Science Transformed?

DEBATING CLAIMS OF AN EPOCHAL BREAK

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13

Technoscience as Popular Culture

On Pleasure, Consumer Technologies, and the Economy of Attention

JUTTA WEBER

The public consumes science for pleasure.
—MIKE MICHAEL

Far from depleting scientific materiality, worldliness, and authority in establishing knowledge, the "cultural" claim is about the presence, reality, dynamism, contingency, and thickness of technoscience.
—DONNA HARAWAY

THE INCREASING MARKET ORIENTATION of universities and other research institutions, the worldwide competition for key technologies, as well as the race for research funding and public attention are changing not only the relation between mass media and technosciences but also research strategies and paradigms of the technosciences themselves. In this chapter I analyze the cultural turn of technoscience(s) and changes in its epistemology, ontology, and rhetoric with regard to recent developments in personal service robotics and especially humanoid robotics. Robotics as a technoscience is not only more and more involved in PR activities, but is increasingly becoming—and stages itself as—an integral part of popular culture. This shift in robotics is accompanied by a move from the traditional expert culture of industrial robotics toward service robotics with its focus on consumer technologies and lifestyle products for everyday user(s).

Personal service robotics with human-robot interaction (HRI) focuses on affect, emotional bonding, and sociality of humans and machines, which is part of the cultural turn in robotics. Understanding "technoscience as an *integral* part of contemporary western culture" (Reinel 1999, 166) and taking its radical epistemological and ontological changes seriously, my main focus here

Figure 13.1. Roboticist Hiroshi Ishiguro with his "twin," the robot Geminoid, 2007. *Source*: Prof. Hiroshi Ishiguro and the ATR Intelligent Robotics and Communication Laboratories.

is less to discuss *whether* we live in the age of technoscience than to elaborate the transformation of robotics as a modern engineering field into a postmodern, "sexy," and media-effective technoscience rooted in pop and consumer culture (figure 13.1).

Toward Technoscience: Science and Technology as Cultural Practice

In the 1980s the cultural studies of science and technology—or cultural studies of technoscience—interpreted science and technology as "cultural practice and practical culture" (Haraway 1997, 66). In the face of the increasing hybridization of science, technology, industry, and society, this approach analyzed quite early the production of new concepts, meanings, and media in and through such technosciences as genetics, cybernetics, computer science, artificial intelligence, and reproductive medicine. One of cultural studies' central preoccupations was to show how the discourses and practices of the technosciences reshaped not only our political culture, kinship structures, and economy, but every dimension of everyday life (Reinel 1999).

Cultural studies of technoscience do not primarily interpret science as elite knowledge production or a social construct negotiated by conflicting interest groups but as a cultural practice that is complex, heterogeneous, and an important and integral part of our ensemble of cultural practices. It entails many different agents, such as concepts, machines, humans, and animals that produce meanings and thereby maintain or refigure cultural boundaries. As a consequence, cultural studies of technoscience not only analyze material and social technologies but also visual and semiotic ones (Haraway 1991 [1985]; and McNeil and Franklin 1991).

Until recently, cultural studies of technoscience, with its feminist and Marxist traditions, has been widely ignored at least by the mainstream of philosophy, sociology, and history of science and technology. Initiated by cultural and media studies, the discussions on technology as media (which draw heavily on cultural studies) and of technoscience as cultural and everyday practice is broadening and adopted in many different discourses. The role of media and visualization practices for the production of technoscientific knowledge is rethought with regard to new computer-generated images (Heintz and Huber 2001; Nordmann 2007a; and Valerie Hanson's and Angela Krewani's chapters in this edited volume) as well as their close affinity between technoscientific research and artistic practices. Another case in point would be the radical epistemological and ontological shifts in technoscience, moving from representation to performativity, from determinism to unpredictability, from causality to nonlinearity thereby abandoning traditional conceptions of objectivity and subject-object relations (Law and Urry 2003; Pickering 2002; see also Martin Carrier's and Hans Radder's chapters in this edited volume).

