Emotional and Rational Aspects of Design Thinking

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Introduction

In order to determine which directions the design education of the future should follow and which aspects of »design thinking« should be emphasized, it is necessary to analyse what might be termed the *contemporary mentality*. The self-image of the people and their concepts about how the problems of the future should be solved also rub off on the field of design, because this discipline doesn´t represent a (parallel) culture which exists alongside and independently of other developments. To answer the question of the aspired development in design thinking it is necessary to discuss the following points:

- Which kind of thinking characterises our era – and is this thinking also detectable in the field of design?
- Which consequences can be drawn for design education?

Characterising the present era

No era was ever shaped by one single way of thinking – in history there were always several drifts which emerged at the same time. In spite of this, it seems legitimate to try to determine the *dominant* way of thinking in a certain period. In order to ascertain this factor and to gain a better understanding of such an era, the philosopher Wilhelm Dilthey (1833-1911) recommended an analysis, which primarily deals with the *representatives* of an age, and later with its works and values (see Dilthey (1910), 203ff.). Furthermore a historic retrospection can help to better classify the drifts of the present and to detect and highlight possible parallels. The baroque era will be analysed in such a comparison. This cultural-historical epoch in continental Europe (approx. 1600-1770) has been designated by historians as a predominantly *rationalistic* era. Considering the architecture of this time and concentrating only on squiggly ornaments, twisted pillars and buxom putti, one could claim that such works represent an out-and-out sensual and emotional era (port. *barocco*: erratic pearle). In fact the main drift of that time in the thinking of the savants was not based on sensual perceptions, but was truly rationalistic: The item and the number represented the core elements of their thinking; in order to find truth »one has to analyse and then to synthesise: Both are extremely rationalistic-mechanistic functions. Mathematics is the universal science, because it alone is able to fulfil all necessary criteria (...). Everything is basically a mathematical problem: The whole physical world which is around us, the mind that perceives it, and even ethics (...).« (Friedell (1927), 496f.). However, rationalistic thinking doesn´t necessarily mean that sensuality and experience are both totally negated: René Descartes (1596-1650) turned against philosophers who were of the opinion that »the truth would – despite disregarding experience – emerge out of their own brains like Minerva out of Jupiters; and so he assumed that astronomy can only be conducted in the first place if the actual movement of the stars, and mechanics can be studied, after the physical movements have been observed. (...) Here the experience is studied as well, but for the rationalist the empirical evidence is less important than the *sine qua non*, which he tries to receive by reason.« (Hirschberger (2000), 88). The immense importance that the natural sciences as well as mathematics and geometry gained in this period, can be seen in baroque architecture, the surrounding gardens – even in the horizontal projections of whole cities: They all were exactly designed geometrical formations, which are not often found in cultural history – and they represent the triumphal procession of the sciences mentioned above – including astronomy: The movements of the planets could be predicted more exactly than ever by applying Kepler´s concept of (almost) elliptical orbits. Bit by bit all the phenomena which were hard to classify before have been made calculable and predictable – so why shouldn´t it be possible to predict the future of the whole world? This idea was expressed most articulately by the French mathematician Pierre-Simon Laplace (1749-1827) and is still well known today as *Laplace´s Demon*: »In his opus called *Philosophical Essay on Probabilites* he argues that in a mechanistic world the present status of nature is the logical consequence of the status before, so that a being that knows at a given point in time all laws of physics, positions and speeds is able to define and predict all past and future stati.« (Eckhardt (2004), 33). Significantly the development of the first mechanic calculating machines, which were able to perform the four basic arithmetic calculations and which can be considered as the ancestors of today´s modern computers, started in the baroque era. The pioneers at that time were Wilhelm Schickard (1592-1635), who used to inform Johannes Kepler proudly about his latest developments in designing these machines (see Mainzer (1995), 34) and Gottfried Wilhelm Leibniz (1646-1716) who also invented the binary system which nearly all modern computers are based on.

The rationalism of modern times evolved – beginning with Descartes – up to the era that is called the enlightenment (»The philosophy of the enlightened human is (...) that of the so-called reason, which is equal to a mechanistic understanding.« (Hirschberger (2000), 263)). Even after Kant (1724-1804) who overcame the rationalistic-empiricist division, rationalism never really disappeared.

