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The conception of the body in computer science

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Abstract:

The following text discusses the thesis that information technologies produce cultural images of the human which reduce the idea of being human on the mind and lead to a disintegration of the human body. A discourse analysis approach to the creation of Artificial Intelligence (AI) in Germany and an ethnographic research in the scientific community of AI give evidence for a different conclusion. Both, human body and mind have been inspiring resources for researchers in the field of Artificial Intelligence. Those inspirations have not got stuck in abstract visions; they have been materialized in technological solutions. The cultural images produced thereby do not disintegrate or ignore the body. They formulate reinterpretations of the body and the mind which are powerful enough to revise traditional concepts of the human self-perception.

The conception of the body in computer science[1]
Towards a redefinition of a cultural topos in the discourse of information technology[2]

The idea of focusing on the body in computer science was prompted by the impression that computer science literature interprets the human body in a specific manner. Written discourse in computer science continually makes reference to the body in comparison to computer technology. The body is a central metaphor through which the relationship between man and technology is interpreted. Through means of the body metaphor, humans and technology steadily converge in discourses of computer technology to the extent that all boundaries between the two dissolve.[3]

These images are formed by specific epistemological backgrounds and disciplinary interests. The discursive convergence of man and technology appears as a recursive process. The human aspiration to attain a specific position in the world by e.g. dissociating oneself from technology seems to incite some scientists to technically reproduce exactly those dimensions shaping the exceptional features human beings are founded upon. Having achieved this, man starts to construct a new self-image by formulating new frameworks which then serve as the new research programs for technical and natural sciences, until they, too, have lost their value and new constructions of the human self become necessary. We as a culture seem to be confined by this technomorph view of ourselves. As human beings we become technically and economically available.

In order to not lose myself in the numerous branches of computer science, I will concentrate in the following discussion on the reconstruction of body imagery within the discourse on artificial intelligence (AI).[4] AI constitutes a part of computer science and is involved in reproducing the performance of intelligence on the computer. Despite the existing love-hate relationship between AI and computer science with their reciprocal and often rather obvious attempts to dissociate, I see manifold similarities between the cognitive and historical identities of the engineering-oriented scientific approach of AI and the technically directed computer science. There are obvious parallels (or similarities) in the inventors' personalities, including their professional heritage, as well as in their attempts to imitate cognitive performance on the computer..[5]

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[1] The following considerations are a revised version of an book section of the compendium “Körper-Konzepte” that was edited by Julia Funk and Cornelia Brück in 1999. It might seem unusual to revert to a scientific publication after five years. However, as this research contributes significant insights to the relation of science and humanities, and as it has not been published internationally, now is the right time (also in my academic career) to discuss it with a transdisciplinary academic audience.

[2] I am grateful for the comments Jennifer Hirte made on this version.

[3] It has been a challenge throughout this paper to convey the notion of the German term „Körperlichkeit“. It includes and emphasizes the internalised and incorporated behaviour, the “body language”, and the culturally shaped dimensions of the body, whereas the English language offers no similarly complex term known to me.

[4] For reasons of coherence only the German discourse of Artificial Intelligence is focussed.

[5] Before reconstructing the conception of the body in computer science, concentrating on AI as an example, I would like to point out that the interpretations of the body in AI here presented appear as dominating ones (in theories, scientific traditions, in powerful protagonists` utterances, etc.) but that they are, however, not as mutually shared in the AI community as they may seem. In my representation I will therefore follow the scientific mainstream of AI.

Organic and technical bodies

It seems quite clear that the suppression of the body is a side effect of a scientific research project that regards human thinking as information processing or as a result of the manipulation of symbols. To describe these trends as *disembodiment,* as is often done in the social sciences, makes little sense, in my opinion, because the body – as we will see in the following discussion – despite attempts to minimize its significance, will always remain a point of reference. There can be no question of a complete negation of the body or even of a total disappearance of the organic body in AI-discourse. The ways in which the body is spoken of in AI-discourse are manifold. Therefore it appears to make more sense to ask about the specific body images that are generated than to make assumptions about disembodiment.

To arrive at the roots of the interpretation of the body in AI, I must at this point extend my gaze beyond the realms of the AI-discourse and examine the earliest attempts of American cybernetics to technically reproduce the human mind. Cybernetics – which at this early stage was mainly occupied with laws of control and regulating mechanisms in technology and biology – created in its discourse images of the body that are still referred to in AI today. In the essay `Behaviour, Purpose, Teleologie´ by Arturo Rosenblueth, Norbert Wiener and Julian Biegelow[6] – fundamental to cybernetics – feedback processes are shown to be of central importance for controlling behaviour. They define the interplay between providing feedback and optimizing behaviour. Behaviour is understood here as a behaviouristic concept that regards the organism as a black box, i.e. only its observable behaviour matters, not the internal processes causing this behaviour.

This black box principle makes it possible to devaluate the distinctiveness of the single (organic or technical) body. Whereas in early cybernetics the whole body was regarded as a black box, over time this view was also applied to its parts: the brain, skin, eyes, etc. The feedback processes, considered to be the central processes controlling behaviour, were differentiated some years later by Norbert Wiener. Wiener made a distinction between homeostatic feedback, such as muscle contraction, which occurs unconsciously, , and intentionally determined, postural feedback.[7] The controlling principle inherent in feedback is that it is seen as being independent of the matter. Scientifically isolated functional elements of the body can then be accorded a technical equivalent. Neurons become relays, nerves become electrical conductors, etc. This establishes the theoretical requirements for isolating biologically perceived (behavioural) processes from their original (scientific) context and applying them to technical systems.

