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"The Five Senses of Science"
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Introduction: The Five Senses of Science

Making Sense of Senses

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Social studies of science are mostly preoccupied with scientific practices that include texts and pictures. An increasing use of images in scientific practice has sparked a greater interest in visual representation, which creates a drift in science towards a dominance of the visual. This interest may be more generally embedded in the predominance of the sight over other senses in Western cultures. This status, however, implies the demotion of hearing, touching, smelling and tasting in the analysis of scientific practice. Even though it has often been pointed out that scientific work is conducted with the whole body, involving all senses, we nevertheless find a preoccupation with the visual in social studies of science. In addition to earlier studies on how the body becomes a subject (e.g. Cussins 1996; Berg/Mol 1998; Mol 2002; Alac 2008) or a scientific instrument in research (e.g. Latour 1986; 2004; Hirschauer 1991; Knorr Cetina 1999), scholars in social studies of science have only recently started to focus on how the body and sensory actions such as, for example, touching, grasping, and pointing are employed, for instance in modelling and image interpretation (Prentice 2005; Myers 2008; Burri 2008). This thematic issue underlines the importance of including the bodily senses in the social analysis of science.

We propose that studying the relevance of all five (or more?) senses in science can roughly be subsumed under three main topics. First, the significance of all senses in scientific work inevitably highlights the significance of the scientists' bodies. Reconstructing science as a material practice, firmly built and inscribed into scientific instruments, at the same time demands understanding science as fundamentally embodied practice.

Second, the materiality of scientific practice cannot be analysed by studying instrumental and embodied practices side by side, but has to be understood as a reciprocal interweaving of bodies and instruments. This may offer some insights into the dominance of the visual, since most scientific instruments deliver a visible output. The microscope and the telescope then serve as paradigmatic models of imaging technologies.

Third, we have to address the relations between the different senses. This

leads to a critical discussion of the hierarchy of senses with respect to institutional conditions of science. Is the sense of sight preferred because pictures, graphs and diagrams make it easier to show results, to present and create evidence – as several prominent STS scholars have underlined (Latour 1986; 1990)? Are sight and speech more public and therefore more convincing in processes of peer review than the personal senses of touch, taste and smell? Or is this bias a mere reflection of the broader visual culture? In the following sections, we will address these three topics in more detail.

1) Embodied epistemic practices in science are often addressed in the discussion of explicit and implicit – or tacit – knowledge. Generally, embodied practices are assumed to express types of knowledge which largely correspond to concepts such as tacit knowledge (Polanyi 1983 [1966]). In this understanding, embodied practices present a contrast to concepts of scientific knowledge as objective and rational. In the body remain those aspects of knowledge which we know but we can't tell, those aspects of knowledge which cannot be put into words (Polanyi 1983 [1966], p.4). In Polanyi's argument, modern science ideally seeks detached and objective knowledge and therefore is prone to the fallacy of disregarding the constitution of all knowledge by bodily perception. Even more to the point, scientific objectivations inevitably rely on prior tacit knowledge, yet this dependency is actively obscured by idealisations of science which emphasise abstract formalisations as the essence of scientific knowing. Thus, the concept of tacit knowledge is closely related, but should not be reduced to, bodily experience. More generally, Polanyi targets the relation of theory and practice. Even though they are closely related, we should not conflate embodied epistemic practices with tacit knowledge.

For instance, Collins (2001) distinguished between three approaches to tacit knowledge: the motor-skills metaphor, the rules-regress model and the forms of life approach. He does not see embodied motor skills as the constitutive element of tacit knowledge, but rather locates further instances of tacit knowledge in traditions as well as the dynamics of social life. In fact, he proposes that a "true" tacitness of knowledge – that which fundamentally cannot be formalised – rests within the vast realm of social dynamics. From Collins' perspective, embodied knowledge in the case of motor skills is, in a way, too "small" to withstand a prolonged analytical scrutiny and subsequent formalisation. Only the contingent interdependencies of social life constitute the fundamentally exclusive realm of the tacit.

Therefore, tacit knowledge is not the answer to the question of embodied scientific practices, because its basic distinction between that which fundamentally can be formalised and that which can't, does not fully coincide with the boundaries of the body. What is needed is a more detailed account of the relation of the senses and epistemic practices. This demand is hardly new (cf. Dewey 1929, pp. 219; Merleau-Ponty 2002 [1945], pp. 77). The contributions to this special issue employ qualitative, microanalytical approaches in order to uncover specific epistemic arrangements and the involvement of the senses. As it turns out, the authors do not find a simple privileging of a single sense (e.g. sight) but a mix of different senses and, interestingly, cases in which modalities are switched. Switching modalities might actually be seen as an epistemic tactic with which the different senses are put into productive relations.

2) The second topic addresses how the senses are engaged with technical instruments. The ways in which senses and instruments may be coupled are manifold. In real-life entanglements of bodies, instruments, and perceptions, the instruments cannot be seen as neutral extensions of the senses, but always entail transformations of perceptions. For instance, a microscope amplifies the visual resolution while at the same time it reduces the scope.

Ihde (1991, pp. 67) has argued that such transformations constitute the perceptual foundation of all scientific instrumentation. However, the question of what is reduced and what is amplified can only be answered empirically. For instance, the mechanisms of initial data production may lie outside human perception (e.g. detecting invisible electromagnetic radiation or minimal seismic movements). However, the presentation of the data must be perceptible to the bodily senses. Similarly, the epistemic practices in the laboratories might include a wide use of different senses, but the subsequent electronic or printed publication mainly allow for written text and pictures.

As Fujimura (1988) has argued, it is not only texts and pictures which circulate in science, but packages of methods, tools and instruments. The authors in this issue explore different fields in which bodily senses and technical instruments are related in various ways. The inclusion of those epistemic practices which cannot easily be inscribed in pictures and texts will be a challenge for future analyses in the social studies of science.

3) The third topic addresses the relation of the senses themselves. Much has been written on the primacy of the visual in Western cultures. Recently, pictorial, iconic, and visual turns have challenged the scientific preoccupation with text and argued for a better understanding of visual culture (Mitchell 1992; Boehm 1994). Also, natural sciences – in line with the Aristotelian hierarchy of the senses – typically conceptualise vision as the primary human sense to which the others are subordinate. In contrast to other mammals, humans are said to primarily live in a visual environment. In sociology, Simmel supposed that exchanging glances might be the most immediate and pure of all social interactions (Simmel 2009 [1908], pp.570). Foucault conceptualised the emergence of the clinical gaze at the heart of the transformation of medicine in the 19th century (Foucault 1973). One motive for assembling this thematic issue was to challenge the preoccupation with the visual in social studies of science and explicitly look for contributions which address an engagement with other senses or the mixing of the visual with the audible, the tactile, as well as smell and taste. This is matched by an increasing interest in the other senses coming from diverse scientific fields (for instance in the journal "The Senses & Society" founded in 2006). The growing field of sonification highlights the importance of the audible in scientific research. But it is not only the classic hierarchy of the senses which is being questioned. Scholars are also questioning the adequacy of the classic taxonomy of five senses and considering its expansion. For instance, neurologists include balance or the perception of heat and pain into a broader set of human senses.

Different perceptual preoccupations of scientific fields or research areas would have to be explained by their object of research (e.g. is it visible or not) as well as their epistemologies and the relation between the two. Any given hierarchy of the senses would then be the explanandum, not the explanans. Again, this thematic issue offers different empirical cases and conceptions of how the senses are related to each other in the respective epistemic practices. We hope that the articles in this special issue will be beneficial for comparing differences and similarities of the interplay between the various senses. Let us finish by briefly introducing the contributions of this volume.

Siegfried Saerberg compares two epistemic strategies, "blind variation" on the one side and "care of the self" on the other. Taking the epistemic practices of blind navigation as a starting point, he contrasts blind and visual modes of perception in everyday life. He relates his phenomenological analysis of different types of orientations and ways of dealing with crisis to the epistemic practices of different scientific communities, namely high energy physics and molecular biology.

High energy physics, because of the invisible and ambiguous nature of its objects, essentially follows a "care of the self" style of perception. In contrast, molecular biology employs a strategy closely related to visual perception and therefore tends to use "blind variation" as a dominant epistemic practice.

Katja Mayer explores performative aspects of the visual cultures of the social sciences. By drawing on ethnographic fieldwork among social researchers working with network diagrams, her essay shows how corporeal and sensual dimensions are involved in visual knowledge production in social network analysis. By criticising theories of embodied knowledge and inscriptions which would treat the body as passive medium, the article suggests the inclusion of corporeality in analyses of the interplay of imaging techniques, bodies, and imaginations. Corporeality should thus be regarded as one important dimension of the visual cultures of the social sciences.

Bernadette Emsenhuber addresses the field of olfactory perception and its impact on science and technology development. In tracing the cultural history of smell and smelling, she draws a line from early enlightenment philosophers' devaluation of smell as disreputable and irrational to the current renaissance of olfactory perception in science, technology and consumer production. Being able to reproduce and to technically identify and distinguish smells, modern research and technology development start to regard the olfactory sensorium as a useful medium rather than an unreliable physical organ.

Michael Guggenheim's essay explores culinary taste and cooking as a new medium in the sociology of translation. Starting from the claim that the sociology of translation follows a belief which builds on mechanical objectivity and exclusively trusts in written texts as valid translation devices, the article considers cooking as an alternative medium of translation. As one example of how this may work in practice, it reports on a buffet that was prepared as a comment to a symposium which discussed the relationship of food and emotions.

Jörg Potthast extends the idea of epistemic practices from the laboratory to the field of security studies. The difficulties of identifying dangerous substances and persons in airport security serve as focal point to analyse different modes of control in departures and arrivals. Even though we see a trend towards instrumentation and increased visualisation, he argues for an analysis the involvement of multiple senses and the extent to which sensory switching and combinations of the senses form distinct patterns of control practices.

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The Sensorification of the Invisible

Science, Blindness and the Life-world

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Abstract

The very act of scientific perception is constituted by prevalent visual forces. Sciences employ techniques of visualization that make one see what is invisible. Embodied practices are black-boxed. But can invisible things also be comprehended in another way? So, for example, how does blindness deal with invisibility? Its epistemic and perceptual strategies are explored. It is compared to the epistemic strategies of blind variation and care of the self. But it is the care of the self that is viewed to predominate in blindness. Contrary to this, blind variation is found in the sighted everyday life-world.

1 The Visualization of the Invisible

Social and historical studies of science and technology encourage a sociological interest in research processes and the facts they produce, and an understanding of them as instances of social agency. They motivate a sociological interest in how scientific research constitutes objects of study. They have argued against any account that treats published scientific data as no more than a 'rational reflection' of an independent empirical world. Social studies in the history of science have pointed out the very importance that has to be attributed to techniques of visualization and the development of visual tools in the production of scientific knowledge.

Disciplining of the senses and the invention of scientific instruments, both of which were meant to make the invisible visible, went hand in hand. Lorrain Daston (2008) has described eighteenth century Enlightenment naturalists' program of vigilant observation and fastidious attention. This regimen "imposed a strict discipline on the observer that was scarcely compatible with any other activity" (Daston 2008: 109). It formed practical sets of skills that can at best be regarded as very elaborate body techniques. Rene Antoine Ferchault de Reaumur, for example, counted the number of bees leaving a glass-fronted, flattened beehive. He arrived at a sum of over eighty-four thousand departures in fourteen hours which is equal to approximately one hundred per minute. And Jan Swammerdam's researches on bees "began at six in the morning, when the sun provided him with enough light, and continued long into the night, when he recorded his observations" (Daston 2008: 109, 110). Ironically, these naturalists often paid for their strenuous efforts with badly weakened eyesight.

Studying Robert Boyle's air-pump experiments, Steven Shapin and Simon Schaffer (1985) have shown that scientific instruments such as the telescope, the microscope, magnifying glasses and the air-pump imposed both a correction and a discipline upon the senses. The latter alone were inadequate to constitute proper knowledge, but the disciplined senses were far more appropriate for this. The eye witnessing public who alone could guarantee sensory observation as true matters of fact depended on the disciplining of the observers' virtues and eyes: As Robert Hooke put it: "a sincere Hand and a faithful Eye". (Hooke cited in Shapin/Schaffer: 78) The experiments' observers had to be taught by Boyle where and how and what to focus their visual attention on.

In the last decades, which have dealt with the details of the scientific observation process, laboratory studies have explored the material environment of the laboratory. Here, the visual construction of scientific facts and scientific knowledge has been described extensively. This has drawn attention to the visually guided process by which scientists make sense of their observations: practical sets of skills to visualize, to produce images, and to read and write, and their material resources like diagrams, lists, formulae, archives, engineering drawings, files, equations, dictionaries, collections, and so on.

Bruno Latour has termed this assembly of visually available materials "inscription devices". He writes: "It seems that whenever technicians are not actually handling complicated pieces of apparatus, they are filling in blank sheets with long lists of figures; when they are not writing on pieces of paper, they spend considerable time writing numbers on the sides of hundreds of tubes, or pencilling large numbers on the fur of rats. Sometimes they use coloured papertape to mark beakers or to index different rows on the glossy surface of a surgical table". (Latour/Woolgar 1979: 48) "But their end result, no matter the field, was always a small window, through which one could read a very few signs from a rather poor repertoire (diagrams, blots, bands, columns)" (Latour 1990: 22).

But contrary to accounts that regard visual devices as evidence for naturalistic claims about objective entities or relationships which then are largely taken for granted, laboratory studies point to their functioning as evidence of methodical practices which are accomplished by researchers working together in social arrangements. Thus, previously hidden phenomena are transformed into *visual displays for consensual seeing and knowing*. This tendency to naturalize images – as vision is thought to be the noble sense of reason – and the invention of technical instruments that outperformed and replaced sensory bodily functions and the derogatory attitude of important scientists toward the sensory body, have led to a *disembodiment of science*.

But these developments in the realm of science cannot be separated from a broader tendency in society and culture. These methods and materials of visualization build on the historical development of visualization that has taken place in western culture since the Middle Ages. Wiliam Ivins (1973) has convincingly shown how the invention of linear perspective in the fine arts has led to a paradigm of a new consciousness of the physical world attained by Western European intellectuals. The same process of visual rationalization has been described by Samuel Edgerton (1976) for the development of technical drawings.

More than that, dealing with the Dutch "distance point" method for drawing pictures, Svetlana Alpers (1983) provides the notion of "visual culture". This notion elaborates on how a culture sees the world, and how it makes the world visible. A "worldview" defines both what it is to see, and what there is to see. A new visual culture which brings about a revolution in the way of seeing the world simultaneously transforms science, art, theory of vision, organization of crafts and economic powers, and everyday cognition and perception. Thus, letters, mirrors, lenses, painted words, perspectives, inventories, illustrated children's books, microscopes, and telescopes come together in this visual culture.

Alpers illustrates this revolution in visual culture with an advice by Comenius concerning the proper mode in which objects should be presented to the senses. "If the object is to be clearly seen it is necessary: (1) that it be placed before the eyes; (2) not far off, but at a reasonable distance; (3) not on one side, but straight before the eyes; and (4) so that the front of the objects be not turned away from, but directed towards, the observer; (5) that the eyes first take in the object as a whole; (6) and then proceed to distinguish the parts; (7) inspecting these in order from the beginning to the end; (8) that attention be paid to each and every part; (9) until they are all grasped by means of their essential attributes. If these requisites be properly observed, vision takes place successfully; but if one be neglected its success is only partial". (Comenius cited in Alpers 1983: 95)

Barbara Maria Stafford (1993) has examined the radical shift that has taken place since the eighteenth century from a text-based to a visually dependent culture. She demonstrates the persisting value of a cluster of leading body metaphors derived from aesthetic and medical practices. In dealing with such questions as "What is the connection between visible surface and invisible depth?", (Stafford 1993: 1) here, diverse and relentless attempts were undertaken to "break into the obscure secrets of the somatic" in order to visibilize the invisible. (Stafford 1993: 2) She shows that these visual body metaphors exert a major impact on society and culture in general and exposes a tendency to collapse all sensory experience into the visual. "This overturning affects all branches of daily life and even the more arcane reaches of humanistic and scientific research and practice". (Stafford: 1993: xviii)

Recent developments in visual studies have shifted their attention from an

isolated visuality to an embodied vision that means something "sensorially integrated, embodied and experienced". (Edwards 2008: 3) Visual studies are concerned with how the visual is felt – emotionally and physically as well as intellectually at the interface "between vision and language, vision and audition, and vision and the invisible, between the seen and the overlooked". (Mitchell 2003: 250) In the field of the anthropology of the senses, building on the increasing critique of the supremacy of vision, a growing cross-cultural body of work on the senses has destabilized the Western five-sense model. "In this model, sight in particular, along with hearing, has been understood as representing the rational and 'nonsensual', according with an objective reality". (Edwards 2008: 5)

This shift to embodied vision has also been reflected on within social studies of science. Karin Knorr Cetina (1999) has described the body of the scientist within molecular biology as a "black-boxed" information processing tool. Analytically, she divides the scientist's body into the sensory, the acting and the experienced body (Knorr Cetina 1999: 93-107). The sensory body refers to the use of sensory organs as instruments of inquiry. Because, firstly, being able to see is a prerequisite for laboratory work and, secondly, experimental work – to a high degree – is manual work, the sensory body comes into the picture not as a primary research tool but in secondary ways as a silently presupposed support mechanism. Often this is done in a holistic way. When, for example, some participants were said to have a "golden touch" or to be "excellent experimentalists".

The acting body "is an information-processing machinery that learns and works without conscious reflection or codified instructions". (Knorr Cetina 1999: 97) A scientist, for example, might insist on meeting a phenomenon face-to-face in order to understand its properties and procedural implications. In a certain situation of research the body picks up and processes what the mind cannot anticipate. But in eye witnessing and manipulating the body remains silent.

The experienced body focuses on the temporal and biographical dimension of embodied work. It entails a silent corporeal memory of competences (tacit knowledge), a bodily archive of manual and instrumental knowledge of how to process sensory information. It is not written down and hardly expressed.

So, to resume, in molecular biology – like in most sciences – the visualization of the invisible builds on embodied practices that are left in the invisible. But the outward appearance of science is a visual one. Here, science is in accordance with the mainstream in modern western society.

2 Blind Sensorifications of the Invisible

I will now explore another strategy that deals with an invisible world. Drawing on my own audio-based studies (Saerberg 2006) I will describe the many strategies by which a blind person solves some navigational tasks and the various ways he makes sense of the environment. As Bruno Latour (1979) in his laboratory studies and John Law and Michael Lynch (1990) in their article on bird-watching as a lay observational activity have stated, the thought process employed by scientists is not strikingly different from those techniques employed in daily life encounters. The divide between pre-scientific and scientific culture is a boundary that is enforced arbitrarily. I would like to suggest that a blind person is a sophisticated lay scientist whose indigenous practices raise some relevant lessons for ethnographers interested in studying the conduct with invisible things for social research.

We will take two glances on blindness: in the first place, blindness is an everyday mode of existence that dwells on a taken-for-granted knowledge of the

life-world and that deals with unproblematic situations. It reveals blindness' immediate access to the world of phenomenal experience. An invisible world is experienced sensorially and through immediate perception. This world is blind and it is experienced by way of sensorification. I will start with giving some holistic impressions of these lived experiences. For purposes of clarity, I will then divide the immediate unity of lived experience by way of phenomenological description to reconstruct the sensorial construction of blind mundane facts and mundane blind knowledge.

Later, in chapter four, I will describe blindness' strategies to handle situations that are problematic. These epistemic strategies are comparable to the care of the self employed by high energy physics. They have nothing to do with blind variation. This raises the paradox that blindness is an attribute of sight and attentive insightful care of one's own self has to do with blindness.

Now I will start with the description of three different basic or grounding sounds, partly from memory, partly from listening to a voluminous body of digital audio recordings that I gathered for the "Ruhr Museum" in Essen in the years 1999 and 2000. (Saerberg 2000a, 2000b and 2004) First of all, I have approached the auditory event "Ruhrgebiet" without any preconditions: everyone and everything, who and that was singing, seething, simmering, seeking, sandpapering, sounding, resounding, ringing, rippling, riding, roasting, roaring, running, rustling, rushing, rumbling, rattling, rapping, tapping, trickling, tickling, tinkling, twittering, tripping, trembling, trotting, trumpeting, humming, howling, heehawing, hissing, hitting, hooting, booing, booming, bawling, boiling, blowing, blustering, bursting, bleating, beating, bumping, bubbling, buzzing, barking, breaking, belling, bellowing, lowing, droning, drumming, drifting, drizzling, sniffling, sniffing, smouldering, snooping, snorting, snarling, snapping, pattering, punching, pinging, mincing, miaowing, murmuring, moaning, yawning, yelling, swelling, swallowing, slamming, slapping, slipping, sliding, gliding, glugging, gurgling, gabbling, gushing, grumbling, grating, grinding, growling, shouting, shooting, shrieking, nibbling, neighing, gnawing, knocking, cooking, quacking, cutting, coughing, cackling, creaking, croaking, crowing, crying, crashing, crackling, cracking, crunching, crisping, clinking, clanking, clicking, clacking, clucking, clattering, chattering, chuckling, chewing, chirping, scraping, scratching, screeching, squeaking, squealing, screaming, sweeping, splitting, spitting, stepping, striking, skidding, thundering, throbbing, frothing, foaming, flapping, fluttering, fizzing, vibrating, whistling, whispering, waving, wafting, wobbling, exploding, erupting, unloading and emptying itself in manifold ways – in short – in thousands of audible events and conditions were the topic of my interest. Here, everything merges into each other. In any case, it is actually peculiar for sounds to mingle with one another and not to hold on to the side by side or one behind the other of visual appearances.