A variety of this thinking – combined with materialistic elements – can be detected particularly since World War II: Parallel to the development of the first electronic computer and the transistor, the thesis of the total computability of nature had been reanimated, but under a new name: It was called *simulation* or *artificial intelligence* (A.I.). The exponents of the so-called *strong A. I.* like Marvin Minsky (*1927) and John McCarthy (*1927) dreamt (and they still do) about an early simulation of human emotions. A quote by Herbert Simon (1926-2001) exemplifies the boundless optimism of A.I. research in those times: »(...) machines will be capable, within twenty years, of doing any work a man can do.« (Simon, in: Crevier (1993), 48). At the latest in the 1980ies it had to be acknowledged that these ambitions were just excessive illusions, because the so-called *computer metaphor* (»The mind is to the brain as the program is to the hardware.«) turned out to be misleading. Meanwhile the research on A. I. tried to gain ground again in »side shows« like chess against humans, identifying hand writing or spoken languages by using »intelligent« computers. Until today the public has been made to believe that the development of computers is already at such a high speed that tomorrow the majority of all human activities could be executed by such machines. Above all they might even be on a par with humans and outperfom them in any imaginable way. Totally unperturbed by the fact that these arguments cannot be supported by today´s knowledge at all, such announcements are always published in extenso in the media. One example are the prognoses of the inventor and »futurist« Ray Kurzweil (*1948), who has been chosen by the US-American *National Academy of Engineering* together with google founder Larry Page and eighteen others to identify the great technological challenges facing humanity in the 21st century. Kurzweil´s predictions are detailed and unmistakeable: In a compilation of papers from the years 2001-2003 Kurzweil wrote in a chapter called »How To Build A Brain« a sentence that was almost too similar to one which Herbert Simon had formulated decades ago: »A machine is likely to achieve the ability of a human brain in the coming years.«, and shortly after that: »(...) a $1,000 personal computer will match the computing speed and capacity of the human brain by around the year 2020.« One has to question the basis of these predictions; reading further, Kurzweil´s »law of accelerating returns« can be found, which is nothing else than the belief that a continuously accelerating development in computer hardware and software has to result in the near future in machines, which would be on a par with the human brain. This argument is easy to disable: If it is assumed that the future is principally *open* and not, as in Laplace´s philosophy, *determined* and therefore trends can only be predicted when they concern the *near* future, then solely an extrapolation of today´s development into the far future is not valid. In addition Kurzweil makes other errors in reasoning: The increase of computing power – a quantitative unit – does not mean that new *qualities* will emerge automatically, which would be necessary to simulate consciousness or emotions. Moreover, there are neither concepts to constitute consciousness artificially nor is a prototypical minimal version of such a consciousness yet known. But if machines using artificial intelligence should one day be equivalent to the human brain, it would be necessary to create a form of artificial consciousness. Until today the main problem for the research activities in the field of artificial intelligence is the fact that *semantics* can only be noticed where *consciousness* is – and in turn consciousness can only be found in living creatures. The complete lack of ideas concerning how to create consciousness and meaning (or semantics) suggests that the development of A.I. is not quite as far-reaching as their pioneers often describe in public.

When one compares the present – the so-called »computer age« – with the baroque era, it seems as if today´s age is a continuation of baroque rationalism, but with different means. The wish to enhance mathematical accuracy, to predict future developments in detail and to explain unknown phenomena is still vivid – a movement that cannot be defeated. It only becomes critical, if one tries to wrap a rationalistic-mechanistic philosophy over all parts of a human culture and if this thinking is considered as the only one which can achieve (scientific) progress. The most obvious analogy to the rationalism of the baroque era is today´s disregard of sensual experience. In addition the misconception of a mechanistic world has been established as one in which you just have to use levers to get to grips with sanitary, social or other problems. Ultimately all difficulties would be a matter of technology only: Happiness, ageing, ecology, education, corporate management. Even if new technologies change a war dramatically, they do not make peace; computers that put paint on canvases produce pictures, but do not make art; electronic learning aids are useful in structuring contents, but they do not create education. Not all problems in this world can be modelled by using computer languages and be solved by inventing and applying new technologies. At the beginning of his *tractatus logico-philosophicus* Wittgenstein wrote: »The world is everything that is the case.« And in the preface he said: »What can be said at all can be said clearly; and whereof one cannot speak thereof one must be silent.« (Wittgenstein (2003), 7ff.). Now there exist things which are clearly »the case« for a person and therefore in Wittgenstein´s sense are part of the world – like the idea of a forthcoming spring. It is easy to talk about this imagery, although its verbal translation will never match the inner picture. Some problems can´t be expressed in computer languages or in natural languages, but are nonetheless »the case«. In order to be able to judge and make decisions and finally to solve a problem, the as of yet unspoiled person uses what Kant, Schopenhauer and others called the two stems of human awareness: Reason (nous, dianoia, ration, raison) *and* intellect (intellectus, entendement, understanding). In short it´s the task of reason, to establish items for the representations and insights that the intellect comes up with – and to work with them (language, logic). On the other hand the intellect´s job is to task with representations (perceptions, images) of all kinds. In order to solve a problem it is necessary to make a judgement of a certain situation (a »fact« as Wittgenstein would say). Kant defines it as follows: »The unification of representations in the mind is called judgement.« (Kant (1988), §22, 171). Because emotions are also representations that come to one´s mind when perceiving a situation, any judgement has to include emotions, too. This insight is supported more and more by cognitive science (see Damasio (1995)).