From this point of view, the difference between technical and organic creatures becomes negligible. The organic body – which can no longer truly be described as a human body, emerging here rather as a peculiarity of a biological species – appears similar to technology as

[6] Arturo Rosenblueth, Norbert Wiener and Julian Biegelow, `Behaviour, Purpose, Teleologie´, in: Grundlagenstudien aus Kybernetik und Geisteswissenschaft, als Beiheft des Jahrgangs VIII (1967), (first edition published in 1943 in the original), 18-24

[7] Norbert Wiener: Kybernetik. Regelung und Nachrichtenübertragung im Lebewesen und in der Maschine, second revised edition, 1963, and: Mensch und Menschmaschine, Kybernetik und Gesellschaft, third edition, Frankfurt a.M., Bonn 1966.

a system. Consequently, this allows for the two to be examined, at least at the behavioural level, with the corresponding methods. The early cyberneticians however did not equate organism with technology.

Rosenblueth, Wiener and Biegelow made the following distinction: *"Whereas the behaviouristic analysis of machines and living organisms is very similar, a functional examination differs enormously between both groups. Regarding the structure, organisms are mainly colloidal and primarily contain large, complex and anisotropic protein molecules. Machines are for the most part metallic and essentially contain simple molecules. From an energetic point of view machines typically show relatively large potential-differences allowing a rapid release of energy; in contrast, this energy is more evenly distributed in organisms. In electrical machines, the electric current relies on electrons, whereas electrical changes in organisms rely on ion-movements."*[8]

The organic body clearly functions as a model and remains a reference and orientation tool for cybernetic research. However, it is also clear that given the technical possibilities, different paths other than those of evolution must be pursued. The exact reproduction of organisms is nevertheless set as a long-term goal. *"In the future, when knowledge of colloids and proteins has grown, engineers may try to build robots which resemble mammals not only in their behaviour but also in their structure. The best model of a cat is of course another cat, no matter whether a cat gave birth to it or whether it was produced in a laboratory."*[9]

The exact reproduction of an organic body via technical processes is considered the ideal case in cybernetics. While the organic body is perceived to have a specific materiality, this substance is merely regarded as the carrier of a certain behaviour one aspires to technically reproduce. Behaviour is here described as always purposeful and controlled through feedback processes, i.e. through the interplay of feedback and behaviour optimizing. The image of the organic body, predominant in cybernetics, is a body already scientifically prepared; it is segmented, functionalized, structured, genderless and therefore useable for technical purposes. In cybernetics the function of the organic body resembles that of the technical body – the latter can be reproduced – although in technology one might seek solutions other than those offered by nature. Alongside matter and energy, information is established as a physical parameter in cybernetics. This creates the basis for the information processing paradigm, which then in turn serves as the epistemological basis for AI. The human brain became one of the objects this idea was tested upon. In doing so, one remained close to the natural model and its evolution, attempting to imitate it by means of technology. The aim was to work 'bottom-up' from models of simple organisms to humans, with the help of *"adaptive networks*" and "*self-organizing systems"*. This attempt to arrive at artificial intelligence by modelling it on neural networks culminated in the development of the so-called "Perceptron" of Frank Rosenblatt (1960), which more or less pursued the principles of autonomy and self-organization to achieve its results.

One criterion for defining when a reproduction of the human mind can be called successful was given by Alan Turing when, in 1950, he developed his imitation game today known as the

[8] Rosenblueth, 22
[9] Rosenblueth, 23

Turing-test. It works as follows: a person and a machine communicate anonymously with an interrogator who asks the same questions of both. If the interrogator was unable to distinguish the machine from the person by their respective replies, then the machine could undoubtedly be seen as intelligent. Turing's texts are imbued with `cybernetic´ body images. Human and technical bodies are regarded as systems which appear to be easily comparable at the behavioural level. The *"thinking machine*" was a term that Turing believed could be applied to humans as well as to digital computers. In the same way that he saw the *"human as a machine*" or the "*cerebral cortex as an unorganized machine*", he described the characteristics of the computer as its *"nature*" or considered how the mental, genetic and cultural evolution of humans could be realized on the computer in form of search procedures. Turing was convinced that it must be possible to technically imitate every single small component of the human being – that humans could be segmented into operative parts and, as a result of this, their behaviour could also be scientifically defined and reproduced. The principle of organization, a much-discussed subject within cybernetics, constituted for Turing the key principle for the technical reproduction of human behaviour. He was quite aware of the importance of the body--and especially of intelligence--for human behaviour. In 1969, he wrote in his essay *Intelligent Machinery*:
"A possible way to pursue our intention of constructing a ´thinking` machine would be to take a human being as a whole and to try to replace all his components by machines. He would consist of TV cameras, microphones, speakers, wheels and `servo-joints´ as well as a kind of `electric brain´. This would of course be an enormous undertaking. The result would be of immense size when producing it with current technical means, even when the `brain´-component was stationary and the body was steered from afar. In order to enable the machine to have experiences on its own, it would need permission to roam freely, and danger for normal citizens would be serious. Moreover, the creature, even when furnished with all the mentioned equipment, still would have no relationship to food, sexual intercourse, sports and many other things that are so interesting for human beings."[10]