When, for example, I am standing in the "Hardt", a huge woodland on the outskirts of the "Ruhrgebiet", I can hear the twittering of the birds and a softly blowing wind roaming through the leaves of the trees. Their echoes make this area sound like a forest. And a forest conveys a totally different basic or grounding sound than a field, a river, a heath, a village, a town, a city or even a highway. And that you are at the edge of a conurbation, maybe searching for a classical idyll traversed in silence by the sound of birds, insects and the rustling of leaves on a sunny afternoon in spring, you can notice from the fact that you are struck by noise, mainly by the vehicles of amateur pilots who prowl around this area. And depending on which direction the wind blows and which season it is, whether the trees are fully cov-

ered by sound-absorbing leaves or whether they stand leafless like skeletons, you can even hear the flow of traffic in and out of the "Ruhrgebiet".

A very different grounding sound I have heard at the "Hengsteysee" near Bochum and at the "Walsumer Aue" near Duisburg: vastness as a deep humming undertone that spreads out over the wide surface of the water, borrowing from the sound of factories and ships that is modulated across the vast fields of water. The materiality of the landscape is incorporated in this listening. It is an eavesdropping for something hidden that remembers orientation in visually inaccessible grounds like a jungle or a savannah, overgrown with tall grasses; a sensitiveness for deep frequency like elephant steps from a distance. Above this vastness – half disappearing and half slightly decorating it – you hear the singing of larks and the cries of gulls. It is a vigilance for high frequency signals like the orientation towards the calls of birds in the visually inaccessible jungle. In addition to this, the wind blows and plays with a different sort of animal of the air, the kites which are flown in need of a rest by the inhabitants of the "Ruhrgebiet".

Or – home at last – an idyll, not in the classical but in a modern civilized way, at the shores of a water resort in the triangle between Essen, Bochum and Gelsenkirchen, where perhaps I have heard the heartbeat of nature in the "Ruhrgebiet". On this sunny afternoon in early summer that has been conjured up so many times, filled with the croaking of frogs, flown through by a multitude of insects, that encourages all ducks to fish, that lures a pack of dog owners, partly housewives, partly pensioners, to chirpily interrupt the yapping of their pets with conversation, cheered on by ecstatic barking from the animal shelter, and that sounds in between the background of low rushing traffic noise, a weekendly sluggishness rests on all bones.

Here, the notion of *basic or grounding sound* is very important: it spreads out around the listener, who stands in the middle of it and is not positioned in front of it as in the case of an object of sight. Hearing functions as a guard that attends on the regularity and maintenance of sound-patterns, startled by sudden changes in this pattern that serve as signalling sounds. So you can hear the ringing of the door bell, not matter where you are in your flat. He who cannot hear the bell ringing, like deaf people, has to look for an optical signal, which he must not turn his back on. She, who is walking in a park or in a fallow industrial estate, is always in the middle of her sounding steps which, by their grating, scratching, snapping or soft gliding on grass, ring on the carboniferous soil of rubble and renaturalization. This is due to the materiality of the acoustic sense.

So, the incorporated and habitualized attention to and the acting treatment of audible appearances can be divided into three dimensions: the communicative function of speech, the vigilant attention of exchange with the environment, and the eavesdropping concentration one summons out of the invisible. They are epistemic and perceptual master strategies in blind orientation. They afford a high degree in disciplining the acoustic sense. Together with perceptual contents such as basic or grounding sounds and typical soundscapes, highly characteristic, even unique echoes, acoustic positions of individual objects, courses of acoustic flows, topographical qualities, smells, tactile sensations and draughts, they constitute the blind style of perception.

Employing the Schützian notions of "standpoint", "system of orientation", "reach" and "schemes of interpretation" (Schütz 1962; 1964; 1966 and 1989) a short and formal description of the immediate and actual perception can be given as follows:

My own body is the centre of spatial orientation. From it a basic system of orientation starts: I move from "here" to "there". I divide the world into "close and distant" "left and right"

"above and below" and into "front and back". I accomplish orientation and produce movement by building up a multimodal space of sensory perception in a sensed unity of the world within my felt, tactile, acoustic, and olfactory reach. I position myself at a certain standpoint by feeling and hearing what is under my feet: a stone platform, metal escalator steps, or asphalt. In this context, different material properties of the instrument of perception deliver different information: hard shoe soles produce more sound, soft shoe soles are more appropriate for tactile sensations and naked feet are very sensitive to heat and cold. It is the nearest part of the world around me, very close indeed to my body. I then elongate this tactile world with my cane. Its tip marks the boundary between the world within my potential and within my actual reach. For a short moment of time an obstacle has invaded the world of my actual reach. But at the next moment I exclude it.

Maurice Merleau-Ponty (1962) has described the relation between the navigating subject and his or her instrument of perception as a unity. He writes: "To get used to a hat, a car or a cane is to be transplanted into them, or conversely, to incorporate them into the bulk of our own body". (Merleau-Ponty 1962: 143) Thus, properties of the material – like the cane or the shoes – have to be taken into account by the navigating subject. And the material properties of the instruments of perception must, in size, weight and stability, be adequate to the materiality of the environment and the sensorially performing body: It has to be a cane, a rope won't do the job.

The ups and downs of a street create a kinesthetically felt structure. Similarly, holes in the ground render orientation. Skin sensations also provide guidance. Cold air on my face, for example, indicates that I am coming close to a stairway leading up to a platform. As described above, sounds serve as concrete schemes of interpretation. They amplify the world within my potential reach by indicating directions. The blind style of perception uses the materiality of the hearing body through directing vigilance and watchfulness into the spatial structure of the environment where all directions are present at the same time and by discovering rhythmic patterns which reveal the temporal structures of the sounds. It reveals practical sets of skills to sensorify, to produce sonic images (poems for memory), to read and write recordings, and some of their artifacts as material resources.

The detailed phenomenological description provides us with a notion of the complexity that governs the interactivity (Rammert 2006) between the sensorial materiality of the body, its standardized and habitualized routines in the stock of knowledge (skills, useful knowledge, knowledge of recipes in the words of Alfred Schütz), material properties of the artefacts of action and the instruments of perception, and the spatial materiality of the environment. Social studies of science and technology might get some inspirations for their analysis of the interactivity between human actors and technological actants out of this that often is foreshadowed by the taken-for-granted knowledge of the life-world from which sociology springs. It might also show how vision can be embodied to an even higher degree as has yet been discovered into the shift to embodied vision in visual studies and social studies of science.

3 Blind Variation and Care of the Self

In the following chapters I will draw a parallel between two different epistemic cultures of science as described by Karin Knorr Cetina (1999) and the blind style of perception which I have briefly began to outline in the last chapter. Karin Knorr Cetina distinguishes between the epistemic cultures of molecular biologists and high energy physics.

In the face of open problems molecular biologists adopt the master strategy of *blind variation* and *natural selection* (Knorr Cetina 1999: 88-93). They vary the procedure that produced the problem and leave its success to the outcome of the experimental reaction. Variation is blind because it is not based on very extensive procedures of scientific investigation and understanding of the problem. They will not embark on an investigative journey in order to understand the problem and why it arose or to explain obscure data. Instead, they will try several variations as for example longer exposure time to increase the strength of the image, using different filter material, including RNA extracted at other time points or the use of a shortened DNA probe in order to reduce the possibility that similar sequences were picked up from other homeotic genes. Moreover, variations rarely involve just one variable.

The master strategy in high energy physics is *self-analysis* and *self-understanding*. Measurements are not to be taken at face value. "Experimental numbers are dependent upon a particular detector configuration and on the criteria applied in extracting information from the detector. Another detector, another set of criteria, yields other measurements" (Knorr Cetina 1999: 53). The theoretical ratio has to be related to the experimental ratio for a given detector configuration. Reconstructions are based on the premise that one knows the detector and all other components of the measurement machinery, most of all by their imperfections and shortcomings. In short, high energy physicists substitute the care of objects with the care of the self. Therefore, if physicists turn to variation they do this systematically in a step-by-step, equal-change sense in order to learn the effect of a variable. They do this by self-understanding, self-observation and self-description.

Self-understanding seeks to comprehend "what happens in every relevant part of the material, what happens over time, and why these things happen" (Knorr Cetina 1999: 57). Self-observation involves vigilance and surveillance, most clearly specified by online and offline monitoring. Self-description contains backtracking in error searches and memory- and history keeping.

In doing that, high energy physics creates negative knowledge or knowledge of the limits of knowing. Physics build on disturbances, distortions, imperfections, errors, uncertainties and limits of research. But they do not put the blame on these components. Rather, they draw distinctions between them, elaborate on them and create a discourse about them. "High energy experimental physics has forged a coalition with the evil that bars knowledge, by turning these barriers into a principle of knowing" (Knorr Cetina 1999: 64).

Corrections, errors and uncertainties are of paramount importance in this regard. Correction includes the limits of knowing into the calculation of positive knowledge. Statistical errors are distinguished from theoretical and experimental systematic errors.

Unfolding, framing and convoluting are ethnomethods, practical strategies that physicists employ to work with liminal knowledge. Unfolding means "the continuing unraveling of the features of physical and technical objects, of their details, composition, hidden sequences, and behavioral implications, through the reflexive redeployment of the approach to the data points generated" (Knorr Cetina 1999: 71). Framing relates different components of an experiment or of the field by checking, controlling, extending or compensating them in comparison with each other. Convolution, perhaps a special case of framing, is a term used for describing "the general strategy of mixing together resources and quantities that come from very different origins in an attempt to come to grips with the limitations of specific data or approaches" (Knorr Cetina 1999: 76).

4 Problematic Interpretations of Space within the Blind Style of Perception

After having described these two distinct epistemic cultures, I will now compare them to the blind style of perception and its epistemic strategies. My thesis is that the blind style of perception is much closer to self-analysis and self-understanding – the master strategy of high energy physics – than to that of blind variation applied by molecular biology. More than that, blind variation seems to be a strategy that is employed by sighted people when, for example, they try to give route descriptions. Being sighted in a world that is culturally and socially visualized in this regard gives opportunity to use an epistemic strategy that dwells on the similarity to the object which it works upon – the everyday life-world. Finally, I will address questions of the configuration of reality.

What do high energy physicists and the blind navigator have in common?

First of all, let me assume that the body of the blind subject is the detector, the navigation is the experiment, and the object of investigation is the environment. Measurements, data and signals are the different perceptions that come alive in the blind style of perception described above.

At centre stage in the blind style of perception is the care of the self. Only by taking the self as the point of departure can the world of objects and the environment be understood.

Because the world immediately springs from the feet that touch the ground and from the hand that is elongated with the cane, the world of objects emerges out of a monitoring of the self by employing vigilance that is directed to one's own body and the environment at the same time. In the second chapter we have already heard that the constitution of basic sounds affords a high degree of vigilance. In this regard, a disciplining of the body becomes relevant: One has to move carefully in order to not overwrite the sounds of the environment by one's own footsteps. More than that, if a cane should produce much noise, it also destroys watchfulness. Also, detecting the qualities of the ground below by feet calls for attentive movement. Thus, the blind subject is involved in self-observation.

In my reconstruction of the blind style of perception I have – up until now – focussed on the well-running process of navigation and spatial orientation in a unity of perceptually and cognitively based schemes of experience. Based on the description of a crisis of navigation, I would now like to come to the farther-reaching cognitive structures inherent in the construction of a total space used in the process of orientation and to the procedural project of action of a progression in time through said imagined space.

4.1 A Crisis of Navigation

To this end I will quote from the transcript of an audiogram dictated into a dictaphone I carried along. It is the self-observation, self-description and self-commentary of my own actions and perceptions while walking through a part of Cologne's main railway station. This means of description changes the reality of the situation far less than minutes from memory. The latter alter the current and subjective interpretation of meaning – because in every moment the world of daily life is an interpreted world, having sense and meaning for us. This is because the reconstructing interpretation and description of a moment x always start from its conclusion, i.e. moments x_1, x_2 to x_n. This structure of description is completely different when commented on and described directly during the succession of experience. The audiogram records as closely as possible within the immediate and currently experienced succession of moments, because it registers the way I interpret a moment – as though only from the past – in a situation of stasis, moment x_2 from x_1 or x, but not from x_n, as I do

not know these moments yet. I conceptualise them and create hypotheses about their occurrence or their nature, while not actually knowing their nature. The audiogram shows meaningful cognition and perception close to the actual moment. This structure becomes especially acute in the construction of knowledge in a situation of crisis, when the safe shores of orientation become shrouded in the fog of uncertainty, when the present is no longer woven into the well-ordered course of past and future. When, due to a crisis, not the next moment but one of the following moments brings on one which was unexpected, one that confirms the crisis or resolves it when foggy enlightenment finally sets in.

"I am now in a more confined situation, to the left something seems to have piled up, maybe a stall or something. So, the gap between left and right wall has grown smaller. This I can feel and hear. I continue on. The sound of the cane does not echo as much as before, is drier. I sense that something has approached me from the right, I touch it with the cane, then with my hand – a windowpane, I would guess. On the right the sound of music, a store, a kind of coffee shop probably or something like that. I carry on. I feel that to the right the wall is closer, another draught, sounds of a locomotive, another way up.

Once more I continue on. Here, the path seems to widen again, the echo is back. By the way, I am walking relatively slow, of course, children's voices behind me. In front of me the sound of the hall has somehow faded. Maybe I have chosen a wrong turnoff now. Um, because here, quite suddenly, it is relatively quiet. Another draught from the right. I'll go and see what's there. There is a slight incline… I am… yes, here is a way up. I go back, feel the wall to the right and follow the curve, the sound of the hall behind me now, in front of me it is rather quiet. Voices behind me, it is almost too quiet, I think. My guess is that I am in a side corridor. Suddenly there is an obstacle before me, a round pillar which I walk around on the left. I believe I have reached the end of the corridor. I hear a woman turn to the left, follow her. Okay. The hypothesis is: I am in a side corridor, I have to turn further left than anticipated to reach the underground." (Protocol "Way through Cologne's main railway station")

The blind protagonist's assumption in this situation was that he was walking down the main corridor of Cologne's central station. He has to take note of the fact, though, that he meets fewer and fewer passersby, a fact which – from its basic sound – simply cannot be consistent with the assumed space: If he had really followed the main corridor, he should by then have been close to the entrance area, the spot which has the most accurate basic sound with a strong echo and a lot of voices.

In order to identify the nature and degree of his divergence, he leaves the corridor and examines an area which, in his assumption and based on a draught, has a stairway. As he finds it, a gross aberrance as for example a divergence into a side corridor used for commercial purposes or into another wing of the building, can therefore be ruled out. The only possible interpretation, which may factor in the far-too-quiet basic sound of the main corridor as well as the existence of a way up, is the new hypothesis "side corridor" – something that, based on the formal perception of space, defines a corridor which runs parallel to the main corridor and is connected to it via a passageway. As a perceptive structure the side corridor resembles the main corridor in length and basic sound: e.g. during less busy times the main corridor closely resembles the side corridor during peak hours.

This shows how strongly knowledge channels wayfinding. This only becomes apparent, though, when the unit of actual perception, project of perceptual action and perception of space can no longer be implemented routinely. Spatial orientation functions properly based on an outline which includes perception of the formal structure of space, one's own position in it, as well as the time needed to travel a certain route.

But the formal, abstract structure of space is supplemented with a richness – let us call it data – whose content is perceived in lively fashion. Both are

part of the conceptual-sensual project of action and space. For example, it is only possible to notice an aberration by way of an assumed use of a space, according to which, at a certain spot, one may expect a situation in which a large amount of steps and voices can be heard. This way, the image of a spatial structure and the anticipated project of motion through this spatial structure join content-wise in time, for example based on the knowledge of a route's sequence of sounds. Should the actual situation deviate from the perceptive surroundings, it is followed first by a problematic interpretation of the current situation of space in the course of which the blind protagonist conducts a closer examination. He collects further information related to the reality of the space, mostly by tactile means.

This interpretation defines the current location against the background of special and general typical topological knowledge pertaining to the space on the one hand, and the route already travelled in time on the other hand. Starting from this new interpretation, a new way of dealing with the spatial situation and of reaching the spatial destination is developed.

If, in the case of severe divergences close to the current location's relative vicinity, no sufficient information may be gleaned, longer return journeys or sideways explorations of a larger degree can be detected.

4.2 The Care of the Self

Example from the year 2004: Twice a year I visit the parent conference day at my eldest daughter's primary school. Due to the rare nature of this on-site visit I have no characteristic feature sedimented in my stock of knowledge, which would tell me when to cross the rather long curve of the road leading to my target, i.e. the school's side entrance. Thus it remains unclear whether I am still in front of or have already passed the entrance after I have crossed the road. As I have been unable to find individual characteristics that might help in identifying the entrance, it has already happened three times that I was indeed in the right place but did not recognise it as such.

In these situations and in order to ascertain my location I then entered a side street. After approximately 300 metres (through no-man's-land) I would find a feature I was familiar with – a left-hand curve with a road sign positioned close to the curb/roadside and a bus shelter which should protrude into my path about one and a half metres onwards. If I were able to find this place, I would be close to the kindergarten whose position in relation to the primary school I was accustomed to, due to numerous visits with my younger daughter. Here now, I would find an Archimedic point of orientation from which an approach to the primary school would prove correct in retrospect and beforehand, as I would have to walk back the way I had come.

Should I not find all of this, though, the resulting interpretation of reality would then tell me that I have gone too far past the school. In both cases I would start to walk back, now equipped with definite instructions.

At this point it becomes clear to which degree this data-collecting spatial orientation is theory-led. In the case of doubt, the data of perception are ambiguous and cannot be easily interpreted. Measurements are not to be taken as they are. In short, in situations like these, the blind navigator dwells on a world of signs. Yet he is perfectly capable of deriving truth effects from sign-processing operations. How is this done? By comparing the signs which appear in different locations. But they are only taken at hypothetical value ("if this were this then that would be that..."). So the blind navigator is going back and forth between different interpretations. To locate a way out of the maze, he identifies and compares audible and tactile clues, points out where paths might

continue, follows some and recalls the design of the maze to evaluate leads.

There is no environment into which a theoretical description is integrated. Much rather, the environment only results from its theoretical description. It would also be possible to say: space results first of all from the theoretical description which runs in time. This does not mean, though, that space is first constructed by way of a theoretical description – no, and up to now this can only be formulated in a metaphorical way, it exists in a blurred form, only gains certain contours through the theoretical description in time. Thus von Senden's (1932) thesis that blindness synthesises space in a temporal fashion is partly correct, but space has to exist as a spatial system in order to result from the temporal synthesis.

But how can the epistemic structure of the acquisition of spatial knowledge be described? Which tactics and strategies are used in this task? Here is another example.

I will now quote further minutes from memory which I jotted down immediately on my return home. As such, they disregard the plethora of perception of the immediate sensual constitution, but adequately stress the theory-constructing and theory-led summary and interpretation on the way to an explicit knowledge-saturated overall interpretation:

"I'm walking back home, using my old way from the kindergarten. I'm contemplating something that has captured my thoughts. This is why I miscalculate the distance I have already covered: I believe to be at the beginning of the village but in reality I am somewhere else. I cross the street because I could reach the expected turn in the road from the other side of the road if I would follow the curb to the left. This way I leave the country road and cross the village street, as I want to follow its assumed course again on the other, the right side in the right direction. Here I continue on until I reach the end of the road where I learn from a passerby who has addressed me that I cannot go any further. I decide to walk back the way I have come until I reach the junction from the country road, where I can then correct the mistake. Thus I move down the same village road towards the country road. Here, something strange happens: I get lost, cross the road and suddenly and totally unexpectedly find myself on a new, unexpected street. This isn't the country road, as there are hardly any cars. I hear that more cars are driving down another street, which has to be the country road. Therefore I head there and try to decide which direction to take. Because now I am doubtful, as the direction depends on the question which side of the road I am on. That something is wrong I realize because I can feel a kind of ground under my feet which should by rights not be here: there is a raised sidewalk whose edge is not covered by flagstones but soil. A place like this should not be here. But at the moment I am unable to interpret this observation.