It is self-evident for humans to incorporate pictorial information (images) in their judgements. This information is never just a picture, it always contains meanings. Compared to the human situation, the calculation process in a computer is diametrically opposed: The computer never uses images, but always a meaningless syntax, which depends heavily on the strict limits of the computer language in use. Whatever a computer does, the semantics will always be added on by humans; no chess computer has knowledge about itself, for example, that it is playing chess and so forth. Although »machine thinking« has very little in common with how humans think, reports about technological progress often suggest the opposite: The »electronic brain« *optimizes* crumple zones, *predicts* tomorrow´s weather situations or *reads* hand writing. Suddenly a lifeless electronic gadget is assigned typical human predicates like the ability to judge, the possibility of making experiences or having intentions. The reasons for this development are not rooted primarily in the progress that computer technology made during the last few years, rather in the manifestation of a rationalistic-mechanistic thinking which is responsible for the following trends:

- Strongly increasing belief in the boon of technology: All sorts of problems will be solved by applying new technologies rather than by changing habits and attitudes
- Ignorance concerning phenomena which cannot yet be scrutinised in a scientific way, because they are still too blurred and fuzzy (ecological problems, alternative medicine)
- Decreasing importance of the humanities in some societies (USA)
- Reinforcing the separation between art and science. It is often ignored that this separation is very »young« by cultural-historical standards. While the representatives of bygone eras were called »universal geniuses«, today's leaders are the »experts« and »specialists«. People are led to believe that it has always been like this, but the specialist »was downright condemned by the Hellenes: he was considered as a philistine. And in the Renaissance, *virtu* was just identical with versatility.« (Friedell (1927), 194f.).
- Revised version of the idea of a human: The human being as a spare parts store, the person as a mechanical being, obeisance of transhumanism and posthumanity
- Increasing devaluation of leisure, intuition, empathy, fantasy
- Revival of philosophical materialism

On the basis of the values and works shown above it seems legitimate to say that the present is an era dominated by rationalistic thinking – just like the baroque era. The consequences of this style of thinking can also be traced outside the field of A.I. research. The best examples are the well-known rankings covering all fields: No matter whether the best pop/rock-song, the »(Wo)Man of the Year« or the best university of a country should be elected – categorisations and evaluations everywhere! Generally speaking, there´s nothing bad about the idea of evaluating e. g. educational institutes, in order to improve their offers. But reducing qualities to a single numerical value is just an incorrect operation: If a complex object gets evaluated, categories and criteria are used. Criteria of the same category can be summed up, but it is not allowed to sum up categories. These ranking are »obsessed (...) with the false idea that to judge means to quantify.« (Liessmann (2006), 84).

What has been shown here on the basis of a single example is the triumphal procession of quantitative measurement. Figures and numerical relations help to support arguments in difficult debates, because they seem to be objective and traceable. It´s just a very small step from this opinion to reductionism, i. e. the notion that the human doesn´t possess a freewill: If thinking, deciding and the mind were just functions of molecules and neurons which behaved according to mathematical principles, then all human behaviour would be determined, the future would be programmed and even the idea of creativity would be obsolete.