As the complete technical reconstruction of the human being appeared impossible, Turing suggested trying to see,*"what can be done with a `brain´ that more or less is without a body and furnished at the most with organs that allow it to see, speak and hear."*[11]
With his suggestion to reduce the complexity of the organic body and limit it to a few essential basic elements he was perfectly up-to-date in 1969. The AI-community at that time, led by Marvin Minsky, was turning its back on cybernetic experiments that attempted to construct a learning network based on evolutionary principles with the brain as its model. The cybernetic path to artificial intelligence found its end here, at least for the time being. In the literature this is attributed to the various technical problems, among them, computer capacity, speed and costs. From then on, AI research was dominated by so-called `top-down´ approaches. These had developed in parallel to cybernetic research and attempted to simulate those human skills on the computer that were regarded as highly intelligent, e.g. playing chess or proving

[10] Alan Turing, „Intelligente Menschen", in: Bernhard Dotzler and Friedrich Kittler (eds), *Intelligence Service*. Berlin 1987 (published in 1969 in the original), 81-114, 97.
[11] Turing, 97

mathematical theorems. They gave up on evolution-oriented strategies of technology development (self-organization and ability to learn) and tried – in the common engineering tradition – to construct intelligent computers in such a way that the internal processes of the technical artefact were planned and determined from start to finish. In theory, this `top-down´ approach was developed by the American AI scientists Allen Newell and Herbert Simon (1975) in their *`Physical Symbol System Hypothesis´* which continues to form the basis of the scientific and technical concepts of classical symbolic AI, and represents a specific type of the information processing paradigm. The *`Physical Symbol System Hypotheses´ (PSSH)* states that knowledge (1.) is mentally embedded in the form of symbolic representations and can therefore be explicated, and (2.) is structured and can be dissected.[12] Newell and Simon are of the opinion that:

"A physical-symbol system has the necessary and sufficient means for general intelligent action."[13]

They thereby laid the groundwork for the widespread idea in AI that humans and digital computers process information in a similar and comparable manner. When focusing only on the reproduction of intelligent behaviour, the organic body can be reduced to the organic system in which the intellect is assumed to be located – the brain. Function and structure do not have to be replicated exactly by technology; it suffices for the output of the system to appear as intelligent behaviour. The cybernetic view of the body as a black box remains, while the differentiated view of the organic body, which in cybernetics had been perceived as being structurally and functionally different from that of the technical body, is lost. Its spatiotemporal conditionality explicitly emphasized by Turing vanishes into oblivion. Although the body experiences an extreme minimization in symbolic AI, this cannot be interpreted as a complete disembodiment. A complete disembodiment might have been the goal of a few AI-protagonists, but the body has always remained a point of reference for the technical project. Newell and Simon also refer to these material dimensions when characterizing their symbolic systems in information processing as `physical´. Furthermore, both scientists stress in their introduction that their research focuses on the combination of material/physical and symbolic/mental processes. *"The machine – not just the hardware, but the programmed living machine – is the organism we study."*[14]

Furthermore, the question remains, whether Newell and Simon understood their PSSH as an exclusive paradigm for AI. They described their hypothesis as necessary and sufficient for intelligent operations, but they never claimed that intelligence could be reproduced with it entirely. Instead, both emphasized the wide range of possible viewpoints in a *"computer science", where its "organism, the machine, can be studied at many levels and from many sides." "For the hare as lecturer will have to make an annual sprint to overtake the cumulation of*

[12] Barbara Becker, „Die Veränderung von (Experten-)Wissen durch den Prozess der Wissensaquisition", in: *KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen,* 4/2 (1990), 31-34.
[13] Allan Newell and Herbert Simon, „Computer Science as Empirical Inquiry" in: *Communication of the ACM* 19/3 (1976), 113-126, 116.
[14] Newell and Simon, 113.

small, incremental gains that the tortoise of science and technological development has achieved in his steady march. Each year will create a new gap and call for a new sprint, for in science there is no final word."[15] Newell and Simon might have understood their PSSH not so much as the key to understanding the human mind but rather as a paradigm which needed to be tested to see how far it could go. The AI-community in the USA as well as in Germany tested the PSSH so extensively that it basically amounted to a confirmation of its exclusive validity. Cybernetic bottom-up approaches completely disappeared from AI research, so that one lost sight of the importance of the body for the phenomenon of intelligence. However, despite all suppression of the material dimensions of intelligence, the brain as an organic system, assumed to create intelligent behaviour, continued to have a model function for the construction of those technical systems which scientists wished to furnish with exactly that kind of behaviour. Even symbolic AI, which had often been criticized because of its implicit disembodiment, consistently related to the organic body – this body, however, having been significantly reduced to the brain. That the mind, which was apparently freed from the body in symbolic AI, found itself tied to a body - even if only to a technical body with a specific materiality – was a fact generally ignored by AI-scientists at this stage.