So I carry on, following the assumed course of the road: I assume that I am on the right side of the country road and walk in the direction I expect the village to be in. I keep walking and walking but the course of the road is not in keeping with my expectations, there should be a junction leading left and up. This is not the case, though. For caution's sake I continue on for a good while in order not to miss anything. Then it becomes clear that I have gone astray, or rather: my hypothesis concerning the route is not correct.

I pause and rethink the situation. It is clear that I am on the country road, this much I can tell from the rate of traffic. What I am not sure of is the direction and which side of the road I'm on.

How can I figure out where I made my mistake?

Well, first of all I have walked in the wrong direction. Consequently I need to walk back into the same direction I have come from. In my mind I follow my route: from a spatial point of view, the direction and side of the road I have taken were correct until I crossed the country road. Then I took the wrong street. I assume that I turned off to early. Am I on the right side of the road? I guess I am, as I know from conversations with my wife that only one side of the country road is bordered by a sidewalk. Thus I walk back on the same side of the road.

After a while I return to the very distinctive part of the sidewalk, hitherto unknown to me, which is surrounded by natural ground. I walk a ways into this street – it leads downwards, which is strange again as I expected it to lead upwards.

As I'm in a state of confusion I walk back a couple of metres, return to the country road and cross it. There I continue on for another couple of metres into the direction

I have now taken, i.e. in the opposite direction I have chosen before. Here, I come to a road and enter it. It leads upwards. That would be correct! I cross this small street and search for anything familiar on the other side of the road or for something that will give me a clue where I might be. Another hypothesis dashes forward: What if I were at the point where the last junction in the village leads upwards and to the left? Then I should be only one or two metres away from a very distinctive spot at which a footpath turns uphill, small, overgrown with bushes. I continue to walk, explore and realise that the hypothesis is correct. The route is the one I suspected, I carry on walking, further singular landmarks appear in the right sequence – a manhole cover, a turn-off to the left, a small stairway. Now I am in a very well-known area and find my way home without any doubts.

Now everything has become clear: Where was I when I lost my way?

In exactly the same road I just turned into and on whose left side the small path branched off. But because I was walking on its right side I stepped into the old familiar cul-de-sac, a place locally known as "Dreiort". And because I walked back on the same side of the road I didn't realize where the road would have led on straight ahead. And now all the following errors ensue from this realization: Namely, that I crossed the country road again without realizing it, that the strangely distinctive spot was a turn in the road which I didn't know before and which led in the other direction. A direction I had never walked in before, precisely because it led straight into no-man's land."

The blind style of perception does not only orientate itself but has to know when not to do it, i.e. the trick is to lose one's way and then be able to identify the right route, starting from the divergence. Thus, the ability to control and understand errors leads to knowledge regarding space and one''s own position in it. In other words, it is not only necessary to commit positive singular characteristics and landmarks to memory but to generate and master spatial structures as well as topological structures and progressions in a theory-led manner. Also, one has to learn strategies of how to find one's way out of errors in reasoning.

The success of the experiment heavily depends on knowledge about one's own position – the body in relation to the environment – as the latter springs from the further and the latter gives hints to specify the position of the further. Therefore it is fatal to lose attention as at the beginning of the protocol. And more than that. As the direction depends on the question which side of the road the lay scientist is on, the monitoring of one's own position, memory- and history keeping is necessary. Also backtracking in error searches is a usual strategy that the blind navigator employs: Going all the way back in order to understand the error, what has happened and why this has happened and then being able to correct it, is the typical strategy of his choice. Observations that are not expected to occur must be interpreted and cannot be left aside. A new experiment must be started to find a solution for the problem. Pauses and rethinking are usual strategies in this process. Following the route in the mind is another strategy to do this.

Looking for a new way "in a state of confusion" might at first glance sound like blind variation. But it is not because the results gathered by this attempt do not speak for themselves or through natural selection. They must be understood and only become interpretable with the help of hypothesis derived from a solidified stock of knowledge. And in the end, when the navigational crisis is overcome, all the errors have to be understood in order to create new positive knowledge out of them.

All this is analogous to the care of the self applied by high energy physicists. In sum, it would not be overstated to conclude that self-observation, self-understanding and self-description are strategies which the blind subject uses to achieve spatial orientation. He tries to create positive knowledge out of the understanding of the limits of research.

But by building on disturbances, distortions, imperfections, errors, uncertainties and limits of research the blind style of perception depends to an even higher degree on the principle of limi-

nal knowledge. For example, it turns the anti forces of the experiment into a resource of knowing. The background – competing processes and classes of events that fake the signal – are not taken as disturbances or distortions but are integrated into the picture as basic and grounding sounds and echoes. Smearing – a distortion of physical distributions in space that makes these distributions wider so that no distinguishable responses to two separate objects can be given – is also integrated into the whole of a grounding sound where singular locations that cannot be detected merge with one another. In a similar way it deals with noise – signals in a detector and in the electronics of the apparatus that mask the desired information. One's own footsteps or the clicking of the cane, for example, produce noise that is used to elicit echoes and sound reflections which reveal information about the size and the character of the place. In this case, even different categories of distortion work together: The noise of the footsteps creates a sound that evokes an echo that illuminates the background, and by doing this renders it sensible.

5 Convoluting

Now I will address a new start, namely the conquering of a new and unknown space. In this case, knowledge concerning individual topological features does not exist. Rather, a new and singular knowledge concerning the space is gradually acquired around a stock of knowledge pertaining to general structures of space. The ethnomethods of unfolding, framing and convoluting, which help to produce liminal knowledge, become easily evident in terra incognita. This terra incognita is the Cologne University's Faculty of Orthopaedagogy.

Slowly, the room begins to fill with texture, sense and stories: On the ground floor I open a door. Down there, where I expected a corridor leading to a staircase up to the first floor, I feel wind and also hear it. What's that?

I walk back and a female student addresses me, asks whether she can help me. Irritable as I am, I say that no, not really, I wouldn't be able to describe where I wanted to go.

Me: "But I have a question: Where does that door lead?"

Student: "Well, there is this kind of open area."

Me: "An atrium?"

S: "Yes, yes."

Sometime before, in a story I had picked up, I had heard about such a fabulous atrium-thingy and here, now – by way of framing it into my research – the story suddenly makes sense.

Then, on the first floor. Another student, who notices the fact that I have lost my way, looks after me and leads me a couple of steps across the first floor:

"Here is the daycare centre. On the parallel corridor are two classrooms, the mass in between is occupied by the daycare centre and there, to the back, is the children's dormitory."

From an earlier visit I know that on the opposite end of the staircase there is a corridor where the professor's office is located. I put this information into the same frame. One of these classrooms in the parallel corridor then has to be the one that I will have to teach in. The first names and spatial conditions come up.

Here comes an interesting unfolding experiment by touching, walking back and forth, and by cognitive structuring of different elements of knowledge:

Luckily the staircase is not integrated into the building in any symmetrical fashion. Thus it is possible to orient myself with the help of the following facts I have felt out: The staircase is attached to a connecting wall. Its wood merges perfectly with the wall made of glass. On the other side is a wooden lagging that serves as a guardrail to the stairwell. Next to it is a corridor. I mean a broad gap. There are two accesses to the staircase, facing away from each other. The first is not directly attached to the wall, it is close to the open corridor. What is attached to the wall, though, is the guardrail above the staircase access.

Beginning at the first access to the staircase there is an easy description to find my room of choice: You have to keep walking about one and a half metres straight on, then turn right into the corridor. In its wall the last door to the left leads to my seminar room.

If you follow the opposite direction out of the corridor, pass the staircase, walk down

the corridor and further on into another one, you will have reached a corridor on whose left side and a few metres further on – important – you will find the toilet. This is where I got lost on my search for the bathroom. Despite the fact that my new theory about the orthopaedagogic building is correct, I have still not been able to orientate myself because I did not look for a sufficient amount of data:

Two female students who had been sitting there seem to have distracted me, so that I did not find the toilet. I asked them both where I was. They did not know. Instead they asked me where I wanted to go. I declined to answer the question and insisted to know where I was.

They described: "You are in a corridor. On the way you have just passed a door. There is room 120."

A mixture of gestures pointing at nothing, observations of the obvious which did not contain information, and a number without context. Afterwards I clarified everything and told them that I was looking for the toilet.

They replied: "Why didn't you say so? It would've been much easier. All you would've had to do was walk straight ahead."

I answered in the affirmative but pointed out the insight we had gained through my silence. They responded with an amused and cheerful laugh.

Fundamental to this situation of acquiring knowledge is that two very heterogeneous strategies are entangled: self-understanding and gathering information from others. And what complicates the situation is that these others come from another planet. So the whole endeavor is ruled by the ethnomethod of convoluting. Note that this strategy sometimes works, as in the case of the second student, and sometimes fails, as in the last example. But even here a single information has been gathered (room number 120) and who knows when it will be of use?

6 Reality

Whereas blindness acts like high energy physics, sighted people tend to behave more like molecular biologists. Let me begin with a short citation from Karin Knorr Cetina's admirable book: "In dissecting the object, molecular biologists rarely argued but preferred to point. By referring to the image, they pointed back to the phenomena and the real-time processes of laboratory work". (Knorr Cetina 1999: 101)

Now compare this strategy to the way in which sighted people give route descriptions (cf. Kita 2003; Jarvella/Klein 1982). Pointing, a visual gesture, is constantly used in route descriptions by sighted people. Deictic expressions depending on visualization accompany the gesture ("This way" "there"). All other gestures they employ are unattainable without a visual script. They even immediately follow this strategy when they try to indicate the route or the direction to a blind pedestrian. Any landmarks given to them are inappropriate (cf. Saerberg 2006 and 2010). The last observation shows that these practices belong to the realm of knowledge taken for granted.

Sighted people will argue that their ability to understand a human being besides the typifications of common sense quickly reaches its limits. What fosters understanding for them is not the care of the self – and reciprocally the more or less emphatic care of another self – as it is in blindness, but being sighted in a world that is culturally and socially visualized. This gives opportunity for an epistemic strategy that dwells on the similarity to the object which it works upon – the everyday life-world. In this regard, the epistemic strategy of sightedness can again best be described as blind variation. To cite Knorr Cetina again: "Since the machinery used in molecular biology is largely the life machinery of the cell and of organism reproduction, attempts at self-understanding the tools and components of the experiment are jeopardized by the same limitations as investigations of the subject matter of molecular biology" (Knorr Cetina 1999: 93).

But we are not allowed to stop here. Because if we did, this would mean that blindness only had to deal with

signs and that it had no immediate access to the world of phenomenal experience. But we have heard that this is always the case in situations that are unproblematic. But what makes reality spring from unproblematic situations?

In order to look for an answer, I would like to compare this quiet room of ortopedagogy to two different rooms – and here we have come full circle. I will try to isolate their similarities by contrasting them.

The train station is frequented by a lot more people, shows more activity and is louder: With my white cane I feel my way along an unknown platform, looking for a place to sit. After searching about for some time I discover something that is built in such a manner that it could be a seating accommodation. It is a mesh of lacquered – most likely metallic – bars in a horizontal position, not unlike a latticework or netting. Its edges are reinforced and there is a more or less adequate area to seat oneself. Consequently it is a seat, as it seems to be shaped for just that purpose. I sit down and suddenly the object rolls away, a cart.

Thus the things in our outside world – which we think we know and which make up our so-called reality – are not things at all in our relation to them. Things are visual schemes, pictures that look like a chair, room, staircase, train or door …

Pictures are of a certain size, shape, contour, limitation. But this is only one, albeit privileged form. The room whose number I had intentionally not committed to memory and which, as the last anchor, could turn into 124, is not the picture of a room off a corridor, it is a space relation: I climb the stairs, test the spatial structure and then know how to get there. More is not relevant and I do not generate any more knowledge. A solid object-shape, solidified into a visual picture, does not exist.

The same is true for the chair or the seating accommodation. It possesses a material structure which suggests that it is a seat, but in this social context it does not have to be one. Due to its material structure it may be used as one, alienated in one sense, appropriate in another.

Passerby: "And how do you know which train is coming?"

Me: "By asking you."

Of course I could also check my watch and listen for an approaching train at its time of arrival and, when it has stopped, draw closer and check with my cane whether its entrance has lowered. Should this be the case it is my train, as it is the only one which is designed like this.

Socially standardised signs and names are shortened pictures, smoothed and reduced to a couple of allowed lines. Pictures, on the other hand, are bloated signs, colourful and with complicated contours. Thirdly, things are sprawling pictures but behind them we find complex relations whose traces are the pictures.

Thus it is not things or objects we find on the bottom of reality but *relations and arrangements*: positions relative to space and objects – even human ones – floating in relation to each other on other things towards even more other things – things that are only perceived as traces of objects but which are unknown in their entirety. The train in its entirety remains un-present, only the eye imagines to have seen the whole train, gliding by or squashed in perspectivity. But images are conventions, social or psychological. It makes no difference. They only represent the whole.

This is the privilege of constructivism: nothing exists without a constructive portion. But this is also the privilege of realism: one construction may be used for purposes other than intended, another one may not, at least not to this end – but maybe to another one. Nexus and idea meet, walk a ways together.

All this has actual parallels to the epistemic culture of high energy physics, as the latter also understands the research process as a construction originating from self-understanding and dealing with liminal knowledge where out of errors, background, noise and smearing constructions of relative validity are produced, which are only visualised as auxiliary means (cf. Benz 2001; Krug 2001) but which could also be paraphrased acoustically or tangibly. In reality, complex relations, numerical sequences, etc. are behind all that, but no colourful space partitionings or objects with contours, sizes and dimensions. As the drone I hear

that signifies the trail of a locomotive, that also hints at a certain power and size, but which does not possess a cast mould.

Science produces and processes visualisations. "Viscourses" (Knorr Cetina 2001) and digital visualisations adjust a certain relationship to the eye. Visual practices, described as paperwork by Latour, shape science's material. Digitalisation, though, has transcended this visual stage: All data are devisualised, they can be made tangible for the blind by using a braille-display.

Reality seems to be a relational term that is vague and infinite and only becomes a full reality insofar as it is incarnated in things or persons. But incarnation depends heavily on a society's taken-for-granted knowledge about perceivable and conceivable persons, things and objects which is realized through their subjective and interactional practices in the everyday life-world.

And in the case of the train another similarity between blindness and high energy physics reveals itself. The object of interest is far too much out of scale ever to be perceived in any other mode than an indirect one, too fast to be captured and too dangerous to be handled directly. The vigilance directed at the roaring sound of the train or the careful touch of a little part of it searches for traces of its presence. It is analogous to handling beds of clay which have preserved the steps of dinosaurs. All three techniques of rendering their object perceivable deal with its dangerous materiality. So paradoxically, blindness is an attribute of sight, and attentive care of one's own self has to do with blindness.

7 Conclusion

In blind navigation it is, in essence, not that important whether one does not see from a physical point of view, but rather whether one is able to move naturally in a familiar space without having to look – in "blind faith" so to speak. In other words it is more important to be able to act without having to check first whether one's own definition of a situation corresponds with the actual situation. Chapter 2 described the self-conscious blind style of perception in which the blind person is allowed to be blind, in which blind variation does work, in which the life-world is sensorised, and which differs from the problematic interpretation presented in Chapters 4 and 5, in which blindness becomes acute and which deals with overcoming blindness via one's own interpretation. In this case, blindness means that the formerly familiar suddenly proves unfamiliar, one has taken a well known way and – behold – has gone astray. One is dazzled. Experiences a crisis. The eyes have to be opened again and the problem has to be analysed until it has been understood and solved and until it has become familiar again – and one is allowed to be blind again. This process is an endless spiral movement. Blind navigation in the unknown and high energy physics now move in the midsection of the spiral, because they move in the unfamiliar – one could also call it the "disembodied". Both try to understand the unfamiliar with the help of abstract theories and, subsequently, by giving it a body again – here a sensorised one, there a visualised one. This also means that everyday life on the one hand, and science and blindness on the other hand always exist in a relationship of embodiment and disembodiment. The latter ones construct extremely abstract interpretations, which they then, step by step, try to incorporate into their life-world via embodying visualisations or sensorifications.

Compared to the blind style of perception, however, the visual style of perception has the advantage of being dominant in everyday life. Correspondingly, it has also manifested itself in a far larger number of artefacts. There are Latour's inscription devices and material resources like diagrams, lists, formulae, archives, engineering drawings, files, equations, dictionaries, col-

lections. Here, I plead for the use of a further term of embodiment, though – one which does not only include tools or the inscriptions of the Actor-Network Theory but one which also includes the materialization of numbers in curves. Graphics may be schematic but they are still visual embodiments – a curve follows the corporeal manifestation of a mountain or a valley. Or bear in mind the numerous visualisations of perfect numerical series as described in astrophysics by Arnold Benz (2001), used to perceive contours and structures more easily. In those visualisations we are dealing with an artificial body, which nevertheless shows the traces of a body. And here, again, is an inverted parallel to the blind style of perception: when a radio journalist edits a feature on his PC with an editing programme, he navigates the mouse through a multicoloured landscape of curves and spikes. To the same end, a blind friend of sounds "simply" enters length specifications, "Edit out between min. 22.42.1242 and min. 23.31.1532". With this phenomenology, the retrospective dependence of such artefacts on a physically and sensorially minted acquisition of knowledge can succeed and the sociology of science and technology can turn the interplay of disembodiment and embodiment in sciences into a topic beyond the black box.

If this is reversed to everyday life in a radical disassociation, the whole visual thing with all its seeming self-evidence appears to be a visual manifestation of an underlying network which remains invisible. By way of such self-evidence, something strange may become routine and has always done so. Because, just as a blind person's soundscapes very often constitute exactly the same strange abstract and unsettling networks for a sighted person, they are, for the blind everyday listener (in the double sense of the word), completely familiar things with skin, hair and a face, i.e. familiar manifest flesh of the world from one's own flesh.

Thus it is of course possible to talk about the dominance of the visual, but that is not manifest in an anthropological determination of the apparatus of awareness for predetermined purposes. Also, in my opinion, there is no hierarchy of the senses in which Vision is predestinated for the achievement of knowledge.

Rather, the interaction between sensorial corporeality, material artefacts, more or less routinised habitualisations, material circumstances of the environment and their social standardisations (e.g. the social creation of the "self-evidence" of the visual or other senses) has to be described as accurate as possible from a phenomenological point of view. Thus it may not be claimed that the differences between the styles of perception are contingent on the visibility or invisibility of an object. Rather, the strategies of visualisation and sensorification are dependent on a very complex set of factors.

Consequently, we are dealing with levels of familiarity, or the unfamiliarity of a style of perception and the corresponding epistemic strategies in a particular environment, life-world or an area of material reality. The greater the familiarity, the greater the blindness – of the sighted everyday person in his/her visualised life-world, of the blind everyday person in his/her sensorified life-world, of microbiologists in their organism-manipulating laboratories. The greater the unfamiliarity of the everyday person in general in view of crumbling clarities in the face of globalisation, technological progress, cultural change, etc., of the sociologist examining this, of the blind navigator in an unfamiliar, visually signposted city, of the physicist looking at his nanoparticles, though, the greater the compulsion to observe oneself, to see and to monitor oneself sensorially, so to speak. Hence the paradox: the sighted everyday person is blind, the blind everyday person at home is blind as well, but often, in problematic situations, he has to see.

The epistemic strategies of social sciences, too, have to fight systematically with the loss of familiarities – i.e. the origin of blindness. According to Hegel, the owls of Minerva first fly in the fading light of early evening. And only with the onset of dusk, when socially constructed life-world self-evidences and obviousnesses are analysed and crumble, does sociology become certain of its blindness – has to first use visual aids, become an owl, but suffers chronically from difficulties of sight as it is unable to follow the constant change of the life-world, which is why its visual aids will never be adequate. Hence it has to invent epistemic and perceptual strategies, has to specify methodically and methodologically in order to visualise and sensorify what is happening. This is why sociology will always generate knowledge when crossing the border between the familiar and the unfamiliar, which is not based on visual matters of course, but has to be closer to uncertain occurrences. Therefore, it will rather be necessary to develop different degrees of embodied and sensorially differentiated knowledge than to increase visual distance.

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Scientific images? How touching!

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Abstract

As contribution to the still rather marginalized study of the visual cultures of the social sciences, this article draws the attention to the visualization of social structures as node-edge diagrams in Social Network Analysis. By going beyond their mere visual dimension, it sets out to explore specific corporeal and sensual dimensions of visualization practices and respective constructions of shared meaning in the social scientific research process. The following questions are addressed: How is knowledge made explicit? How do researchers depict and look at social structures? What corporeal and embodied practices co-constitute and shape their epistemic vision?

Starting from an ethnographic encounter with a print of a network diagram at a research team meeting, this article delves into the context of its production. Taking into account the performative aspects of visual knowledge, the tangibility of depicted social relations, the elaborated metaphorical and colourful visual language, as well as the ergonomic normalizations that come with instrumentation and experience are highlighted. Analyzing knowledge production within the realms of aesthetic practices calls thus for a treatment of the scientist's body as an active agent and not as an automatism to be blended or as passive precondition. Furthermore, such an approach might broaden the outlook towards a more body-aware scientific reflexivity.