One could argue that the existence of freewill, the mind-body-problem or other similar questions are not really of importance in design education. But the strong attention that is drawn today to the field of brain research and its mechanistic interpretations as well as to the research on artificial intelligence often create the impression that learning and creativity are indeed complex, but nevertheless just electro-chemical procedures, based on quantifiable measures. Knowledge is being interpreted as an accumulation of data which is processed by certain brain areas – just like CPUs handle bits and bytes. This assumption often goes along with the naive idea that »instruments« (»nanobots«, stimulants) could be used to enhance these functions and speed them up. Constantly new fashionable items are being published that let the public believe that in the near future, the brain will be able to be reprogrammed in any way. Ray Kurzweil believes that he already knows how this procedure will continue: »By 2030, electronics will utilize molecule-sized circuits; the reverse-engineering of the human brain will have been completed (...). It will be routine to have billions of nanobots (nano-scale robots) coursing through the capillaries of our brains, communicating with each other (over a wireless local area network), as well as with our biological neurons and with the Internet. One application will be to provide full-immersion virtual reality that encompasses all of our senses. When we want to enter a virtual-reality environment, nanobots will replace the signals from our real senses with the signals that our brain would receive if we were actually in the virtual environment.« (Ray Kurzweil (2003), 12). These prognoses which are just an excessive extrapolation of today´s developments block the view that even elemental processes in the human brain are far from being understood. Not only the emergence of semantics is totally unclear, also the question as to what exactly the syntax of the brain consists of in detail has not yet been answered properly.

The popularity of the computer metaphor induces the assumption that precision and accuracy have something to do with counting, and judgement with calculating. This fact shouldn´t be underestimated in any kind of education, because the upgrading of numbers is often accompanied by the devaluation of emotions. Like feasts, dresses or ornaments make one believe that the baroque era was a truly emotional one, it seems that today there is a similar situation: Never ever has the word »emotion« been used so extensively in advertising slogans than today; there are »emotionalized« products and services everywhere. But still it can´t be claimed that the present is dominated by emotion. The devaluation of emotions goes so far that even the item called »intuition« has gained a bad reputation: Hardly ever does a manager confess that his decisions are based on intuition. This feeling is nothing more than a representation in the mind that is closely connected to human experience: »Intuition does not grow out of otherworldly inspirations and is not opposed to rational knowledge. But it suffocates under fragmented knowledge; out of concurring knowledge it blossoms. Intuition is not, in its origin, an irrational feeling – it becomes the most rational feeling through the highest possible aggregation of knowledge.« (Hansch (2004), 262f.). The field of brain research which was once severely infected by the computer metaphor supports today, with its research results, the importance of emotions in the decision making process (emotions like harmony and disharmony, intuition). Persons who suffer from a lesion of certain brain areas such as the prefrontal cortex show significant deficits in decision making processes. Even if the IQ-tests that have been carried out *after* the damage do not differ from the ones *before*, all people are greatly affected. Their dramatic lack of emotions caused by this lesion results in the fact that rational aspects of a problem cannot be incorporated with emotions any more (see

Damasio (1995), 35, 82f.). Truly *irrational* behaviour is the consequence of the overemphasis of the rational aspects of a given problem. It can be perceived as being detached from »real life« or being unable to solve simple everyday problems. Another consequence can be pedantry – as it was described by Antonio Damasio as well as by Arthur Schopenhauer in the nineteenth century: Schopenhauer was of the opinion that pedantry results from a lack of belief in one's own intellect and one doesn´t want to leave it to intellect to recognise directly what is what. Therefore pedantry means sticking strictly to a form, a manner, an expression or a word, which replace the essence of a matter (see Schopenhauer (1987), 112f.).