The body, which AI tried to narrow down to the brain, would have been defined as gender neutral, had feminist criticism not pointed out that such seemingly genderless scientific concepts often hid an androcentric world view. Particularly the concept of the logical machine, adopted from cybernetics and having influenced the scientific approaches in AI over a long time, refers to the culturally dominant symbolic system in which *man and mind* and *woman and body* are associated in manifold ways. It seems no coincidence that symbolic AI limited its scope of research to the brain while attempting to rid itself of those parts of the body culturally linked to illogicality, emotionality and reproduction. Particularly those dimensions that our culture allocates to the domain of women were regarded as insignificant and relegated to the rest of the body, which in cybernetics had still been regarded as enormously important for personhood.[16]

These so-called feminine, body-oriented dimensions were not only eliminated in AI research but had already been excluded from the concept of intelligence. Even the Greeks had viewed *intelligentia* as a pure mental state, regarded as divine and open only to humans in certain situations. According to a study by Heike Stach, this higher spirituality found its place among the ancient Greeks in the masculine world of philosophy which stood in opposition to the prevailing subordinate feminine sphere of the body. *"The male sperm was regarded as virtually spiritual. Pregnancy was envisioned as the mere material embodiment of the structural instructions given by the man to the woman in the form of semen during the act of procreation*."[17] Although the term 'intelligence' has undergone numerous semantic changes throughout the centuries up until the present day, its association with the male domain and simultaneous elimination of the female domain has remained extraordinarily stable and only recently been put to question from a feminist point of view.[18]

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[15] Newell and Simon, 114.
[16] cp. e.g.: Gernot Böhme: „Am Leitfaden des Leibes – das Andere der Vernunft", in: Ilona Ostner und Klaus Lichtblau (Eds.), *Feministische Vernunftkritik, Ansätze und Traditionen*, Frankfurt a.M./New York 1992, 53-65.
[17] Heike Stach, „2000 Jahre Intelligenz?", in: KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen, 9/4 (1995), 47-51, 48.
[18] The semantic changes of the term 'intelligence' were reconstructed by Stach (see 13).

In retrospect, it can be said that the persistence of AI´s discursive and theoretical aspirations to reduce the body to the intellect provides ample evidence for the failure and futility of these attempts. This futility has been recognized today by a number of male and female scientists in AI research when encountering limits in their research and development. They have therefore turned to reproducing the organic body in a more complex technical manner.

The technical reconstruction of the body

The phase of the 'minimization of the body' in AI is meanwhile coming to its end. In Germany, towards the end of the 80's, a technical reconstruction of the body, harking back to the cybernetic traditions of self-organization and learning ability – a development that had already started earlier in the US, took off. Today, human cognition is no longer exclusively reduced to processes of symbol manipulation. Instead, physical dimensions are perceived within the AI community as a precondition for cognitive performance, while at the same, time symbolic AI is regarded with growing skepticism.

Particularly in the attempt to automate intellectual abilities, AI became increasingly aware of the importance of the body and – compared to technical possibilities – its enormous achievements. The body also entered the discourse of scientific and technical AI approaches through a paradigm conflict between symbolic or classical AI, which up until then had remained unchallenged in guiding AI research findings, and subsymbolic or connectionistic AI. In contrast to classical symbolic AI, which attempts to explain cognition only on the basis of matter-independent, symbol manipulation, connectionism refers to neurobiologically won knowledge that regards intelligence as an emergent phenomenon and as therefore connected with its organic substratum, the brain. In accordance with these neurobiological research findings, connectionistic AI tries to technically convert the materiality of the brain into forms of *artificial neural networks* which differ from classical symbolic AI computers in structure and function. The so-called parallel `computer architecture´ of artificial neural networks consists of a multitude of very simple processors that are linked to each other without being controlled or determined by a central processing unit (CPU).[19] Knowledge is no longer depicted in symbolic representational structures as in classical AI but in the form of activity patterns which create themselves by `practicing´ learning examples – in other words, they are not explicitly programmed. Artificial neural networks[20] should acquire required knowledge based on the principle of self-organization, in a way similar to the brain. Thus, one hopes to profit from the advantages the brain has over the computer. Essential goals of connectionism are on the one hand, the previously mentioned learning ability, and on the other hand the human brain's error tolerance that enables humans to understand a given meaning even when information is faulty or incomplete; the overall ability to perform is maintained even when particular neurons and neural systems fail to function.

[19] However these neural networks do not necessarily have to be realized as hardware with single interconnected processing units – it is also possible to simulate them by using the appropriate software on traditional "Von-Neumann-Architekturen". For the users of such systems it is in most cases not traceable whether a connectionistic or classical AI-system is implemented on their computer.

[20] Connectionistic systems are based on a multitude of simple processors which correspondingly can only carry out simple functions and are networked. This networking enables a simultaneous interaction of processors that should lead to the aspired solution of a problem. To picture such a system it can be thought of as a network of several knots, in which each knot represents a certain concept or content. The connections between the knots are referred to as links which are weighted differently according to the intensity of the connection. If this network represents the plan of a house the individual knots represent concepts such as windows, walls, stairs, etc.. Depending on the strength with which these concepts/knots are tied to each other or how strong the weighting of the connecting links is, one can identify different types of houses. High-rise buildings for instance have a lift; high-rise buildings and lifts therefore obtain a link with a high weighting in this scheme. Detached family houses, however, hardly ever have lifts but often have a garden, so that the connection with the link to the lift is very low, while the connection with the link to the garden is weighted highly. Strongly associated knots have a high value of activity due to their connection with links, which depending on the intensity of the connection will increase or decrease. In this way, connectionistic systems are able to, in a sense, "learn". cp.: Joachim Diederich: "Trends im Konnektionismus", in: KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen, 3/1 (1988), 28-32, 28.

