J. Lahtiranta and K. K. Kimppa

The Use of Extremely Anthropomorphized Artefacts in Medicine

Abstract:

Anthropomorphized, or human-like artefacts, have been used in teaching and training of medical skills for a long time. The most famous artefact used today is probably the Resusci ® Anne CPR training manikin, which is used for training of resuscitation skills. However, what has changed over the lifespan of these artefacts is the level of human-like features in them. All around the globe, highly anthropomorphized ICT artefacts are used in training of medical skills. Amongst others, the UNAM University in Mexico City and Royal North Shore Hospital in New South Wales use artefacts, which are closer to human-like robots than traditional manikins in teaching. The purpose of this article is to look deeper into this phenomenon, consider its potential implications for the patient-physician relationship and quality of patient care, and to propose some practical methods for minimizing the possible risks emerging from the use of these extremely anthropomorphized artefacts.

Agenda

Authors:

J. Lahtiranta:

Department of Information Technology, Information Systems, University of Turku, FIN-20014 Turku, Finland.

☎ + 358 - 2 - 333 8674, ✉ janne.lahtiranta@it.utu.fi

K. K. Kimppa:

Department of Information Technology, Information Systems, University of Turku, FIN-20014 Turku, Finland.

☎ +358 - 2 - 333 8665, ✉ kai.kimppa@it.utu.fi

There are various arguments for and against anthropomorphism in the Information and Communication Technology (ICT). Some argue that anthropomorphism, or introducing human-like features, into ICT artefacts ensures better user acceptance and creates a positive user experience (Cassell et al., 1999; Gong, 2002). On the other hand, others are adamant about potential risks and threats of anthropomorphism, claiming that it has a negative impact on the user interaction, creating unpredictability and vagueness (Shneiderman, 1988).

Regardless of the arguments for and against anthropomorphism, it is inherent to humans to anthropomorphize different things. Every day we encounter anthropomorphism in various situations. For example, anthropomorphism is widely used in entertainment and advertising. Movies like "Madagascar" by the DreamWorks Animation SKG (2005) or the famous cartoons by Walt Disney are casebook examples of anthropomorphism. Unintentional, or implicit, anthropomorphism is probably even more common. For example, we have a tendency of rationalizing actions of some (computer) artefact by referring to it as "he" or "she".

Already during the 60's there were clear cases of computer programs being anthropomorphized. One of the most famous case being ELIZA, a computer program by Joseph Weizenbaum (Weizenbaum, 1966), which parodied a Rogerian therapist. However, recently the anthropomorphism has been used in the ICT applications probably more than ever before. For example, in applications and systems of medicine (i.e. in electronic health, telemedicine, consumer health informatics, etc.) anthropomorphism is used not only in graphical user interfaces, but also in patient-physician interaction, teaching and patient care (figure 1).

Figure 1. Examples of the use of anthropomorphism in medicine.

In the first example, a remote controlled robot is used to visually examine a patient. With this solution, physicians are capable of interacting with the patients whether they are in another part of the hospital, or even in the another part of the world (Reuters, 2005a). In the second example, medical students are trained by using robot dummies. The robots are equipped with mechanical organs, synthetic blood and mechanical breathing systems (Reuters, 2005b). In the last example a robot nurse called "Pearl" assists elderly people with their day-to-day activities (Jajeh, 2004).

While these are just examples about anthropomorphism in medicine, they raise a question of what kind of impact, if any, anthropomorphism has on patient-physician relationship or on quality of patient care. Patient-physician relationship has always been one of the cornerstones for comprehensive care. The development from human-to-human to human-and-computer-to-human, and finally to computer-to-human "relationship" creates further space for the critique directed towards the use of applications and systems of ICT in the established medicine. A potential consequence from this is that the human is more easily regarded as an object rather than a real feeling subject.

What is known about anthropomorphism in human-computer interaction is that it has some effect on human behaviour and decision making. For example, in some cases a human-like (or social) interface can be used to invoke trust in the user (Bickmore & Picard, 2004). It is also demonstrated in numerous psychological studies, that people treat computers and new media as real people and places (Reeves & Nass, 1996). Considering the applications and systems of electronic health in widespread use today and the future possibilities created by a general technological advancement, the question about the potential impact is a current one and requires close attention.