Another characteristic of a rationalistic age – which goes along with the devaluation of feelings – is the belief that thinking always means *verbal* thinking. In a world where problem solving and judging often mean that endless lists of criteria have to be implemented, this habit is not really astonishing. Hence the Latin verb »cogitare« means originally »to round up«, i. e. the combination of representations in the mind – no matter whether they are verbal or non-verbal. In fact thinking is not limited to the verbal dimension and accuracy has not necessarily something to do with language: »Of all forms of intellectual work verbal thinking is the most articulated, most complex and most vulnerable to contagious diseases and whispered suggestions. And because language can become a kind of connection between the thinker and the reality, the real creative work often starts, where language ends.« (Koestler (1966), 186). Non-verbal representations in the mind can bear an accuracy which they are not assigned with outside the field of art: »Sometimes we have to get rid of language in order to think clearly.« (Woodworth, in: Koestler (1966), 182). Surprisingly the history of mathematics is full of examples that show the importance of thinking in non-verbal representations. Einstein said once that »in my thinking words or sentences as they are written or spoken seem to have no importance. The physical units which work as basic elements are certain signs or more or less clear images which can be reproduced arbitrarily or be combined.« (Einstein, in: Koestler (1966), 180). Proceeding in a creative process means following a certain idea, which is a non-verbal representation also (a picture) and not a verbal concept. Thinking in these pictures is essential for creative work – and this is independent of the type of application. The separation between science and art – seen from the viewpoint of the research on creativity – seems to be totally irrelevant, but this separation has been carved into the collective consciousness so deeply that their most important common denominator is ignored: »Art and science face each other in creativity.« (Eigen (2000), 29). It is natural that in this case aesthetics cannot be limited to the field of art. From the viewpoint of a strictly rationalistic thinker it might seem as if Kepler´s elliptic orbits were just the consequent translation of Tycho Brahe´s data. Kepler didn´t accept the abnormalities between the observations and the predictions any more and calculated an oval orbit for the first time in history. What seems today to be just a simple sample calculation was in fact the contention with a new kind of aesthetics: »Why an oval? The perfect symmetry of spherical or circular forms had a deeply reassuring, unconscious effect – otherwise this dogma couldn´t have been untouched for two thousand years. The oval didn´t have this archaic appeal. Its form was arbitrary and skewed; it destroyed the ancient dream of the planets´ harmonies (...).« (Koestler (1966), 130f.). Kepler was an exception in the thinking of his time: He managed to substitute an old and traditional harmony by his own vision, because he did not only believe in the accuracy of Brahe´s data, but also started to *enjoy* the oval orbits. Surely it didn´t happen by coincidence that Kepler´s laws were formulated in a time in which the baroque architecture with its oval-orientated ground views started to spread over Europe. Kepler got rid of the aesthetics of his predecessors; he was inspired by newer, more modern aesthetics which guided him in his work. That these aesthetics are also important in the field of natural science or mathematics – and not only in the field of art – can be shown by means of some statements by two of the most influential mathematicians of the 19th and 20th century, Henri Poincaré (1845-1912) and Jacques Hadamard (1865-1963). Poincaré was absolutely certain that any real mathematician is familiar with what he called »aesthetic feeling« – and Hadamard always highlighted the fact that a mathematician normally cannot foresee if an effort will be fruitful or not, but in any case »the sense for beauty shows us the way; I couldn´t name anything else which enables us a similar foresight.« (Hadamard and Poincaré, in: Koestler (1966), 151). Such insight hardly finds its way into universities or other educational institutions. But at the same time the call for a Europe which utilizes its creative capabilities to the maximum in order to maintain its position in the world is getting louder and louder. Intuitively it is clear that there is an acute need for action – but what should be done in detail?

Consequences for design education

If it is correct that the present era is dominated by a rationalistic-mechanistic world view and, furthermore, if it is true that this world view limits people in fully deploying their creative capabilities, then the consequence has to be drawn that during professional education, certain parts of the following disciplines have to be emphasized more strongly in the future:

I. Philosophy of mind: Rationalistic-mechanistic theories still control common ideas concerning the mind, cognition and emotions: The digital age is about to reduce the act of perception to a process similar to that of electronic devices (e. g. scanners); the mind is often described as a mirror which is sharply defined against the area of the unconscious and so forth. As long as these ideas are still in existence and are not modified, it will be difficult to detect representations in the mind which are necessary for creativity and the decision making process. More adequate ideas concerning perception and consciousness will result in a more intensive discussion about what happens in the mind during the creative process. If perception is considered as an active rather than a passive process, more possibilities will be offered to influence this perception positively. The same is true for consciousness: Everybody who has got a better idea of what it can contain will try to explore it even in those areas which are normally just slightly illuminated.