> "That would be the highest thing for me" – so saith your lying spirit unto itself – "to gaze upon life without desire, and not like the dog, with hanging-out tongue: To be happy in gazing: with dead will, free from the grip and greed of selfishness – cold and ashy-grey all over, but with intoxicated moon eyes! That would be the dearest thing to me" – thus doth the seduced one seduce himself, -"to love the earth as the moon loveth it, and with the eye only to feel its beauty. And this do I call immaculate perception of all things: to want nothing else from them, but to be allowed to lie before them as a mirror with a hundred facets." – Oh, ye sentimental dissemblers, ye covetous ones! Ye lack innocence in your desire and now do ye defame desiring on that account! Verily, not as creators, as procreators, or as jubilators do ye love the earth! (Nietzsche 2008: XXXVII)

1 Introduction

In the preceding quote, Nietzsche sneers at the advocates of an abstract mind that lays pure and disembodied in an objective sphere of judgment and cognition. As restrained observers, philosophers and scientists alike trust in genuine sight guided by reason, and the wish for an "immaculate perception", not touched or contaminated by unpredictable sensation and fleshly intervention. Nietzsche condemns this treatment of perception, describing it as a frozen stare at a supposed beautiful truth while pretending to be without desire, without the wish for manipulation and intervention. Nietzsche's critique is in line with opponents of a "spectator theory of knowledge" (Dewey 1929). Treating the knower as passive and leaving knowledge production to "mirrors" (James 1920; Rorty 1979), be they recording devices or specific representational language games, divorces knowledge and action. Thus, the such criticized oculocentrism of western cultures in the construction of truth, which trusts a certain correspondence of truth and world in accurate descriptions, produces hypocritical science (and philosophy), which always has to hide desire and creative or aesthetic intervention.

This article tunes in the critique of "immaculate perception" by addressing the performative aspects of visual knowledge production in scientific research. The handling of pictures in sciences appears paradoxal if proof should be as untouched and unaffected as possible, as subsumed by Galison (2002: 300): "We must have images. We cannot have images." Scientific objectivity and aesthetics involved in image production and perception seem incompatible, even though they obviously cannot exist without each other.[1]

The pragmatic turn towards a sociotechnical construction of knowledge in science history and science and technology studies drew attention away from paradigmatic theory building and institutionalization to the sociomaterial practices of knowledge production. A special emphasis on visual practices in these disciplines dates back to the 1970s, when authors "described scientific seeing as richly rooted in the practices of field and laboratory" (Mody 2005: 176) and reflected perception as socially constituted.[2] Studies devoted to knowledge production in the context of scientific laboratories and the related daily routines revealed the power of "inscription devices" (Latour/Woolgar 1986): the dominant role of images in the creation of evidence and their vital embedding in inner-scientific discourse, rendering them to "viscourses" (Knorr-Cetina 1999b). Investigations of meaning, logic, roles, functions and popularization of scientific images, and their orientation to "looking, gazing, reading, and other things done

[1] Zimmermann (2009) demonstrated inter alia that the notion of objectivity comes with certain aesthetics itself.

[2] See e.g. Rudwick 1976; Shapin/Schaffer 1985; Lynch 1985; Latour 1990; Lynch/Woolgar 1990; Cambrosio et al. 1993.

with the eye" (Mody 2005: 175), underline the importance of the visual dimension in the sciences. Studying the visual dimension of knowledge production, the processes of "making visible" (Rheinberger 2006), reveals the importance and indispensability of imagery in every phase of knowledge creation, even though only a few pictures, if any at all, are made public in the end. Additionally, the performative perspective of knowledge production, dealing with human and non-human agency, emphasized that scientists create what they study, they enact what they analyze (Law/Urry 2004) and scientific inquiry often opens up unintended "collateral realities" (Law forthcoming). Furthermore, such investigations dealt with the distinctiveness of visual cultures in science (e.g. Lynch/Edgerton 1988; Lynch/Woolgar 1990; Galison 1997; Knorr-Cetina 1999a; Beaulieu 2002) and diverse global "image markets" (Pörksen 1997), bringing the distribution and deployment (Burri/Dumit 2008) of scientific images outside the laboratory into the focus, e.g. the use of brain scans as "demonstrative evidence" (Dumit 2004) in courtrooms.[3]

The turn towards the visual in the sciences resulted in numerous studies of natural, technical or medical sciences. Visual cultures in the humanities and social sciences only partially move into the focus of science history and science studies (cf. Fyfe/Law 1988; Lynch 1991; Nikolow 2005). The most relevant research is done in the respective fields, like sociology (Barlösius et al. 2001; Keller 2006; Pauwels 2006), and rarely reach the science history or science studies communities. This paper is intended as a small contribution to the study of visual cultures in social sciences. It addresses the practices of visualizing social structures in the form of node-edge diagrams within the field of social network analysis that deals with large data sets. Specifically, I would like to highlight the corporeal and sensual dimensions of the procedures of making visible. How is visuality constructed in this field? How do researchers "see" social structures? What corporeal practices co-constitute and shape epistemic vision?

When dealing with the multimodalities of visualization practices in scientific research and asking how shared meaning is constructed, it is necessary to focus also on the corporeal and sensual interactions[4] of researchers and their imagery, where the scientist's body is not only treated as a simple precondition to conduct experiments with. Karin Knorr-Cetina distinguishes in her study on epistemic cultures in molecular biology between the "acting body", the "sensory body", and the "experienced body" in scientific practice. Linking these three dimensions together, the body is treated as "silent" in her analysis, working best when it is black boxed into the "empirical machinery of research". The concept of inscription is projected onto and into the body that becomes unconscious and merely intuitive: "By the scientist's body I mean a body without the mind. If the mind were included, hardly anyone would deny the presence of the body. The body, as I use the term, refers to bodily functions and perhaps the hard wiring of intelligence, but not conscious thinking", Knorr-Cetina writes (1999: 95). Similarly, when it comes to the corporeality of scientific practices (apart from a focus on bodies constructed by science), concepts like "tacit knowledge" (Collins 2001; Polanyi 1967), or implicit, personal and hardly transfer-

[3] Some of these investigations lead to the insight that in countless epistemic (and other) fields, scepticism of the appropriate application of images prevails. Especially in fields that deal with invisible, very small or distant phenomena, like particle physics (Galison 1997), astronomy (Lynch/Edgerton 1988), and brain sciences (Beaulieu 2002).

[4] Cf. Ochs et al. 1994; Griesemer 2004; Bergermann 2006; Meinel 2006; Myers 2006; 2007; 2008.

able knowledge prevail, treating embodied know-how as knowledge bound to a body and/or disciplined and trained through experience and education. Knowledge becomes describable as a process of knowing (Polanyi 1962), always knowing more than can be articulated or reflected. In line with such both valuable but also simplistic perspectives, the knowing body and the "sensory body" alike are becoming black boxed and in danger of being reduced to a rather intuitive and solely passive capacity of perception, and the sense of sight, leaving "little room to account for passion, affect, and sensory engagement" (Myers 2007: 243) in science. Even though the aforementioned approaches might at least help to challenge the philosophical duality of body and mind, they are in a way perpetuating a "myth of bodylessness" (Haraway 2004; Myers 2007: 243) into a myth of sense-lessness and fall too short in regard to the active, conscious, reflected, affective and communicative dimension of "body work" (Myers 2008) when "doing images" (Burri 2008). Therefore, the focus of this paper will be on various manifestations of corporeality in social scientific visualization practices as implicit and explicit knowledge production (cf. Hirschauer 2008: 982).

> "Whatever the pictorial turn is, then, it should be clear that it is not a return to naive mimesis, copy or correspondence theories of representation, or a renewed metaphysics of pictorial 'presence': it is rather a postlinguistic, postsemiotic rediscovery of the picture as complex interplay between visuality, apparatus, institutions, discourse, bodies and figurality." (Mitchell 1994: 16).

In line with W.J.T. Mitchell's quote, this paper strives to pay attention to "researchers' corporeal and affective entanglements with available concepts and modeling media, and with the visualization machinery" (Myers 2007: 67). It does not want to reduce the powerful roles and functions images have in the research process to their mere visual dimension. On the contrary, it will tempt a widening of perspective on visual cultures in science by grasping several corporeal and sensual dimensions of scientific practice, like Natasha Myers proposes. Pointing fingers, touching models, the haptic dimension of visuality, for example, can be conceptualized as active sensual perception, or *aisthesis*, which can lead to a wider understanding of aesthetics. An understanding that encompasses not only style, art and beauty, but the study of sensation and perception. Placing knowledge production into the realms of aesthetic experience and configuration emphasizes the body as an active agent and not as an automatism to be blended out.

In order to find out how specific scientific images "make sense", to allocate their evidential capacities within practices of exploration and demonstration, I invite the reader to follow me into a social scientific institution dedicated to social network analysis. The empirical material presented in this text is drawn from my ethnographic PhD research of visualization practices in the field of social network analysis. Over the course of four years (2006-2009), I visited several institutions, did participatory observation, interviewed scientists within and outside the core community, followed several discussion groups, and attended conferences and workshops.[5]

The controversial status of network images in public debates attracted my attention: advocates use, plead and campaign for enhanced and colorful network information visualizations to deal with complex data; opponents warn against their power of delusion and persuasion, and that they are not adequate representations of the data. I was interested in how such imagery is used in the research process, whether it is used at all, or if it is only produced

[5] The research reported here was made possible in part by support from the Austrian Science Fund FWF and the research project: P17600 Materiality and Temporality of Performative Speech Acts.

for popularization of knowledge otherwise hardly presentable.

In the course of my investigation, it became apparent that the usage of imagery is ubiquitous in network analytic research processes: graphs and node-edge diagrams served as exploratory space, rationale, and proof. My ethnographic analysis of observations and interviews shows how image practices and styles, including interpretation, are marked by the degree of expertise in imaging techniques, and that reflexivity of visual knowledge production is largely dependent on this degree of expertise (Mayer forthcoming b).

Shortly, I will recollect an event at one of the visited institutions, which employs social scientists and philosophers that are also visualization experts and working on developing a visual language for the mediation of social structures.[6] Taking this as a starting point for the examination of "how researchers' bodies become key resources in producing knowledge" (Myers 2007: 51) by means of visualizing, I direct the attention to kinesthetic or "gestural knowledge" (Griesemer 2004), narrative strategies, and the training and normalization, but also the playfulness, of researchers' perception. In what follows, I hope to show how social structures are not only becoming visible as graphic networks, but also palpable, and how this realization is connected to corporal and sensual competencies and practices. In line with Nietzsche's critique of immaculate perception, such a fragmentary and exemplary glimpse into the visual worlds of network science should emphasize the touching qualities of network diagrams, both literally and figuratively, and the "liveliness" (Haraway 1997) of cultivating a feeling for the object of research with which it is realized.

[6] A description of this event is also featured in Mayer 2009.

2 Retrospect

Social Network Analysis is a scientific method of studying social structures and group behavior. Social networks as an analytical concept consist of actors and their respective relations. Since its inception as Sociometry in the 1930s in the USA, such structures are surveyed, measured and interpreted with the help of diagrams. Actors are represented as nodes and their ties as lines or edges. This supposedly simple figure – the node-edge diagram – has a long history and can be traced back to the first conserved tree-like depictions of pedigree, and it is rich in its capacity of variation (cf. Gießmann 2008). It is to be found as a basic epistemic scheme (and realization) for a relational perspective in many scientific disciplines, like mathematics, chemistry, engineering, neurophysiology and philosophy. Nowadays it co-shapes societal self-descriptions as network(ed) societies (Mayer forthcoming a).

Sociometrists and anthropologists were formalizing social structures into ad-hoc and ex-post network diagrams even before mathematicians and especially graph-theorists were interested in real world graph problems. Jakob L. Moreno, trained as a physician and social psychologist, originally developed interaction diagrams and later "sociograms" for improvised theatre and psychodrama in the early 20th century. "Before the advent of sociometry, no one knew what the interpersonal structure of a group 'precisely' looked like." (Moreno 1953: lvi) By making structures visible, sociometrists wanted to explore the social space together with their research subjects. Sociograms should function as "social microscopes" (Moreno 1967) and should support intervention and social change through social "diagnosis and healing". With the help of sociometrists and their "scientific socialism" (Moreno 1967: xxi), participants of sociometric experiments should become active agents in matters con-

cerning their life situation once their embeddedness in social texture became evident to them.

According to Moreno, it was the sociogram that first allowed the experimental study and "precise exploration" of complex relationships, which since that time have been considered as "social networks" and "places of origin of public opinion" (Moreno 1967: 267). The field of social network analysis has been growing consistently since the 1970s, bringing with it new methodologies and visualization instruments. With the mathematization of social networks and the application of graph theory and statistical methodologies, networks can also be treated as graphs and allow computation and measurement of even very large datasets. Automatic Graph-Drawing has largely replaced manual drawings and has opened the network perspective to new scales of complexity. Sociograms come as visual surfaces of complex technical assemblages and interactive interfaces. As such, they are vital elements in the research process, be they on paper or on a computer screen.

How does a team of network analysts work with sociograms; what kind of communication do they evoke; how entangled are the researchers' bodies with the scientific image or even built into their instruments? These questions will be addressed after the following section where an encounter with a printed network diagram is staged.[7]

3 Staging

The scene of a regular weekly meeting: Monday morning at a social scientific research institution specialized in social network analysis. In addition to several computer screens, there is a projector, a flipchart and many posters showing network visualizations on the wall, which stem from completed research projects and serve as successful examples of the institution's development. After having already projected a crucial network diagram to the wall, and then having drawn a detail of it on the flipchart, five social network analysts and I are now waiting eagerly for the plotter to finish the first print of the colored and elaborated visualization. The team leader explains to me, the ethnographer, how important it is to work with such large printouts even though they are very expensive. First to explore and control the displayed content, second to examine if the intended content and its appearance are still readable after such a change of medium. Finally, as the team needs to prepare a poster for a conference; it is tested whether this image could be further developed for this purpose.

Conversations revolve around the data pool, the problems of inquiry, and the potential interpretations as the network picture is an important part of this process. Immediately after the cleaning, ordering and input of the data into the software for network analysis, the first network visualization was produced on the screen. The diagram was colored, tagged, and iteratively adjusted with automatic layout algorithms so that it became easier to read. The further composition, including the fine tuning of labels, positions, coloring of the background, nodes and lines, was done manually by a researcher, and always in comparison with the data in the tables and rankings, and several distribution graphs. Furthermore, the visualization was elaborated in regard to the institution's own corporate identity: its look that results from long engagement

[7] I want to ethnographically elaborate my observations by means of a meeting around a printed diagram, and not with the typical modes of image production in the research process that happen largely in computers, because nowadays still mainly printed or projected diagram leave the social scientific laboratory in the end. The juxtaposition of computer-aided visualization processes will help to deepen the understanding of corporeal and sensual configurations.

with the development of a diagrammatic language. Shortly before the print is ready, the director of the institution addresses me, smiling: "One always thinks, it is creative work we are doing, but in fact it is all about the coloring and exporting of JPGs." While thinking how sarcastic his statement was meant, knowing how laborious and demanding the production process is if one wanted to create an effective, contemporary and pleasing visualization, the print is ready. The network materialized like a "synoptic tableau" on the table: its surface glossy, the colors strong, the nodes and edges precisely positioned on the available space.

As soon as the bearer steps aside, the fingers of the surrounding team start traveling the picture. The team leader takes on the role of the pointer and commentator; his fingers leave traces on the paper while he remains in a dense region of the network: "What does that show, it is a clique. Where are they brokering into? … Their positioning at the periphery cannot be contingent." A researcher responds "I am not sure, I have no feeling for the data, as I did not collect it, but…" his finger trails towards one node, all eyes following, "…here seems to be the gatekeeper. Through this, one has to go to reach the key players." He knocks on the circle representing an actor. Another researcher adds "Somehow this is not well-arranged; it is far too dense. I cannot see the actors in the important clusters clearly. I would prefer to have them on the left side so that they come into my view immediately. By the way, I think there is a mistake. This institution is duplicated, here, but slightly different spelling." There is an error in the dataset, which is instantly opened by another research on his laptop and corrected. The team leader is already further in his interpretation: "But look at the center, it is so dense and rigid, it is blind. There are the most important actors…" he clenches his fist "… and they are frozen without even being aware of it. All the movement emanates from the periphery." His finger moves rapidly between several nodes at the margin of the picture. He takes his fingers from the picture and points to a poster on the wall. "It is always like this. Do you remember that study? It was similar. Look at the distribution. The clusters are connected by several loose couplings." All eyes follow to the wall and examine the reference addressed that now serves as a model for a recurrent social constellation. In the course of the meeting, many more pointers are made, and it happens that fingers are pushed away if they are blocking the sight or the path of other traveling fingers.

Based on this ethnographic encounter, the following sections will be dedicated to a further analysis of how knowledge is made explicit with the help of corporeal interaction and instrumentation, be they gestural, narrative, trained, normalized, or playful. The printed network diagram at hand serves as important working equipment beside the often solitary work in front of a computer screen. Its explorative function consists in the "materialization of questions" (Rheinberger 2006: 25). It allows for collective interpretation and is the central tool of a consolidated perspective of the data, but it is not only looked at, as shown in the story above. It is carefully constructed so that it can be seen, touched and bespoken. While being investigated for patterns and paths, it is put in reference to other pictures: on walls, on flipcharts, on screens, and even to concurrent graphs to prove that the available data mount is an actual social network and not an accidental distribution. Its referents are transversally layered (Latour 1996: 203). The network diagram is not simply referring to data, but also to the tools of its construction and to a cohort of contextual and visual knowledge, and it is embedded in a cascade of transformations. This knowledge of

data is re-ordered, but also further transformed into computable figures (Mersch 2006: 97), which shape a topography for further configuration and interpretation.

4 Pointing – grasping – touching

The introduced visualization of a social network can be regarded as part of a social scientific experimental setting. Hans-Jörg Rheinberger (1992: 26) calls the basic movement in such a setting "groping" or "thinking with hands". The fingers and hands of the observed network analysts do not only operate computers to construct effective diagrams, they operate themselves in all media and add corporeality to the present materials. The fingers undertake the missing dynamic of the static image by traveling the network and supplementing them with interaction. The forefinger is here a means in the mode of "explorare" (Mersch 2003) as it travels through the depiction, leaving trails and collecting positions. It also acts as a literal index in a mode of "demonstrare",[8] leading the gaze, outlining patterns and linking to references and even errors. This "haptic gaze" (Burri 2008: 212) is a corporeal technique, actively invoking the tactile sense to grasp depicted social relations. Network diagrams provide a material experience, and such a haptic experience leads to a "better feeling for the data", as repeatedly declared in interviews by several observed network analysts. The haptic exploration and interpretation of the plotted diagram as recollected in the aforementioned situation is a collective effort. The creation of touchable maps of social networks helps to synchronize communication through discussion and a mutual process of exposure, of pointing, and "drawing things together" (Latour 1990).

Another aspect of the importance of working closely with plotted diagrams is outlined by the team leader: "We need to print the visualizations in order to test them. You cannot test it only on the screen, especially not in a group of people. It is the combination of immersing ourselves together into the diagram, touching it, scribbling on it, and looking at it from a distance. For example, when mounted on the wall, that helps us to understand the network, or, maybe, to understand what we have done with it. Even more, it shows us whether it could be understandable to others." The comparison of the diagram's appearance from close proximity and distance in combination with pointing to or touching of its surface, guides the exploration of the research object, and it helps the assessment of its appeal to external spectators. Furthermore, the team leader points to the active and reflective dimension of the employed haptic gaze for testing and its importance in the further production of visualizations that are to be published or presented.

As mentioned in the introduction, Karin Knorr-Cetina (1999b) calls the interplay of visual images and their integration into discourse "viscourse", and relates the use of images to the telos of successful communication. But there is more to the deployment of network images than just their communicative performance. Touching the network picture highlights certain actors and links, making them more evident by the directing of attention. The synaesthetic experience of simultaneously sensing something and sensing oneself fosters the experience of evidence in the experimental setting (Bergermann 2006). Ulrike Bergermann refers to "haptic evidence" (2006: 316) that is characterized as a particular mode of proof, but is difficult to communicate other than via touching the research object and the so called "hands on" experience. The collective touching of the diagram as concerted securing or rejecting of proof enriches

[8] Showing and pointing in a demonstrational mode are employing a specific visual logic that is different to a discursive logic in regard to how meaning is constructed and stabilized (Heßler/Mersch 2009).

the analysis in the experimental social scientific setting.