Anthropomorphism and Medicine

Susceptibility to anthropomorphism is always individual. Some of the users are more prone to it than others. Similarly the effects of anthropomorphism change from one individual to another. Due to this individuality, defining what could be called as optimal anthropomorphism, or creating a balance between positive user experience and complicated user expectations, is extremely difficult. On the far end of the scale there are interfaces and technologies stripped from all human characteristics, including the used style of writing. On the other end are the highly anthropomorphized human-like artefacts that mimic human looks and behaviour as far as technologically possible.

In medicine, there is a need for the whole scale from "man to machine". For example in the clinical decision making the users need information, such as numerical laboratory results, in a concise and explicit form. In training the users practice their clinical skills with anthropomorphized artefacts, such as the Resusci ® Anne CPR training manikin with realistic full-body anatomy. Between these two examples, there is a wide range of different artefacts with varied degrees of anthropomorphism for different types of users (i.e. consumers, patients, doctors, etc.).

In a situation when the users operate with a single artefact at a time, they are usually more aware of its type, role and significance. For example, in health care an ICT artefact could be a conveyer of information, source of it, or just a tool for practicing and demonstrating clinical skills. Unfortunately, especially in today's operational health care work, the users operate with various types of artefacts at the same time. Furthermore, these artefacts usually form a mosaic-like structure and hierarchy, potentially concealing some of the artefacts (and even actors) from the user. Especially asynchronous Internet-based services where the user and service provider do not interact face-to-face in real time, or services which employ (semi)autonomous agent technology, are prone to this kind of complicating effect.

A potential problem occurs when the user becomes blinded by the layers of technology and the true identity of the service provider becomes obscure. Such situation could occur due to the intermediating channel, type of the service or to the aforementioned mosaic-like structure. The situation is more problematic if the identity of the service provider changes between an ICT artefact and a human actor. This change becomes a liability when it occurs unnoticed, without informing the human actor or the one acted upon. In this kind of situation the user may consider the source of the information to be a human actor, while in reality it could be an ICT artefact. The impact and consequences of this kind of muddling effect is further explored in Lahtiranta & Kimppa (2004).

A more interesting scenario, in the context of this article, occurs when the user is given a single highly anthropomorphized tool to operate with and all potentially muddling effects of different layers of technologies are stripped down to minimum. In this kind of situation the user is prone to the most basic, implicit, anthropomorphism typical to the human nature. What are the potential effects of anthropomorphism to patient care when the user is trained with a highly anthropomorphized artefact, such as the robot dummy used in simulating childbirth (figure 1) and the students at some point must apply what they have learned to a living subject?

Extremely Anthropomorphized Artefacts in Medicine

It is true that medical students must practice their skills using different kinds of resources. Some of the necessary information comes from the literature, some from the teaching and training, and some from adapting their skills into practical patient care. Practical training requires real, live patients but before the students are skilled enough, they are usually trained with dummies, charts, ICT artefacts, etc. For ages, different kinds of models and manikins have been used in training. However, now more than ever, these manikins are given extremely lifelike qualities. In medicine the ICT artefacts, namely manikins and robots, have become subject to unconstrained anthropomorphism.

In robot design, or in design of "a machine that looks like a human being and performs various complex acts (as walking or talking) of a human being" as defined by the Merriam-Webster's Online Dictionary, the robot features can be analyzed in a design space consisting of three dimensions (figure 2).

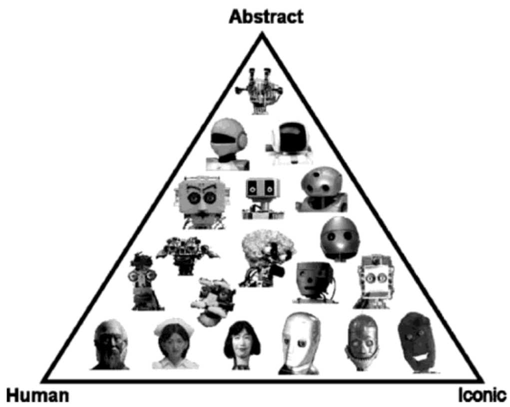

Figure 2. Anthropomorphism design space for robot heads (Duffy, 2003).

