. Each of the four thematic blocks will be opened with parts of Steve's retrospection, which either underline the importance of particular issues or recommend particular actions. We hope that this book occasions rich conversations, supports management scholars and practitioners in their quest for innovating businesses, and provides helpful insights for those of the design professions in search for a fundamental competence redefinition.

Michael Shamiyeh

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Jean S. Clarke ❮ Jean S. Clarke is an associate professor at Leeds University Business School, the University of Leeds. She completed a BSc in psychology at Queen's University, Belfast, followed by an MSc in occupational psychology at the University of Sheffield's Institute of Work Psychology. She completed her PhD in 2006 at the University of Leeds and has stayed on at Leeds as a staff member since then. Her research focuses on how entrepreneurs use visual cues in interactions with relevant stakeholders such as investors, customers, employees to develop legitimacy for their new venture. This work divides into two main streams. One focus is on understanding how entrepreneurs use and manipulate visual symbols (dress, props, settings etc.), and the second is on how entrepreneurs use body language and in particular hand gestures to communicate. She uses a variety of visual methodologies in her research including visual ethnographic work, micro-analysis of body language and gesture, and more recently video-based experimental studies. Her research has been published in leading international journals such as *Academy of Management Review*, *Journal of Management Studies*, *Journal of Business Ethics*, and *Journal of Management Inquiry*. Drawing on her research, she is also working with Connect Yorkshire to develop training materials for use throughout the UK, which aim to train entrepreneurs in effective pitching and negotiations. Clarke has recently been awarded a grant (£250, 000) from the Economic Social Research Council to continue her research into the body language of entrepreneurs.

Louise Connell ❮ Louise Connell heads the Embodied Cognition Lab in the School of Psychological Sciences at the University of Manchester. She has an interdisciplinary background in cognitive science, experimental psychology and computer science. Her research concentrates on investigating the nature of mental representations using a variety of behavioural techniques.

Joep Cornelissen ❮ Joep Cornelissen is an author and Professor of Communication and Organization Theory at VU University Amsterdam and the University of Leeds. He has taught courses on communication, strategic change and organization theory at Universities in Manchester, Leeds, and Amsterdam. His much-loved textbook, *Corporate Communication: A Guide to Theory and Practice* will be published in its 4th edition in 2014, fully revised, extended and updated to take into account recent developments in strategic and corporate communication. Besides his writing and teaching commitments, Joep is also an active researcher within the fields of communication and management and a previous General Editor of the *Journal of Management Studies*. His own current research focuses on the role of framing and narration in strategic change, entrepreneurial and innovation contexts.

Hugh Dubberly ❮ Hugh Dubberly is a partner in Dubberly Design Office (DDO), a San Francisco-based consultancy that focuses on making hardware, software, and services easier to use, more effective, and more fun, through interaction design and information design. At Apple Computer in the late 1980s and early 1990s, Dubberly managed cross-functional design teams and later managed graphic design and corporate identity for the entire company. While at Apple, he co-created a series of technology-forecast films, beginning with *Knowledge Navigator*, which presaged the appearance of the Internet and interaction via mobile devices. At Netscape, he became vice president of design and managed groups responsible for the design, engineering, and production of the company's web portal. In 2000, he co-founded DDO. Dubberly also served at Art Center College of Design in Pasadena, California, as the founding chair of the Computer Graphics Department. He has taught courses in the Graphic Design Department at California State University, San Jose, the Design Department at Carnegie-Mellon University, the Institute of Design at IIT, and the Computer Science Department at Stanford University. He edits a column "On Modeling" for the Association of Computing Machinery's journal, *Interactions*.

Jane Dutton ❮ Jane Dutton is the Robert L. Kahn Distinguished University Professor of Business Administration and Psychology at the University of Michigan, which she joined in 1989 after being on the Strategy Faculty at New York University. She received her Ph.D. in Organizational Behavior from Northwestern University. Dutton's current research focuses on how organizational conditions enable humans to thrive. In particular, she explores how the quality of connection between people at work affects individual and organizational flourishing. Her research explores compassion and organizations, resilience and organizations, and energy and organizations. Her previous work was on the management of strategic change. Dutton has published over 100 articles and book chapters, edited 12 books, and written a book for managers entitled *Energize your workplace: How to build and sustain high quality connections at Work* (Jossey-Bass Publishers). Her newest book (co-edited with Karen Golden-Biddle) is entitled *Applying a positive lens to social change and organizations* (New York: Routledge, 2012). In 2009 she co-edited a book on Exploring positive identities in organizations (with Laura Morgan Roberts; Routledge Publishing). In 2007 she edited *Exploring positive relationships at work: Building a theoretical and research foundation* (with Belle Ragins, Lawrence Erlbaum Publishers). She is a co-founder of the Center for Positive Organizational Scholarship. In 2012 she was awarded the Scholarly Contributions in Management Award for the Academy of Management, which is a lifetime achievement award, as well as the Distinguished Scholar Award for the Management and Organizational Cognition Division. In 2002, she was awarded the Organization and Management Theory Distinguished Scholar Award, and in 2001 the University of Michigan Senior Scholar Award. In 2003, she won the Researcher of the Year award at the University of Michigan Business School. In 2005 she received the PhD Teaching Award.

Martin J. Eppler ❮ Martin J. Eppler is a full professor of media and communication management at the University of St. Gallen (HSG), where he is also the managing director of the Institute for Media and Communication Management. He conducts research on knowledge management, knowledge visualization, and knowledge communication. He has been a guest professor at various universities in Asia and Europe. He has been an advisor to the United Nations, Philips, UBS, the Swiss Military, Ernst & Young, KPMG, Swiss Re, Daimler and other organizations. Eppler studied communications, business administration, and social sciences at Boston University, the Paris Graduate School of Management, and the Universities of Geneva and St.Gallen. He has published more than 100 academic papers (in journals such as *Organization Studies*, *LRP*, *Harvard Business Manager*, *TIS*, *EMJ*, and *IV*) and 13 books, mostly on knowledge communication, management, and visualization.

Peter Esmonde ❮ Peter Esmonde is trained as a filmmaker at Yale and the American Film Institute Conservatory. He spent too many years working in New York City, Los Angles, and Washington, D.C., at various thankless tasks in the film industry. After toiling as a producer at Discovery Channel during the 1990s, he found himself targeted by executive headhunters, and spent some years foraging in the corporate jungles of North America. Esmonde finally emerged in 2005 as a producer and director of documentary films. *TRIMPIN: the sound of invention* is his first feature. (The first edition of "Notes on the Role of Leadership and Language" was written by Esmonde, working as a consultant for the Dubberly Design Office.)

Elena Esposito ❮ Elena Esposito teaches Sociology of Communication at the University of Modena-Reggio Emilia, Italy. She has published many works on the theory of social systems, media theory, and the sociology of financial markets, among them *The future of futures. The time of money in financing and society*, 2011; "The structures of uncertainty: performativity and unpredictability in economic operations," *Economy and Society*, 41: 2012, 1-28; *Die Fiktion der wahrscheinlichen Realität*, 2007; and *Die Verbindlichkeit des Vorübergehenden. Paradoxien der Mode*, 2004.

Manfred Faßler ❮ Manfred Faßler, Professor at the University of Applied Arts, Vienna, 1995- 2002; 2000-2003. Head of the Media and Communication Sociology Section of the Deutsche Gesellschaft für Soziologie; since 2000, professor at Goethe-University Frankfurt/M.; 2003-2005, guest professor in Media Sociology at University of Basel, 2003-2005 guest professor at the University of Applied Art in Vienna, October 2004-Sep. 2005; 2010 Visiting Professor at University of São Paolo/ECA; Founder and Head of FAMe (Forschungsnetzwerk Anthropology des Medialen); IBM Faculty Award 2009 "Global Dissipative Knowledge"; Google Research Award 2013 "in-situ Online-Privacy" (together with the University of Darmstadt / Fraunhofer-Gesellschaft). Present position: Director of the Institute for Cultural Anthropology. *Foundation of Institutes*: 1991 Co-founder, with Prof. Dietmar Kamper, Prof. Arthur Engelbert, Dr. Wulf Halbach, and Prof. Jochen Boberg of the Medien Institut Berlin; 2003 co-founder of the Center for Media, Knowledge Cultures, Imagination and Development (CCID) at the Goethe-University (with Prof. G. Welz, Prof. B. Richard, and Cyrill Gutsch). Books since 1999: Faßler has published more than 20 books and numerous articles with a focus on media theory, media and cognition, Human-Media-Inter(Re) Action, digital networks, 2nd order cybernetics, binary media and cultures, communication, visualization, and media evolution. 2012: *Das Soziale. Entstehung und Zukunft menschlicher Selbstorganisation* (München: Fink-Verlag); 2013: *Kampf der Habitate. Neuerfindungen des Lebens im 21. Jahrhundert* (Wien, New York: Springer-Verlag).