"It is fun to work with the visualization, more fun than the other work, here you can be creative. But it also can be very laborious, takes a lot of different steps, different programs, until we have what we like in the end. We are sometimes cursing the software, as it is not doing what we want," a researcher says. And she continues: "Having the visualization in my hands, being able to crumple it up, or put it on the wall later as guidance is important for me. I need to get away from the screen sometimes." Another scientist and interview-partner also remarks the importance of the plotted picture in order to explore and evaluate it, but he prefers to interact with the network diagram on screen: "While we need to plot visualizations in critical project phases, where the collective interpretation, or better the collective evaluation, is needed, I can better dive into the network when I have it on the screen." He then describes his "desire for pictures" when analyzing social networks as desire for physical intervention. He continues: "I want to literally touch it; I want to immerse myself in it, mesh it." Even though on screen, the scientist associates physical touching with his actions that encompass touching the network structure with the computer-mouse: turning it, zooming in and out, switching from the 2D to a 3D perspective, and sometimes even "flying through" a visualization to "approach" certain nodes or links and examine their neighborhood closely. When asked if he is mimicking his routines from the examination of the network on screen when he explores a printed diagram, he laughs, but does not exclude this possibility. On the contrary, the team leader when asked the same question, recalls former times without interactive computer interfaces and says: "I was always groping my printed visualizations, walking them with my fingers, knocking on them, long before we had such fancy software. […] Rather the software is mimicking what we were doing all along."

In the aforementioned meeting room, there are also molecule assembly kits laying around with which the scientists sometimes model e.g. selected Levi-Straussian "elementary structures of kinship" (1947), as they explained to me referring to an influential recurring model in their knowledge practices. A researcher mentioned that such collective "playgrounds" are fundamental to their work as "one cannot always sit alone in front of the screen and stare into it." The 3-dimensional material model kit allows the researchers to tinker in detail with a pattern found in a network. Pondering about physically and mathematically possible forms of connections between a number of actors is best done via manually sticking little balls together, and then by looking at the model from different sides. It is also an aspect of theory building; when there is no 3D model kit at hand, such exemplary social patterns are scribbled on flip charts, paper or on the plotted poster of a visualization.

"I really wish for better interfaces, […] like in the movies, […] I would love to wander around in my holographic network, well, if it is not dense like a jungle.", says yet another network analyst in the interview.

While holographic interfaces are a rather utopian form, various haptic technologies (Bergermann 2006) from other research fields, like molecular biology or chemistry, or from the gaming industry, are entering the field of social network analysis. I am not aware of joystick-like command interfaces, but touch screens and 3D animations are already very common. Many programs let the analyst follow the animated mounting of the network iteratively, as if observing the algorithm at work, whereas an intervention of a printed network diagram is only possible through discussion, drawing, touching, cutting or similar acts. Computer interfaces provide more opportunities for interaction with the im-

age:[9] one can turn it, zoom in and out of it, reduce it, even fly through 3D projections of it. Colors and tags can be adapted and positions of nodes and edges changed on screen. Until recently, algorithmic work on network layouts has been largely devoted to static graphs, but the development of visualization tools is on the verge of dynamization: transforming longitudinal network data and time series into interactive network movies (Bender-DeMoll/McFarland 2006). Until this comes packaged in software, researchers have to work with rather static notions of networks when trying to visualize e.g. change in networks.[10]

The next section is dedicated to the playful, viscoursive negotiations and the metaphorical continuations of the depictions that shift the boundaries of the printed, static network picture and expand its symbolic space both with regard to the interpretative context and missing interactive dynamics. Furthermore, it will deal with the construction of a metaphorical, but nonetheless corporeal, space that adds imaginary and physical realism to knowledge production across several modes and media.

5 Enacting metaphors

The depiction of the network serves as delineation for further, metaphorical dimensions of grasping, as the aforementioned situation illustrates. The invoked metaphorical space encompasses both techniques of language and embodiment while adding narrative and corporeal realm to the social network visualizations. In the discussion of the image as described before, several metaphors and rhetorical figures become noticeable and with them certain imaginations. Whereas in social sciences the condition of their own images and rhetoric is often overlooked in favor of a focus on data and interpretation (Keller 2006), the observed institution has actively elaborated a visual language and a rich figurative repository in order to compensate missing information in their imagery. Sophisticated, iconic language is used to create the context for a relational perspective, which is often not familiar to research partners and clients. However, it also further broadens the possibilities of interpretation in the research process itself. The researchers in the observed institution are constantly refining their metaphorical repertoire: firstly to create experimental narratives that promote their relational hypotheses, and secondly to communicate their visualizations to the public.

> "Often it is as if people blank out the lines between the nodes. They only look at the nodes. […] people are not used to looking at the interspaces. They are not familiar with a relational perspective. So we have to reconstruct not only the grammar for them, like measures and diagrams, but also the semantic space, the context. We have to link it to well established semantics to help them build up mental pictures." explains the team leader.

The exemplary situation around the glossy network picture is dominated by several distinct types of metaphors which stem from economics and anthropology: spatial, like periphery, center, disciplinary, like brokerage, cluster, gatekeeper, key player, attributive, like blind, frozen, rigid, and so forth. Such figurative speech guides thinking and talking as well as gestures and makes the visualization graspable in its iconicity. With the usage of metaphors from different fields, the researchers try to focus on the interspace, drawing the attention to the relations and a bit away from the nodes, by activating common semantic repositories to establish a feeling for the relational perspective. When speaking about dense areas of the network that restrict the agency of

[9] A popular network visualization software is named "Touchgraph".

[10] To give an example: the software Pajek allows to work with longitudinal networks and to compare network structures at different points in time like time slices.

actors, in contrast to porous areas, metaphors like "frozen" or "liquid" are enacted, as exemplified by a researcher:

"We call dense and tight regions in this project frozen. But there are also liquid parts, where we find warmth or even heat. The experience of the social structures is imagined as cold or hot. Liquid means heat until the point of total disorientation. In contrast, we see frozen parts up to the complete immurement, the sclerosis."

Another researcher adds while pointing to the respective regions on the network diagram:

"Here we have the psychotic situations, like schizophrenia, and there is neurosis. We are looking for a state that is in the middle of such extremes, that is endurable, meaning neither total order, nor total dissolution. […] It is a matter of power relations, but from a very different perspective."

He is interrupted by the first respondent:

"The freezing of water is a good allegory for the situation of this network. Water freezes erratically. There are unpredictable ramifications in such a complex process. This is happening to the structures here. The freezing opens up possibilities, but closes other paths, links are cut."

This excerpt of a dialogue stems from the discussion of an ongoing project and illustrates the need to charge the network visualization with familiar concepts in order to create shared understanding. The underlying data and hypothesis are translated to work with the network image and to shape the analysis. The second researcher takes up the terminology and spins it further to grasp the objective of the project, which is to look for certain constellations of power in a corporate network. Hans Blumenberg (2001: 412) states that rhetoric creates institutions where evidence is missing. At the same time, they foster the evident patterns materialized as network visualization and make it allocatable and attributable.

Furthermore, visualization experts in social network analysis make use of visual analogies taken from other genres like pop culture, media art or from other scientific or technical fields. They experiment with displays similar to temperature scales, radar monitors, galaxies, and microscopic organic traces, to name a few. The desire for realization exceeds a purely functionalistic handling of scientific images. They are not only supposed to be efficiently readable but also "stylish and contemporary in their appearance, both in research processes and in popularization", remarked a researcher in the interview. The described plotted diagram referred to chemical structures and showed the color scheme in a box at the bottom, which looked a bit like a temperature scale. Where the employed visual analogies did not suffice to explore the dynamic attributes of the network picture, narrative and also embodied analogies were enacted.

Metaphors of force and movement are central to the discourse on social networks, which seems paradoxal since most of the published images nowadays are static. Moving fingers, knocking on nodes, clenched fists or crossed fingers when demonstrating dense network areas are the corporal equivalents to such metaphors. With such "gestural knowledge" (Griesemer 2004), still images can be made to appear more dynamic and lively.

Additionally, there are also technical equivalents incorporating metaphors of force and movement that apply such gestural knowledge by enabling haptic experience in the process of image production and interpretation. The calculation of social networks is conducted with the help of graph theory, which does not take into account the spatial positioning of nodes and edges as diagram. In order to visualize complex networks projection, procedures based on assumptions of visual efficiency and optimization of readability are needed. "The graph drawing community has developed objective criteria to measure the quality of a drawing. One of these criteria is the number of crossings between edges in the draw-

ing. We want to have as few crossings as possible. Other criteria are the length of the edges of the graph and the number of bends in the edges. The goal is to find the optimal embedding." (Mutzel & Weiskircher 1999). Careful construction is needed to allow for efficient readability and, hence, to reduce ambiguity. Approaches like distance or multidimensional scaling are also used to reduce the interpretative flexibility of social networks. So called Spring Embedders, to give an example, apply hypothetical physical forces to the ties and treat the network as a physical system, a simple analogy used e.g. also in molecular modeling (Folkers 2001: 168). These force-directed algorithms simulate springs between nodes, which pull them together or push them apart until the system stabilizes in an equilibrium state. "Generally, edges between nodes are represented as an attractive force (a spring pulling them together), while nodes that do not share a tie are pushed apart by some constraint to help prevent overlap." (Moody et al. 2005).

Some software packages even equip interface functionalities with such analogies to make them more interactive. If a node is virtually pulled with the computer mouse and then suddenly released, it will swing slowly back into its former position. This twitching of nodes is a popular occupation during meetings, e.g. when a network image is projected and discussed or while contemplating over the picture on screen. It also gives a feeling of the strength and stability of a position, as one researcher claims in the interview. In 3D models this interactive feature is used when looking through the network, when a node is blocking the view. As an applied metaphor, the (playful) spring-tie adds an extra layer of realism to the visualization, referring impressively to the technicity of the diagram and the formalization of social structures into a visualization.

Figurative and gestural enactments of printed network images as well as the equipment of on-screen diagrams with physical analogies span a metaphorical space without which the depiction of social structures would not make sense. In line with these observations, the classical epistemological distinction between seeing and feeling becomes obsolete and cannot be employed as a measure for the quality of knowledge (Bergermann 2006: 315). Making meaningful and visible social structures encompasses several corporeal entanglements. Therefore these practices help to enact social networks as epistemic things.

6 Ergonomic normalization versus taste in instrumental perception

According to my interview partners, it is vital to develop a visual language, both for the better analysis in the research process and to shift the attention towards the interspace in order to foster the relational perspective. It is important to employ aesthetic strategies like coloring of the background, the nodes and relations to add an additional information layer to the visualization in addition to captions, symbols, scales and so forth. This section is therefore dedicated to the coloring practices that involve different corporealities, such as color perception, normalization and further aesthetic issues in negotiation with the instrumental framing.

Some network visualization software come with built-in psychometric color schemes. To make the image efficiently readable the information is automatically presented carefully colored. In such settings the psychometric quantification and description of human color perception serves as basis for the automated coloring of diagrammatic properties. Colorimetric models are based on standardized comparisons of single hues and delineate human color perception through statistical averages which result from the measures of

"standard observers" in the normalized environment of a color lab. Computer monitors are assemblages of different color technologies. We are surrounded by standardized colors in our daily lives. Every industrial color product, from light bulbs to printer ink, is nowadays fit into schemes administered by the International Commission of Illumination, a statutory corporation for standardization of colors.

Visual instruments based on such normalized schemes can nowadays produce millions of discriminable colors, if not to the human eye, then supposedly to the human brain. With such ergonomic image processing "the computer acts as an extension of the eye and the brain by selecting information the scientists cannot see" (Blumenthal 1982). It seems software developers care about the scientists' eyes, and their computerized prostheses, which are confronted with a large complex visualization of a social network. It is all about the efficiency of perception, which also means that the technical extension of the eye needs to be imperceptible.

Colored actors are perceived as similar or gradually different; therefore, quantitative attributes can be communicated. Two dimensional layouts could so be furnished with a third dimension, color, and even a fourth through gradients of luminosity, and as a result more information could be communicated with one image. Automatic efficiency optimization via coloring is an imaging technology in itself, a further generative element of the image production process. In addition to psychometric color schemes making perception more efficient, they also serve the purpose of reducing aesthetic intervention by the network analyst. Normalized color usage is just one of many standardizations embedded in automatic network visualization, which inform aesthetic practices and scientific construction of evidence.[11]

Colors play an important role, not only to create distinctive and graspable interspaces for spectators with normalized gazes, but also to arrange oneself into the visual space. One researcher calls this "sich einrichten", referring to furnishing his research environment. Whereas most users apply the default color schemes and, therefore, have to deal with ergonomic decisions made for them via "standard observers", the observed experts in network image processing tweak color schemes in accordance with their own taste or so called corporate identity. They have actively chosen to develop their own aesthetic framework, and not to discipline their gaze with supposedly more efficient strategies. Several researchers working with visualizations style their networks to comply with their own aesthetic criteria: "If I spend so much time with it, then I have to feel comfortable with it.", says X, who prefers earth colors, whereas Y favors strong colors. X also crafts nodes with a slight 3D effect, and Z likes to use shades. Sitting with X and Y, we go through old diagrams together, residing in an archive on the institute's server. All of them are immediately assignable to their respective creators, even though they hold no signatures. It is their style that makes the creators identifiable. My interview partners explain their mutual stylistic influences and sometime jibe at the other's taste. This historical review of diagram production in the institution reveals the improvement in imaging

[11] Another common form of normalization is the usage of colors such as blue and red, or the positioning from left to right, to depict e.g. active and inactive actors in the network. Such normalizations bring with them credibility and plausibility (Gugerli/Orland 2002), and for social network newcomers it connects the imagery to prevalent visual cultures, especially if it converges traditional imaging techniques with common associations and new visual experiences (Gugerli 2002).

technologies and graphical language over the years. It has been a long road from the first use of default settings in network visualization software to the self-programmed algorithms that bring about more scopes for design, like the coloring of edges, fonts and keys that are vital for the development of a visual language. The elaboration of specific styles to enrich and adapt the research process in demarcation to predefined standardization shows once more the active dimension of aesthetic practices in knowledge production.

Nevertheless, the handling of instruments in order to create network visualizations shapes the daily routines in network analysis as "stable environments" (Rheinberger 2006: 29). Goethe once criticized the aesthetic deficiency of instrumental perception because it supposedly cuts the unity of perception and corporeity. He complained about the loss of sensitivity and sensual richness for substantial awareness (Goethe 1999). In network analysis model kits, computer interfaces or paper frame visualization practices. The preparation of data for input into software trains the sensitivity for the datasets and the attention for the information to be highlighted. The instrumentation distances the researcher not necessarily from her data, it brings them together in a transformation and creation processes; it provides space for sensual richness of analytical objects that are created in the research process. It makes epistemic things tangible and figuratively inhabitable.

The resolution capacities of the researchers' perception and their rich instrumental sensibility go hand in hand. Whether on paper or on screen, the tangible environment with the network diagrams as interfaces trains the researchers in the simultaneity of measuring and representation. Their representations shape and "constitute the physiognomy of the object of the research", and they can be regarded as "revelatory objects […] which simultaneously analyze what they reveal" (Lynch 1990: 154) by embedding the instrumental medialization in an associative context. Imaging practices mean singular or collective "doing images" (Burri 2008). Groping, pulling, knocking, gesticulation, transferring, overdrawing, crumpling, zooming, turning, changing perspective, coloring, highlighting, fading, and so forth both extend the sensual richness of the epistemic object, and co-constitute and enact it. Measurements and calculations are increasingly experienced at the surface of the images. Numerous changes of mode, format and media, and analytical-aesthetic interventions shape the knowledge of data and the social networks as epistemic entities. Exploration and demonstration blend into each other, being further embedded in metaphorical and aesthetic space, which is providing the logics for interpretation. But most importantly, the interviewed researchers described the epistemic imaging processes as excitingly sensual and sensible work, going far beyond the scope of "coloring of JPGs".

7 Let's keep in touch

In line with the "pictorial turn" (Mitchell 1994) in science studies, without losing sight of the various corporeal and sensual entanglements of researchers with their objects of study, this article aimed at exploring corporeal practices involved in the production of network diagrams in the social scientific research process. As part of the experimental system the network visualization unfolds its epistemic virtue embedded in a series of images through a variety of media. The ethnographic encounter with a printed network diagram in the meeting room, laying on the table presented how it is discussed in the team, being produced and interpreted with the deployment of graphs, instruments, bodies, metaphors, colors, forms, and materials, even if it emerges only shortly as a stabilized entity in the research proc-

ess. Soon after the meeting, it is changed again. By taking such epistemic images, in particular diagrams of social networks, seriously and following their production, the manifold materialities and corporealities that co-constitute the object of research through collective aesthetic experience were taken into account. It was shown how the tactile sense, the careful construction of metaphorical spaces and sensual realisms, but also the conscious rejection of pre-defined ergonomic concepts of efficient vision, co-constitute the visuality of social structures in creating a "feeling for the data". Furthermore, making visible is just one step in the creation of evidence: It is the tangibility of the networks, the rich metaphorical and colorful visual language that lead to the experience of evidence in the experimental setting of social network analysis. Networks can be literally and figuratively grasped. Additionally, it has been exemplarily shown, how senses are incorporated into instrumentation, as well as counted for to create such collective experiences and the necessary contexts for exploration and interpretation. Aesthetic practices – no matter how embodied, mediated or normalized, – make knowledge "explicit" (Hirschauer 2008: 982) when handling visualizations.

Hence, the paper suggests to open the perspective to new modes of reflexivity beyond a purely "tacit" corporeal performance. Theories of embodied knowledge and inscriptions often treat the body as passive medium that can be conditioned by training. While this is a legitimate perspective, it is too narrowly considered. This paper argues that conceptualizing corporeal visualization practices requires thinking beyond "corporeal memory" as a "bodily archive of manual and instrumental knowledge" (Knorr-Cetina 1999: 99). Such an approach falls too short when the professional gaze encompasses a dynamic interplay of imaging techniques, bodies and imaginations while making social structures visible. Corporeality in aesthetic practices should not be blended out as automatism or tacit skill; rather it should be regarded as an active and reflexive medium and criterion of epistemic practice. The corporal employment happens with purpose, actively and is both dedicated to successful communication, and part of the sensible, lively, playful, and palpable knowledge production.

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The Olfactory Medium

Smell in Human-Computer Interaction

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Abstract

The relevance of olfactory perception and the corresponding olfactory communication changed, and attitudes of cultures towards smelling differed through the ages. Finally Enlightenment philosophers declared odour and the sense of smell as immeasurable, unimportant and therefore unusable for scientific purpose. In the last few years more and more artistic multimedia installations used odours, scented products were sold and the increasing application of aroma therapy indicate a changed attitude towards social odours. Emotionalizing scents are more and more used for influencing customers' behaviour in sales rooms and scientists are currently investigating the mystery of smell. The technological progress meanwhile allows for measuring and reproducing odours. Therefore odours are also becoming interesting for technical information transfer or communication, especially in Human-Computer Interaction. Smell seems to be an unrecognised medium and a new channel in multi-media.

1 Introduction

Perceiving something means getting information through an information channel e.g. a visual, acoustic or haptic information channel, through a medium. But also perceiving odours is an information transfer and therefore a medium. Smell hasn't been handled as medium so far, because olfactory perception has been regarded as marginal in communication processes. Reasons for this inclination can be found in the cultural history of smell, which reflects the relevance of smell in social coexistence through the ages.

Since the end of 20th century only some cultural history researchers have been concerned with the perception of odours and the relevance of smell in cultural and social context. Human and natural scientists didn't really care about the sense of smell and the processing of olfactory information; they nearly refused working on this topic. This attitude has its beginning in the Enlightenment, when philosophers declared the sense of smell as disreputable and not rationally explainable. Smell couldn't be measured and was intangible for researchers. Also media studies, mainly guided by the development of technical media, haven't given attention to the olfactory medium so far.

Different from the Western civilisation where the sense of smell and realization of olfactory information fell into oblivion, in Japan odours have always played an important role in social interaction. Especially this positive attitude to smell has Japanese computer scientists enabled to lead the way in processing olfactory information. But European and American researchers catch up.

During the last decade an attitude change of Western scientists could be noticed. On the one hand psychologists tried to explain therapeutically effect of odours to body and soul as well as the evidence of an olfactory memory, on the other hand physiologists investigated the sense of smell. Also technical scientists like physicists and chemists have focused their research activities to the development of olfactory sensing and dispensing technology.

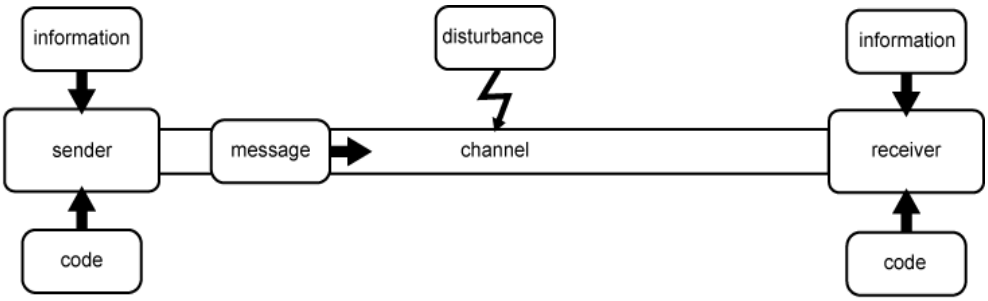
New results of latest research show that odours play an even more important role in face-to-face communication than assumed so far. Progress in researching the human's olfactory perception like the decoding of the first olfactory receptors or the discovery of the Jacobson organ brings smelling back to the researchers' field of interest. Besides physiological research also neuro-psychologists are concerned with odours as interface to our emotional centre and the long-term memory. The sense of smell is unique in influencing emotions and in recalling long-forgotten memories.