The cultural turn of technoscience is indicated by new media of persuasion such as immersion, the new affinity of technoscience toward art as well as the self-understanding of scientists not only as entrepreneurs but also "closet artists" (Risan 1996). Science and technology—that is, technoscience—is no longer mainly about representing the laws of nature and intervening in its processes, but mostly about (re)shaping new and hybrid worlds from a constructivist viewpoint (Weber 2003). This cultural turn is encouraged by technosciences' new epistemologies and ontologies that interpret our world as our product (see Carrier in this edited volume; Haraway 1992), where nature itself becomes an entrepreneur and engineer (Haraway 1997). In this frame of thought, geneticists, nanotechnologists, brain researchers, or roboticists are perceived as technoscientists who mainly support, improve, and perfect nature. We find a new openness to interdisciplinarity, as we know it from the prime time of cybernetics in the 1940s and 1950s, to foster innovation and problem solving by integrating the humanities and social sciences as a promising resource for the undertakings of an entrepreneurial technoscience.

The emergence of new everyday technologies like the PC or the cell phone, possibilities of enhancing bodily functions (for example, prenatal testing, in vitro fertilization, or Viagra), and the increasing integration of human and technological systems, the orientation of technoscience toward application from the 1980s on (Forman 2007), as well as the more intimate relation between science and society after 1989 (Gibbons et al. 1994) has led to a growing public interest in technoscience. Therefore, many technoscientists and science managers invest increasingly in the popularization of technosciences not only to demonstrate the innovative character of one's work in the face of limited societal resources and succeed in the intensified competition for research funds, but also to demonstrate the usefulness of technosciences' endeavors for the public. Aspects of personal service and entertainment are especially coming to the foreground. In such a sociohistorical context, the performance of new robotics with anthropomorphic and zoomorphic artifacts (Aibo, Pleo, Pino, and so on) becomes a promising technoscience that is on the one side consumer-oriented high tech but at the same time inscribes itself into popular culture, promoting the fun part through a very broad variety of entertainment and edutainment applications—without losing the aspect of innovative, high-tech masculine breakthrough work.

Machines of Wonder and Curiosity

From a historical perspective the production of entertaining human- and animal-like machines to rouse feelings of wonder and amazement in their spectators is not new. The automata of ancient times and in the sixteenth and seventeenth centuries were built as media of illusion, as curiosa, as fascinating and entertaining entities that had at least partly also symbolic function (Karafyllis 2004) (figure 13.2).

In contrast to this, the automata of the eighteenth and nineteenth centuries were used as models of perception for scientific research. With the abandoning of the mechanical model of the organic at the end of the nineteenth century and the emergence of its biocybernetic concept in the twentieth century, which shifted the translation between humans and machines to the *systemic and micro-level*, the construction of humanoids was no longer interesting from a scientific perspective. Beginning in the 1950s, the credo of robotics was to develop *functionalist* machines as efficient and optimal problem solvers. And while humanoids as talking, identity-challenging machines were the frequent stars in science fiction (SF) film and literature in the twentieth century, humanoid robots did not play a role in Western academic research until the 1980s.[1] Humanoid robots from science fiction films and literature served as a resource

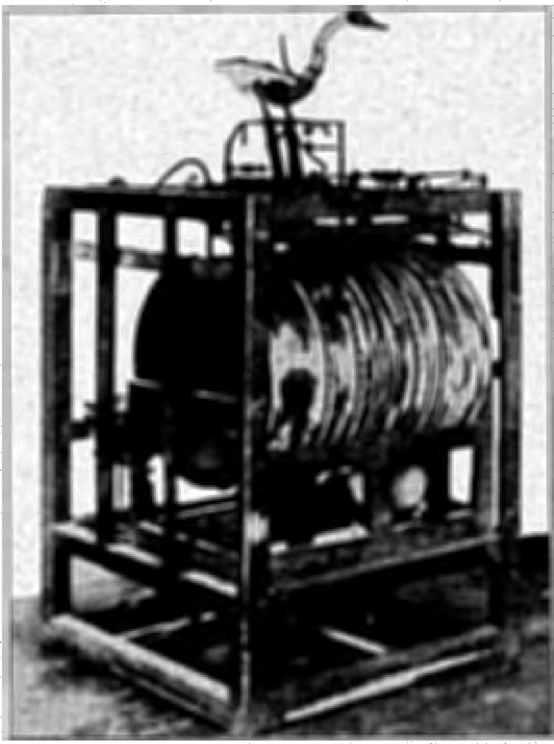


Figure 13.2. In 1737 the French mechanic and inventor of the mechanical loom, Jacques de Vaucanson, built a mechanical duck that could drink, swim, and excrete.

of inspiration for many roboticists but were not themselves a central object of research.[2] In the past decades this old "division of labor" seems to be changing—and this change is also related to one in research paradigms in robotics.

