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# Emerging and enabling technologies. A challenge for technology assessment

ITAS – Institut für Technikfolgenabschätzung und Systemanalyse

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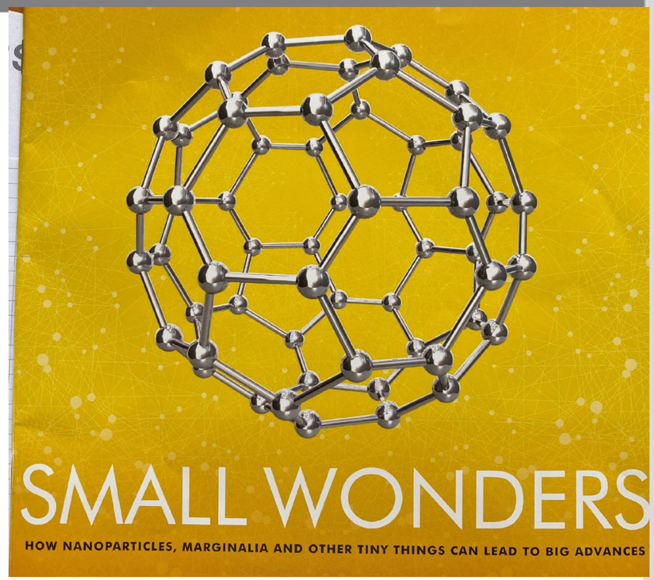
**15TH NANOTRUST CONFERENCE**
**Austrian Academy of Science**

**14TH SEPTEMBER 2023 VIENNA, AUSTRIA**




Aperio Front Cover
Fall 2023/Issue 05

# Structure

1. Introduction
2. Technology Assessment - Motivation and Demands
3. Technology Assessment – New and emergent Technologies
4. Conclusion

# Institute for Technology Assessment and Systems Analysis

**ITAS at the Karlsruhe Institute of Technology (KIT), *Helmholtz Association***

**Research Institute at KIT:**

Research Topics: Sustainable Development Issues, Digital Transformation, Nuclear Waste Disposals, Transition of the Energy System, Biomass to Liquid Fuel, Batteries research, etc

**Research for Policy Advice:**

ITAS runs the Office for Technology Assessment at the German “Bundestag” and is member in the European Parliamentary TA Network “EPTA” 26 Members

ITAS coordinates the European Technology Assessment Group (ETAG) of 8 European parliamentary TA institutions

ITAS advices the German Federal Ministry of Education and Science (BMBF) as well as other Federal and Regional Ministries

# Technology Assessment – The Beginning

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## The OTA at the US-Congress

Act for the Office for Technology Assessment (OTA):

- „To establish an Office for Technology Assessment for the Congress as an aid in the identification and consideration of existing and probable impacts of technological application".
- "As technology continues to change and expand rapidly, its applications are […] increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment.
  Therefore, it is essential that, to the fullest extent possible, the consequences of technological applications can be anticipated, understood, and considered in determination of public policy on existing and emerging national problems."

United States Senate (1972):
Office of Technology Assessment Act. Public Law, S. 92-484

# Technikfolgenabschätzung – The Beginning

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**The OTA act:**

- “It is necessary for the Congress to equip itself with new and effective means for securing competent, unbiased information concerning the physical, biological, economic, social, and political effects of such (technological) applications.”

- The need for advice was central: Congress wanted to be able to better exercise its control function vis-à-vis the executives, was increasingly confronted with studies that also contradicted each other, and missed decision-related information (Büllingen 1999, p. 412)

# TA – Motivation and Demands

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"As technology continues to change and expand rapidly, its applications are […] increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment." (OTA act)

**Demand oriented**

**Ambivalence of Technology**

**Technology conflicts**

**Sustainable development**

**Relevance management and decision support**

Decker, Grunwald
„Demands for and motivations of Technology Assessment"
Handbook of technology Assessment ed. A. Grunwald, forthcoming

# Ambivalence

"Bright Side"

New technology opens up opportunities for shaping the world according to human goals and purposes.
It broadens the range of choices available, diminishes human dependency on nature and on humanity's own traditions,

"Dark side"

Serious adverse effects of technology-based innovation occurred, either as specific events like accidents in technical facilities, others as processes like climate change, spreading of microplastics, and threats to public and democratic communication culture by social media.