The explosive potential connectionism brought to AI[21] in terms of epistemology was discursively eased by defining connectionism not as an independent paradigm but merely as an operating strategy, and further by only putting it into practice in this way. AI could, paradoxically, only acknowledge the organic body by reducing it to its medial functions of information processing, thereby again ignoring the central dimension of bodily concepts such as the materiality of the organic substratum and its evolutionary conditions. In this way, the AI-community integrated a "bottom-up-approach" attempting to conceptualize intelligence within its organic preconditions, with an ideational structure that was molded by symbolic AI, without having to revise either its epistemological basic assumption or the computer metaphor of the mind. The successful integration of connectionism can be seen as precedence for the further perception of embodiment in AI. Its integration came to represent the consideration of bottom-up-approaches throughout the German AI community.

This acknowledgement of the bodily aspects of intelligence could develop only gradually, however, due to competitive conditions within the community. Initially, it limited its focus to the organ where the mind was assumed to be located; sensations, motility etc. were hardly taken into consideration. However, the basis for reassessing the role of the body within AI research was laid: (1.) The principle of *self-organization* was newly established in technological development. It describes the biological process by which more highly evolved creatures are able to, as one might put it, construct themselves – a thought further developed in the principle of *coded self-organization*. Early cybernetics had explored this idea before, but, being too technically difficult and too expensive to pursue, it was dropped,. Applied to AI, the idea would be that the internal processes of a technical system organize themselves. Thus, one abandons traditional notions of engineering work, such as thoroughly structured construction plans, knowledge of internal processes of systems, planning and controlling feasibility, etc. (2.) Since the successful harmonization of connectionism, AI has increasingly opened up to bottom-up approaches and neurobiological and -physiological findings, which it eclectically uses for its own interests. (3.) Well-known principles of `biological body-production´ have become more attractive to AI, namely evolution and genetics. *Genetic algorithms* and also concepts of *heredity* in object-oriented programming languages are two of the metaphors which demonstrate AI's technological approach to the biological body. The shared basic assumption of the information processing paradigm in gene research and AI alike offers an ideal precondition for this. The term *genetic algorithm* originates from *Artificial Life* (Alife), a field of research that

[21] Connectionism and its neurobiological references evoked topics in AI that had so far not been dealt with. The basic assumption of connectionism that intelligence as an emergent phenomenon is tied to the brain as an organic, evolutionary substratum, fundamentally questions the feasibility of artificial intelligence. Connectionism confronts AI with basic questions: Is it possible to examine intelligence independent of humans or specific creatures? Can intelligence be regarded as an individual phenomenon when taking into consideration that patterns of perception and thinking are culturally formed? Can AI-systems acquire the ability to learn in the same way humans do? The AI community's attitude towards the connectionistic paradigm was correspondingly critical and negative. On the other hand connectionistic methods were attractive to AI because they brought technical success to those areas which up until then had not allowed any approach to solutions, such as the ability to learn or adapt to environmental conditions. The technical options connectionism offered were as important to the AI community as the aspiration to create mechanical intelligence. After hefty disputes among the different parties it became possible to ignore the epistemological explosive force of connectionism and thereby make the connectionistic methods adaptable to symbolic AI. In the discourse, connectionism was reduced to dimensions which did not question the computer metaphor of the mind and consequently fit into the ideational construct of AI. That connectionism could also be integrated on a technical level was a necessary precondition for its acceptance in AI. This union of connectionistic and symbolic methods could be made in so-called hybrid systems which were especially wide spread in robotics. Today, connectionistic methods have achieved a highly visible position in AI.

developed at the end of the 80s. This field examines basic principles of life, and allows the synthetic creation of alternative forms of life – including forms that are not necessarily related to biological models. The Alife-approach takes up the cybernetic tradition and applies bottom-up approaches in examining and replicating fundamental features of autonomous systems necessary for autonomy and survival. Accordingly, it is necessary for the further development of Alife to create interactions between artifacts and habitat – a problem AI is also engaged with, especially in the field of robotics, as well as in speech recognizing systems and other areas.[22]

The body metaphor in the current technically oriented AI still refers to a technically reproducible body, although the demand that this be met entirely has slightly decreased, at least in terms of the technical production. When considering the principle of self-organization, which was already applied in cybernetics, the demand for control and knowledge of the computer's internal conditions is relinquished in exchange for its ability to function. The body then is only examined in search of specific abilities regarded as profitable and necessary for technical development, focusing on categories such as sensory skills and the ability to perceive, move and orient. These appear to be the dimensions AI-systems lack in the performance of intelligence. The body is here perceived as a location of input, as interface of man and environment, only having achieved importance because bodiless concepts of intelligence have proven unrealistic. The new perception of the body in AI can be tied into the already scientifically-technically prepared, functionalized, organic body. Similar to the brain, the organic body as a whole is now seen as a subsystem of information processing. The body is perceived as a home for a higher project, the intellect. Scientific approaches in AI regard the body merely as an additional category that must be considered in order to perfect technical functions. The hierarchy of mind and body remains. The abilities that cannot be reconstructed logically and therefore appear to be tied to the body are defined, not without a certain devaluation, as "intelligence without reason".[23] It appears that AI can forgo certain dimensions of the mental-physical sensorial nature – the above-mentioned term 'sensory skills' might be more appropriate here. In principle, emotionality seems to be feasible, but it is not regarded as useful – for the time being. As one of the founders of AI in Germany points out: *"As soon as you consider the specific characteristics of humans, their relation to their bodies, their emotional life, the ability to move around freely and their interpersonal relationships, you realize that first of all it would not make sense to duplicate these – when the body of an artificial creature is not the body of a human – and that then also certain values, aims, intentions and also the perception and rating of relevance would be different when done by a machine! That means there are natural areas where one can imagine using mechanical intelligence and then again there are others, … where it does not make any sense! And about these one cannot really say much. Well, one would just not want to bring mechanical intelligence into these areas."*[24]

[22] cp: Kerstin Dauenhahn, „Artificial Life = Künstliches Leben?", in: KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen, 9/2 (1995), p.34; or: Stephen Levy, The Quest for a New Creation. New York, 1992

[23] Wolfgang Bibel and Ulrich Furbach, „Logik, KI und Intellektik". In: KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen, 6/3 (1992), 91-94, 93.