From the Manipulation of Things toward Personal Services of Well-Being

In traditional industrial robotics, robots were understood as multifunctional manipulators and problem solvers. According to the functionality of these robots, the relation between the roboticist-expert and the machine was modeled as a master-slave relation: the engineer directs the actions of the machine, while the latter carries them out. This traditional understanding of robotics is visible in the (still valid) robot definition of the Verein Deutscher Ingenieure (VDI, translated as the Association of German Engineers) guideline for industrial robots from 1990: "A robot is a free and re-programmable multifunctional manipulator with at least three independent axles, *to move materials, parts, tools, or special machines on programmed, variable tracks to accomplish various tasks*" (qtd. in Christaller et al. 2001, 18; my translation and emphasis).

But in the late 1980s and the 1990s a radical shift emerged in robotics toward biology and the neurosciences. While traditional robotics was mainly oriented toward mathematics and formal logic, engineers now started to use biological principles to build more intelligent machines. The new approach stressed the importance of robustness, autonomy, embodiment, and situatedness for the creation of intelligent systems.[3] These new systems were often shaped zoomorphic, for example, as snakes, bugs, or ants. This development laid ground for the emergence of "social" robotics or HRI in the 1990s, which builds not zoomorphic but humanoid prototypes with features such as facial expressions, gestures, emotions, "natural" humanlike ways of communication including turn-taking (see, for example, Breazeal 2003).

Today's definition of a service robot is quite different from the traditional one of industrial robotics. The United Nations defined a service robot in the following way: "A robot which operates semi or fully autonomously *to perform services useful to the well being of humans* and equipment, excluding manufacturing operations" (qtd. in Euron and IFR 2004, 1; my emphasis). In HRI the robot is conceptualized as an infant that needs to be cared for and educated. At least the strong approach in HRI follows theories of developmental psychology and uses analogies between robot and child development, searching for more effective ways to build intelligent robots. They want to "evolve" robots that can be educated and shaped as humanoid "cognitive companions."

To give an example of this approach, the European Union's research project Cogniron (2006–9)—funded with 6.5 million Euros by the European Community and Switzerland—describes its research goals in the following way: "The project will develop methods and technologies for the construction of such cognitive robots able to evolve and grow their capacities in close interaction with humans in an open-ended fashion. *The robot is not only considered as a ready-made device but as an artificial creature, which improves its capabilities in a continuous process of acquiring new knowledge and skills. . . . The design of cognitive functions of this artificial creature and the study and development of the continuous learning, training and education process in the course of which it will mature to a true companion, are the central research themes of the project.*"[4]

Notwithstanding the fact that EU research policy fosters research that relies on the rhetoric of breakthrough and radical innovation beyond incremental research (Nordmann 2007b)—and thereby supports stories of salvation, wonder, and curiosity—it is nevertheless amazing how the monstrous repetitive manipulators and industrial problem-solving machines have "evolved" to babylike, self-learning artificial creatures of HRI that need to be educated to serve as one's own true companion and that are supposed to support the indi-

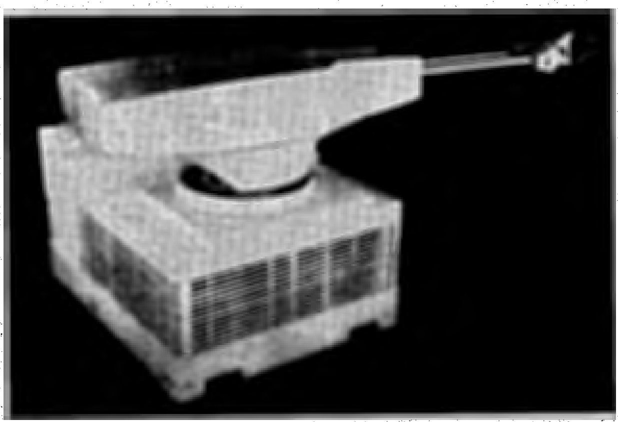


Figure 13.3. Unimate, the first industrial robot deployed at the assembly line of General Motors in 1961.