# Ambivalence

- Innovation: “The fundamental impulse that
  sets and keeps the capitalist engine in motion
  comes from the new consumers’ goods,
  the new methods of production or transportation, the new markets,….
- [This process] incessantly revolutionizes the economic structure *from within,*
  incessantly destroying the old one,
  incessantly creating a new one.
- This process of **Creative Destruction** is the essential fact about capitalism.”

(Joseph Schumpeter (1942): *Schumpeterian Growth)*

# Ambivalence

- Innovation „creates“ winners and losers
- Different impacts are caused by innovation:
  - Positive/negative impacts
  - Un-/intended effects
  - Un-/desired consequences
  - Main/side effects
  - Chances and risks
- Technology Assessment is doing research on these „impacts“ of *technical* innovation
  - *“Thinking about futures”*
  - ***“Problem-oriented inter- and transdisciplinary research“***

# Ambivalence

At the regional and local level,

unintended consequences can be more easily observed and assigned to a polluter., e.g. by water pollution in the neighborhood of mining sites, by air pollution close to factories or by noise resulting from an airport.

At the global level

effects are becoming more and more relevant, which add up to many causes that are also globally distributed. Climate change, loss of biodiversity, acidification of the oceans, microplastics, or the depletion of resources – they all have been recognized, amongst others, as global phenomena since the 1970s (e.g. Schellnhuber/Wenzel 1998).

# Technology Conflicts - clash of interests:

Different groups are concerned with and affected by technology in different kinds and to different degrees. Examples:

- interests of a local population differ from the interests of decision-makers in a globally acting company.
- interests of shareholders differ from the interests of stakeholders.
- interests of currently living people differ from the assumed interests of future generations.
- interests of people living in a nice landscape differ from interests of the state to build a high voltage power line across this region.
- interests of people exposed to certain risks differ from the interests of those earning money by using the technology that creates the exposition – and so forth.

*Analysing those clashes of interest and contributing to fair and just solutions is among the motivations of technology assessment.*

# Technology Conflicts – value conflicts:

Moral questions regarding the permitted, the desired, the ought, or the undesired are answered differently by different communities, frequently leading to moral but often also to social and political conflict. Examples:

- Whether nuclear power is responsible,
  facing the possibility of accidents and the long-term challenge of safely disposing nuclear waste,
- Whether gene editing may be used for interventions into the human germline,
- Whether human enhancement should be undertaken
- Whether climate engineering is an ethically sound response to climate change

*TA contributes to constructive problem-solving,*
*usually in cooperation with specialized fields of Applied Ethics.*

# Technology Conflicts – *legitimization* is crucial

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For preventing severe conflicts around technology, and for exploring constructive pathways for dealing with them, *legitimization* is crucial.

Formal processes in representative democracies reach limits:

Political decisions are not always accepted by those affected or by the general public, even though they were the result of formally correct democratic decision-making procedures.

E.g., German story on Gorleben as the formerly foreseen final disposal site for high-level radioactive waste.

Large infrastructure projects motivate protest and rejection by the local population.

*Legitimization must transcend the established mechanisms of representative democracy and include elements of ‘deliberative’ (Habermas 1992) democracy with participation of stakeholders and citizens which is a major motivation of TA.*

# Sustainable Development

Technology is part of almost any sustainability consideration.

However, technology has a double role: it is a *problem* for sustainability but simultaneously also may be a *solution* or at least part of solutions to sustainability problems.

This ambivalence calls for shaping technology and its societal embedding according to sustainable development:
Technology should be developed and used to exploit the positive sustainability effects of innovation and minimize or avoid the negative consequences to sustainability.

# Sustainable Development

Sustainable development is a normative postulate based on two ethical principles:

actively taking responsibility for future generations, and ensuring equity among those living today (WCED 1987).

According to this vision, technology as well as societal processes and structures shall be reoriented to ensure both ethical principles:
to enable current generations to fulfil their needs without creating risks for the fulfilment of the needs of future generations.