Steven W. Floyd ❮ Steven W. Floyd is an endowed Professor at the Isenberg School of Management at the University of Massachusetts. Prior to coming to Isenberg, he held positions as an endowed professor at the University of Virginia, a Chaired Professor and Director at the Institute of Management, University of St. Gallen, Switzerland, and the Robert A. Cizik Endowed Chair of Strategy, Technology, and Manufacturing at the University of Connecticut. His research focuses on strategic decision-making processes, corporate entrepreneurship, and the management of strategic change. Floyd's work has been published in the *Strategic Management Journal*, *Academy of Management Review*, *Academy of Management Journal*, *Journal of Management*, *Journal of Management Studies*, *Journal of International Business Studies*, *Entrepreneurship: Theory and Practice*, *Organization Studies*, and *Journal of Organization Behavior*, among others. He is the co-author of three books, *Strategic management: Logic and action*, *Building strategy from the middle: Reconceptualizing strategy process* and *The strategic middle manager*.

Giovanni Gavetti ❮ Giovanni Gavetti is an Associate Professor of Business Administration at the Tuck School of Business at Dartmouth College. He received his B.A. in Economics from Bocconi University in Milan and his M.A. and Ph.D. in Management from The Wharton School, University of Pennsylvania. Before joining Tuck, he was in the faculty of the Harvard Business School. He is currently teaching "Competitive and Corporate Strategy" in the first year of the M.B.A. program, and "The Psychology of Strategic Leadership" in the second year. His research explores the cognitive foundations of strategy.

Michael Geoghegan ❮ Michael Geoghegan was born in Ireland, he earned his PhD in chemistry at University College, Dublin. He came to the United States and worked as a post-doc at Columbia University in New York, where he also received an MBA. He had a long career at Du Pont in management and research, and was appointed Research Fellow, allowing him to pursue his own research agenda. From the freedom of that position, he studied the work of scientists, cyberneticians, and social theorists, while funding research on the nature of wealth creation in a networked society. He is currently working on a book synthesizing what he's learned about thermodynamics, cybernetics, and evolution to explain how economic potential can be calculated in advance of investment decisions.

Cheryl Heller ❮ Cheryl Heller is the founder of Heller Communication Design and an advisor to PopTech, a laboratory for disruptive innovation focused on technology and social change. She is a pioneering communication designer and business strategist, and has twice been nominated for the Cooper Hewitt National Design Award for Communication Design. She has been successfully practicing social innovation and sustainability for many years, with major corporations such as Seventh Generation, L'Oreal, Hachette Filipacci, and Sappi, non-profits such as WWF, Audubon, IDE (International Development Enterprises), The Cloud Institute for Sustainability Education, and the Girl Scouts of America. She created the Ideas that Matter program for Sappi in 1999, which has since given over $10 million to designers working for the public good. She also advised Paul Polak and the Cooper Hewitt National Design Museum on the exhibit "Design for the Other 90%." Heller has been a core faculty member for the PopTech Social Innovation and Science Fellows, mentoring the most exciting social entrepreneurs in the world as they create and scale new models for solving issues of poverty, water, health care, energy, and conservation, often through the use of technology. She has also served as core faculty for the Boston College Center for Corporate Citizenship. She received her BFA, magna cum laude, from Ohio Wesleyan University, and attended the School of the Museum of Fine Arts in Boston.

Mark T. Keane ❮ Mark T. Keane has been Chair of Computer Science at University College Dublin since 1998. From 2004-2007 he was Director of ICT (2004-2006) and Director General (2006-2007) at Science Foundation Ireland (SFI), where he oversaw a €700 million+ research investment. He advised the Irish Government on its €3.7 billion Strategy for Science, Technology & Innovation (SSTI, 2006-2014). He was also Vice President of Innovation & Partnerships at UCD (2007-2009). He has a BA (UCD) and PhD (TCD) in Cognitive Psychology and previously worked at the University of London, the Open University, Cardiff University, and Trinity College Dublin. He is one-time Fellow of Trinity College Dublin (FTCD) and an ECCAI Fellow. Professor Keane has published 150+ articles, has an H index of 34 with 6,000+ Google Scholar citations. He is co-author, with Professor Mike Eysenck, of a popular textbook, *Cognitive psychology: A student's handbook* (Taylor & Francis, 2010), now in its 6th edition, which has been translated into five languages. Keane conducts research in cognitive psychology, cognitive science, and artificial intelligence, mainly on the problem of how new knowledge can be generated from old knowledge.

Bernhard Krusche ❮ Bernhard Krusche studied anthropology and psychology. After his field work in West Africa, he worked as internal consultant at Mercedes-Benz. Over the last 20 years, he has specialized in developing the innovation capabilities of leaders and their organizations. He is one of the co-founders of the Berlin-based consulting studio Ignore Gravity (www.ignore-gravity.com) and publisher of REVUE Magazine for the Next Society (www.revue-magazine.net). He is the author of several books on leadership and lectures at the universities of Klagenfurt and Kassel.

Peter J. Lane ❮ An entrepreneur turned academic, Professor Peter J. Lane, PhD, uses rigorous scholarship to address real-world problems in corporate strategy, leadership, change management, and technological innovation. His model of relative absorptive capacity in learning and innovation is one of the most highly cited strategic management studies of the past fifteen years. Lane has worked with MBAs, managers, and executives in the U.S., Europe and Asia as both an educator and a consultant. He has helped a wide range of corporations and organizations improve their effectiveness and ability to respond to challenging environments. He currently serves as Associate Dean of the Paul College of Business & Economics at the University of New Hampshire, were he holds the rank of Professor of Strategy & Technology. Prior to joining UNH in 2003, Peter was on the faculty of Indiana University's Kelley School of Business and Arizona State University's W.P. Carey School of Business, where he served as curriculum co-director of the full-time MBA program. He has won several prestigious awards. The 17 articles that Lane has published in leading academic journals have been cited by other scholars over 2,300 times. He has served on the editorial boards of *Organization Science, Journal of International Business Studies*, and *Journal of Management*. Lane has been elected to several leadership positions in international academic associations, including treasurer and executive board member for the Academy of Management's Business Policy & Strategy Division, and board member for two of the Strategic Management Society's interest groups.

David Obstfeld ❮ David Obstfeld (Ph.D.) is Associate Professor of Management at The Mihaylo College of Business and Economic, California State University, Fullerton. His research examines how knowledge-intensive, network-based social processes that result in organizational change and innovation unfold at the local and firm levels. Currently, his research interests focus is on how the interaction of social network-based brokerage activity, knowledge articulation, creative projects, and collective action influence entrepreneurship, innovation, and firm strategy.

Bolko von Oetinger ❮ Bolko von Oetinger is Chairman of the Board of Trustees of the Eberhard von Kuenheim Foundation (BMW Group) in Munich. The foundation is active at the intersection of business and society with focus on employment, education and corporate sustainability. He has taught Strategic Management at the WHU Otto Beisheim School of Management in Koblenz/Vallendar (Germany) since 1998. Bolko von Oetinger worked for 34 years with the Boston Consulting Group in Menlo Park, Paris and Munich, and was head of the company's operations in Germany, member of the Executive Committee, head of global marketing, and founder and director of the Strategy Institute. Until his retirement in 2008, he led the Kronberg Conferences, BCG's top strategy forum in Germany. Von Oetinger has published several books on strategic thinking and innovation: *Das Boston Consulting Group Strategie Buch*; *Hänsel und Gretel und die Kuba Krise*; with Heinrich von Pierer, *A Passion for Ideas (Wie kommt das Neue in die Welt)*; with Tiha von Ghyczy and Christopher Bassford, *Clausewitz on Strategy (Clausewitz - Strategie denken)*. Von Oetinger holds a master's degree in political science and received his doctorate from the Faculty of Economics and Social Affairs at the Freie Universität Berlin in 1972. In 1974, he received an MBA from the Stanford Graduate School of Business.