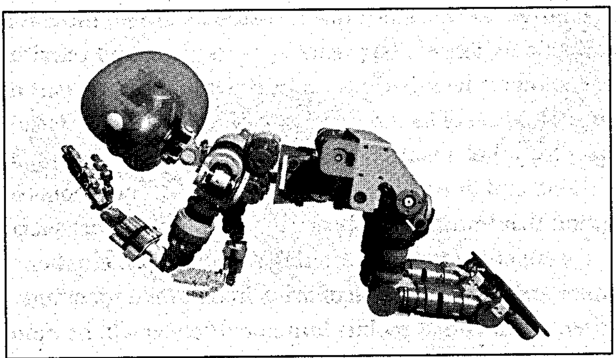


Figure 13.4. Model of iCub. iCub is a humanoid developed by the EU project Cogniron, which was meant to be not only an artificial creature but a "true companion." *Source:* Prof. Giulio Sandini.

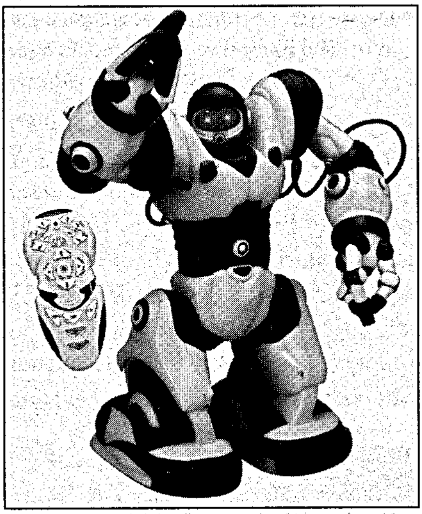
vidual human user in the long run. Anthropomorphic, emotional, and social artifacts, once the traditional and exclusive domain of the popular culture of science fiction, are now developed for everyday users. Robotics has shifted from manipulating things and moving materials to providing service gadgets for the well-being of humans, from the mastery of nature toward personal comfort and sociopsychological and therapeutic services, from industrial production to service products and popular culture—a shift that is accompanied by epistemological and ontological changes and a move from infrastructural technologies toward the production of consumer technologies (figures 13.3 and 13.4).

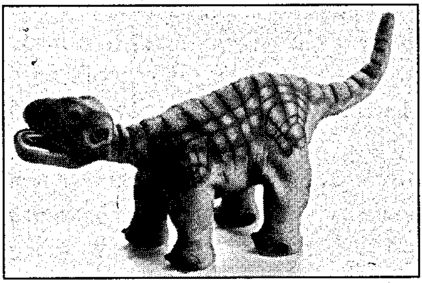
From Biologically Inspired Machines Toward Hyperrealistic Humanoids

But while HRI could be interpreted as the logical precursor of biological-inspired robotics, one should not overlook the epistemological difference. The older biomimetic approach is a biologically inspired approach where biological mechanisms and principles have mainly the function of inspiration and are not copied in a 1:1 fashion, because many organisms are only semioptimal for the task an artificial agent is supposed to fulfill; significant differences are seen between the logic of nature and that of technology. For example, the development of planes was inspired by mechanisms in birds' flying behavior but they were not copied precisely. Airplanes do not flap their wings.

In HRI we find a branch of humanoid robotics that focuses on the construction of (hyper)realistic 1:1 copies of humans. Some engage in copying the bodily shape of humans as perfectly as possible.[5] Others develop mechanisms to copy human facial expressions, gestures, and "mechanisms" of social interaction (e.g., turn-taking) as "natural" as possible. Now humanoids are no more the subject of science fiction alone. Since a few years ago, aesthetic and physical features of so-called social robots have become an intrinsic and central part of the roboticists' work in HRI. Many of its researchers believe the claim by Byron Reeves and Clifford Nass (1996) of a natural tendency of humans to anthropomorphize computers. Along that line, many roboticists make the questionable and unproven assumption that humanoid robots would make a perfect social interface. Humanoids are supposed to help encourage an increased emotional bonding toward machines and the immersion of users into human-robot interaction. Another unproven claim is that mobile humanoid robots will be more easily accepted because they might be perceived as less threatening than functional designed machines (Kiesler and Hinds 2004).