The design space defined by Duffy (2003) specifies an illustrative map for designing robot features and defining how closely these correlate to human physiognomy. Features in the iconic dimension employ a very minimum set of human characteristics often found in comics and cartoons. The abstract dimension refers to functional or mechanistic design. Naturally, the human dimension describes features with close resemblance to a human counterpart.

In medicine, the appearance of robots and manikins belong to the human dimension for practical reasons. For example, in CPR training the used manikin must have a close resemblance to the human physiognomy in order to provide the most effective training experience. If the manikin used in training would have iconic or even abstract features, it would probably have a negative impact on the overall medical training. It is not feasible to make abstract patient manikins and robots when the purpose is to prepare the students for a real-life experience.

Mori (1982) defines a region in the robot design when the robot is not quite humanlike as "The Uncanny Valley". Robots, which design falls to this region, are considered a bit peculiar or even absurd and interacting with them can feel somewhat uneasy. Considering that a close resemblance, or even an exact match, to a human counterpart is a necessity in designing certain ICT artefacts used in the training of medical skills, it can be argued that their design is crossing the region. When the design of a robot or manikin crosses the Uncanny Valley, they are potentially becoming more accepted as humans than ever before (Mori, 1982).

In addition to the physical appearance of the artefact used in training, the familiarity of the artefact to the user can be analyzed by using the core set of features defined by Duffy and Joue (2005). These features are:

> Control: the ability to influence the robot, or our environment through it.
>
> Predictability: a human-like, not too simplistic, predictability of the robot.
>
> Dependency: how dependent the robot is of our actions.

When the focus is on training of medical skills using extremely anthropomorphized ICT artefacts, the control feature is highly presented. For example, when medical students practice CPR with a manikin, they strive to stabilize and gain control of the artefact's life-like functions. In this context, the control is realized as medical care and nursing. In training, the used artefact should be as human-like as possible, including appearance and physical responses to the care. Therefore, it can be assumed that the predictability, namely human-like predictability can be high from mechanistic perspective. Furthermore, if the manikin is extremely human-like in appearance, it may create an unfounded illusion that it reacts in all the possible physical responses like a real human would even though it is unlikely to cover them all. Misinterpretations like this with anthropomorphized manikins without any kind of social interface, such as the Resusci ® Anne CPR training manikin, are clearly less likely to happen. The psycho-social dimension of predictability is lower however since with the current level of technology it is hard or nearly impossible to mimic psychological and social behaviour patterns of a human. Since the purpose of the artefact is to imitate physical responses of a human patient in need of a care, the dependency from the care provider is highly presented as well.

From the perspective of the three core features of control, predictability and dependency, it can be argued that the extremely anthropomorphized ICT artefacts used in the training of medical skills have a high potentiality of familiarity to their users. However, we must acknowledge the limitations and restrictions of the used technology and design, which primarily focuses on mimicking human-like appearance and physiological responses to the care.

Optimal Anthropomorphism in Medicine

In the context of medicine, and especially in training of medical skills with extremely anthropomorphized ICT artefacts, it is hard to define an optimal degree of anthropomorphism. From purely didactic perspective, one could be anxious to say that optimal anthropomorphism from design perspective is achieved when the artefact matches to a human counterpart. In addition, one should be able to analyze the performance and effect of the care, which may require dismantlement of the artefact or connecting it to other ICT artefacts, etc.

This mechanistic view however has some drawbacks. A human is a social and psycho-physical entity, an individual. With a mechanistic view to design it is impossible to capture the nuances of working with a living patient. From this perspective optimal anthropomorphism in design should be able to mimic the "vagaries of a human mind" as well as the "fragility of the human body" in all its dimensions. This however, is beyond current technology.

In training of medical skills using extremely anthropomorphized ICT artefacts an optimal anthropomorphism is a delicate balance of three factors. The first two, as suggested by Duffy (2003) are human expectations and capabilities of the artefact. In the context of training, the third factor is formed from the didactic requirements. In addition to the physical form, or completeness of it, the key question is the social interface. The social interface plays a significant role in how the students perceive the artefact to be emotional, sentimental of even intelligent.

A social interface as a supplement to an extremely anthropomorphized form can be viewed as a disadvantage or hindrance, or as a benefit. The interface can be perceived as a hindrance if it has a negative effect on the overall learning experience, such as when the interface diverts the attention of an unpractised medical student away from the physical indications and from the real learning emphasis. On the other hand, a social interface can be used to convey additional information about the success or progress of the administered care (e.g. when the artefact can demonstrate changes in the degrees of pain), or in some cases, about the preconditions of care (such as way of living, use of medications, and so on).