Paul Pangaro ❮ Paul Pangaro is an entrepreneur, teacher, and performer. His current startup, New York-based General Cybernetics, Inc., is founded on the observation that digital convergence – content, communication, and computation – has evolved greatly, while experience convergence – context, continuity, and conversation – has not. For this reason he is developing a platform for a new way of reading and the next way of writing in digital media, continuing a product roadmap that began when he met Gordon Pask while working in Nicholas Negroponte's lab at MIT. The vision has persisted through his own research company and a handful of Internet startups on the East and West Coasts of the US. He co-taught a course in Cybernetics & Design with Hugh Dubberly in Terry Winograd's program at Stanford University for six years, and has continued this curriculum in the MFA program in interaction design at the School of the Visual Arts in New York since 2007. He is Chair of the Trustees of the American Society for Cybernetics and on the board of Artship San Francisco. He received his PhD from Brunel University with Gordon Pask and was awarded his BS in Computer Science and Humanities with a minor in Drama from MIT. He has performed in musical theater and cabaret.

Gerhard Roth ❮ Gerhard Roth was born in 1942 in Marburg/Lahn. Studied philosophy, German, and musicology in Münster and Rome. 1969, PhD in philosophy. Studied biology in Münster and Berkeley, California. 1974, doctorate in zoology (Dr. rer. nat.). Since 1976, Professor of behavioral psychology at the University of Bremen, and until 2008, Director of the Brain Research Institute in Bremen. 1997-2008, founding rector of the Hanse-Wissenschaftskolleg (Hanse Institute for Advanced Study) in Delmenhorst near Bremen. 2003-2011, President of the Studienstiftung des deutschen Volkes (German National Academic Foundation). Since 2010, coordinator of the European Campus of Excellence. CEO of Roth GmbH – Applied Neuroscience with registered offices in Bremen. Some 200 publications in the field of cognitive neuroscience, personality research, and neural philosophy, including 12 books. Most recent publication: *The long evolution of brains and minds* (Heidelberg: Springer, 2013). Awards: Urania Medal of Urania Berlin and the City of Berlin, Lower Saxony Cross of Merit with Ribbon of Merit, Merit Cross 1st Class of the Federal Republic of Germany.
In 2009, Roth was heralded by *Cicero* magazine as the most important German-speaking natural scientist alive today.

Steven J. Sasson ❮ Steven J. Sasson joined Eastman Kodak Company as an electrical engineer, working in an applied research laboratory. He engaged in a number of early digital imaging projects. Among these was the design and construction of the first digital still camera and playback system in 1975. Steven continued to work throughout the 1980s in the emerging field of digital photography, receiving over 10 key digital-imaging patents. In 1989 he led the development of the first prototype mega pixel electronic digital camera, utilizing DCT compression that stored images to flash memory cards. He continued his work throughout the 1990s by developing one of the first photographic quality thermal printing systems, derivatives of which are still in use in self-service imaging kiosks around the world. Before retiring in 2009, Sasson was a project manger in the Intellectual Property Transactions group at Kodak. Steven attended Rensselaer Polytechnic Institute (RPI) in Troy, N.Y., and in 1973, he graduated with a BS and a Masters Degree in electrical engineering. During the summers of his college years ('68 –'73), he had several jobs that included being a "runner" on Wall Street (before e-mail!). Steven Sasson has received a number of international recognitions and honorary degrees for his work in the field of digital photography. Among these are induction into the National Inventors Hall of Fame and the United States National Medal of Technology and Innovation (2009).

Siegfried J. Schmidt ❮ Siegfried J. Schmidt, born in 1940, studied philosophy, German, linguistics, history, and the history of art in Freiburg, Göttingen, and Münster. PhD in 1966. 1965, Assistant in the Philosophy Department at the TH (University of Applied Sciences) Karlsruhe; 1968, habilitation in philosophy; 1971, Professor of text theory at the University of Bielefeld; 1973, Professor of literature theory, also in Bielefeld. Since 1979, Professor of German/General Literature at the University GH Siegen. 1997, Professor of Communication Theory and Media Culture at the University of Münster. 2004, Honorary Doctorate from the University of Klagenfurt. 2006 retirement from the University of Münster.

John R. Searle ❮ John Rogers Searle (born July 31, 1932) is widely noted for his contributions to the philosophy of language, philosophy of mind and social philosophy, he began teaching at Berkeley in 1959. He teaches philosophy of mind, philosophy of language, and philosophy of social science; recent seminars topics include consciousness, free will, and rationality. He received the Jean Nicod Prize in 2000; the National Humanities Medal in 2004; and the Mind & Brain Prize in 2006. Among his notable concepts is the "Chinese room" argument against "strong" artificial intelligence. Recent books include The Mystery of Consciousness (1997), Mind, Language and Society: Philosophy in the Real World (1998), Rationality in Action (2001), Mind (2004), Freedom and Neurobiology (lecture collection; 2004), Mind: A Brief Introduction (summary of work in philosophy of mind; 2004), Intentional Acts and Institutional Facts (essay collection; 2007), Philosophy in a New Century: Selected Essays (2008), and Making the Social World: The Structure of Human Civilization (2010).

Michael Shamiyeh ❮ Michael Shamiyeh helps organizations to define the framework for compelling innovation strategies, to sense, create, and implement desired futures, and to build their own capabilities, systems, and structures that are right for change in organizations. His customers include leading international enterprises from the fields of engineering & assembly, global energy & materials, telecom & high tech, as well as consumer & leisure. He is founder and head professor of the Design Organization Media Research Lab (DOM) and CEO of Shamiyeh Associates - an operative unit for developing desired futures. Michael studied strategic management and architectural design (at Harvard, AA London, TU Vienna, and St. Gallen, Switzerland) and has published in many international journals, books, and popular media. His work has been nationally and internationally awarded many times.

Kathleen M. Sutcliffe ❮ Kathleen M. Sutcliffe (Ph.D.) is the Gilbert and Ruth Whitaker Professor of Business Administration and Professor of Management and Organizations at the University of Michigan, Ross School of Business. Her research program has been devoted to investigating cognitive and experiential diversity in executive teams, how organizations and their members cope with uncertainty, team and organizational learning, and how organizations can be designed to be more reliable and resilient. She is currently investigating organizational safety and high reliability and resilience practices in oil exploration and production, wildland firefighting, and in healthcare organizations. Her research has appeared in numerous scholarly journals including the Academy of Management Journal, Academy of Management Review, Journal of Applied Psychology, Organization Science, and Strategic Management Journal to name a few. Two books include Medical error: What do we know? What do we do? (co-edited with Marilynn M. Rosenthal, Jossey-Bass, 2002) and Managing the unexpected: Resilient performance in an age of uncertainty (co-authored with Karl E. Weick, Jossey-Bass, 2007). She was awarded the 2006 Ross School of Business Researcher of the Year. In late 2012 she was appointed by the National Academy of Sciences Institute of Medicine to a research panel to study workforce resilience in the Department of Homeland Security.

Mary Tripsas ❮ Mary Tripsas is a management scholar whose research and teaching focus on innovation, entrepreneurship, and strategy. Her work on the transformation of industries by new technology has illustrated the importance of organizational identity and managerial mental models in shaping strategic responses to technological shifts. She has explored the emergence of digital imaging, the evolution of the typesetter industry, and is currently engaged in studies of eBooks, air taxis, and innovation in music. Prior to joining the Carroll School, Professor Tripsas was on the faculties of the Harvard Business School and the Wharton School. Before entering academia, she was a strategy consultant in the Cambridge and Milan offices of the Monitor Group and worked for IBM in the early 1980s as both a software developer and member of the sales force. She served on the board of directors of Lexar Media (NASDAQ: LEXR) from 2003 to 2006, when the company was acquired by Micron. *Selected articles*: "Prior industry affiliation and framing in nascent industries: the evolution of digital cameras," (with M. Benner) *Strategic Management Journal*, 2012, 33:277-302. "Technology, identity, and inertia: through the lens of 'the digital photography company' " *Organization Science*, 2009, 20(2): 441-460. "Thinking about technology: Applying a cognitive lens to technical change" (with S. Kaplan), *Research Policy*, 2008, 37(5):790-805. *Professional activities*: Current: Program Chair-Elect, Academy of Management Technology and Innovation Management Division (five-year rotation) 2004-2008 INFORMS College of Organization Science Board of Directors, 2004-2007 Academy of Management Organization and Management Theory Division Representative at Large.