These claims leave open the question of why machines need a humanoid shape to support the interest or even bonding with machines. We already anthropomorphized computers when they still looked like boring tin boxes. Obviously, anthropomorphization is not dependent on machine design. If there is a "natural" tendency to anthropomorphize computers, it is grounded in a human tendency to ascribe computers identity or personality. The "unpredictable" behavior of computers and especially of "self-learning" and "autonomous" machines might support these processes, but this behavior is not limited to the field of computers and robots—think, for example, of the anthropomorphization of cars. At the same time, the applications areas for humanoids are only described very vaguely. In the report of the International Federation of Robotics, humanoids are praised on the one hand as "the ultimate human machine"





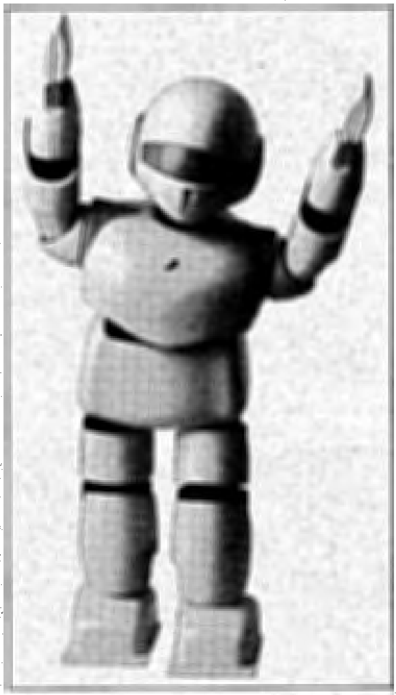


Figure 13.5. (top, left) **Robosapien is a humanoid robot advertised as "multifunctional, thinking, feeling robot with attitude!"** *Source*: Sebastian Budich and Sablon Germany GmbH / WowWee Group Limited.

Figure 13.6. (bottom, left) **Pleo, the robotic baby dinosaur.** *Source*: Derek Paul Dotson from Innovo Labs / COO.

Figure 13.7. (right) **Pino, the "interactive robot friend."** *Source*: Nobuko Imanishi and ZMP Inc.

because of their adaptability to human environments, but on the other hand the report states very vaguely that they will be "able to potentially cover a wide variety of jobs" (Hägele 2006, 424). And the text proceeds: "However, technological and manufacturing challenges still remain to be solved until reliable machines can be produced in significantly high quantities" (Hägele 2006, 424).

Up to now, the most important field of application for personal service ro-

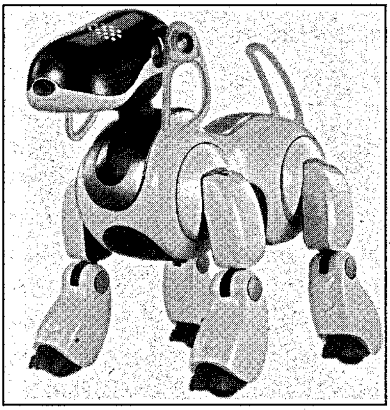
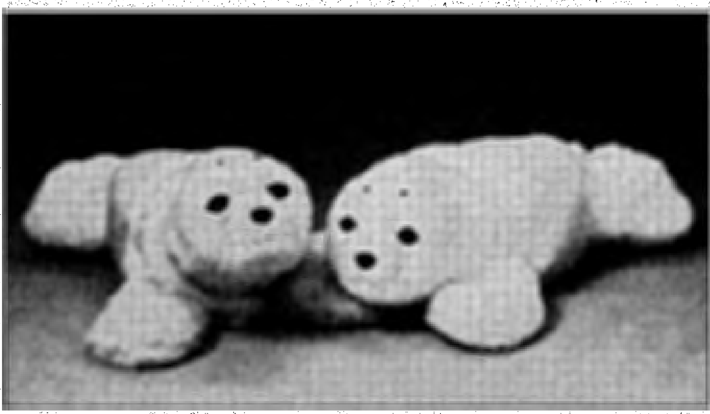


Figure 13.8. (left) Aibo is an autonomous robot and interactive pet. *Source*: Désirée Kuhn and Sony Deutschland GmbH.