Considering the potential benefits and drawbacks of a social interface it is hard, or nearly impossible, to define what level of anthropomorphism is optimal in this matter. In some cases it could be justified from pedagogical point of view that the artefact shows intentional behaviour, carries out a meaningful conversation and creates an illusion of a living patient. An alternative could be drawing a line to the type of discipline in question. A meaningful restriction for not using extremely anthropomorphized artefacts could be that they should not be employed in teaching and training in the fields of science that deal with mental processes and behaviour of a human being (e.g. psychology), or in other fields that deal with mind and behaviour. This line, however, is drawn in water since it can be argued that social or mental aspect of care is inseparable from medical care.

Conclusions and Recommendations

It is true that it takes more than a human face on a computer monitor to create an illusion of life and intelligence. It may require a use of human-like verbal cues or body language to facilitate social interaction; or just a little bit of user imagination. However, with the examples presented in this article, it may not require a great leap of faith to consider a robot closely resembling a newborn child as its human counterpart. Actually, the situation may be quite the opposite: the users must actively remind themselves that they are practicing with a dummy.

Extremely anthropomorphized artefacts have been used in medicine only such a short period of time that it is difficult to give a definite answer to the question about potential effects to patient care. However, it is clear that the boundaries between a target of care and the tools used for training will become muddled. The history has proven that we will create as anthropomorphic robots and manikins as possible. For example, toy and entertainment industries are full of vivid examples of this.

There is a great potential value in practicing health care with the anthropomorphized ICT applications and systems of medicine. Being able to make the first tries, and the first mistakes, on a lifelike application instead of a real person is an indisputable benefit. It even seems to be our duty to steer the development of the artefacts used in teaching and training of medical skills to this direction. It benefits the patients, both in not having to submit to the fumbling tries of the unskilled trainee, as well as possibly saving lives from the first mistakes. However, we express concern that if the artefacts used in teaching and training of medical skills become human-like enough to fool the medical students and yet the artefacts do not actually react like a human being, the students may consider that this is the way a real human being acts under the treatment. This perception is likely to be false since patients are individuals and they can respond very differently to the treatment, for example due to the individual's pain threshold – or even due to one's imagination.

It is already clear that the current extremely anthropomorphized artefacts such as the robot dummy used in simulating childbirth (figure 1) cannot be fully equivalent with the actual counterpart they simulate – even though the artefacts seem very real. Especially in the near future when the artefacts are probably even more life-like, it is paramount not to mistake the artefact's operation or artificial life-signs it produces as an extensive description of all possible outcomes in real-life. Similarly, the conclusions drawn from the artefact's operation should not always be interpreted in the same way as in a real-world situation.

Until we can rest assured that the used technology is sufficiently human-like to represent an actual correspondence to a real human and the training is repeated long enough to make the differences human beings have in responding to the treatment clear, the artefacts used in teaching and training of medical skills should be clearly marked as tools, however anthropomorphized. Before the technology reaches its peak and the students can practice with artefacts that respond exactly like human beings we must define principles and ensure in practice that the transition from "manikin to man" goes with as few complications as possible. To decrease the potential complications later during the career of the medical students, the instructors should be able to orient the students into a right state of mind prior to actual training.

Both regulators and ethicists are often criticised for being late with their recommendations on how to utilize or apply ICT applications. Therefore it is important to take a proactive approach to the technology development and consider its potential impact on the patient-physician relationship and quality of patient care. Even though the technology today is limited to mimicking human vital functions mechanistically, there are clear sings that the robot functionality is coming closer and closer to imitating human activity. See for example work by Cynthia Breazeal (Breazeal & Scassellati, 2002; Breazeal, 2003; Breazeal et al., 2004) and her expressive robotic creature, Kismet[1].

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Britta Schinzel

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

Author:

Prof. Dr. Britta Schinzel:

Institute for Computer Science and Social Research, University of Freiburg, Friedrichstr. 50, 79098 Freiburg, Germany

☎ + 49 - 761 - 2034953 , ✉ schinzel@modell.iig.uni-freiburg.de, 💻 www.mod.iig.uni-freiburg.de

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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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