[24] Interview with Prof.Dr. Neidhardt (names have been altered), transcript, 5. The interview with Prof.Dr. Neidhardt, one of the founders of AI and today in a leading position, was carried out by me when doing field research in the AI community. Also the two

The pointlessness of reproducing emotions is accounted for by stating that there are areas where it makes sense to use technology, and areas which are originally human and where mechanization appears to be futile. The boundaries between these originally technical and human areas are described as naturally given, i.e. they follow (as is common in sciences) a fixed law and are consequently clearly defined – or in any case not culturally constructed and thus flexible. In this argumentation a certain contradiction cannot be concealed. on the one hand, technology penetrates the area of emotions, while on the other hand, this area is characterized as originally human. The "*natural area*" of technology, when looking more carefully, turns out to be a territory defined by scientists, i.e. they are the ones defining the border between humans and technology.

The topos of sexuality is completely omitted in AI scientists' discourse on the body - it does not exist in the technical reproduction of the organic body. Reasons for omitting this theme are certainly complex and manifold. If one wishes to speculate on this, then sexuality can, on the one hand, of course, be characterized as one of those areas that is "*originally human*" and so appears to be technologically pointless. On the other hand, it could be assumed that the topos of sexuality, which is apparently omitted from AI discourse, implicitly emerges where AI-language is imbued with metaphors of creation and life. In this respect, a reason for remaining silent about sexuality appears to be that the natural act of reproduction is a continuous challenge, particularly to those technologies that attempt to reproduce organic bodies either in part, meaning certain specific functions, or completely. The interest in the organic body is a technical one. From this technical point of view, the body is defined and made available for the project of mechanical intelligence. And it is clear from the start that when reconstructing the body technically, its material dimensions also have to be considered.

interviews quoted later were part of an empirical study integrated in my dissertation concerning the theme: Technikgenese und-gestaltung als kultureller Prozess. Das Beispiel Künstliche Intelligenz".

New materials of artificial intelligence

Symbolic AI is still dominating research, but the perception activated by connectionism and the eclectic integration of bottom-up approaches might herald (or introduce) a new tendency. I would like to outline this tendency in the following discussion and single out its speculative nature, which only becomes apparent occasionally: the reconstruction of the body in AI could be associated with an increasing understanding of how closely humans identify with their bodies. Although AI largely perceives the body in a functional manner as a system and a medium, the consideration of material aspects is beginning to appear. Thomas Christaller, a well-known AI scientist has recently alluded to new results in cerebral research showing "*that those processes which are commonly interpreted as neuronal information processing are constantly changing their physical-chemical basic mechanisms. In other words: cerebration affects matter and energy, which provide the material substratum for its process, in a way that can change the process of cerebration itself so that in principal it becomes irreproducible."* Based on this, Christaller arrives at the following conclusion in respect to AI´s research strategy*: "The demand for embodiment, for situatedness and bottom-up construction points in the right direction. But the existing empirical findings in the natural sciences have to be taken up on a much larger scale to formulate a research program for artificial intelligence that allows the construction principles to develop for potential intelligent artefacts on the basis of insights won from nature.*[25] This suggests a return to the idea formed by cybernetics and clearly emphasized by Turing: materials other than electronics are better suited to reproduce the phenomenon of intelligence. The heightened consideration of the material aspects of cognition could ultimately lead to a rejection of the computer metaphor and a turning to organic materials.[26] This would, however, also include a qualification of the cybernetic thesis that behaviour is independent of matter. The consideration of the body in its entirety as well as its material aspects could - at least provisionally - result in a new form of differentiation between human and technology, which is not qualitative but quantitative in its hierarchy of intelligence. Here, as well as in other parts of AI discourse, the argumentative strategy of emphasizing the uniqueness of humans when compared to technology becomes apparent, although it is still disputed in scientific issues and research objectives. The dissolution of the boundaries between humans, animals and technology is not hereby reversed. Intelligence, even when regarded as a phenomenon bound to the body, would still remain a shared feature, a combining element between the bodies of humans, animals and technology. Organic bodies could, even with this – for humans seemingly

[25] Thomas Christaller, „Von Artificial Intelligence zu Artificial Life und wieder zurück", in: KI, Künstliche Intelligenz – Forschung, Entwicklung, Erfahrungen, 10/4 (1996), 41-44, 43.