Figure 13.9. (below) Paro, the "therapy" robot for elderly people. *Source*: Takanori Shibata PhD and AIST Japan.



bots and especially humanoids are the entertainment and edutainment industry, like Robosapien, Pleo, Pino, and other toy robots. In 2005, 1 million units in total were sold worldwide. For 2006 through 2009 the numbers are estimated about 5.5 million (Hägele 2006). The sex industry might also be an important application area. In Korea we already find robot hostess services, but numbers of sold units are not available (figures 13.5, 13.6, and 13.7).

In addition, the research field of humanoid robotics struggles with the problem of the "uncanny valley." This thesis postulates that only vaguely humanlike machines are willingly accepted, while hyperrealist humanoid machines cause not only uncanny feelings but the rejection of these robots. Cartoonlike or zoomorphic robots for emotional bonding and immersion would do as well—as we can see with the successful robodog Aibo or the baby seal robot Paro (figures 13.8 and 13.9).

Having these difficulties and theoretical shortcomings in mind, the question is: Why are humanoid robots so attractive for research and development? What might be the most promising about humanoids is that they serve as promotion devices for consumer technology in the context of (life-style) design. For example, the already mentioned Report on World Robotics describes the EXPO 2005 in Aichi as "[a] highlight for humanoid robot technology" because "it staged a robot week in June of that year with a large variety of demonstrators and prototype robots from companies, research institutes and universities. *Humanoid robots have been a highlight in particular as these were displayed in impressive shows and settings*" (Hägele 2006, 423; emphasis added). Maybe this is the most convincing explanation for the huge interest in and the funding of the quite expensive but not very productive field of humanoid robotics.

Design, Affect, and Consumer Technologies of Personal Service Robotics

Since the 1970s, the borders between technoscience and society have become increasingly permeable.[6] The "sacramentalism of science" (Bensaude-Vincent 2001, 108) in the twentieth century permanently lost ground with the growing criticism of such social movements as the ecology movement, the women's health movement, as well as antinuclear activism, the end of the cold war, and the growing public awareness of the ambiguous role of science in the production of crisis (Michael 1998). Science and technology became increasingly a contested terrain with rising claims for the justification of research funds and policy.

At the same time, the orientation of technoscience toward application, the higher dependency of universities on government and international funding, and the pressure to participate in the production of key technologies calls for the efficient promotion of one's research in the mass media. "Social," emotional, and humanoid machines endowed with a rich techno-imaginary are quite attractive and effective tools in the media economy of attention. Smiling humanoids climbing stairs, dancing with human partners, or talking with curious visitors easily find their way into the latest news. They ensure public attention via the mass media, and this might compensate for poor application areas. On the other hand, personal (humanoid) service robots fit very well into the demands of a growing service economy that does concentrate less on infrastructure technologies but on individual consumer technologies for the (white) middle-class techno-educated users (figures 13.10 and 13.11).

The general interest in humanoid robots and their function as eye-catchers and high-tech demonstrators in conferences, fairs, and media events has at least four aspects:

Figure 13.10. PBDR, the Partner Ballroom Dance Robot for shy guys. *Source*: Prof. Yasuhisa Hirata and the System Robotics Laboratory at the Tohoku University, Nomura Unison Co., Ltd., and TroisO Co., Ltd.

Humanoid robots serve as charming, pleasurable, entertaining, and aesthetic artifacts and as a "living" sign for the high-tech culture his or her owner belongs to. Their "humanness" reawakens the old feeling of magic and wonder—which brings us back to the function of automata as media of illusion, as curiosa, as fascinating and entertaining entities. Personal service robotics invests in the development of individual consumer technologies using immersion, affective bonding, and attractive design to promote caring, assisting, and especially entertaining machines. Therefore, human-robot interaction (in analogy to human-computer interaction) becomes an innovative research field that relates successfully to the aesthetization of everyday life and the requirements of consumer culture. Tomorrow's humanoid robots are already praised as the artifact with an unbelievable wide variety of possible functions. Working properly, they are supposed to be substitutes for human workers in the service economy on a wide range—as industrial robots have in the industrial sector from some decades ago until now.