Such fundamental research results allow computer scientist to work with the olfactory medium now. Olfactory information offers new possibilities to Human-Computer Interaction (HCI). In the last few years information engineers undertook first steps using odour as interface between user and computer. Gas sensors, artificial noses and digitally controlled scent diffusers allow the digitalization of olfactory information and reproduction of odours. The progressive development of such olfactory technology demonstrates the existence of an olfactory medium, also in a technological manner, which takes its place in the real as well as the virtual world.

2 Communication Principles in Human-Computer Interaction

Media studies define medium as the transmitter of information. Another definition describes medium as a channel between sender and receiver without any consideration of social or technological influence (cf. Leonhard et al. 1999). Shannon added to this definition a code known by both sender and receiver and a disturbance influencing the channel (cf. Weaver/Shannon 1949).

Figure 1: Shannon-Weaver model



The Shannon-Weaver model (Figure 1) is one primary concept of technological communication processes. Therefore it is also a principle of computer science and Human-Computer Interaction, an area of research being focused on developing human-computer interfaces. Such interfaces mainly use the visual and acoustic communication channel to transmit information bidirectional between user and computer. A current issue of Human-Computer Interaction research is an increasing information overload. Therefore computer scientists try to find alternative and unconventional interaction modalities.

Computer scientists are betting on the multi-medium, a communication channel including all forms of perception, which currently means sight, hearing and touch (cf. Herczeg 2006). Especially haptic and tactile interaction interfaces are becoming more and more important where visual and acoustic perception is overstrained (cf. Riener 2010). Foremost the paradigm of a "natural" interaction between human and computer has top priority. People shouldn't realize that they are interacting with a computer anymore. Therefore one issue of HCI research is to find "natural" interaction modalities, which do not merely include visual, acoustic and haptic perception. There are also two further forms of perception, smell and taste, which are more unconventional modalities of interaction and which are not yet included in Herczeg's multi-medium.

Olfactory communication has been a biological term for the interaction via pheromones between animals so far. The exchange of olfactory information hasn't been subject to research neither in communication theories nor in technological sciences.

By the end of the 20th century researchers began to focus their attention on measuring and processing volatile components as well as decoding the neuropsychological and biochemical olfactory perception processes. Also economists got into olfaction and found the sales-promotional effect of smells. Some researchers found olfaction in the course of their search of the sixth sense. Now some unexplainable phenomena of perception can be explained by olfactory and veromonasal perception.

During the last decade olfaction received new meaning and relevance especially for human, natural and technological science. Exploding technology progress and information overload makes people search for alternative interaction modalities and new ways to 'implant' information in the human brain.

3 The Cultural History of Smell in a Nut-Shell

Human perception was already a research interest of ancient philosophers, but olfaction was neglected till the last decade. Why does the sense of sight and hearing get more attention nowadays and why haven't researchers been concerned with the sense of smell before the last decade?

Walter Benjamin attributed the change of the social relevance of perception as

people's adaption to new technical media (cf. Kloock/Spahr 2000). Therefore the hegemony of visual and acoustic perception is due to the rise of telegraphy, photography, film, radio and television. However, as Anne Peach (1999) wrote in her article *Das Aroma des Kinos*, shortly after first cinemas had opened there doors, also first experiments to scent movies had been coming up. These pioneering efforts demonstrated the beginnings of a new media on the one hand and encountering resistance on the other hand, involving psychological effects which will be discovered only a hundred years later.

Evolutionarily, the sense of smell was the first existing possibility of perception, as proved by German researchers who identified the reaction of sperm cells to lily of the valley aroma (cf. Hatt/Dee 2008). In prehistoric ages when visual and acoustic amplifiers didn't exist, perceiving and evaporating odours was crucial to survive. Studying indigenous peoples and feral children shows the relevance of olfactory perception far from civilisation (cf. Classen et al. 1994). Regarding the contemporary history there is a decreasing impact of smell corresponding to a growing civilisation.

Ancient advanced civilisations like those in the Mediterranean area or in the Middle East were the inventors of the perfume. Primarily ancient people used scents to render homage to gods. Hygiene and sanitation were an important part of cohabitation and bad body odours became inadmissible. So, higher castes affording these luxury fluids scented themselves and their habitat with perfumes. Body odour came to be an indicator for class differences and a tool of social distinction as a consequence.

Scent as a spiritual instrument also found its way into religions like Christianity or Buddhism. Incense occupied a central position in getting connected with god in both persuasions. Generally Asian cultures have a special relation to smell and especially to body odour. On the one hand Asian people have nearly no own smell, on the other hand hygiene and fragrances play an important role in their social coexistence and caused the development of a bathing tradition. In the early Middle Age crusaders brought this tradition to Europe and consequently expedited the installation of bath houses. Increasing plague epidemics and errant behaviour in these bath houses supported the church's opinion that personal hygiene makes sick and boosts flagitious behaviour. Accordingly bath houses were closed and stinking was a daily occurrence.

The incomprehension at personal hygiene existed for several centuries. In *The Foul and the Fragnant* Alain Corbin (2005) describes the olfactory situation in the 18th century in France. Before the French Revolution the baroque society not only suffered from political instability and excessiveness, but also from unbearable sanitary conditions and diseases. Because of their ignorance scientists ascribed dissemination of infections to the malodour in the air and appealed for the improvement of hygiene in the public. As protection against miasma people used a plethora of perfumes and scented powders, which contributed both to the olfactory air pollution and to the development of capitals of perfume like Grasse. It's not amazing that Süskind (1994) chose that period of time and that location for his novel *Perfume.* Only such environment can be the perfect coulisse for an olfactory genius like Jean-Baptiste Grenouille. At the end the olfactory situation was so unbearable that Enlightenment philosophers had also claimed personal hygiene. With the French Revolution, Corbin says, there came along an "Olfactory Revolution". The installation of sewerage systems and another comprehension of hygiene constituted another prominence of smell. People became more sensitive to misma but also fragrance and preferred light scent (cf. Stafford 1993). Enlightenment philosophers brought up again

the issue of a hierarchy of senses and labelled the sense of smell as unworthy of mention. Smells were undesirable and olfactory perception was classified as animalistic and ignoble (cf. Jütte 2000). Invisibility, immeasurability and subliminal perception of smell were the main reasons why scientists abandoned olfaction.

As already mentioned Asia occupies a special position in the cultural history of smell. Smells, body odour and personal hygiene play an important role in traditions, medicine and the daily life of Far East people. It has its roots in an early arisen understanding of hygiene and the awareness that scents have a healing effect. In contrast to Western cultures peoples of Eastern Asia preserve their ability to smell and don't ignore olfactory incentives to date. They define smells, smelling and the sense of smell as naturally part in their common life without any taboos or scruples.

The comparison of civilized cultures shows how Enlightenment philosopher effectively influenced the perception of smells in the Western world. The olfactory Revolution caused an increasing disapproval of smells until smelling became a taboo in European societies and a topic off the records. Only the good old perfume survived the era of "Desodourization" (cf. Corbin 2005). The commercial launch of Chanel No. 5, the first perfume consisting of artificially produced fragrances, initiated another olfactory revolution, because perfume was no longer a luxury good and achievable for everyone. To be scented was no longer a social class distinction. But this wasn't the last break in the cultural history of smell. I would say that we are going through a third olfactory revolution now. Scientific success in olfactory research like the decoding of the first olfactory receptor by Linda Buck and Richard Axel (cf. Hatt/Dee 2008), discussions about the olfactory disturbance by cigarette smoke and biogas plants (cf. Deutsches Umweltbundesamt für Mensch und Umwelt 2006) or the development of the first smell recorder and smelling mobile phones in Japan (cf. Wyszynski et al. 2005) indicate a new relevance of odour today.

4 The Physiology of Smelling

The scepticism about the sense of smell in social and cultural history is rooted in a lack of understanding of the smelling process. There has never been a rational explanation for smelling before. Since the end of 20th century researchers especially neurologists, psychologists and biochemists have been trying to explore the myth of olfaction.

Olfaction is both evolutionary and embryonically the first developed sense. This is the reason why the neurologic olfactory centre is situated in the oldest part of the human brain. Olfactory perception also includes the sense of taste because tasting without smelling is possible only in a limited capacity. Therefore the perception of aromas can be defined as only one sense.

In comparison to other senses smelling takes a special position within the modalities of perception. The process of perceiving volatile components is characterized by spontaneous recall, inevitableness, unfiltration, unconsciousness and emotionality. As researchers have found out in the last years, primarily neurological factors account for these characteristics.

Perceiving a smell starts with a biochemical process based on a key-lock principle at the upper end of the human nose. There can be found the olfactory epithelium, which consists of about ten million olfactory receptors, which are sensitive to about 350 different volatile components. In 2006 Linda Buck and Richard Axel got the Nobel Prize for the decoding of the first olfactory receptor. Meanwhile another two receptors or sensory neurons have been decoded (cf. Hatt/Dee 2008). In comparison: a dog's epithelium consists of about 220 million receptors. If an odourant molecule docks to the right receptor, an impulse is

sent to the olfactory nerve, also called olfactory bulb, which is the connector to different cerebral areas. The discovery of these neuronal connections now allows an explanation of the extraordinary characteristics of olfaction.

Perceiving odours happens spontaneously and is only avoidable by closing all respiratory tracks which would lead to death sooner or later. This unavoidable nature is caused on the one hand by a lack of an "olfactory" palpebra and on the other hand by a straight connection between the olfactory epithelium and the long-term memory. Olfactory signals are processed by our brain without any filtering. Every perceived odour is saved in the long-term memory in combination with the current situation, which includes locations, plants, persons, emotions, etc. Smelling this odour repeatedly exactly recalls this situation including each detail. Researchers call this phenomenon an "olfactory memory" or the "Proust-Phenomenon" which has got its name from Marcel Proust's explanations of sensual impressions in *In Search of Lost Time* (cf. Chu/Downes 2000; Herz/Schooer 2002).

We are always exposed to smells but often they are too diffuse for a conscious perception and we subliminally perceive them. As ancient cultures already knew odours can cause positive as well as negative emotional reactions, which are due to close ties between the olfactory and the limbic system, our emotion centre. How the perceiver is emotionalized depends on his or her memorized impressions. The combination of inevitableness of perceiving odours and the emotionalization could be dangerous relating to psychological effects. The human olfactory system is equipped – more than other senses – with a functionality of habituation. The human olfactory system rapidly habituates if the same smell is present for a long time. So it is almost impossible to identify your own body odour or the body odour of close relatives. Also, a constant environmental odour is no longer perceptible by habitants. Only foreigners such as tourists or visitors can notice it (cf. Deshmukh/Bhalla 2003). The tight connection between smells and emotions causes a faster olfactory than visual or auditory habituation. The nostrils can't be closed instinctively, as eyelids. Therefore olfactory habituation is a protective mechanism that keeps us from having to constantly bear smells, which we can't escape and which may leave emotional harm.

Another subliminal perception of volatile components is the perception of pheromones. Both humans and animals evaporate pheromones sensed by the veromonasal or Jacobson organ to cause instinctive reactions within their species, which is also called olfactory communication. Most recently there was a discussion of whether humans have such an organ and generally communicate via pheromones (cf. Watson 2001). Through numerous tests, scientists have now found out that the human species is capable of perceiving and reacting to pheromones. After the discovery of the human Jacobson organ at the internal nasal septum, also the first human pheromone was extracted (cf. Sturmheit 2008). The sex steroid Androstenone, which was previously only isolated from the saliva of boars, could be found even in the male armpit sweat and urine (cf. Brand/Jacquot 2007). Another argument for the existence of veromonasal communication is the ability of women to identify if a man genetically correlates to their own DNA by checking his body odour including pheromonal information. Pheromones also play a role when mothers recognize their babies through smelling the baby's body odour. But it is also known that pheromones of other species can influence humans. Perfume components like cibet or musk are animal scents which contain sexual pheromones of the male cibet cat and musk deer. Women find a little bit of such animal scents charming but do not instinctively react on them (cf. Watson 2001).

Evolutionarily and neurologically the sense of smell is our basic instinct and also bears this functionality today. Odours can give information about good or bad food, how toxic things are, or if something is burning. Generally we use this functionality every day and can identify at least 16 different scents. Others like perfumer or gourmets train their olfactory tool and can isolate up to 1000 fragrances. This aptitude shows that we don't usually use our sense of smell to its full capacity.

5 Aroma-Chology® and the Psychological Effects of Odours

By understanding the human smelling process also psychological effects of special fragrances can be explained. Neurologic research results show the psychological effects of odours to the olfactory centres due to being intimately connected with the limbic system. An area of expertise concerned with these effects is Aroma-Chology®, a term created by the Sense of Smell Institute (cf. Warren/Molnar 2010). This scientific group accumulates an established knowledge of olfactory perception and the relevance of smell related to behaviour, emotions and mood.

Meanwhile different psychological tests circumstantiate aroma therapies, the improvement of learning situations, the existence of human pheromones as well as the general importance of smell. While computer scientists first of all are analysing the relevance of olfactory perception for Human-Computer Interaction, marketing experts are using smell as sales-promotional appliance since years.

Food designers were among the first who explicitly applied fragrances for sales-promotion. The food industry is reliant on colour-odour associations informing the consumer about taste and smell of products. Heinrich Frieling (2005), a colour psychologist and expert for colour associations, explains how colours influence consumption and why different sensory stimuli can complement another. Table 1 shows colours and the associated odours or tastes as they are used for food packaging and advertising. The tasting process is actually a smelling process because the olfactory epithelium determines flavours through the internal channel to the pharynx. Tasting and smelling are nearly the same perception process, an important fact for food producers. Colour-taste and colour-odour associations are derived from natural experiences. Therefore it would be contra productive to produce e.g. blue gummy bears with orange flavour. However, over different cultures such association can diverge,

Table 1: Colour-odour associations by Frieling (2005)

Colour	Odour
PINK	sweet, mild
LAVENDER	sweet, unerotic
MAGENTA	heavy, narcotic, charmingly, sweet
INDIGO	Scentless
BLUE	Scentless
MINT	juicy, fresh to salty
GREEN	fresh, fragrant, perfume with green fragrance
OLIVE	Musty
LIME GREEN	sour, dry, fresh, bitter
YELLOW	perfume, flower
ORANGE	Hearty
RED	sweet hefty, hot
GOLD	sweet, good, stunning
OCHER	sourly, neutral
BROWN	aroma, musty

which forces producers to adapt their products for various markets.

Another exceptional quality of olfactory perception is a direct connection between our smelling system and the hypothalamus, a neurologic area which controls amongst others the autonomic nervous system. This connection allows influencing the viscera by perceiving odours and it is the reason why aromatherapy works. Air designers are geared to colour-odour associations and the aroma therapeutic effect of fragrances when they are developing perfumes.

5.1 Example: Scent Marketing

Scent marketing applies current research results in real life. At the same time it is an example of how odours can influence our behaviour. The area of research which analyses neuropsychological effects of advertising and commercial activities on the consumer is called "neuro-economics". The term "scent marketing", which came up in 2002, defines a subarea of the neuro-economic research and describes the usage of scents for marketing purpose (cf. Bartzos 2008).

The main target of scent marketing is the creation of a pleasant atmosphere for clients. They should stay in stores as long as possible and should enjoy the ambience in order to accordingly buy more products or raise consumption (cf. Hirt 2009; Michell et al. 1995). In former days bakeries, coffee houses and restaurants often unintentionally worked with scents as attractants. Their chimneys and ventilation systems released enough food aromas that people's mouths watered. Today such shops systematically work with synthetic fragrances to effect similar reactions.

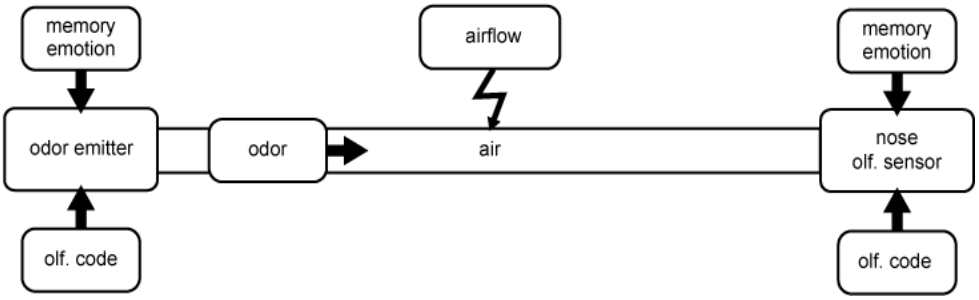
Furthermore customers should treasure these shopping scenarios as pleasant and relaxed which is due to the already mentioned Proust phenomena. This effect gives stores, hotels and service chains an idea of using fragrances as part of their corporate identity. Every time a client perceives the unique perfume of the chain, he or she should recall the shop, the situation and this pleasant atmosphere (cf. Morrin/Ratneshwar 2000). In 2006 hotel chains like Westin, Sheraton, Omni, Four Points or Hyatt incorporated special fragrances as part of their brand image (cf. Higgins 2006).

Another form of scent marketing is the improvement of the ambience in negatively afflicted locations like hospitals or dental practices. It is a social impact of the western world that people get scared when they are smelling chlorine-camphor and phenol, which give disinfection agents the typical smell. To cope with this issue, dentists tried to improve the atmosphere of their practice by gilding a "doctor's fragrance" to put the patients at ease (cf. Lehrner et al. 2005).

The scent of goods also plays a relevant role in selling products. Not only food aroma has to meet one's expectations, also other products are liable to associations and connotations. As an example, new cars do not smell like plastic and metal. They are sprayed with an oil or leather fragrance to let drivers feel more familiar with them. As the Royal Automobile Club Foundation found out this can lead drivers to overestimate their own capabilities and accordingly produces a higher accident risk (cf. Nicholson et al. 2005). Nonetheless, some producers experiment with such associations and perfume their products with unexpected aromas in order to get a unique selling proposition or to jolly their costumers along. Products like scented writing utensils, socks, CDs, USB sticks, papers, etc. have been introduced to market (cf. Everything-Smells 2010). EPAMEDIA (2008), an European public space advertising company, equipped some of their illuminated panels with move-detecting perfume dispensers as olfactory support for perfume advertisements.

Marketing strategies often include promotional events as advertising platforms and presentation of provider's individuality. Event managers use the

Figure 2: Shannon-Weaver Model for olfactory communication



latest entertainment forms to compete for visitors and publicity. Thus, scents also became interesting for event managements and it is not astonishing that there is a new occupation called "*Aroma Jockey*" lifting the audience's spirit with fragrance compositions (cf. Emotion 2008). Affecting ones mood by evaporating special fragrances is also used during social interchange like meetings or class room situations (cf. Higgins 2006). Researchers noted that some fragrances could contribute to improve the ability to think and the powers to retention (cf. Herz et al. 2004).

The exploration of psychological effects of odours and the example scent marketing explain how powerful smell can be especially for Human-Computer Interaction research and the "natural interaction" issue.

6 The Olfactory Medium

Olfactory perception allows a very special form of communication, which is nearly impossible to compare with other interaction modalities. No other sensory stimuli are so unignorable and unconsciously perceived than smelling something.

The scent marketing example demonstrates that smells can have a special meaning and can invisibly and spontaneously transmit information, which other media can not. Odour can bear information like emotions, warnings, memories but also genetic information as body odour or pheromones. Therefore odour is media-theoretically definable as a medium. Based on the Shannon-Weaver Model can also be defined as a sender-receiver-based communication system.

Related to McLuhan (1995), who said "The medium is the message", odour is also a message. According to Shannon's (more technical) information theory air would be the medium and odour the message. He said that each message needs syntax, semantic and pragmatic, in one word: a language, which is spoken by sender and receiver. Relating to the odour as medium – which means that odour transmits additional information (e.g. the odour of smoke transmits the information, that there is something burning) – there is no unique olfactory language. Syntax, semantic and pragmatic are defined by culture and individual experience, but also by profession. Perfumers, sommeliers or food designers have their own language within their community. Also some indigenous peoples have their own olfactory language. However, all others have forgotten that we can smell and consciously communicate via smells. We use odours every day, but not deliberately.