Bill Wooldridge ❮ Bill Wooldridge is Professor of Strategic Management at the Isenberg School of Management at the University of Massachusetts, Amherst, where, he teaches courses in sustainable business strategies. He received his MBA and PhD degrees from the University of Colorado, Boulder. His current research focuses on relationships among social networks, knowledge creation, and strategic renewal. His research has appeared in both academic and professional journals and he is the co-author of two books that examine the role of middle managers and how strategy forms from within organizations. He is currently serving on the editorial boards of the *Journal of Management* and the *Journal of Management Studies*.

Karl E. Weick ❮ Karl E. Weick is the Rensis Likert Distinguished University Professor of Organizational Behavior and Psychology, and Professor of Psychology, Emeritus, at the University of Michigan. He joined the Michigan faculty in 1988 after previous faculty positions at the University of Texas, Cornell University, University of Minnesota, and Purdue University. He is a former editor of the journal *Administrative Science Quarterly* (1977-1985), former associate editor of the journal *Organizational Behavior and Human Performance* (1971-1977), and former topic editor for Human Factors at the journal *Wildfire*. His work is summarized in books including *The social psychology of organizing*, first published in 1969 and revised in 1979; *Sensemaking in organizations* (Sage, 1995); and *Managing the unexpected*, co-authored with Kathleen Sutcliffe (Jossey-Bass, 2001, 2007).

Sonja Zillner ❮ Sonja Zillner studied mathematics and psychology and did her PhD studies in computer science, specializing in knowledge management. For several years she has been project leader of technology and innovation projects at Corporate Technology, Siemens AG. She is Professor for Innovation Management at the Steinbeis School of International Business and Entrepreneurship and the author of many patents and publications. Her current research focus is in knowledge management, innovation management, future management, as well as big data technologies.

THE EMERGENCE OF THE NEW (WHAT) ‹

MICHAEL SHAMIYEH ‹

We propose: In organizations, the new is not something that is being created in someone's individual mind, which then has to be transferred to others with great skill and effort. Rather, we suggest that everything new evolves in a process of co-creation; that is to say, innovation is not about the transfer of individual content, but about social construction. The new is not carried into an organization like lost luggage just waiting to be found somewhere and brought into the organization. It evolves in the interaction with employees, suppliers, customers, users etc. – again and again.

In the following chapter, scholars from various disciplines illuminate the social construction process of reality. Guiding questions for their contributions are: How can we develop something new in social construction processes? When do we recognize something as new? And, how can we imagine cognitive processes at work in the human interpretation of something new?

Gerhard Roth's opening account of the first thematic block shows how social reality is a construct of our brain from a neuroscientist's perspective. Following his argument, there are as many individual realities as there are brains. The consequence of this may be experienced whenever people communicate with each other: Words or phrases – e.g., scenarios of a desired future – may not have the same meaning for every person. Philosopher **John R. Searle** examines the role of language in the creation and maintenance of social reality. As he outlines, reality is just what we humans choose it to be. It exists by human agreement and, from this, we agree upon the nature of objective reality. **Louise Connell** and **Mark T. Keane** discuss the critical role of plausibility in assessing (new) scenarios from a cognitive psychologist's perspective. Research findings have led them to the insight that a highly plausible scenario is one that fits prior knowledge well; that is to say, with many different sources of corroboration, without complexity of explanation, and with minimal conjecture. Thus, the use of hypothetical entities or the introduction of radical new perspectives renders even the simplest, best-supported scenario less plausible. Philosopher and communication scientist **Siegfried J. Schmidt** explains how the transition from a mediated reality to the construction of reality makes the cherished and reassuring distinction between reality and mediated reality disappear. "Reality," he notes, is consistently put in the plural, and the assessment of the reliability of each reality relies on the criteria that are applied in a social system. Sociologist **Elena Esposito** closes the section by illuminating the criteria that guide us in making judgments about something in terms of its newness. For her, to answer this question we don't have to look at the world, but rather at the observer – it is to the observer, according to his or her categories and expectations, that a given object appears as new.

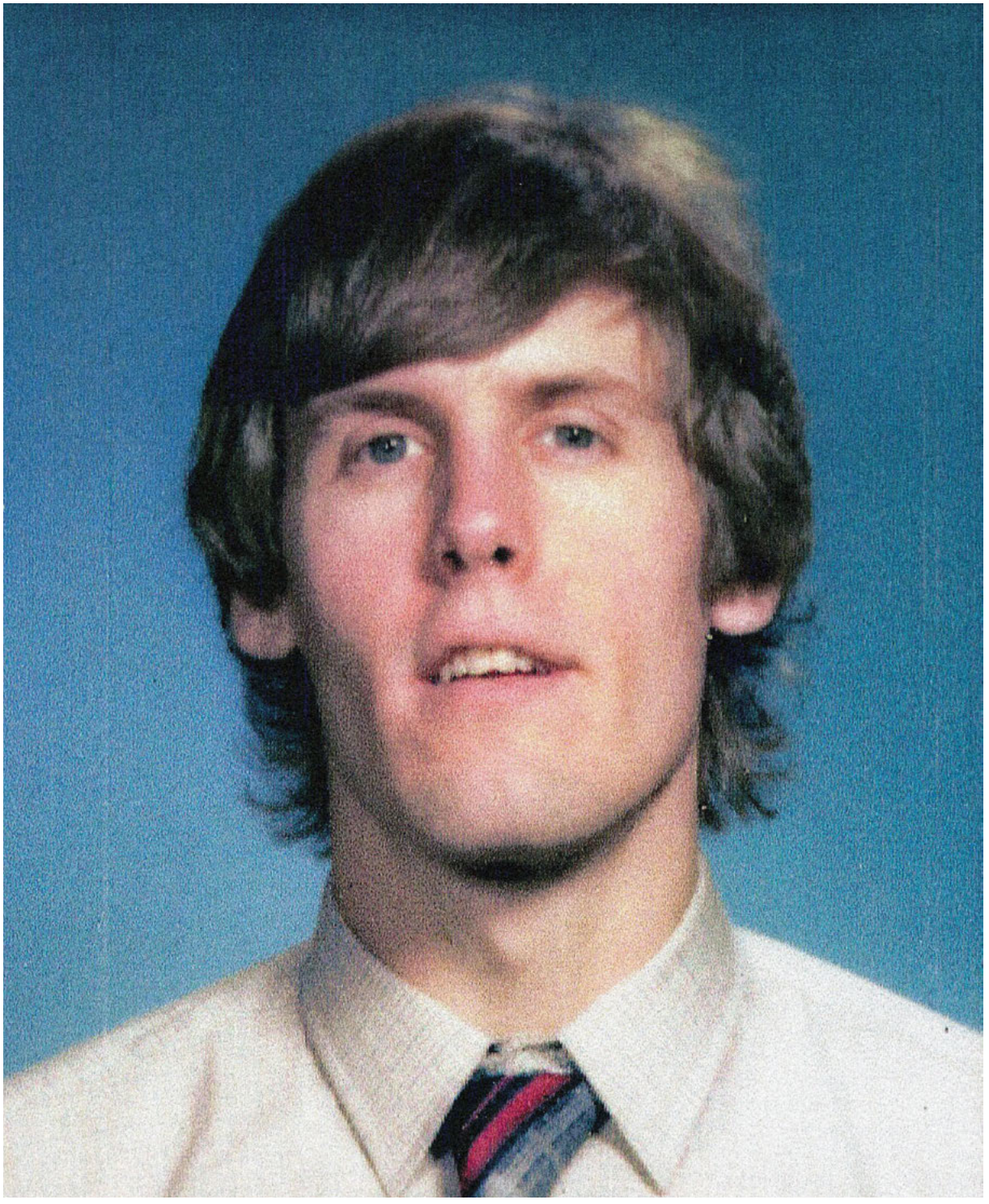

FIGURE 1
Image of Steven Sasson's Kodak employee pass in late 1970s. © Steven Sasson

DISRUPTIVE INNOVATION AT THE EASTMAN KODAK COMPANY ❮ PART I

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An interview with American electrical engineer, inventor of the digital camera, and digital imaging pioneer Steve Sasson about the challenges to move radical new ideas into organizational processes. Steve Sasson. 2013. Personal Interview. Part I. April 9. Rochester.

PREAMBLE

Michael: Steve, I would appreciate if we could structure the interview in three major parts: starting, working, and initiatives at Kodak. Thus, first, I would like you to recall the time before you entered Kodak. It would be great to learn about your educational or professional background, your interests and motivations, as well as about your perceptions of the company at this time. Second, I imagine talking with you about your time at Kodak. I would like to get a very broad sense of your specific role within the company and how it changed over time. Additionally, I would like you to define a broad picture of how you think the company has changed over time; think of activities Kodak pursued in various domains and about the company's beliefs. Finally, third, I would like you to remember situations in which you were trying to push an idea into an organizational initiate.