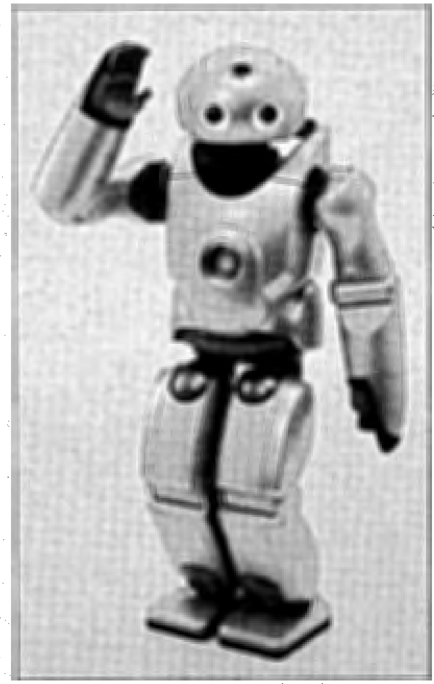


Figure 13.11. Qrio, a humanoid robot and proposed follower of Aibo, also developed by Sony, which was supposed to substitute the Aibo but never did. *Source*: Désirée Kuhn and Sony Deutschland GmbH.

At the same time, the future personal robot—then endowed, it is hoped, with "true intelligence"—also reawakens old colonial and sexist dreams of the always available, obedient servant or submissive housewife who never makes any demands but cares for the master and anticipates his wishes. But imaginations about personal servants also carry the promise of freeing one from everyday duties in the home and the extensive care for the owner of the personal robot. Also, human-robot interaction inscribes itself efficiently into today's Western popular culture with cute artifacts such as Aibo, Asimo, Pleo, or Pino while demonstrating its high-tech capabilities.

"Technoscience Is Fun!"

In terms of science communication, humanoid robots are very rich resources playing not only on the techno-imaginary of science fiction pop culture but also on the tradition of artifacts as source of wonder, curiosity, and amazement. The idea to entangle users in HRI instead of enabling them to control the robot, as well as the importance of humanoid aesthetics, results from the changing relationship of technoscience and media, of today's technosciences, and popular culture. This strategy of immersion is supplemented with one of edutainment and partial participation.

Edutainment and toy robots, such as Aibo or Pino as well as other humanoid or zoomorphic artifacts, provide good opportunities not only to involve laypeople in one's technoscience but also to attract future researchers. Think of the latest dream of the robotics community—a soccer game between humans and robots in 2050. Science festivals like the annual robot soccer competition RoboCup, science fairs, courses in "educational robotics," science museums, and artists-in-residence are other popular strategies and events to attract public attention and to heighten the performativity of one's research and latest artifacts. Robotics—like AI before it—is quite effective in marketing its latest achievements and visions. Edutainment as well as sweet-looking and friendly artifacts help to reshape robotics from a boring engineering discipline with its ugly machines toward a sexy, challenging, and interesting field with friendly, social, intriguing, and—if desired—sexy and unpredictable artifacts. Robotics equips itself with a high entertainment value and stages itself as the result of hard and innovative high-tech breakthrough work at the same time.

This way of self-representation of emerging technosciences can also be seen as a new style in science communication. Science communication transforms from a one-way channel used by an authoritative expert culture to communicate their research findings to the public toward a technoscience communication that builds on edutainment and fun. In a time when citizens are often equated with consumers (Michael 1998), technoscience is presented as fun and edutainment and reshapes itself as user-friendly and open to the public.

Technoscience Engineering Philosophy

At the same time, the old authoritative style of science communication is not totally abandoned; rather, it is reconfigured in an interesting way. While robots are transformed from problem solvers toward social, sexy, and entertaining machines, engineers transform from producers of problem solvers to applied philosophers. As neuroscientists or geneticists were before them, roboticists are now frequently consulted by the media not only to give their technical expertise but to inform us about proper conceptions of humanness and the human condition.[7] Interestingly, although science must justify its research and its work must be application-oriented, we have at the same time a trend toward a renaturalization of body, mind, and society. In search of new certainties, not only the expert opinion of technoscientists but also their "philosophical" judgment is increasingly gaining importance. Technoscientists are increasingly staged as public "philosophers" not only rebuilding bodies and artifacts but consciously and skilfully reshaping our human nature. Roboticists themselves claim that research on robots is helpful to learn about human physiology and nature. Humanoids are interpreted as necessary tools to understand the functioning of humans.[8] And this might be more than a justification for expensive research where applications are still missing.