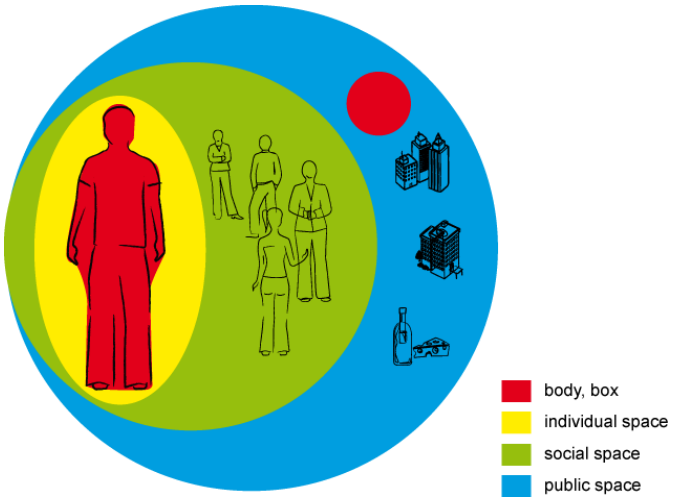
6.1 Olfactory Human-to-Human Interaction

For understanding the olfactory human-computer interaction we should first understand how the olfactory medium works within the communication between humans. In olfactory human-to-human interaction sender and receiver are both persons, which emit or perceive an olfactory message. An alternately exchange of information between sender and receiver is possible, if both stay within an area defined by

the coverage of a medium. This area is known as the interaction zone.

Jürgen Raab (2001) was concerned with the sociology of odour nowadays. He makes this unconscious communication modality explicit and defines interaction zones for olfactory interaction between humans based on Erving Goffmans territories of the self (cf. Figure 3).

Figure 3: Olfactory interaction spaces in human-to-human interaction



The body defines the individual odour and is a source of the most familiar fragrance. The personal space encloses the body and varies its extension depending on olfactory sympathy. Unpleasant body odours of interaction partners can maximize the extension of personal space, pleasant ones can minimize it. Special smells allows constituting a social identity, an affiliation to a social group, which defines the social space. Smells of regions, localities or goods define the public space as interaction zone. Such smells are more accepted than foreign smells in the personal space, because they consist of a communal territory, exempt from boxes. The box is a private territory in public space, which is occupied by an individual and its individual fragrance like a table in a restaurant or a seat in a train.

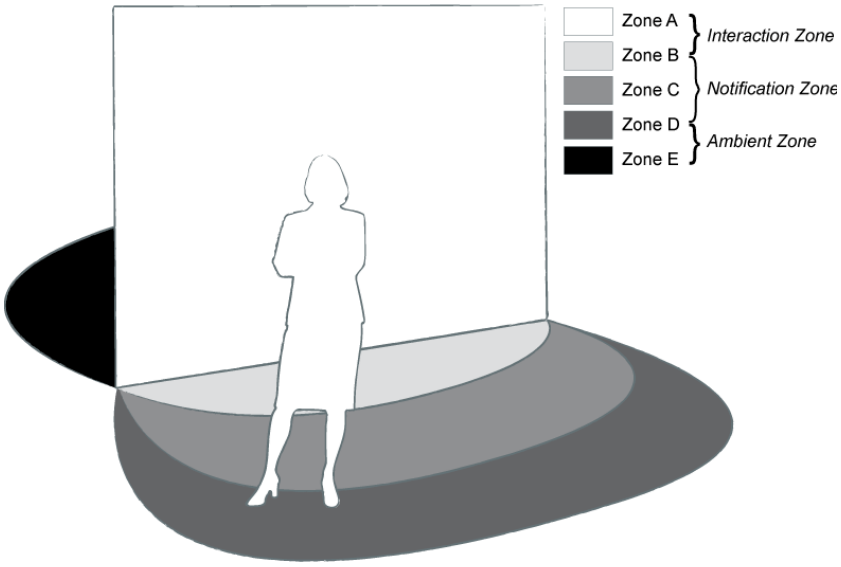
These olfactory zones of interaction are the basic principle for olfactory interaction zones in Human-Computer Interaction. An olfactory communication process can only be acceptable for a person if the computer sends smelling information without violating the human interaction areas.

7 Human-Computer Interaction and the Sense of Smell

Raab's olfactory interaction territories are comparable with interaction zones used in HCI, apart from the fact that one interaction partner is replaced by an intelligent computer system, also called iSpace (cf. Hansmann et al. 2001), an intelligent or pervasive environment. Such installations can explicitly or implicitly interact with a user. Explicit interaction means that the user has to do an explicit action like pushing a button to initialize an interaction. In case of an implicit interaction the system autonomously reacts to the user. But generally Human-Computer Interaction is only possible if there is an interface between human and computer on one hand and if users accept this interface on other hand. Every interface requires the following functionality: the digitalization of physical information, the transmission of information and the reproduction to physical information.

In HCI three zones of interactions are distinguished – the *interaction zone*, *notification zone* and *ambient zone* – which are generally further divided in five different zones, which result from implemented HCI interfaces (Figure 4). Zone A and B need a physical contact between system and user for a working interaction. Therefore information exchange is primarily done via haptic/tactile interfaces. Interaction in zone C and D uses the visual information channel, in contrast to zone E where visual information can't be observed anymore and only acoustic or olfactory information is perceivable.

Figure 4: Interaction zones in HCI



Increasing information overload in the interaction and notification zone causes a focusing on the ambient zone in HCI research. Computer scientists are trying to transmit all information with lower priority by ambient interaction modalities which reach the user later and maybe unconsciously, but definitely (cf. Ambient Media; Ishii/Ullmer 1997). An example for such ambient media is the acoustic signal of the mobile phone if a text message arrives. This signal is an ambient notification which won't have the high priority as the ringing of an urgent phone call.

Communication via odour acts within an unconventional ambient zone of interaction. Each odour-emitting human or thing is surrounded by a definite waft of scent like an olfactory aura defined as "Olfactory Interaction Zone" (cf. Emsenhuber/Ferscha 2009a). This zone can be dynamically extended from square meter size to square kilometre scale. Consumers are often able to smell aromas of nearby bakeries or restaurants over many meters leading them from the street to their salesroom like an "olfactory direction sign". Within an olfactory interaction zone the priority of information is defined by the intensity of an odour and the odour itself. As an example the odour of fresh bread won't be such important than the odour of smoke.

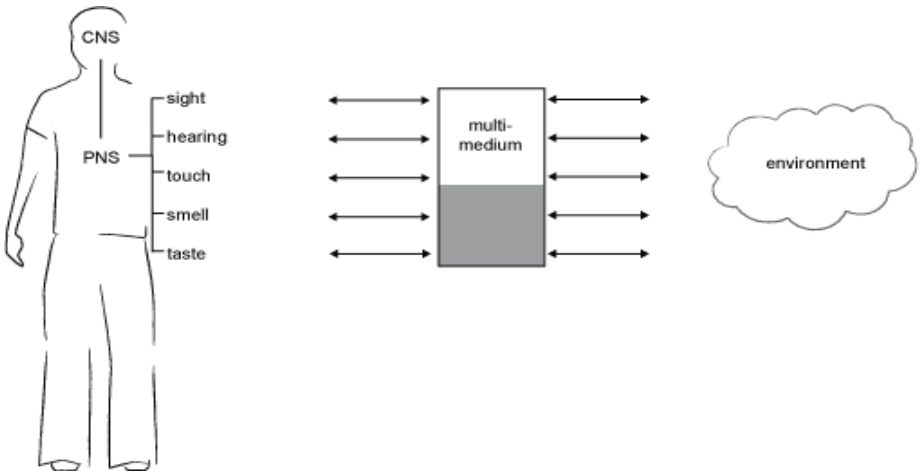
With the increasing development of digital smell diffusers primarily for scent marketing purposes computer engineers are acquiring a taste for using smell as such ambient interaction modality. Within the last decade we can notice a careful approach to this topic in computer science. Decisive for that were probably numerous multimedia (artistic) installations using smell as additional interaction channel, like the 5D cinema (cf. Storz 2010), but also an increasing demand for scent marketing technology.

Today there are different interfaces which can produce or detect odours or

volatile components (cf. chapter 7.3). Now there are basic components available and which make possible an olfactory technological communication according to the model of Shannon and Weaver (Figure 2).

often based on science fiction stories like Star Trek or in the case of olfactory interaction, like Kurd Laßwitz's (2001) *Bis zum Nullpunkt des Seins* or Aldous Huxley's (2000) *Brave New World*.

Figure 5: Herczeg's multi-medium extended by smell and taste



Also Herzceg's multi-medium which includes only sight, hearing and touch, so far, can be extended by smell and taste to complete the real multimedia experience and allow for an ultimate natural interaction between human and computer, which integrates all senses (Figure 5).

7.1 Olfactory Human-Computer Communication

As we have seen in the preceding chapters, olfactory communication between persons and technological systems isn't merely a theoretical concept. It already exists. During the last century creative heads have developed different rudiments to complete the ultimate multi-media adventure, which had to include smell. Ideas and concepts for human-computer systems are

An olfactory Human-Computer Interaction needs olfactory interfaces, which detect smells or reproduce them. The increasing development of olfactory technology now allows for equipping computer systems with such olfactory interfaces for a useful olfactory Human-Computer Interaction. We can distinguish between *olfactory displays* which evaporate smell and *olfactory sensors* which detect it.

First technological systems working with humans via smell were the first time-triggered cinema scenting installations as Hans E. Laube's *Smell-o-Vision* (Figure 6a.) or Morton L. Heilig's *Sensorama* (Figure 6b.). Since the beginnings of cinema people have tried to add an olfactory channel to this visual-acoustic experience.

Figure 6: a. Smell-O-Vision – Todd & Laube, b. Sensorama – Heilig, c. Odorama Rubbelkarte – Wates d. SniffMan©– Ruetz

The advertising industry seized that idea. Odours are a further possibility to persuasively present consumer products. Systems, like the ones described in the following chapters, are currently used for scent marketing purpose, HCI prototypes (most of them never reached the maturity phase) or forensic, medical and food investigation systems. They are all indicators for the tangibility of smell and how computer scientists could use the olfactory medium in HCI.

7.2 Sending Olfactory Information

Most scent marketing systems in salesrooms are integrated in the air condition, but there are also heat-based standalone devices. The first commercially available air design systems could not adjust running time, fragrance or scent volume, they continuously run and lead to an "aroma flood". Modern systems offer an adjustment of time and volume as well as changing between various fragrances.

Today digitally controlled odour diffusers are not only applied for advertising purpose, they are also developed as ambient indicators like an olfactory display for HCI-systems (Figure 7). For instance, Keye reported on an ambient olfactory reminder system (cf. Keye 2000). An integration of an augmented reality application with an odour machine to improve on the augmented reality experience is presented in Emsenhuber et al. 2002.

NTT Communications (2007) have developed a smell machine called *Aroma Geur*, laying the path to the first olfactory emails in 2004. This device was also used to create an ambient smell when listening to Tokio FM. In 2005 TriSenx (2005) launched their *Scent-Dome* to enable websites emitting scents. The only system which reached the maturity phase and can be bought now is the Osmooze Personal Diffuser.

Meanwhile, telecommunication industries have also found the olfactory information channel to be a useful medium and are marketing the first scenting mobile phones (cf. Motorola 2007; Softpedia 2007). The special smoothness of olfactory interaction spaces was the central subject of the *Space-of-Scent*-project realized by Haque Design & Research (2002).

Figure 7: a. AromaJet Pinoke, b. DigiScent iSmell, c. FH Hagenberg SmellBox, d. NTT Com Aroma Geur, e. TriSenx Scent Dome, f. Osmooze Personal Diffuser

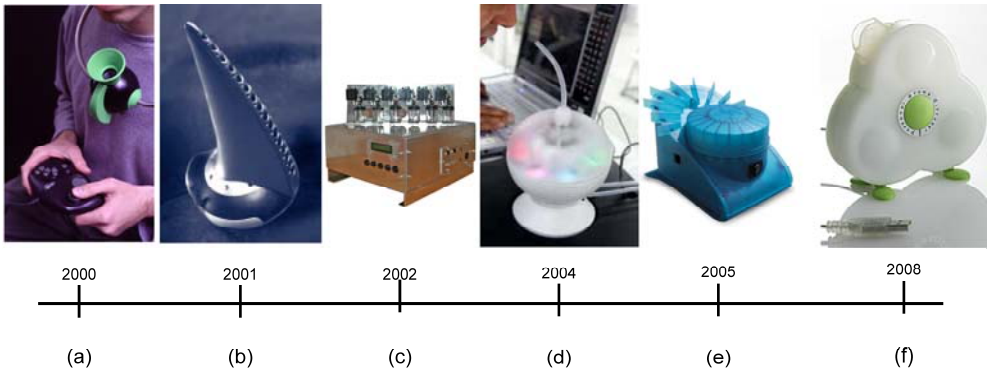
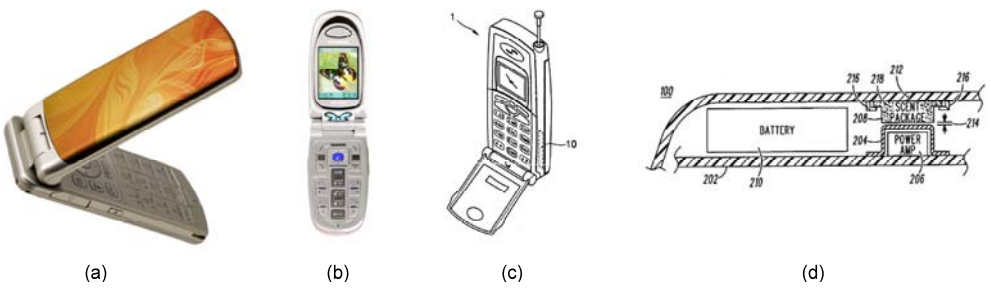


Figure 8: a. Sony Ericsson SO701i, b. Hyundai MP280, c. Samsung patent, d. Motorola Smell-o-Phone patent



For telecommunication industry smell has been successfully introduced as a new sensory modality for interactions between human and mobile devices The first "smelling" mobile phones were placed on the market in 2008 (Figure 8). The Sony Ericsson SO701i is scented with an aroma therapy fragrance to support relaxing during stressful phone calls. To satisfy different preferences the mobile phone is available with eight different fragrances, which can also be useful for advertising purpose and tagging personal things like mobile phones with corporate scents. Also Hyundai (2005), Samsung (2006) and Motorola (2007) have developed such mobile phones. German inventors have already patented a mobile phone with a smell chip which allows sending and receiving *smell messages* (cf. Inside-Handy 2008).

7.3 Sensing Olfactory Information

Not only the output of olfactory information is an increasing subject for information technology research, but also using volatile substances as input for digital communication becomes increasingly useful. Gas sensor arrays and electronic noses are especially used in forensic investigation for the detection of explosives and in medical sent a recorded odour by email and reproduced it at the receiver.

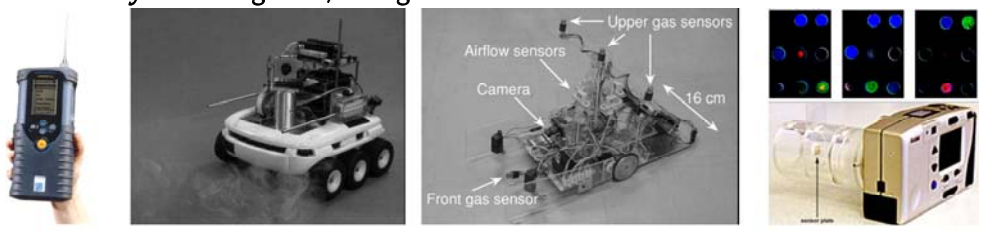
Researchers at the Austrian Konrad-Lorenz-Institute are currently developing a system to recognize individuals by their body odour which represents the individual DNA like a volatile fingerprint (cf. Penn et al. 2007). Body odour is the volatile state of sweat whose components are genetically influenced. Emotions like fear can also manipulate the sweat composition and contribute to the production of cold sweat (cf. Chen et al. 2006). According to this, body odour has the potential to become a new data source for intelligent systems to recognize individuals as well as their emotions.

In consideration to the fact that, apart from simple scent marketing dispensers and simple gas sensors, most of the above-mentioned systems, never came into the market shows that there is a lot of research work to make these systems more "intelligent". Current olfactory systems don't tap the full potential of the olfactory medium.

8 The Future of Smell

The rediscovery of smelling has followed from an increasing understanding of olfactory perception during the

Figure 9: a. wearable e-nose Smith Detection Cyranose 320, b/c. robots with gas sensor arrays for navigation, d. Digital Smell Camera



(a) (b) (c) (d)

science to diagnose diseases like cancer (Figure 9). Today they are also used to control digital systems. For instance the Japanese *Hanahana*-installation allows manipulating flower-animations by ten different perfumes (cf. Kuyoko et al. 2007). Wyszynski, Yamanaka and Nakamoto (2005) already last decade. Physiological, psychological and technological research results allow for using smell as a communication medium with very special characteristics. Because of the olfactory memory and unconscious emotionality of olfactory stimuli as well as its physical properties, the olfactory medium has acquired an exceptional position

among media. But these characteristics make smell also to a physically and mentally controllable information channel.

Current usage of odours in human-computer systems, especially for scent marketing purposes is based on psychological knowledge of olfactory perception on the one hand but it also enters unfamiliar territories. There haven't been enough psychological investigations yet to analyse the whole extent of mental effects of olfactory stimuli. Maybe in the near future we have to fight not only against visual and acoustic information overload but also against olfactory information floods. As we suffer from visual and acoustic impressions every day, nobody knows which mental damage numerous fragrant waves would cause. Olfactory information overload can lead to two different scenarios: scenario A describes a complete habituation of olfactory perception and a complete loss of our sense of smell. Scenario B would be another olfactory revolution as it came up in 18th century, when malodour became unignorable and unbearable (cf. Corbin 2005). To avoid these scenarios users of the "smelling" medium have to carefully dose olfactory information which also needs respect for individual preferences and sensibility.

The very subjective interpretation of olfactory stimuli requires an adaption of olfactory messages to the individual. Therefore olfactory systems need to become more intelligent, or *smart*. General scent diffusers like scent candles, fragrance lights or other kinds of air fresheners work mechanically, without any electricity. But electric scent gadgets developed in the last few years are tending to replace their analogue predecessors. Room scenting product lines like *Brise Sense & Spray* or *AirWick FreshMatic* are the first sensor-controlled mass-market scent diffusers for the private. Fragrance and intensity can be individually adjusted by hand. In public space especially for scent marketing such systems need more flexibility, because fragrance and intensity must be autonomously adapted to people's preferences or moods. Maybe in the near future smart scent marketing systems will be able to react to individual emotional states and manipulate them with aromatherapeutic scents at the same time. Also mobile "smelling" devices like smell phones offer a further possibility for mobile advertising -- they are offering a new method to send not only informative but also emotional advertising messages.

Sensing odours could be a useful instrument for finding out more information about people, especially about their emotional states. Computer scientists call it *emotional computing* (cf. Picard 1997), a research which is concerned with the development of HCI-systems reacting to the user's emotions and moods.

Another valuable data are individual odour preferences which could be examined by identifying their body odour or personal perfume. Furthermore such preferences would refer to colour preferences which could be useful for e.g. fashion style suggestions for fashion stores.

Whereas digital scent diffusers were already brought to market, the development of gas sensors and artificial noses is still a topic of fundamental research. Especially for HCI-systems there aren't any useful gas-sensing interfaces yet. Interviewed computer scientists pointed to this aspect as a reason why smell is uncommonly used for Human-Computer Interaction. A second argument is the problem of the social acceptance of such systems. Scent marketing systems are becoming more and more popular, are widely-used, but unaware by consumers who are subliminally exposed to lulling fragrances. But how would people react if they realize that they are "manipulated" by smell? Raab's olfactory interaction zones can be the base for social acceptance of olfactory Human-Computer Interaction systems. Also a technological system has to respect

olfactory borders and personal spaces. That means an HCI-system should not cross these borders by e.g. evaporating a flood of fragrances.

The Shannon-Weaver model implies that sender and receiver need to have the same knowledge about the meaning of a message for a running digital communication process. This meaning, code or language is a connotation of information to a word, number, a picture, a sound or a smell and must be spoken within such system. In human-to-human interaction spoken languages are restricted to countries or culture groups. Olfactory languages like aroma classifications of perfumers or terms of oenophilists, but also the meaning of smells within indigenous groups are even more localized. The digitalization of olfactory information allows for defining a general digital olfactory language for computer systems. As an example each component of a smell can define one bit of an olfactory message (cf. Emsenhuber 2010). This is different from HCI communication processes which have to translate both digital information to a human language and a human language to digital information. Therefore odour-using HCI-systems need to know the user's cultural affiliation and his or her individual olfactory language. The future challenge for computer scientists and other developers or designers of HCI-systems will be the definition of general or the spontaneous individualization of olfactory languages.

Another question in discussing digital olfactory interaction is how seriously we should take developments like smell phones or smell-enabled websites. Are they a flash in the pan or do they have a future? Computer-controlled scent diffusers like the *Trisenx ScentDome* (2005) aren't produced anymore, while *Osmooze Personal Diffusers* are still offered. But it is quite plain that aroma-dependent products, like perfumes or food are difficult to sell digitally.