Steve: Well, let's start at the beginning. I was born in Brooklyn, New York and lived in the Bay Ridge section of Brooklyn. As a kid I got interested in technology really early. I worked with a neighbor friend of mine and we sort of did two things. We did chemical experiments where we tried to make things like gun powder and things like that, which today I probably would spend some time in jail because I was doing it, but back then it just seemed like fun, you know. But then I also got interested in electronics at a pretty early age.

I STARTED TO BUILD AMPLIFIERS AND READ BOOKS ABOUT AUDIO, OR LEARNED ABOUT RADIO,

and became a Ham radio operator.

We lived in a small row house in Brooklyn, you know and I put up an antennae, ham radio antennae on my roof, which was quite interesting to the neighbors because sometimes I'd interfere with their television sets when I transmitted, you know. That was about 13, so that was in the early 1960s I was doing that.

I used to go around the neighborhood and get my electronic parts from old television sets, because back then people used to, when they got done with their television sets, they'd throw them out on the curb; and I'd drag them home and I'd take all the resistors, capacitors, and take the tubes out and keep them. Those were the parts I used to build my projects.

I built, like I said, amplifiers, transmitters, radio receivers, things like that. In doing that, I gained a lot of real curiosity about electronics. I liked to build things. It was just something that sort of developed at that time and it stayed with me ever since. I always say I'm kind of a tinkerer, you know. I was always interested in engineering. I went to Brooklyn Technical High School, which was a specialized school in New York City that specialized in engineering education. That was a really good school and then one day one of the people said where do you want to go to college and I said I don't really know, but I'm interested in technology and engineering and they said a really good school is Rensselaer Polytechnic Institute. So I said all right, let me try there. Lo and behold, they took me in and I went there. So I had a chance to get a really great education at RPI up in Troy, New York. I graduated in 1972, but I decided to stay for a master's degree so I got a master's degree in 1973.

When I was looking around for a job, this was the timeframe when the push for the going to the Moon and a lot of the romantic stuff with the space race was sort of dying down a little bit. So I looked around and someone mentioned Kodak in Rochester, New York. Of course

I HAD HEARD OF KODAK, BUT I WASN'T TERRIBLY INTERESTED IN PHOTOGRAPHY;

but I thought the company was pretty interesting. So I went for a visit and I was really impressed with the people I met there. At the time, they took you for interviews in different parts of the company and then they took you back to the Kodak office and you'd sit down with the HR person.

They offered me a job that day. They said, where do you want to work? One of the places I visited was a really interesting place. It was a research laboratory called The Apparatus Division Research Laboratory and I really enjoyed talking to the people there, because they were so many different types of disciplines, all kind of within earshot of each other, and they were working on all different types of problems.

THERE SEEMED TO BE A NUMBER OF TINKERERS THERE, TOO.

So I said I sort of like that place. So there I started in June of 1973. I started working in the electronics group at the Apparatus Division Research Laboratory. As I mentioned, the research laboratory was a place where people mainly solved problems, both for products and for manufacturing lines. It was a very interesting and broad set of skills being applied to a broad range of problems.

FIGURE 2
The Eastman Kodak Co. Corporate Headquarters. Nov 3, 2011. © Getty Images

Michael: What was your perception of the company at this time? What was your association with the company? Was it a film company? Was it a technology company?

Steve: Well, I didn't think much about Kodak before I went there. Like I said, I wasn't terribly interested in photography.

THEY TOLD ME THAT THEY REALLY DIDN'T HIRE THAT MANY ELECTRICAL ENGINEERS,

but they were starting to hire some more now, because cameras were getting more electrical in their nature. In other words, more of the unit manufacturing costs of a camera were going toward battery control, flash control, exposure control, these kinds of things, and so they needed more skills in this area. So I thought well, okay, that's interesting, it's electrical problems, that's what I like to work on. That was my impression. It was going to be an interesting place to work. I had no idea I'd work there my entire working life, but I liked the environment and they, as I said, were working on a broad range of problems and there seemed to be some really smart people there.

That was my impression of the company. It was also very well regarded. Most people spoke very well of

KODAK. THEY TREATED THEIR PEOPLE WELL.

They had a lot of extracurricular activities, that kind of thing. It had a very good reputation in the hometown of Rochester, as well. It was a very large company. I worked at the Elmgrove Plant, which was an enormous complex and it was getting bigger. They were building on to it as I was starting to work there. So there were thousands of people working there.

Michael: Could you roughly describe the organizational structure of Kodak? How many business divisions are we talking about? How many people were actually working on film? How many in research labs or manufacturing?

Steve: Well, Kodak was an enormous group. There were tens of thousands, maybe 50,000, 60,000 people working there around this time and the next few years after I joined. I worked at the Elmgrove Plant, which was dedicated to the design and production of equipment, all the equipment in support of consumables or film, or paper. I really didn't know much about Kodak Park, other than it was really big. They had lots of smoke stacks and a lot of old buildings there. I didn't really associate with them; this Elmgrove plant was a newer facility. The buildings were newer. They were built in the 1960s. As I said, they were dedicated toward design and production of equipment. So my exposure to Kodak was really the equipment side and I didn't really know much about film side.

Now having said that, one of the things that Kodak did for new employees is they gave you an education. They introduced you to the concept of photography. They had you take pictures and develop them, and they taught you about the different equipment. So I learned about that through several courses that I took when I first got there, but

I DIDN'T HAVE FIRST-HAND EXPERIENCE WITH FILM PEOPLE, FOR EXAMPLE, FOR MANY YEARS.

I was really dedicated to the equipment side. That was my vision of it. I didn't really think about the entire company. I knew that film was fundamentally the product that we were most sort of proud of. People knew most about it. We were also very proud of the cameras we were making, at the facility I was at. I didn't really think too much about the film side of the equation.

CHAPTER I - THE EMERGENCE OF THE NEW (WHAT)

Michael: Steve, is it fine for you heading on to the second part of our interview: working at Kodak? What was your first assignment?

Steve: Oh my first assignment, this was so cool. The supervisor I worked for was Gareth Lloyd, a very interesting man. I started with a couple of other new engineers and in the laboratory, they'd give you these projects to do. They were very careful to give you a project that was challenging,