In 2015, the Sustainable Development Goals (SDGs) were approved by the United Nations to be reached by 2030 (UN 2015) and became a major driving force of international policy-making.

## Sustainable Development

Typical challenges and motivations for TA in this respect include (following Grunwald 2012)

investigations how and to what extent new or modified technologies can contribute to sustainability, taking interactions with e.g. human behaviour or regulation into account;

which incentives may be appropriate to trigger development, production, and dissemination of more sustainable technologies;

which methods and indicators are needed to measure and assess the sustainability impacts of new technology;

how to proceed in cases of trade-offs;

how opportunities for learning and further development of technology can be realized in order to allow for reflexive governance towards sustainability (Voss et al. 2006).

# Sustainable Development

Several experiences have been made in TA to shaping technology for sustainable development. The life cycle assessment (LCA) and related methods have been developed as tools to be used in development and planning (ISO 2006).

The transformation of existing infrastructures such as energy supply, water supply, transport, and information and communications towards more sustainability raises particular challenges.

The socio-technical nature of infrastructures (Edwards 2009, Büscher et al. 2019), issues of acceptance, equity, access, user behaviour, governance, regulation, incentive systems, power and control have to be considered together with the substitution of technologies, rendering the transformation to a socio-technical one involving complex systemic issues and societal controversies (Rohracher 2008, Verbong/Lohrbach 2012).

# Sustainable Development

In contrast,

the sustainability assessment of emerging technologies at early stages of their development is confronted with different requests because only little knowledge about innovation paths, products and services, and possible unintended effects is available.

Prospective assessments of e.g. of new battery systems or AI systems have to apply *prospective* life cycle sustainability assessment (Fleischer/Grunwald 2008, Zamagni et al. 2013) with mostly only few and uncertain data available.

Hence, in these cases the epistemological situation might be the limiting factor resulting in high needs for coping with high uncertainty.

# Relevance management and decision support

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The claim of technology assessment thus seems insoluble.

On the one hand, one would like to integrate the knowledge available today and the known cause-effect relationships for overcoming societal problems into possible alternative courses of action, and must flank these - because they are future-related statements - with uncertainty assessments.

Comprehensiveness, because one would like to consider

all relevant aspects in the analyses,

assess all possible consequences for various societal options for action and their uncertainties

develop alternatives for action of the type,

"if we take this measure today, we will achieve these goals according to the described state of knowledge, whereby the following uncertainties must be considered" (Grunwald 2019).

# Relevance management and decision support

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Different time requirements conflict here:

comprehensive scientific analyses and sustainability assessments need time as well as adequate resources,

but societal decisions have to be made urgently in a timely manner, either because the facts of the case do not allow for any delay, such as the achievement of climate targets, or also because politically pragmatic decisions have to be made within election periods (Decker/Grunwald 2001).

The urgencies of decision-making were particularly drastic in the initial phase of the Covid pandemic, when new epidemiological findings (such as on contagion behavior) led to political decisions (such as school closures) virtually on the following day.

*The demand for relevance assessments.*

# Relevance management and decision support

The urgency of pending decisions and practicality reasons do not allow TA studies with unlimited duration. Thus, a decision must be made for a study as to which facts are considered and thus deemed relevant for the upcoming decision and which are not. This decision influences the uncertainty of the results.

Ultimately, the degrees of relevance then become transparent: Because a highly contagious deadly virus was spreading, policy decisions were urgent. In Germany, education for schoolchildren and students was severely restricted and social contacts minimized; in other European countries, such as Switzerland, a higher incidence/death rate was accepted, and education was maintained. On the other hand, intensive medical care was not closed. With regard to the patients, this was plausible, since death was imminent either from their own illness or from the virus. The nursing staff was thus exposed to a risk that was considered acceptable.

# Relevance management and decision support

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The TA community has a knowledge base that addresses specific questions. Justifying relevance decisions thus presents a specific challenge.