[26] While frantically searching for faster and smaller circuit components, the computer industry has now been working for many years on the development of so-called protein circuit components to replace the semiconductor material silicon. The basis for such circuit components is the enzyme bacteriorhodopsin which is used on a molecular level and can be utilized as a storage element through exposure to light. This experimentation with organic molecules is described in so-called "hybrid systems" as a connection of electronic and biological components. (compare: Jens Krätzschmar, "Das Ei des Kolumbus, Eiweiß als Nachfolger von Silizium", in: c´t, magazin für computer technik, o.J./10 (1996), 106-108). A first breakthrough appears to have been made meanwhile in display screen technology. (compare: Jürgen Rink, "Leuchtendes Plastik, Erstes hochauflösendes Polymer-Display", in: c´t, magazin für computer technik o.J./5 (1998), 38-39). It would, however, require a closer look to see if this really is heralding the era of "*living components*" in computer technology. Because in these applications proteins i.e. the `modules of life´ are merely employed on a molecular level and the functionality of protein molecules rests on actinic- and not on metabolic processes, which are regarded as characteristic for life.

safe – buffer of difference, still and probably even to a greater extent, remain technically and economically available. Thomas Christaller points out (or puts his finger on) this development: "*Let the intelligent robots come. Their construction will certainly be inspired by our knowledge of our brain and our intelligence. But they will always have a different brain from ours because they will always have a different body and different `needs´ for social interaction. When constructing intelligent robots, it seems sensible, howeve,r to ensure that there is some kind of communication possible between us and them, maybe of a kind similar to that we already know with other forms of life, for example, with dogs."*[27]

[27] Christaller (see 21), 44.

The body as a cultural topos of self- and identity construction

It is therefore out of the question to claim that information technology causes disembodiment. It rather seems that through the medium of bodies or through the metaphor of the body a further convergence of man and technology is taking place. This can also be seen from the developments in AI and many other research areas which work, from different angles, on the mechanization of humans and life in general. They show that the boundaries between technical and organic bodies have long vanished in science – an area which strongly produces cultural interpretations in our society.[28] Ethical discussions and regularizing laws resemble sham fights in light of the freedom of sciences and the powerful interpretations of scientists at universities and in industry. The concept of the *body* that once replaced *physicality* seems to be superseded by the concept of a technical-organic hybrid creature the *cybody*. Perceiving the manifold dissolutions of boundaries between nature and culture, between man and technology, between humans and animals, between women and men, Donna Haraway[29] suggests that we have passed the point of no return. According to her, the development of the cyborg has already happened – there is no way to turn back, we would have to follow, we would have to become active and involved in order to define these technological and social developments for a feminist purpose – those are her claims. In her *Manifesto for Cyborgs* she pointed out that the body, in the process of its scientific treatment and handling today, has become a cultural topos of self-construction and identity construction which, while informing our identity, is constantly being reinterpreted and reconstructed. New findings and theories in natural and technological sciences have constantly changed our self-perception and caused us to reconstruct our identity. Technology's somatogenic influence, meaning the body building impact of technical imagery, becomes apparent not only in the area of AI research discussed here, but also in other disciplinary contexts, e.g. in medicine.[30] The discourses on the body, the technomorph treatment and adjustment of the body, its scientific exploration and technical reproduction, our handling of the body, all amount to let the body appear as a *technology of the self* in the terms of Foucault. According to Foucault this allows the individual *"by one´s own efforts or with the help of others to adopt a series of operations on the body or its soul, or its mind or its behaviour or its way of existence with the aim to change oneself in a manner that allows him to achieve a certain state of happiness, purity, sagacity, perfection or immortality*."[31]

The work on the body – scientific, technical, discursive, decorative, sportive, etc. – has become an important technology for understanding, perceiving and effecting ourselves. When working on our bodies, we encounter limits defined by their organic materiality that we do not accept but try to overcome or exceed – mostly with the help of technologies. However, the attempts to

[28] The various modes in which technical and organic bodies are ideationally and materially interwoven are e.g. shown by Marie-Anne Berr, Technik und Körper, Reihe Historische Anthropologie Bd. 11, Berlin 1990.
[29] Donna Haraway, „Ein Manifest für Cyborgs, Feminismus im Streit mit den Technowissenschaften", in: D.H., Die Neuerfindung der Natur. Primaten, Cyborgs und Frauen. Frankfurt a.M./New York 1995 (original version, 1985).
[30] How medicine changes the way we perceive our bodies is the focus of the work of Barbara Duden: Geschichte unter der Haut. Ein Eisenacher Arzt und seine Patientinnen um 1730. Stuttgart 1991; B.D.: "Technogene Realitätsvermittlung", in: Gert Kaiser, Dirk Matejovski und Jutta Fedrowitz (Eds.), Kultur und Technik im 21. Jahrhundert, Frankfurt/New York: Campus 1993, 213-218.
[31] Michel Foucault, „Technologien des Selbst", in: Martin H. Luther, Huck Gutman, Patrick Hutton (Eds.), *Technologien des Selbst*. Frankfurt a.M 1993, 24-62, 26.

exceed one's limits technically do not liberate us from the body, but rather place it in different contexts of reference and experience.

Moving in virtual worlds, for instance, allows us to enter, apparently independently of our body, new spheres, but this also does not work without the body. When moving in these virtual worlds, the body plays a key role. One can only act in those worlds through physical actions conveyed by corresponding human-machine interfaces like datagloves or –helmets. The experiences of the body in the real world are nonetheless of little use in virtual spheres: here one can easily break through walls or accelerate without experiencing centrifugal force.[32] The body gains new potentials and loses others, it can however still be experienced –

and as a medium, it remains indispensable. Even in *MUDs*, the virtual adventure games on the internet, in which a virtual world of castles, knights, fairies, elves, gnomes and monsters is created only by the suggestive force of language - i.e. solely by linguistic forms without any visual incentive – the real experienced body of team-mates is constantly referred to. These can choose their virtual identities freely by adopting the virtual bodies of fairies, elves, gnomes, etc., but they are always confronted with their own physicality, for example when a male team-mate in the role of an elf tries to feign a female identity and has to realize that he does not master the necessary female codes of behaviour.

