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Gender and ethically relevant issues of visualizations in the life sciences

Abstract:

Here moral problems created by the use of constructive imaging technologies within the life sciences are discussed. It specifically deals with the creation of dichotomies, such as gender, race and other differences, created and manifested through the contingent use of scientific and computational models and methods, channelling the production process of scientific results and images.

Gender in technology studies has been concerned with destabilizing essentialist and dichotomous co-constructions of gender and technology. In the technological construction process gendered social constructions of stereotypes and inequalities both of the technological models and of the presumptions in life sciences become structural properties of the artefacts, again flowing back into the seemingly objective results and knowledge of the life sciences. Here we will deal with the construction of gender differences via biomedical imaging and the creation of norms in atlases. Additionally, the de-contextualized images, showing idiosyncratic selections and reducing complexity are used to popularize gendered assumptions about biological facts.

Agenda

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Relevant publications:

- Schmitz, Sigrid & Schinzel, Britta (2005): Grenzgänge. Genderforschung in Informatik und Naturwissenschaften. Königsdorf: Ulrike Helmer Verlag, 173 S.
- Schinzel, B., Taeger, J., Gorny, P., Dreier, Th., Holznagel, B. (Hrsg.): E-Learning im Hochschulverbund, DUV Wiesbaden, 2004, 272 S.
- Schinzel, B.: Computer Science between Symbolic Representation and Open Construction; in Lenski, W. (ed): Logic versus Approximation: Essays Dedicated to Michael M. Richter on the Occasion of his 65th Birthday Springer Lecture Notes in Computer Science Volume 3075 / 2004 ISBN: 3-540-22562-5, 16 S

Introduction

Computer Science with its technological products has more or less changed all the sciences and their production processes intensively in general. Its symbolic methods and mathematic-technical paradigms penetrate their model building processes and its methodological instruments, since the data memorizing and integrating capabilities and its visualizing potentials are used also in biomedicine and in the life sciences. The uniform computing methodology of formalization, which is usable independent of the subject, leaves much room for different ways of problem solving and their specific realizations in software: specification (which means de-contextualizing a certain part of the world, abstracting from it, such that it can be represented in discrete symbolic items), architecture, algorithmic solutions and the very implementation and coding. The space left open for specification and modelling alternatives is huge and it opens doors for moulding in one-sided selective views, for idiosyncratic and biased design and for contingent re-contextualization.

Technologically mediated textual, imaged and formalized knowledge is currently changing the order of knowledge (Spinner 1994) through new channels of categorization (e.g. building ontologies in semantic web representations, or search machines), the reduction of complexity and context, formalization and standardization. The vast collection of complex data sets, produced with the help of information technologies brings humans' cognitive capacities to their limits. For this reason, visualization technologies are used more and more to display the essence of results instantaneously. Scientific knowledge therefore is increasingly represented in images, graphics, mathematical and biomedical visualizations (called visiotypes by U. Pörksen 1997). But this turn from text to picture is vice versa also forming our knowledge. The imaging of scientific facts is per se ethically relevant, because images do not explicate their semantic content in the same way as text does. Their meanings are much more dependent on culture, pre-knowledge and interpretations one is familiar with than would be the case of text, even from a hermeneutic view of text. In addition images are also stereotyping and contributing to standardization and normalisation. This makes popularization of scientific images even more subject to false interpretations, as e.g. biological determinations. In particular the new medical imaging methodologies, which are opening enormous possibilities for diagnosis and scientific investigation, also are posing new epistemological, ethical and validity problems: E.g., bodily properties that can be visualized on a one-to-one scale are emphasized in favour of those which cannot be locally and distinguishably represented within a picture. Moreover, the abstract and complex character of data extraction and processing produces a very loose referential tie between body and image, but this is hidden by the very realistic appearance of the images. In addition, their use for standardizations and norms are problematic for many reasons: among others, that new definitions of sanity versus sickness arise and new dichotomies are built up.

Computerized Imaging in Biomedicine

The combination of physical and physiological effects with mathematical and information technological methods have brought up many new methods for the introspection of the inner body without dissection nor invasion, such as Computer Tomography (CT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET) and others. The production of the final images relies on the electromagnetic exchange between the atomic structures of the body, delivering masses of raw data to be processed, interpreted and visualized in extremely complicated and contingent combinations of model driven algorithms, computations and visualization techniques. For most of the contrast mechanisms established in practice for imaging today there exist plausibility explanations at most, i.e. there is no deep understanding of the microstructure of tissue, which would allow sound interpretation of what is being seen (Hennig 2001). Thus, the impressive images may be misleading as they seem to show realities of the inner body, whereas they show visualizations of interpreted data, i.e. images of bodily properties are derived – in epistemologically problematic ways - from long and complicated chains of interpretations of physiology in models and computational constructions, which always bear the danger of showing medical artefacts that do not correspond to physiological realities within the inner body (see e.g. Schinzel 2003, Schmitz 2004). The naïve use of such images without reflection of their production process is ethically relevant.