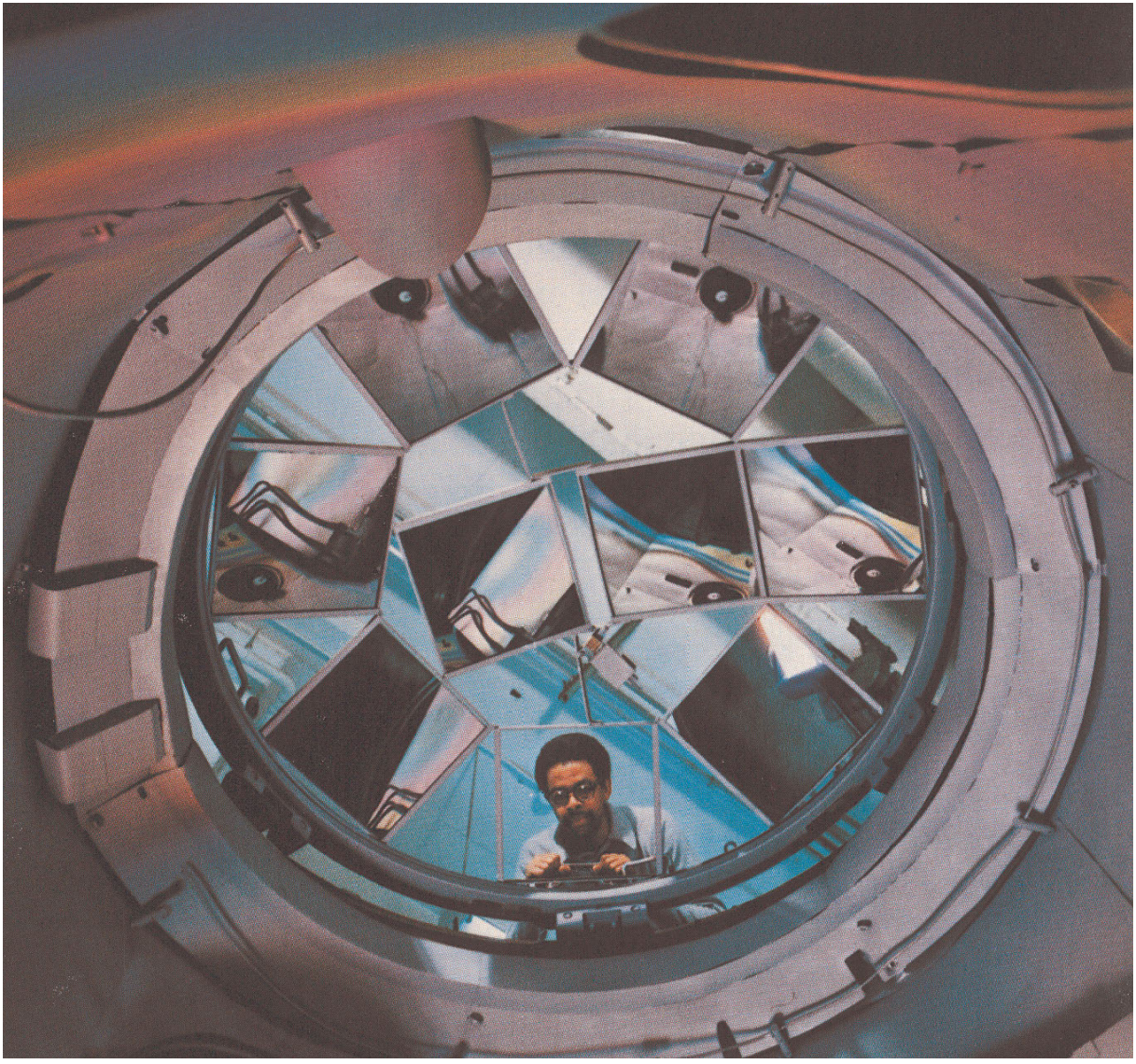

FIGURE 3
Mirrors for the Kodak Ektaprint copier/duplicator are coated in this special coating chamber at KAD's (Kodak Apparatus Division) Hawk-Eye Plant. 1981. Photo and caption © Eastman Kodak Company

but wouldn't overwhelm you. I was in with my office-mate Greg Moberg. He knew a lot about analog electronics, so I learned a lot from him, but for some reason, one day they came in and said, we need somebody to develop the control system for an automatic lens-cleaning machine, because they were coming up with a process of automatically doing finished glass lens assemblies for slide projectors.

They had developed this process, but they needed a control system for all of the steps that went along with it; the cleaning of the lenses, the barrels and stuff. So I got this job. I remember talking to Gareth, I said, boy, I've got to do all this sequential logic – microprocessors were just coming out. The Intel 4004 was the first chip, and the fellow next to me, Ed Wanzenreid, had been working on it, because they were thinking about putting it into a copier. I thought maybe I could try that. I remember going into Gareth, and he said no, it's too new for this. This is something we've got to get done, it's got to be working, so you might want to go with just discrete logic.

At the time I was disappointed, but actually it was the best thing that could have happened to me, because I had a chance to do all this logic – there were boards, and boards, and boards of this thing. It was all timers and countdown, but I learned all about sequential logic and actually the parts that were used at that time to accomplish these functions, and that came in very handy in the project I'm going to talk about next. So this all went together. I was so proud of this lens-cleaning machine,

IT WAS JUST SO COOL.

It worked for well over 20 years. I was a much older engineer in another part of the company and I once got a call that the machine had broken and they wanted me to come and fix it. It was 20 years later. [Laughter]. Oh, that's fun. Anyway, that was my first project. It was a good learning experience and I got a chance to learn about some of the actual technology being used.

Michael: What was your age at that time?

Steve: Twenty-three.

Michael: I assume finishing this first assignment extensively enriched your credibility within the company or at least within the research division.

Steve: There were a lot of really smart people there. I was learning. I was really down toward the bottom. I was just a new engineer and some of the more senior engineers would have fun with us sometimes. [Laughter]. They'd give us little jobs to do, because they didn't want to do that kind of thing; but we learned, and it was great. But I didn't think of it as building a reputation.

I JUST THOUGHT OF IT AS LEARNING SOMETHING AND GETTING A CHANCE TO KNOW PEOPLE OUTSIDE OF THE LAB.

I certainly got to know people inside the lab, but when you're working on solving a problem for someone in another part of the company, then you got to go to meetings. I was a college student, I didn't really go to meetings. So I went to meetings and you had to take notes, and you had deliverables, and so you learned all that stuff. It was a really great experience.

Michael: What happened after this project?

Steve: I worked on a couple of other things, little problems that would come up, and I'd work with some of the senior scientists in the lab, on things about flashes for the pocket cameras and things like that. They were little jobs, a couple of weeks at a time. Then one day, Gareth came into me, and I remember this quite distinctly, I was sitting at my desk. There were two people in the office there, Greg and I, and he came in and he stood beside my desk and he said, "I've got a job for you. Actually, you can have your choice. I've got a task where we need to do some exposure control system modeling for XL movie cameras: exposure control system modeling." I could use the analog computer and that kind of thing, which was interesting. But also, he said, "There's a new type of imaging device called a charge couple device. It has just started becoming available. You could look at that and see what its imaging performance would be like. Maybe we could use it to do

some measurement stuff, find out about it." Two pretty open-ended tasks.

I had a sneaking suspicion Gareth knew which one I wanted to take, because he knew that I was more interested in digital than analog, because Greg was interested in analog, see. The other part of it is I had done my master's thesis on optically controlled thyristor converters (it's a mouthful!), but basically it was how to use pulse light to control the current flow in a silicone control rectifier that was optically sensitive. Usually you send electrical signals, but these devices required an optical pulse. I wanted to be able to control the current in a rotating armature without any physical attachment, no brushes going to the armature.

SO I STARTED TO GET INTERESTED IN HOW LIGHT AFFECTED SILICON.

He knew I was interested in that, because he knew my master's thesis was on that.

So I jumped at the chance to do this CCD. Our conversation probably took 20 seconds. I mean that's all it was! It was a side project. There was really no budget, no review process, just go and do this and tell us something. So I started looking at the device and then I thought about well, they didn't really tell me what they wanted me to do, but they said they wanted to know what its imaging performance would be like. So I would have to, in some way, capture images and then sort of measure how they performed – what's good about them. You know, measuring modulation transfer function and that kind of thing. I thought, well, I could build a little test bed and just shine a target on it and maybe get it to run and see how it would work. That didn't seem like much fun, so I thought maybe I could capture an image with this thing. I thought, "Wow, if I could capture an image with it that would be cool. It'd be like a whole electrical camera."

Then I thought well, I'm going to have to look at it somehow, but I have electrical signals, so how do I do that? I've got to store it somehow. This all sort of naturally came about going forward. I thought I'd try to build a camera and I thought, well, cameras are portable, so I'm going to try to build something portable. Then being an electrical engineer,

FIGURE 4
Steven Sasson building the prototype in the actual lab at Kodak. 1976.
Photo and caption © Eastman Kodak Company

FIGURE 5
KAD (Kodak Apparatus Division) trains skilled trades people in various fields such as automation mechanics, optical mechanics, instrument-making, drafting, precision sheet metal, tool and die making, and other skills that we need for the day-to-day operation of the division. 1981.
Photo and caption © Eastman Kodak Company

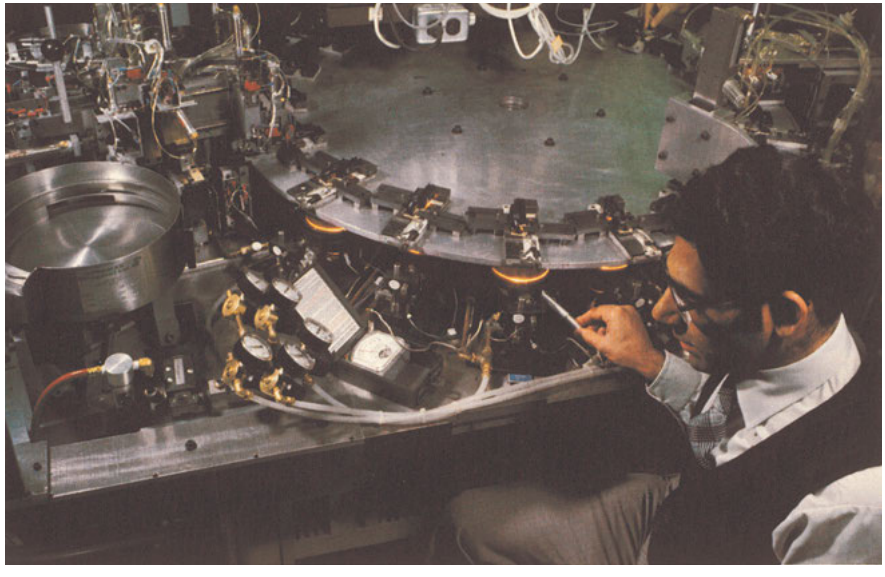

FIGURE 6
Code assemblers perform routine assembly tasks automatically. This is a major factor toward maintaining high productivity in product manufacturing. 1981.
Photo and caption © Eastman Kodak Company

I was surrounded by mechanical engineers. I thought it'd be really cool to make one with no moving parts at all. That was just to get them going. In order to do that, I couldn't go with any of the conventional ways of storing in any kind of a video signal, like video tape helical scanning. I knew I had to digitize it, and that way I could store it; then I didn't have to have any mechanical moving parts. So I went digital to avoid a problem.