Humans become the inspiration and model for machine design, and in a feedback loop humans are interpreted in the light of machines. Research programs are "positing the intelligent machine as the appropriate standard by which humans should understand themselves. No longer the measure of all things, man now forms a dyad with the intelligent machine such that man and machine are the measure of each other. We do not need to wait for the future to see the impact that the evolution of intelligent machines has on our understandings of human beings. It is already here, already shaping our notions of the human through similarity and contrast, already becoming the looming feature in the evolutionary landscape against which our fitness is measured. The future echoes through our present so persistently that it is not merely a metaphor to say the future has arrived before it has begun. When we compute the human, the conclusion that human beings cannot be adequately understood without ranging them alongside the intelligent machine has already been built into the very language we use" (Hayles 2003, 116).

It is not surprising that our future copies are so well functioning in the economy of attention. From a functionalist perspective it would be more interesting to build functional robots that solve problems that are unsolvable by humans—for example, by using infrared sensors or laser scanners. In the field of humanoid robots useful functions in the sense of problem-solving capabilities seem to become secondary while the field adapts to the demands of the service economy and consumer culture focusing on entertaining and edutaining and media-effective artifacts. At the same time, it plays on techno-imaginaries from technology history and science fiction pop culture. The integration of technoscience into popular culture becomes a higher priority as technoscience communication is reconfigured as edutainment, fun, and philosophy.

At a historical moment when the relation between science and society opens up and a renewed discourse between public and professional science seems to be possible (Bensaude-Vincent 2001), I wonder if there could be alternatives beyond a hierarchical organized technoscience communication from technoscientists toward the public. A popular but not popularized technoscience embedded in a public discourse could be such an alternative. Educational robotics would be a perfectly suited field for such an enterprise instead of humanoid robotics. But instead, technoscience communication lingers between (re)presenting technoscience as edutainment, fun, the foundation for philosophical expertise, and a source for magic and wonder.

On the one hand, the sacramentalism of science is increasingly deconstructed and a more open and user-friendly marketing of technoscience can be observed. But this new discourse focuses on pleasure, emotion, and immersion, thereby following the demands of today's consumer culture and the stereotypical and more simpleminded aspects of old techno-imaginaries. Technoscience is either reduced to fun or serves as truth discourse on the human condition. I wonder whether at least the fun part—in a less simplified version—could be a starting point to reinvent a new culture of public science. In this new technoscience culture we would not be immersed in old-fashioned stereotypes of master-servant, infant-caregiver relations; instead, we would be immersed in dreams of overall wellness but revive a public culture of participation and the search for more liveable technoworlds.

NOTES

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1. Related to its historical and cultural situation, we already find research in humanoids in the 1970s in Japan.
2. Roboticists are also working in animatronics for the film and theme park industry.
3. See Weber 2008. Some cybernetic researchers, such as Grey Walter, built on self-learning, autonomy, and robustness in the 1940s but were marginalized from the 1960s on with the growing dominance of symbol-processing AI.
4. Cogniron, "The Cognitive Robot Companion, FP6-IST-002020," online at http://www.cogniron.org/InShort.php (emphasis mine).
5. See the pictures of the Geminoid project of Prof. Ishiguro in which he and his research group developed a robot that aims to look like a twin of the professor or the shaping of humanoid robot heads like Einstein, Julio, or Alice by Hansonrobotics (see http://www.irc.atr.co.jp and http://www.hansonrobotics.com/products.htm). I call these humanoids hyperrealist because of the enormous efforts undertaken to make them more "human" than a human can ever be. It reminds me of the performative and elaborate work of transvestites to stage the perfect woman—thereby being more "female" than a woman can ever be.

6. Bernadette Bensaude-Vincent (2001) gives an illuminating historical overview of the relationship between science and the public. She shows that in the eighteenth century, popular science as a common practice was highly valued, and from an amateur perspective science was often perceived in a broad perspective. In the twentieth century a gap between science and the general public grew in the context of new physics and its radical break with common sense.
7. Many thanks to Alfred Nordmann for mentioning this important aspect.
8. See, for example, the new research Institute for Cognition and Robotics at the Bielefeld University, where sport scientists want to work out strategies of optimal human movement by studying the movements of humanoids.

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