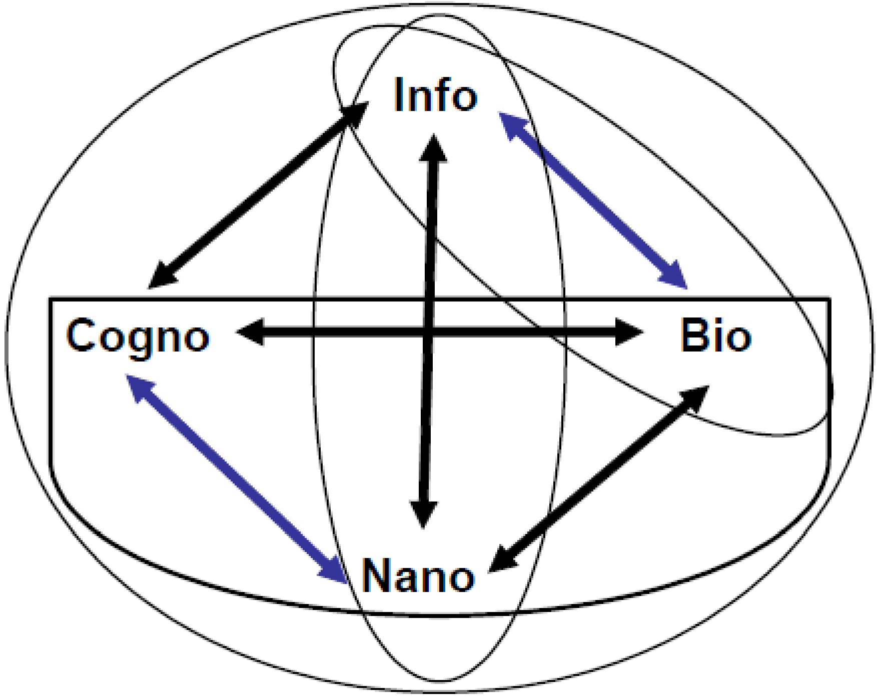
In the knowledge base, scientific knowledge from all disciplines is collected and re-evaluated and integrated from the perspective of TA. In particular, knowledge is generated about cause-effect relationships and relations between different issues, which can then inform relevance decisions.

TA research programs designed for the long term enable the TA community to generate knowledge over a period of years, to explore interrelationships of effects in and between the different sectors.

On the one hand, this enables the development of more comprehensive scenarios for the future.

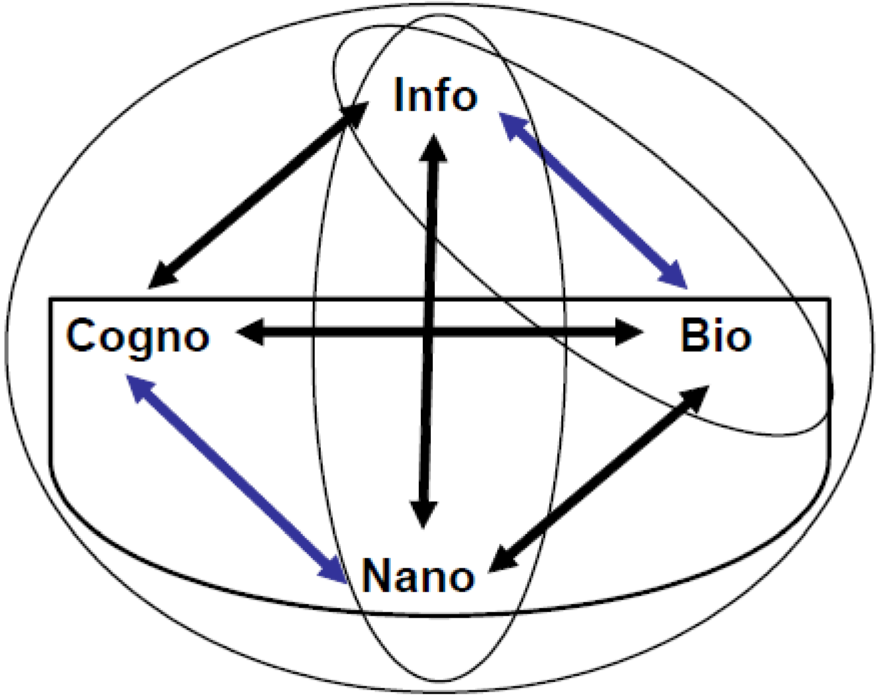
On the other hand, this knowledge base enables the TA community to justify relevance decisions particularly well in terms of alternative courses of action.