Michael: You are talking about CCDs. How is it possible to capture images with this device? How do they function? Moreover, do you remember how well established this technology was? In the early 1970s, so I assume it was a fairly new technology.

Steve: Let me tell you a little history of what went on there because the CCD – the Charge Coupled Device – was invented by two fellows (Boyle and Smith) at Bell Labs in 1969. They were trying to solve a problem, too – actually, they were trying to solve a problem with keeping funding for their work, they were electrostatic people, and bubble memory, which was a form of magnetic storage that involved magnetic domains, was getting all the attention. So their management told them, you might run out of money if you don't do something interesting with this. They looked at bubbles and they said, maybe we can make charge packets act the same way.

I READ THIS STORY, AND I FOUND IT FASCINATING,

because they were trying to solve a problem, and they came up with this really clever idea of taking charge packets and being able to physically move them on a silicon chip and yet preserve the actual number of electrons in each packet without losing any.

So this, coupled with the fact if you raise the voltage on some of the electrodes, you'd create what's called the depletion region and underneath if you shined light on it, would create electrons that would be gathered into this depletion region. So all of a sudden you could get a number of electrons that are proportional to the amount of light that was incident on the surface at that point. Now you had this interesting device that could convert a light pattern into a charge pattern, and I had a way to move that charge pattern out of the device, keeping its integrity in place.

THAT WAS THE BASIS OF THEIR INVENTION.

They received a Nobel Prize for this only a few years ago. But it took a couple of years before actual devices started coming out.

The first devices were just line arrays. That is just a line of these little charge packet storage devices and you would move them along like that. They use them for delays, basically, to be able to delay time a little bit. But then Fairchild Corporation first offered a two-dimensional array of these little sensors and they were 100 by 100, so there were 10,000 of these things. This was an enormous chip, just enormous. Today it's 0.01 megapixels, so it doesn't seem like it's big today, but back then it was really significant. The device itself was very experimental. In order to sell the device, actually, they had done some astronomical work with it and did some very impressive pictures of the Moon. They did that on a stepper table, because the pictures they showed had much higher resolution than the device itself had.

They showed that they could maintain mechanical integrity and stability with this, so you could take very accurate scientific pictures. Those pictures became quite famous. But then they became available for sale, they were very, very, experimental devices.

I WAS ALLOWED TO ORDER TWO OF THEM ACTUALLY.

They cost about $300 or $350 each, if I remember correctly, which was a lot of money back then. I had not budgeted for this, by the way. I was allowed to buy the CCD; for everything else I was on my own. When the CCD chip arrived, it came in this little plastic box, pressed into foam. They had the 24-pin chip. Then when you opened it up, there was a little piece of paper on top of it and written in pencil next to each one of the voltage pins (there were 12 of them

by the way, the actual voltage that this particular device worked at on the line before they shipped it to me). So this particular one had VDD to work at 11.3 volts. You had to set all those voltages right. At the bottom it said, "Good luck."

Well, the reason is because if anything changed from the required voltage settings, you just got no output, and you had no idea which one was off. Think about it, it's fundamentally a transducer. You're shining light on it and then if you do everything right, you have all the voltages right, 12 voltages, clocking just the right way, you'll get a charge pattern out, right? That was the thing. So if the charge pattern stopped coming out, you had a lot of options as to what the problem was. So it was a very, very finicky, very difficult to work with device.

IT WAS VERY EXPERIMENTAL.

The first challenge was to see if I could just get this thing to work. It came with an application note, but that was it. That was the only one that was available. I went to the library to see if anybody had worked with this or done anything like this, and I couldn't find anything.

So I said well, okay, let's try this. When you look at the problem that I was trying to solve, it really wasn't that hard a problem to conceptualize. I was trying to replicate a photographic process, which up to this point had been done with film. And film is just marvelous material, that basically takes light and turns it into a chemical reaction, using a short period of time, and then stores the image right there until you develop it and then it stores it as an image; not a latent image, now it's a developed image. Then you can use that to actually project an image. So it's all in this one piece of film. Well, this CCD could only do a small fraction of what film could do. It could only change light into a charge pattern; it did that pretty well given the resolution restrictions, of course, but it couldn't store it. The charge pattern would go away in milliseconds if you didn't move it out using the charge coupling. It was a terrible storage device, so you had to get it off of the device really quickly, and then I had to find a reliable storage mechanism.

This is where that experience with the lens-cleaning machine taught me that once I got something into a digital form, I could store it, I could move it around. I didn't have the time constraint that I would have when it's sitting as a charge pattern in a CCD. So the basic architecture of the device had to use the CCD to convert the light pattern into a charge pattern, then clock it out of there really quickly, then change it into a digital signal. That is, take each one of these little charge packets and turn it into a number and then store that number in RAM, Random Access Memory, which was now becoming available. But then

I HAD ANOTHER PROBLEM.

Because film was a really good storage device, you could store a latent image for years and years, but I could only store these digital words for as much time as my battery lasted, because it required a battery to keep the memory going. So what I had to do is come up with another form of storage, which was permanent.

So what we did was we took the RAM memory, which was powered by the battery, and we quickly stored the image in there. When we captured an image, it was a 50-millisecond exposure and we read it out in 50 milliseconds and we stored it in that memory. Then we read it out very slowly to something that didn't require a battery to store it. The only form of storage I could find that was reliable – and

I WANTED IT TO BE RELIABLE, BECAUSE I KNEW IT WOULD BE COMPARED WITH FILM

– was magnetic tape. So I used a magnetic tape to store the sequence of digital words that represented the captured image. The architecture that evolved was to use the CCD as a transducer, then quickly get it out of there, because it's a terrible storage device. Put it into a temporary storage device that can be loaded very quickly, and then load it from that temporary storage device to a more permanent storage device. Even after all this time, that basic architecture still exists today with digital cameras, because that's exactly how they work today.

FIGURE 8
Kodak Office, Rochester, New York. 1978.
Photo and caption © Eastman Kodak Company

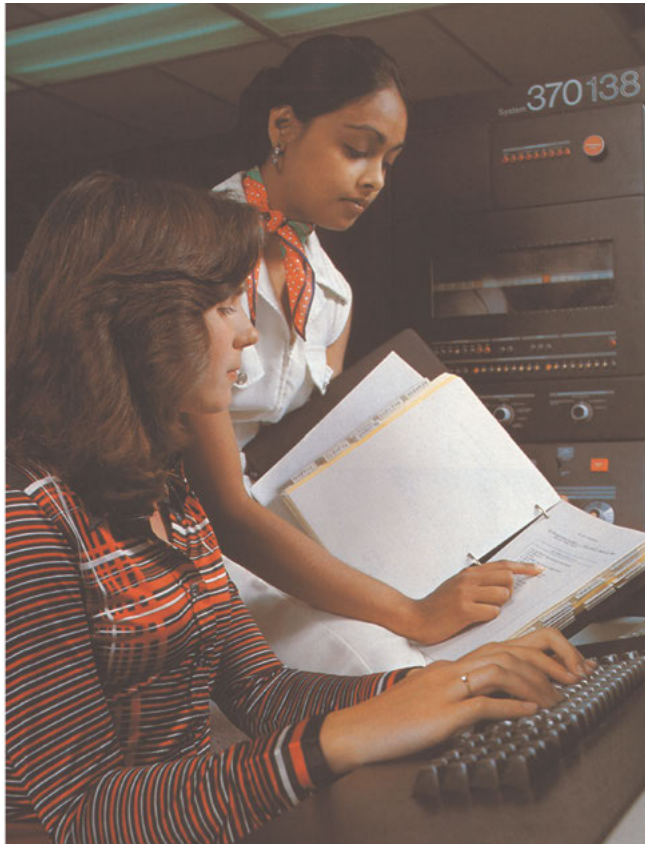

FIGURE 9
Computer technology is an important aid in ensuring that Kodak products are available in the right quantity, at the right place at the right time. 1978.
Photo and caption © Eastman Kodak Company