These methods have brought a revolution for diagnoses and scientific production, especially within neuroscience. It is obvious that they are very useful and that they deliver insights into the living body that have not been possible before. However, the claim cannot be held that the use of such techniques always leads to "objective" correspondence with the referent body. I.e., the pictures may contain artefacts stemming from technology itself or from the interaction between technical depiction and the living body. Moreover, by the use of contingent physiological and computing models, simulations and image producing technologies they are loaded with added meanings, which may meet the concrete bodily facts or not. The bio-medical images visualize non-pictorial collections of complex data sets, which have been processed through a lot of "cleaning", analyses, transformation and interpretation steps. E.g. the stray and other data collected at the CT wall do not include the body's space coordinates, which makes complex mathematical region reconstruction necessary. And the constructive image giving methods, ruling out supposed fuzzyness and dirt, intrapolating supposed voxel-values between slices for 3D-representation, rendering, i.e. triangulating surface and inner structure of the body for cuts, deformations and transparent views, and sometimes also colouring the images, e.g. the brain's activation areas for differentiation are preparing the look of the pictures for cognitively adequate understanding. These images therefore are stuffed with interpretations of their constructors and they also produce new meanings, e.g. of reading sanity vs. sickness or needs of therapy from pictures instead of from clinical evidence, or of normality though contingent mathematical averaging methods, of life and of sex and gender.

Moreover, the pictures are driven from a moment's situation which might alter within a minute, a day, or more, according to experience. The images fix this moment's appearance as a biological fact, which has emerged due to "embodiment" (Fausto Sterling 2002) through the contingent conditions under which this appearance arose, in particular for the most variable part of the body - the brain, as described below.

Still there are huge projects, like the Human Brain Project HBP, that try to define standards of the human brain. Here standardized anatomical and functional atlases are constructed, through complicated mathematical averaging methods, diversified by age, sex/gender, sicknesses, race/ethnicity, and in all these dimensions at one point in time. However, such dichotomized standard atlases of brain anatomy and function carry with them the danger of localizing sickness, normality, ethnicity and gender within the imaged body and placing other kinds of (non)evidence into the background.

In the medical practice on the other hand, e.g. in neurosurgery, there is an aspiration to refer to norms, like brain atlases, in order to navigate more safely within the brain. Establishing atlases has become a scientific field in itself, between medicine and mathematics. Considering the problems mentioned above, the questionable correspondence between the bodies under inspection and the images constructed, the contingency of the brains' material and functional status, the validity of such standards is problematic as well. Although without such atlases virtual or real navigation in the brain is even more taping in the dark, it is still an ethical question whether to rely on such standard atlases or not, whether to take such pictorial evidence as scientifically sound and to use it as major tool for evidence in medical practice.

The depiction of illness, especially in illness atlases (see e.g. Narr et al. 2001) brings ethical questions as well, such as whether an individual's image that has similarities with an illness atlas shows that he/she really has that illness, or is in danger of contracting it. Making diagnoses and decisions about a therapy in preference of visual evidence instead of on clinical findings could occur as a consequence. Another epistemological question is whether the deviation shown is a cause or an effect of a possible sickness (see also Schinzel 2004). Furthermore, changes in how human beings view themselves, in the body and in "humanness" have been established, such as the assumption that the mind is materially located and pictorially represented in the brain, and that this might be "the whole truth" about human beings' thoughts, mind, feelings and behaviour. The new, momentary neurologically founded debate concerning free will (Geyer 2004, Hochhuth 2005) is one consequence of this new self-image of concretisation of human beings into the neuro-chemical and neural-physiological.

The Plastic Brain

Considering now the interaction of material and experience, brain functions rely on the switching of the brain's nerve cells into an information processing network through the building up of synapses. This network and switching changes with our experiences, both concerning structure and the brain's function, and it needs these sensual inputs and sensori-motoric experiences in order to work at all. The extreme neuronal and synaptic plasticity of the brain is the basis of our potential to learn and memorize: every experience, every action and every thought is physiologically manifested within the neuronal and synaptic switching within the brain, at least temporarily. Individual experience therefore creates not only the vast inter-individual variability of brain structures and functions, but also the high dynamics (through learning) during a lifetime, i.e. the intra-individual variability.

Clearly then, brain imaging will not only show genetically determined structures, but also the organizational material manifestations of different individual lifetime experiences. As life and experiences of different groups and populations, especially of women and men differ in our societies, these differences are to be expected within the brain structure and matter in some way or the other. That is, such differences are not essentially biological ones, but contingent, context dependent and variable within a population and during the lifetime of an individual. As many investigations have shown, alterations of the synaptic and neuronal structure do not hold on, and they may be reversible, unless repeated activation temporarily fixes the structure.