# New and emerging Technologies
# NBIC tetrahedron




Convergence of Nano, Bio, Info and Cogno (NBIC) (Roco and Bainbridge 2003, p. 2)

# NBIC tetrahedron




Nanoscience and nanotechnology;

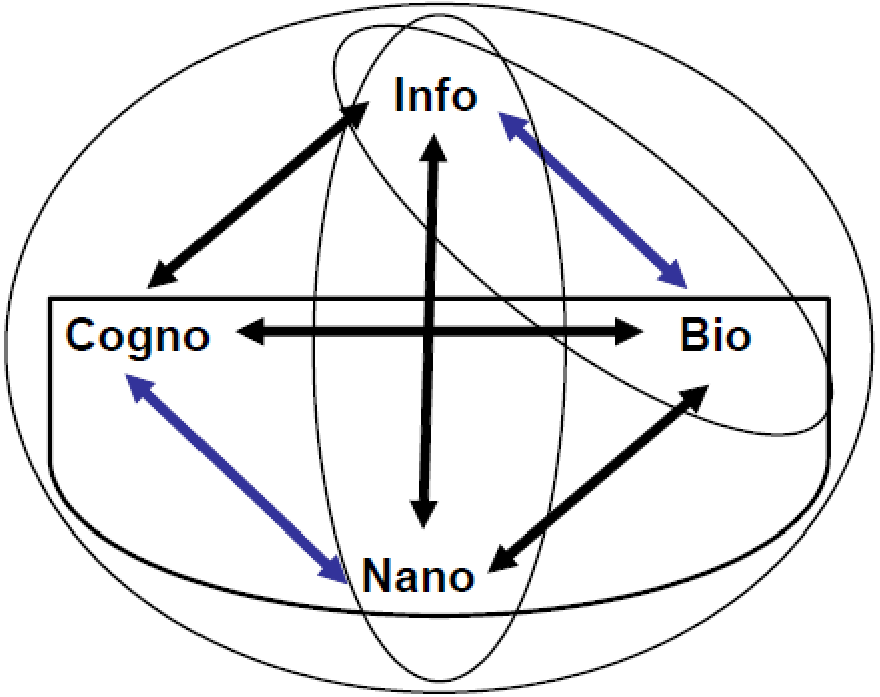
Biotechnology and biomedicine, including genetic engineering;

Information technology, including advanced computing and communications;

Cognitive science, including cognitive neuroscience;

Convergence of Nano, Bio, Info and Cogno (NBIC) (Roco and Bainbridge 2003, p. 2)

# NBIC tetrahedron




[These sciences have now] "reached a watershed at which they must combine in order to advance most rapidly" (Roco and Bainbridge 2003, p. 2).

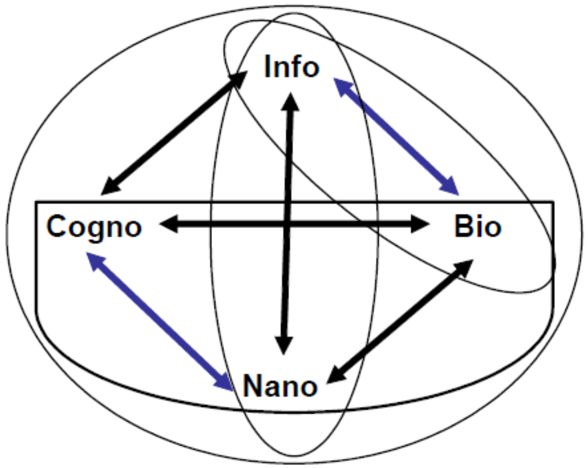
As structuring principles for future technologies the research objects of the NBIC fields like atoms, genes, neurons and bits are accounted for (Roco and Bainbridge 2003, p. 71f).

Referring to the NBIC concept, it has been suggested that "(a)t the nanoscale atoms, circuits, DNA code, neurons and bits become conceptually interchangeable" (Bouchard 2003, p.12).

# NBIC is technology push …

… but raised questions concerning its implications for society, education, and governance.
Structure of the first report (Roco and Bainbridge 2003):

- Expanding human cognition and communication
- Improving human health and physical capabilities
- Enhancing group and societal outcomes
- National security
- Unifying science and education.