REALITY AND ACTUALITY ‹

GERHARD ROTH ‹

41

The world we consciously experience – the phenomenal world – is composed of three domains: the world of our body, the "outside" world surrounding that body, and the "mental" world. The reliable distinction among these three worlds is an essential part in the development of a child's mind. These three worlds are directly perceived by the conscious ego – there are no sense organs and no brain in between. However, neurobiology convincingly tells us that these three domains of the phenomenal world are constructed by different parts of our brain. Since I can observe my own brain while creating my phenomenal world including my brain, this leads to the logical paradox that my brain exists inside and outside itself. This paradox can be resolved only by the assumption that there is a world called "reality," existing independently of my conscious experience, in which entities, i. e., "real brains," exist that construct a phenomenal world called "actuality." This latter world is composed of "actual" objects including brains and even my own brain, as I perceive it. Thus, the "actual" (phenomenal or consciously perceived) brain is not identical with the "real" brain as constructor of actuality. The actual world is the only one we have access to, and it does not include its own creator (as Köhler and Schrödinger had stated correctly). This means that neuroscience – like any science and any perception – deals with actuality and not with reality, which is inaccessible. Any scientific statement, however plausible it may sound, is about actuality, not reality.

ACTUALITY AS A CONSTRUCT OF THE BRAIN

The world of our consciously experienced or *phenomenal* world consists of three domains: the outer world, our bodily world, and the world of our "inner" mental and emotional states. These three domains are usually clearly separated. Thus, we usually do not confuse the objects and events of the outside world with the parts of our body and the events occurring in it, and such confusion would have painful consequences. Similarly,

OUR THOUGHTS, IDEAS, AND MEMORIES ARE USUALLY CLEARLY SEPARATED FROM EVENTS IN THE OUTSIDE WORLD.

It would also be disastrous to confuse objects and events in the outside world with our ideas and wishes.
Separating bodily processes on the one hand, and mental and emotional states on the other, is more difficult. We typically situate mental states in our bodies, typically in our heads, between and a few inches behind the eyes. However, this type of localization of mental states is not necessary; ancient and medieval philosophers placed them in the heart or in the diaphragm. In line with Occidental tradition, we do not view mental states as something physical, but again this demarcation is not self-evident. When it comes to our feelings, this is even more difficult, because we do not usually locate feelings in the head, and associate them with the processes there, but instead in the body (for example, the well-known "knot in your stomach" in case of fear or your heart beating faster with joy or excitement). Feelings seem to be something between mental and physical.
Perceptions also occupy a strange intermediate state. On the one hand, we assume that they have something to do with the head, and this is where our most important senses, which are necessary for perceptions, reside. On the other,

WE DO NOT LOCATE THE THINGS WE PERCEIVE IN OUR HEADS, BUT IN THE OUTSIDE WORLD OR IN OUR BODIES

– that is, where the things and events that are believed to produce these sensory impressions are located. I situate noises in my closer surroundings; this book is located on the left of my desk and the computer keyboard that I touch with my fingers is directly in front of me; I locate a pain in my left forearm.
This is not surprising at first sight, for where else should the perceived objects and events reside than in the external world, or in my body? None of this seems strange until I realize that perceptions arise because sensory receptors are stimulated by corresponding processes in the external world and in my body, and that they send electrical impulses to the brain. Accordingly, we should feel the sensations in the brain, but this is not the case.
This fact of "direct" or "peripheral" perception has caused much confusion for many physiologists, psychologists and philosophers, and given rise to the following question:

HOW DO THE OBJECTS OF OUR PERCEPTIONS WHICH ARISE "IN THE HEAD (OR BRAIN)" GET BACK "OUTSIDE"?

Many temerarious hypotheses have been advanced to explain how this could happen. For example, it was assumed that perceptual content was "projected back" via sensory pathways into the world (cf. Sass, 1989). But there are no plausible neuronal mechanisms for this, and they would be of no use even if they did exist, because the space around us, into which objects are supposed to be "projected out," is something that arises in the brain, just like all other perceptions. Others locate conscious perceptions and sensations in the sense organs. Based on our current neurobiological knowledge, this is just as nonsensical. Whatever takes place in our sense organs is never accompanied by consciousness; also most of the details of our perception, and particularly their meanings, do not come from our current sensory stimuli, but are created "centrally" by our brain. Finally, we can also have sensations without any stimulation of the sense organs, for example hallucinations, dreams, or as the result of brain stimulation.
So where do the objects of perception exist? A solution to this problem was presented by the famous Gestalt psychologist Wolfgang Köhler in 1929, in his essay "A

legacy pseudo-problem." Köhler here presents the view that *nothing at all* is projected outside, but that everything I perceive only comprises one world, which is referred to by Köhler and his colleague Wolfgang Metzger as the "phenomenal world" (Köhler, 1929; Metzger, 1975). In his book *Mind and Matter* Erwin Schrödinger (apparently independently of Köhler) took a very similar position (Schrödinger, 1958, 1986). In this world, which I referred to as "actuality" in an essay of 1985,

THERE ARE THREE DESIGNATED DOMAINS: THE WORLD OF MENTAL STATES AND THE EGO, THE BODILY WORLD, AND THE OUTSIDE WORLD.

These three domains are *subdivisions* of the phenomenal world, of actuality. This actuality is conceptually compared with a *transphenomenal* world called "reality," which cannot be experienced and accordingly does not exist in the phenomenal world.

This means that all transactions between me and my body, between me and the outside world, between my body and the outside world, occur *within actuality*. When I touch an object or speak to a person, I touch an actual object and talk to an actual person. These three domains of actuality are seamlessly adjacent or transition directly into one another. This is why my perceptions appear to be *immediate*; my body has direct contact with the objects of the world. In this world of experience, my will directly affects my actions. There is no mediating instance in the form of sensory organs or a brain.

How does all of this go along with all the facts that we have gathered about the activities of the sense organs and many areas of the brain and which show us what an intricate process perception is?

TO RECONCILE THESE SEEMINGLY CONTRADICTORY ASSUMPTIONS, WE MUST ASSUME THAT ACTUALITY AND ITS STRUCTURING INTO THREE DOMAINS IS A *CONSTRUCT* OF THE BRAIN;

to be more precise, a construct in which the physiological-neuronal processes of the brain that underlie the mental states do not occur. We can study these states as *external events*, but we cannot *experience* them.

The fact that actuality is a construct can also be proven quite well empirically. The boundary between the body and the outside world seems firmly and clearly drawn, but it is unstable like all "cognitive" borders and collapses if it is not permanently confirmed. The sensation of my body and its limits presupposes both activity of the body-related motor cortical areas (A4, A6) and the somatosensory areas (A1, A2, A3) and activity of the posterior (rear) parietal lobe, which (together with subcortical centers) provides the body's spatial reference to its environment. Injuries in these areas lead to massive disturbances of the body schema, as we can learn from neglect patients (Kolb and Wishaw, 2008). These people view parts of their body as absent or as foreign objects. The same thing can also be caused by the destruction of sensory reafference from the limbs to the brain. Maintaining what would appear to be such a fixed body schema obviously relies on constant confirmation by the body sensors and motor functions. Massive disturbances of the body schema are also known in schizophrenic patients. For example, such a patient might maintain that a person is standing next to them who looks exactly like they do, or a schizophrenic patient views their own body as a "shell."

Events that affect our bodies are thus represented in a specific way in our brains; among other things, this is founded on the fact that motor mapping of the body in areas 4 and 6 (also known as the "motor homunculus") more or less exactly corresponds to a sensory mapping (in fact, there are actually several) in areas A1, 2 and 3. Both mappings are located in front of and behind the central sulcus of the cortex and confirm one another reciprocally with every movement. I can view my hand as an object lying on the table top next to other objects. I do not know from merely looking at it that it is my hand and thus belongs to my body, but from the fact that it moves in the way I intend, and that I receive characteristic feedback from my somatosensory system. My brain concludes: "this is my hand." Without this feedback, I see it as a "sewn-on" foreign body part. As O. Sacks vividly describes, this does not change in the least, despite the fact there are no