   For teachers of music it is self-evident, that permanent practice leads to a sublimation of hearing; the same applies for the perception of colour: »The amount of distinguishable shades of grey depends on optical abilities as well as the human threshold. This threshold can be sublimed so that the number of perceivable shades increases.« (Itten (1983), 46). Because colours and pitches are normally not perceived individually but are always rooted in overtones and foregrounds with backgrounds, automatically emotions of harmony and disharmony appear in the consciousness. These emotions can be sublimed just like thresholds.

II. Aesthetics: Since Alexander Gottlieb Baumgarten (1714-1762) established aesthetics as a science, this discipline has often been considered as the weakest of them all; some even argued that aesthetics had just a life span of approximately 150 years and is already »dead«

(Dahlhaus). If aesthetics are reduced solely to a matter of taste then automatically all connections to other disciplines are cut off: If the designer abandons this field without a struggle, psychologists and marketing people will jump on this matter using »verified scientific« methods and data. Also if aesthetics is factored out from scientific work, its ability to guide the decision making processes will be brought to an end.

III. Philosophy of science: Normally a designer has to work together with representatives of many different disciplines. These people often like to refer to objective data (e.g. measuring design effects) in order to come up with prognoses (e. g. future sales numbers of a certain product). Therefore it is also important for a designer to know basic principles of the philosophy of science; it might be useful to find out what *can* be measured by using specific methods – and what *cannot*. The heated debate around these questions does not mean that design should be considered as a science from now on, but it results from the fact that any designer has to work in a variety of disciplines and at the same level as all the other team members.

IV. Demystification and clarification of features that are of importance for artistic-scientific thinking, such as intuition, emotion, harmony, disharmony, idea, representation, consciousness and so on. This vocabulary is not a matter of course in all segments of education. It is only in the field of art that nobody shies away from using them, even if they are not always used consistently. In the field of design people seem to be more afraid and often the discussions tend to stop at an early stage: More »emotional designs« are sought-after or emotions should be »stimulated«. Often one gets the impression that a person´s emotion can be adjusted solely in a one-dimensional way, just like the temperature of a stove which can be altered by turning a knob. Especially in design education it is not sufficient if only *some* students understand a specific context just intuitively, but are not able to talk about these insights and communicate them to others, because they lack proper theories. Gropius allegedly said that a good theory supports intuition. It is not only the task of philosophers to translate intuitions into abstract knowledge, but also teachers are requested to do so.

V. Importance of art: The signification of multidisciplinarity is not to break down boundaries, but its task is to keep these boundaries permeable where ever it seems reasonable. This does not necessarily result in fuzziness or even spark off an identity crisis in some disciplines, but rather enriches all participating fields. On this account it seems strange when the boundaries of design are emphasized consistently – especially in the field of painting and sculpturing, just because »function« has a different meaning in each field . The history of culture features many cases in which art and science enriched themselves that much that even new disciplines emerged: The famous dispute between Goethe and Newton about the composition of visible electromagnetic rays finally led to a *physical* and to a *psychological* description of light, from which the psychology of colour took its starting point. In addition, Goethe described the phenomenon of colourful shadows (see Goethe (1998), 119), which were painted later for the first time on canvases by impressionistic painters like Cézanne or Monet. The public laughed at them. Scientists first showed little interest, but finally they came to the conclusion that these colourful shadows were mainly the result of a brain activity which had the aim of stabilizing human perception in different lighting situations.

Sometimes art is considered as being an unnecessary additive to daily life and could be skipped easily, because it doesn´t seem essential for survival. If this kind of thinking prevailed, the human would be well on the way to degenerating into a bunch of Kurzweil´s transhuman beings. The importance of art for an educational system lies not least in the fact that it enables people to find out about the variety of their personal talents and abilities. How can anyone realise the significance of playfulness for his creativity, if practical, free and playful work was never on the agenda during his professional education? Friedrich Schiller´s extensive thoughts concerning the interrelation between playfulness and creativity can´t be taught just theoretically, because this teaching will always be fruitless as long as »art« and »artist« remain two items without practical experience.

A future design education of this kind could be at the forefront of a development that attempts to improve the integration of both rational and emotional capabilities in a person in order to come up with results which in the end will not be »scientific«, but can be supported by science and personal experiences in the field of art as mentioned above. The designer would be able to play an important role in the industrial societies of the 21st century by rebalancing the relationship between science and art and acknowledging »emotional information« as being *as exact* and therefore *as important* for his design process as quantifiable dimensions.

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