Playing MUDs or moving with datagloves and –helmet through virtual worlds are only two of a myriad of the possible ways to experience one's own body.[33] The present need to experience the body in new and different situations also becomes apparent from the boom in extreme sports like free-climbing or in tests of courage like bungee-jumping.

The various ways of impacting the body refer to a range of potential self-perceptions that are in no way as technologically determined or consistent as one might expect from the dominance of science and technology in creating body images. Interpretations of the body that might appear inevitable with regard to scientifically gained insights appear not necessarily to be so. Interpreting bodies in a way that eliminates their limits and opens them for technological access and economic use is a manifestation of the balance of and interest in power. The way interests are mainly weighted in scientific and technical areas such as AI can be shown in the following example: when interviewing AI scientists and developers, it becomes obvious that particularly so-called feminine skills such as emotionality, sensitivity, etc., which are of low value in society, have to be regarded as extremely complex when compared to highly valued skills such as intellectual performance. "*Within the AI community we might have lost our respect for some types of intelligence because we can now produce them ourselves – e.g. things like playing chess and all that which were once regarded as the epitome of intelligence! … Now we know that a simple search will suffice – and be better than any intelligent program. And here respect certainly has disappeared entirely. Whereas one knows now that the simple things, which were earlier taken for granted such as feeling, perception and vision, demand an enormous amount of work. Now we know that this is the very place where intelligence is to be found. And I believe*

[32] For further examples of reconstitution of the experience of the body see Stefan Beck, „Der Körper als hybride Verlaufsform, Technologisches `body building´, Grenzregimes und Autotopographien". In: Tübinger Korrespondenzblatt, Nr. o.J./47 (1996), 41-57.
[33] Some possibilities cyberspace provides for the work on identity were described by Rosanne Alluquere Stone, „Will the Real Body Please Stand Up? Boundary Stories about Virtual Culture" in: Michael Benedikt (Ed.) *Cyberspace, First Steps*, Cambridge, MA 1991, 81-119.

that also in cerebral research and medicine it became more obvious to what extent the brain is involved in such things.[34]

The high regard for humans' so-called *basic performances* such as vision and the allegedly feminine skills of emotionality and sensitivity is based on a technological perspective. These skills receive increasing attention and are recognized (or acknowledged) for their complexity particularly due to the fact that they are so difficult to produce technically. They become components of intelligence because major parts of the brain are obviously involved in enabling such performances. However, such insight does not lead to a greater appreciation of these skills. Then again, if it were possible to perform the functions and skills described in the interviews through a technological system, this would be rewarded with a high scientific and economic reputation*: If we take AI as our basis today, the dusting of a glass cabinet is something so extraordinarily intelligent that even in 30 years no robot will be able to perform it. And this, this is … exactly contrary …to the social picture we have of cleaning cupboards, or of a cleaning woman or housewife, etc.. Washing glasses is something stupid. But what a powerful demonstration of intelligence from this point of view it is to approach transparent objects carefully and to hold them in a balance of tension and pressure etc., and to adapt to these according to their depth parameter, and so on. To handle all that, these are problems that are so intelligent that we will not be able to model them .. for a long time because we have no idea as to how they work.*[35]

It is only the technical reproduction of these diverse, complex, and so evidently physically bound abilities and skills that would allow them to gain prestige. In the end, however, this would again only benefit the scientists, their intellect and technical systems, and not those who display these skills on a day-to-day basis. Cultural values of mind and body are as clearly apparent here as is the interest of every scientist to uphold these values to their own advantage and maintain the technologically connectable, economically useful image of the body in AI. It is precisely these scientific findings in AI concerning the complexity of so-called simple activities that, without a doubt, might just as well have led to a reassessment of the old hierarchy of mind over body.

As this example also clearly illustrates, these mind-body hierarchies implicitly creep into technological projects and their output. Implicit and subtle, hardly noticeable interpretations of the body are reproduced and produced anew in research fields such as computer science, which at first glance appear to have little to do with the body. These rather concealed interpretations of the organic body and the influence of these sciences on human self-conception are no less powerful than the interpretations of the body that are quite explicitly produced and discussed, such as in the field of medicine. In light of the subtle influence of self-concepts on collective identities, it seems that not only our individual identities, but also the frames of our cultural and social life, depend on this influence: *"Through its performative strength, speech pervades the reality within which we live. The structure of meaning that we create within and through speech, articulates, hands down and changes the different ways of*

[34] Interview with Prof. Dr. Wieland (name has been altered), Transcript, 9.
[35] Interview with Prof. Dr. Binder (name has been altered), Transcript, 30.

speaking and experiencing the body, and simultaneously with it ourselves and the image of our self and the expectations we have of the societies we wish to belong to."[36]

[36] Elisabeth List, „Das Phantasma der Einheit, Zur Rolle des Körperimaginären in der Konstruktion von kollektiven Identitäten", In: *Mitteilungen der Johann Wolfgang Goethe Universität*. Zentrum zur Erforschung der frühen Neuzeit. Frankfurt a.M. 1995, 151-187, 158.

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