The section "Unifying science and education", and also three subsequent reports (Roco and Montemagno 2004, Bainbridge and Roco 2006a, Bainbridge and Roco 2006b) contain extensive discussion of the role of the Social Sciences and Humanities as a research area.

# NBIC is technology push ?

„Europe‘s response“:
Examples of more or less direct reactions to the NBIC report are the setting up of a

**High-level expert group**
"Foresighting the New Technology Wave"
by DG Research of the European Commission
which developed the CTEKS Agenda
("Converging Technologies for the European Knowledge Society")

(for other examples cf. Rader et al. 2007; TAB 2008).

# NBIC framed as demand pull…

*Nano-Bio-Info-Cogno-Socio-Anthro-Philo-*

HLEG
Foresighting the New Technology Wave

Converging Technologies –
Shaping the Future of European
Societies

*by Alfred Nordmann,*
*Rapporteur*

Report

2004

*Geo-Eco-Urbo-Orbo-Macro-Micro-Nano-*

# NBIC framed as demand pull…

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In contrast to the U.S. approach
which exhibits a strong technodeterminist approach
(see for example the analysis of Schmidt 2007),

the European approach to converging technologies
*starts with social and environmental goals*.

In its report "Converging Technologies –
Shaping the Future of European Societies",

the European High Level Expert Group encourages research on topics that are highly valued, thus hoping to initiate technology developments in the *desired* areas (HLEG 2004):

# NBIC framed as demand pull…

- **Health**, including "lab-on-a-chip" technologies for fast screening and early diagnosis of diseases, intelligent prostheses interacting with brain signals from patients and transmitting sensory information.

- **Education** with applications like invisible knowledge space, learning objects and smart surroundings.

- **ICT Infrastructure** with environmental monitoring through ambient sensing devices to alert agencies of pollutants and inform individuals about the distribution of allergens, integration of information about food products.

- **Energy** with new energy carriers and forms of storage, new energy sources emulating nature, exploring renewable energy sources, photovoltaic, hydrogen, geothermal and solar energy.

# Converging Technologies in the media

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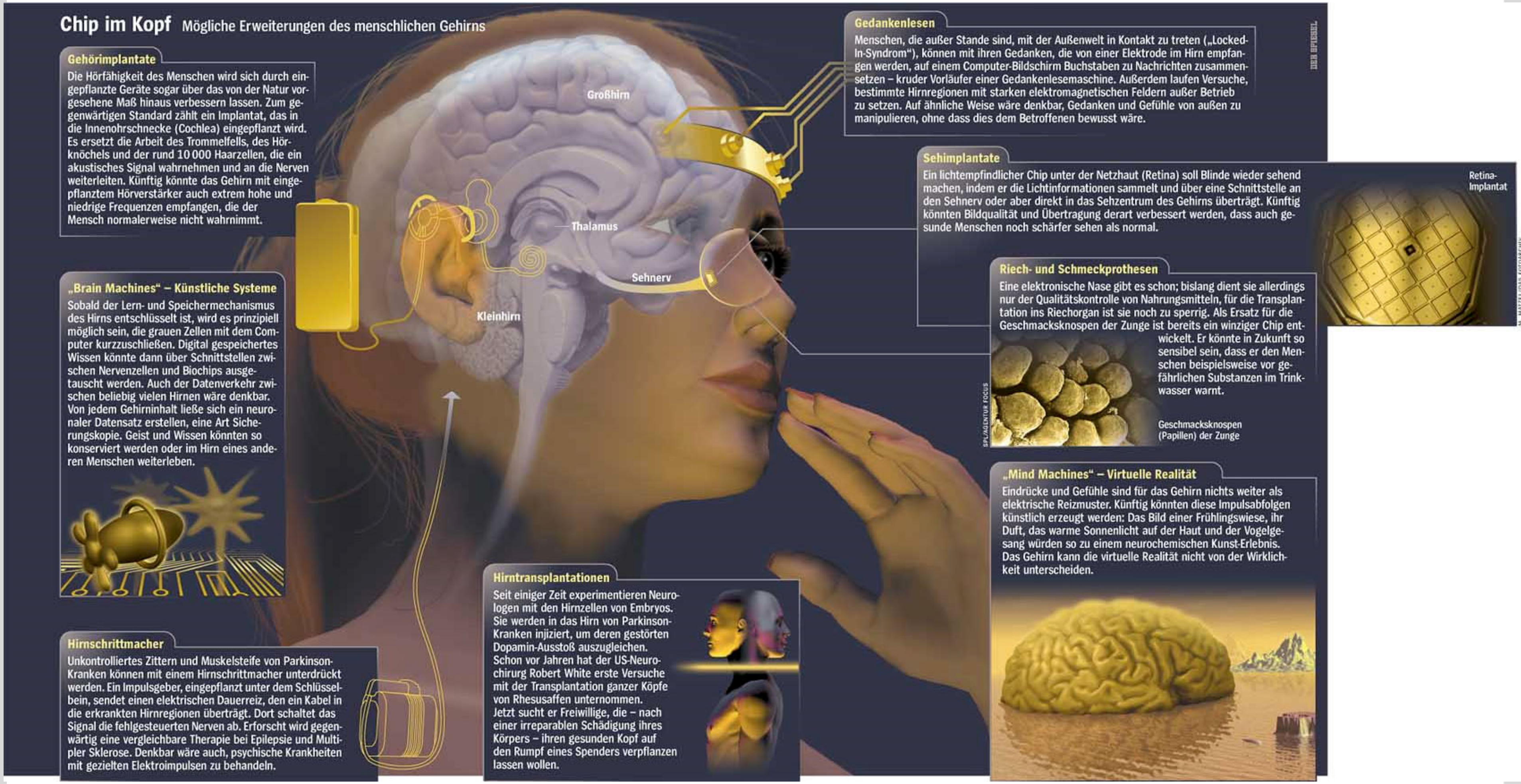