The brain's plasticity is the most evident example of Fausto Sterling's (2000) embodiment theory. This theory states that the interaction of the body with the environment shapes and transforms the whole body, bones, muscles, organs and nerves. In particular, sensori-motoric experiences are imprinted into the human organism, into psyche, behaviour and into the body's material reality. The human brain, both in structure and in function, at any time of our lives, is embedded into and influenced by the relationship with all its endogenous and exogenous conditions. This of course also holds for sex/gender with respect to the brain and its socio-cultural conditioning within our society. Every kind of analysis of sex/gender differences within the central nervous system therefore has to respect these open developmental dynamics of the nervous differentiation with respect to the environment.

On the other hand, brain images, let alone the constructive aspect of their production, present a momentary image that may change within the next moment, during the female cycle, with weight, with pain, with aging and with disease. Therefore, these images may not be considered as representing "the status-quo", but as moments in time during the development of the respective interaction between behaviour and brain structure and vice versa. It is immediately evident with such fluent "material" as the brain's constituents that standardising becomes problematic.

The huge scientific cartographic programs like the mentioned HBP (see e.g. Thompson et al 2000) is held in high regard for its imaging of structures and functions of the brain, for its combination of different ones into standard brains, for its transforming of individual ones into the standards, of building atlases by brain imaging and mapping. The standard atlases are constructed according to the very selections of individuals subject to imaging (large persons do not fit into the tube, more white western persons can afford to be tomographed), according to the different standardizing technologies (e.g. volume based or landmark based averaging, statistical analyses and warping), the mathematical models on which these rely, etc. Standards are always subject to specific ideas, presuppositions, and in case of brain imaging, subject to the contingent brains' state and the contingent conditions under which the images are taken. In particular, with model driven image construction, the normalization process becomes circular. Moreover, normality in our culture selects certain concepts of sanity, of sex/gender and being normal that often also means being male.

Gender and Brain

Since the existence of medical imaging, sex/gender relevant brain areas and cognitive functions have been pointed out, such as the corpus callosum and some of its parts, the splenium and the isthmus, the laterality of the left and right brain halves, or the lateralization of language capabilities. But all these findings can be put into question. Schmitz (2004) und Nikoleyczik (2004) e.g. criticised publications of functional language tests using fMRI: Shaywitz et al. (1995) investigated in rhyme identification and found that 19 test persons showed a strong activation on the left side of the frontal lobe, and that 11 of the 19 test persons showed marked activation on both sides. However, in these tests no parallel differences in performance were found. This much cited study is propounded as evidence for women's strong bi-laterality of general language processing in contrast to men's uni-laterality. In a study by Frost et al. (1999) of 100 test persons, though, no gender differences were found in language performance, nor there was activation-asymmetry identified in the examined brain areas. But this work, in contrast to that of Shaywitz et. al., is seldom cited. In a recent study, Kaiser (2004) was able to show that a small variance in the setting of fMRT-measuring had an influence on the fMRI-imaging of lateralised language performance: at one time gender differences were visible for the same persons, but with other parameter values they were not, and yet with other values even the sides in the mens' pictures became interchanged.

Visualisations of the thinking brain proffer themselves as a result of neutral technical-natural scientific workmanship that is built upon natural scientific objectivity using effects delivered by physics to enlarge human sensory perception. Digital images of the body, its organs and their functions should objectively represent unaffected truths. However, the publications mentioned above serve as examples of the deconstruction of sex/gender differences in scientific publications.

Still, popularized literature on neurology and brain science is keen on showing sex/gender differences, although their complexity is reduced in many respects: in regard to the construction process, the brain's plasticity, and the difference between sex and gender. This is not only problematic, but even dangerous, especially for adolescents without a settled gender identity.

It seems that in societies, and even more in science, there is a desire for categorizing and defining differences. It is well known that in the empirical sciences, which are making use of statistics, there is a severe publication bias, the selection of results which show statistically significant differences (Easterbrook, Berlin 1991). This holds especially true for publications on empirical findings about gender differences in the brain. As a consequence these findings are, oversimplified, often interpreted as (biological) sex differences. In contrast, gender research has shown that there are also contradictory results to any of the research results differentiating sex/gender. Nonetheless, findings not showing gender differences are much less likely to be published (Wacholder 2004). The reason for the unreliability of such findings is the complexitiy of the research question as already mentioned. The great variability inherent within every population would require considering biographic impacts and the contexts of the investigations, larger proband sample sets and more exact interpretations. Moreover the incorrect use of statistics in empirical findings is well known (Joannidis 2005).

Building dichotomies is ethically problematic, because binary relations, such as between women and men, nature and culture, healthy and unhealthy, can be easily put into hierarchical order. Norms standardizing such differing and variable subjects as the human brain introduce another ethically problematic aspect of medical imaging and atlases, as individual brains then are compared to the seemingly healthy standard brain. Through embodiment, that determines the effects of individual experiences and their manifestations within the brain, such "knowledge" contributes to the construction of incorporated and manifested sex/gender differences, both in structure, function and competences. Thereby they are inscribed again into our bodies and then really become scientifically provable facts (Schmitz 2004). This, finally, is the most subtle ethical challenge in regards to the publication of such dichotomies.

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