# Vision Assessment

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TA approach of “transformative vision assessment.”
It aims to enhance anticipatory competences, reflexivity, and responsibility of actors in science and society through modulating the visions that influence technological development.

The approach responds to the dominant visions in public and scientific discourse that promise a technology-driven reorganization of society, e.g., a fourth industrial revolution, and fail to meet the complexity of Grand Societal Challenges.

Thus, transformative vision assessment analyses technological visions and modulates visionary discourse through adding sociotechnical complexity and fostering dialogue between science and society.

C. Schneider, M. Roßmann, A. Lösch and A. Grunwald, "Transformative Vision Assessment and 3-D Printing Futures: A New Approach of Technology Assessment to Address Grand Societal Challenges," in *IEEE Transactions on Engineering Management*, vol. 70, no. 3, pp. 1089-1098, March 2023

# Vision Assessment

It is not uncommon in Vision Assessment to consider the imagination of artists when creating potential future scenarios (cf. Frey, Dobroc 2022).

However, almost exclusively works of science fiction, literature or film have been considered here so far, which, in contrast to works of art, reach larger social groups. Works of contemporary art do not have a comparable social impact, but could be analyzed qualitatively as an indicator of social perspectives on technology.

Compare the Asimov's Three Laws of robotics

The current debate on Artificial Intelligence

# Conclusion

Technology Assessment is an scientific endeavor motivated by an extra-scientific demand

Ambivalence, technology conflicts, sustainable development relevance management and decision support

Emerging and enabling technologies: vision assessment

The TA-Community's knowledge base enables high quality relevance decision even in urgent decision situations

The TA-Community is well established
At the National Level (EPTA-Network http://eptanetwork.org/ )
At the European Level (ETAG Network www.itas.kit.edu/etag.php )
At the Global Level?

# Literature


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# Thank you!


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# Ambivalence

Technical and social changes are mutually dependent.

Current observations on automation, digitization and artificial intelligence have the **potential to trigger fundamental cultural changes.**

The changes in the labor market are affecting almost all sectors of the economy and thus creating winners and losers on a large scale

(Frey, C. B., & Osborne, M. A. (2017).

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Transformations like these lead to re-distributions of income, regional welfare, access to services, social reputation etc. Increasing surveillance, manipulation, and threats to privacy and data protection are unintended side-effects of ongoing digitalization.