Digitally controlled olfactory mass-market gadgets are the first indicators for an increasing relevance of olfactory communication, even though they were still used both for wellness purposes and to improve the atmosphere of the own home. But it is only one step from "stupid" time-triggered scent diffusers to event-triggered customizable *scent organs* – as Huxley (2000) put it – and the olfactory medium would find its way into everyone's home.

9 Acknowledgments

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The Proof is in the Pudding

On 'Truth to Materials' in the Sociology of Translations, Followed by an Attempt to Improve It[*]

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Abstract

What could it mean to use cooking as a medium or translation device for sociology? Why is the use of media other than writing so unusual in sociology, but not in other sciences? The sociology of translation has made the claim that sociology should stay true to its object. Rather than jumping into abstractions, sociology should translate its object step by step. I show, that if this holds, then the sociology of translation fails its own claim to what I call "truth to materials", because in its practice it engages in jumps in media from objects, such as food, image or body, to text. Instead, I propose to take the issue of truth to materials more serious by engaging, as other sciences, more directly with the senses. What prevents the sociology of translation from doing so is a belief in mechanical objectivity that excludes all other forms of translation except texts. For the case of taste, this suggests to engage in cooking. In the second part of the text I provide an attempt to create such more nuanced translations in the form of a buffet that we cooked as comment to a symposium. Some of the issues that were discussed with the help of the buffet were new kitchen technologies, the relationship between the visual and the olfactory, and the relationship between knowledge and taste.[†]

[*] Cooking: Michael Guggenheim and Florian Keller, Photography: Andrea Ganz.

[†] Many thanks to Jörg Potthast, Monika Krause, Michalis Kontopodis, all the participants at the GWTF/STS-CH workshop on "Die fünf Sinne der Wissenschaften" and the reviewers and editors of this thematic issue for enourmously helpful comments.

1 Amuse Bouche

What could it mean to use cooking as a medium or translation device? It is striking how much STS continues to work with writing as a single medium. I do not refer here to the objects of research. Clearly, these have widened and nowadays routinely include visual documents, including films and TV-shows, documents from the Internet, as well as analyses of noise and music, food, drinks, odours and touch. Indeed one of the central preoccupations of STS, and of the sociology of translations in particular was to research how others, mostly scientists and artists, "translate" the world into objects and inscriptions. Thereby, a rich repertoire of such translation techniques has been found and documented. This article seeks specifically to contribute to a literature that has tried to analyse the production and consumption of food for a sociology of translations such as the works by Antoine Hennion (2005), Geneviève Teil (2001) and Annemarie Mol (2008), works that expand on other anthropological and sociological studies of food and smell such as those by Elias (1989) or more recently Cunha and Durand (1999), Gary Alan Fine (1996), or Jürgen Raab (2001).

But with regard to the media and translation techniques that scholars use in the sociology of translation to document and display what they have found out, the sociology of translation, as sociology in general is an impoverished science. In this article I want to discuss why this is the case and I want to report from an attempt to solve this problem for the realm of taste and smell. What follows focuses on the sociology of translation, however, many of the points also apply to STS and sociology in general.

I begin by reconstructing how the sociology of translation is based on the claim to truth to materials (2.1). I contend that if this claim holds true, the sociology of translation fails its own claim by taking shortcuts from taste to text. In the next paragraph (2.2) I explain why the aspiration of truth to materials is a good one: It is the basis for hardening a science. However, as I show in the following paragraph (2.3.), the sociology of translation is founded on a belief in mechanical objectivity that excludes all other forms of translation except texts. This prevents the sociology of translation from using other media and thus from becoming a harder science. However, the belief in mechanical objectivity does not extend to writing itself, as I demonstrate in (2.4.). Also, the belief in mechanical objectivity is not shared by other sciences of taste such as food science (2.5). Rather than trying to turn taste into instances of mechanical objectivity, I propose to follow the example of writing. The sociology of translations can use more creative forms of translation in those areas where devices that would allow mechanical objectivity are absent.

What follows in the third part is a buffet, an offer of various attempts to create such more nuanced translations in the field of a sociology of translations of food and cooking. I report from a buffet that I created with Florian Keller as a symposium comment. Here I try to show on several levels how cooking can serve as a medium for sociology of translations that allows to represent experiences of smell and taste. To conclude, I offer as dessert some further ideas how to develop the themes of this article.

2 Starter: Writing about Eating is like Dancing about Architecture[1]

2.1 The Sociology of Translation and its Claim to Truth to Materials

The central preoccupation of the sociology of translations is to strive for a sociology that gives justice to its objects rather than to take shortcuts into sociological abstractions. The task of sociology is not to explain phenomena away, but to elucidate their empirical existence by following attachments, networks and translations. Latour writes that sociology can only differentiate good from bad attachments, when referring to "justice immanent to things" (Latour 1999a: 25). Despite Latour's claim that "we have never been modern" he borrows directly from deeply modernist impulses striving for "truth to materials".

Truth to materials[2] is and was a central claim of modern design and architecture. The guiding principle of this idea is that a sculptor, a designer or an architect should use a material for what it is and according to the properties it possesses and not against it (Bandmann 1971). Modernist designers would use exposed concrete, rather than to paint wooden grain or conceal it with a layer of brickwork. Designers should not add materials to an object that are unnecessary for the functions of a building or the expressive qualities of a piece of art. Faking materials and using materials against their properties is considered kitsch. Of course, the idea of truth to materials is not merely an aesthetic guideline, but moral and political. It is based on the belief that something like a "true" quality of a material exists and that a designer betrays the material (and possible users and onlookers) if she conceals this truth.

The sociology of translation is guided by a very similar impulse: Do not explain your phenomenon away with something else that is not part of the phenomenon! Stay true to your materials! Do not become a kitsch-sociologist who does away with the properties of the social world with the help of external categories that do not belong to the phenomena that you want to analyse. Antoine Hennion has made the same point in great clarity and detail for the case of "taste", both in its sociological and culinary meaning, which is also the theme of this article (Hennion 2007).

Hennion details the mistakes of what he calls "critical" sociology, such as the sociology of Pierre Bourdieu. In critical sociology, according to Hennion, taste is explained away with the social position of a person, by "blind forces that grip you and of which you are ignorant. You think you love things, when no, it is your milieu, your origin, your formation that makes you appreciate them" (Hennion 2007: 102). Against such a critical sociology Hennion puts a properly "reflexive" sociology, whereby reflexivity is a kind of collective work that performs taste "at once a central modality of amateur's activities, a modality of the presence of objects, and a necessary method for the sociologist" (Hennion 2007: 107). The central implication of reflexivity is

> "its tie with the activity itself (in other words, to continue outrageously to simplify the question, turning from the actors to the actors, and from the actors to objects – and vice versa). No activity can be defined outside of its own accomplishment, the support, the frames by which, making emerge in the same gesture its participants and its objects, it defines 'itself'" (Hennion 2007: 107).

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[1] The saying "Writing about music is like dancing about architecture" has been ascribed to Thelonious Monk, Elvis Costello, Frank Zappa, Laurie Anderson and various others.

[2] In German, the term is "Materialgerechtigkeit", which is more precise. "Gerechtigkeit" implies not an epistemological relationship to material, but a doing justice to materials, in the sense of being fair to them, by considering the right features. "Materialgerechtigkeit" in that sense already accepts a translation, but it asks for an adequate translation as opposed to a distorting one.

This is the imperative of truth to materials of the sociology of translation: never explain an activity with something "outside its own accomplishment"! From this premise follow some methodological problems, since if a social practice such as taste has to be understood within itself, how is it possible for a sociologist (who is an external observer) to reconstruct it?

As Hennion remarks himself, the sociologist cannot take "the taste of wine or a musical object [as] given" but has to reconstruct them as "a result from a performance by the taster, a performance that relies on techniques, corporeal training, repeated experiments" (Hennion 2007: 108). Since these performances are deeply embodied, sociology runs into the classic problem of phenomenology that bodily experiences cannot be transmitted from one person to the other. This is why, for Hennion, the

> "the primary sociologists of taste are the amateurs themselves. It is not possible for the exterior observer, the sociologist, to observe taste in the same way that they themselves think that the amateur looks at a work of art" (Hennion 2007: 108).

But because the amateur does not write a book of sociology herself, the sociologist needs to translate what the amateur does and experiences into a text.

What the sociology of translation ends up with, is to reconstruct the experience of taste through observing amateurs and reporting what the amateur says. The sociology of translation aims to keep the experiences of the amateurs as *experiences* of amateurs. What it ends up doing, however, is to translate the experiences into the words of amateurs elicited through interviews, into observations from sociological observers and finally into sociological descriptions. What happens in these translations is jumps from one medium to the other. These are jumps from an experience of smell and taste into words and books, and these jumps are not accounted for. The jumps do not explain away the experiences into social class but they explain away the experiences into other media. From the viewpoint of truth to materials it is questionable whether this is so much better than jumping to class.

The sociology of translations fails to adequately translate the senses, because it lacks media and technologies to do so. In other words, the truth to materials of the sociology of translation holds as a critique of critical sociology, but does not extend to its own practice. True, the sociology of translation takes other and maybe fewer shortcuts than critical sociology in translating taste into sociology. It adds some interim steps by first translating the experience of amateurs into descriptive texts, but it still does huge unaccounted translation jumps.

One step out of this impasse is to claim that any scientific text needs to translate its objects, which is undoubtedly true. But then one would not understand why the sociology of translation is so critical of critical sociology. To understand the claim for truth to material and why sociology might want to go on improving on it, one needs to understand why translation jumps are a problem.

2.2 Science as Good Translations

As Bruno Latour has argued, the sciences generate facts by transforming their objects step by step, by creating links between different forms of "inscriptions" to form networks (Latour 1986). A fact holds, if the cascade of translations from the object into its inscriptions is made durable. The more steps between objects and description and the better each step is based on agreed upon and possibly black-boxed procedures, the stronger the facts.

Such translations need not depend on high-tech. The stabilization of facts, according to Latour, is based on the stabilization of networks. What counts is the minimization of the jumps from one translation to the next and the

subsequent stabilization of the results. As Latour has shown in his example of the Amazonian rainforest biology, the translation of inscriptions, from soil sample to a scientific paper, can occur by very simple technologies (Latour 1999b, chapter 2). The creativity of science, as countless studies have shown, is the invention of new tools and new forms to translate the world into facts by intervening into the world with various devices.

However, while some disciplines have been extremely prolific in creating new forms and tools of translation, the sociology of translation has been rather conservative. Latour has proposed himself that sociology should dare to intervene and allow for "things [to] strike back" (Latour 2000). The conservatism of the sociology of translation is based on a strangely split view of translation tools: for writing it accepts complex translation processes, including very complex and creative forms. For every other sense it only accepts media that lend themselves to mechanical objectivity and ignores everything else.

2.3 The Special Status of Writing as Translation Tool

Let me first elucidate the special role of language and writing: In the sociology of translation, as in sociology in general, the use of language as a tool is accepted to add items to the societal stock of existing text. In a most basic sense, this is unavoidable: Each sociological text is nothing but another text, another description, another invention, another carefully crafted cultural production added to the stock of existing texts. In a more positive sense, sociology as a "third culture" between literature and science has always been acknowledging that its own production of texts is not merely an instance of mechanical objectivity, but also a form of translation, a creative process (Lepenies 1988). Since the debates on reflexivity that emerged in anthropology and spread to sociology this view has become accentuated (Clifford/Marcus 1986; Woolgar 1988). More specifically, it is accepted to invent new words and to add new forms of description to the stock of existing ones. Think of "anomie", "unintended consequences" or "obligatory passage point". These are clearly very complex translations of societal facts, "inventions" by the social sciences that add new ways to see the world (Deutsch et al. 1986). Social scientists would probably not deny that these conceptual inventions are scientific, just because they are inventions. This holds true not only for individual terms, but also for theoretical and empirical texts in general. In sum, for the case of language, the sociology of translation does not consider it problematic to create its own inscriptions and transformation devices that produce the phenomena one is trying to capture. But because it does not treat writing devices on a par with other devices, many possible forms of translation appear to be outside of the field.

2.4 Sociology's Belief in Mechanical Objectivity

The reason why the sociology of translation does not include other media and work with other senses is based in a strong belief in what Lorraine Daston and Peter Galison call mechanical objectivity.

> "By mechanical objectivity we mean the insistent drive to repress the willful intervention of the artist-author, and to put in its stead a set of procedures that would, as it were, move nature to the page through a strict protocol, if not automatically. This sometimes mean[s] using an actual machine" (Daston/Galison 2007: 121).

The sociology of translation only accepts writing, calculation technologies and sometimes photographs and excludes almost all other technologies and senses. The belief in mechanical objectivity implies that diagrams, words and photographs are acceptable, because the sociology of translation assumes that the objects portrayed get onto the film or the piece of

paper without artistic distortion. Visual data have a clear advantage here over smell, touch and sound: They are of the same materiality as writing and can be published together in dissemination media such as books and scholarly journals.

As Felix Keller has shown, in sociology in general, even photographs are on the decline (Keller 2006). In his analysis of the American Journal of Sociology, Keller shows that the number of photographs and also of non-statistical diagrams has constantly declined. He explains the decline by modern sociology's conception of society: According to sociology, society or culture is not composed of humans, but of interaction, communication, habitus, structures, networks, culture, neither of which can be photographed. Society refuses to be visually captured by technologies that provide mechanical objectivity.

In this scheme, other visualization techniques that do not rely on mechanical objectivity but on more complex forms of translations are already excluded. The use of sketches, drawings, wax figures, or cardboard models, media that are or at least were firmly established in disciplines such as biology, medicine and architecture cannot be found in the sociology of translation, as in sociology in general for a rare exception based on drawing, see (Kräftner/Kröll 2009). Even visual sociology after the reflexive turn is mostly based on film and photography and ultimately mechanic objectivity (Harper 1998). Drawing, sketches etc. are considered to be art forms (as opposed to science), because they seem to be based on the whims of the drawer, rather than the nature of the object. They do not lend themselves to mechanical objectivity. These forms of representation are considered to be so unscientific that they are not even explicitly forbidden, but are merely repressed forms. This also holds for other technologies and other senses such as touch, hearing and sound, or cooking, smell and taste.

For sound, at least the possibility of mechanical reproduction exists and it is used in a small field called soundscape studies (Schafer 1994). In other instances recordings of music are used in bibliographies, as things that can be referenced. The social scientist does not have to do the recording, because the recording already exists. In ethnomusicology, sound recording is the medium of choice, but again, the approach is one of mechanical reproduction, rather than working with the materials.[3]

Another instance is sound recording as a method for interview recording. This is a common use of recordings in the social sciences and indeed has changed how sociologists and anthropologists conduct interviews (Lee 2004). However, interview recordings are rarely understood as sound recordings, but as mechanical devices to transform spoken words into text, i.e. as extensions of textual devices rather than sound devices (if a machine were invented that could directly transcribe interviews into text, no doubt such a machine would immediately replace sound-recording). In fact, the widespread availability of sound recording has rather led to a pauperization of what is "recorded" in an interview: in the 1920s, a "verbatim interview" recorded with pencil and without tape recorders, would contain a "report of the interview, in anecdotal form, including gestures, facial expressions, questions, and remarks of the interviewer" (Cavan 1929: 107; quoted in Lee 2004: 870). Tape recording has led

[3] There are rare but interesting exceptions such as the works of Wayne G. Marshall a.k.a. Wayne and Wax, a DJ and ethnomusicologist, whose works seamlessly combines academic texts about carribean music, annotated DJ-mixes and his own productions that extend, exemplify but also critically discuss his research subject in the format of music, see http://wayneandwax.com.

to an ever-increasing precision in transcription techniques at the expense of non-recordable instances of the interview that do not lend themselves to mechanical objectivity.

For smell and taste, no mechanical recording yet exists. Technologies to analyse and reproduce smells are being developed, but they have yet to mature, and the social sciences so far have not shown any interest in them. At the moment, this is more an issue for the perfume and advertising industry (see the contribution by Bernadette Emsenhuber in this issue). If the social sciences need to use smell and taste as media, they cannot resort to mechanical objectivity, but have to resort to other forms of representation.

In the social sciences taste and smell are almost exclusively translated directly into text, as for example when Annemarie Mol eats an apple (Mol 2008). But even the social scientist actually engaging in eating is an exception. It is far more common, and more acceptable to the moral standards of social science to reproduce and analyse taste and smell descriptions that already exist: Texts by or ethnographies of wine tasters (Teil 2001; Teil/Hennion 2004), interviewing and observing cooks and eaters (Fine 1996), archival sources and literature about the sounds or smells of a city (Corbin 1986).

In short, in the sociology of translations, as in sociology in general, only two ways of working with bodily experience exist: Either one resorts to pre-existing devices that seem to allow mechanical objectivity and that are treated as if they were no translation devices, or one jumps directly to text when such devices are not available.

2.5 How to do Translation in the Field of Food and Smell

One of the most obvious places where this omission can be observed is in the sociology of taste and smell, and it becomes immediately apparent when comparing sociology to other sciences. Two interrelated traditions where it does not hold can serve as exemplars here. First, there is a research field that can be described as sensory research (for a recent overview see: Finger 2009). Researchers let subjects taste food with the goal of finding out about why (different kinds of) people (dis-)like specific smells and tastes. How do we smell apples? What makes something taste bitter? To devise such experiments, experimenters have to cook or at least choose food, then people have to eat and finally, the process of sensory experience has to be recorded. The research interest – just as in the sociology of translation – is focussed on differences in perception of different people, without explaining the taste sensation away with recourse to class. It differs from the sociology of translation, because the researchers themselves offer the subjects food. The researchers decide on the tastes and smells they want to research and they create the consumption situations themselves; they do not leave these decisions to the research subjects. Such research is similar to the method of photo elicitation in visual sociology (Harper 2002): a cultural product is presented to people in order to elicit observations about this product and thereby find out about culturally varying perceptions.

A second field of research is food science: This is like the engineering continuation of sensory research. Here the goal is to create new forms of food and drink, based on knowledge derived from the first field. A research question might be: How is it possible to create a sandwich that can be frozen and then reheated and the breadcrumb stays crisp? The research starts with known cultural preferences for and practices that concern specific kinds of foods: people like sandwiches; they like to buy frozen food in supermarkets, but they do not like the breadcrumb limp. From these preferences, food science goes into engineering the very prod-

ucts (Howard et al. 2004) – rather than limiting itself to the description of how people eat limp sandwiches (as the sociology of translation would do) or telling people to buy fresh sandwiches (as critical or interventionist sociology would do).

The success and acceptance of such research cannot be inferred from the physical and chemical properties of the products. It is one of the mysteries of food and drink that different people judge very differently. Thus new developments in food and drink have to be tested by real eaters, both by professionally trained sensory technicians as well as lay people.

Food science is a science that routinely produces new kinds of smells, tastes and textures and produces data by consuming these smells and tastes or having others consume them. In sensory science, the hardness of data comes from knowing both the tastes and smells and the reactions of consumers. In sociology so far, the food and taste produced have earned little analysis, let alone the idea that sociologists could produce those smells and tastes themselves.

What follows is a first attempt to fill the missing gap by producing smells and tastes as media for a sociology of translation. It is a first attempt to complement ink and paper with heart and brains. It is a trial to ultimately recreate full networks that go all the way from food products, to the stove to the mouth and nose of eaters and a description of these and the reactions of the eaters. It also goes back to understanding the audience of a sociology of translation not merely as "virtual witnesses", who read and who are made to believe the writings, but as embodied witnesses (Shapin/Schaffer 1985: 55ff.). I try to include the bodily sensations into the analytical instruments of a sociology of translation. As detailed above, these first attempts to do so cannot be easily classified. These are first attempts at widening the spectrum of media. They are defective in many ways, and they cannot do justice to a new research program that is still in its birth. Necessarily, these first steps borrow from many precursors and venture into other fields, such as sensory science, food science, cooking, as well as installation and performance art. Most notably, they profit from the idea of understanding cooking not as refinement of recipes but as de- and reconstruction of smells and tastes and social situations (misleadingly sometimes called "molecular gastronomy" and originally developed by practitioners in Chemistry and Physics (McGee 1984), as well as chefs, such as Heston Blumenthal, Ferran Adria, Wylie Dufresne and Grant Achatz. They equally profit from the works of Daniel Spörri, an artist who ran a restaurant called "Spörri" in Düsseldorf in which he created various dishes that questioned what and how we eat (Hatch 2003).

3 Buffet: From Spinach to Brain

From Spinach to Brain was a commentary in the form of food, taste and smell to a scientific workshop with the title "Emotions on a Plate". The workshop discussed the relationship of food and emotions. It highlighted the complex relationship of sensory and cultural reactions to different kinds of food. The workshop was held on March 20th and 21st, 2008 at Collegium Helveticum, ETH Zürich. The menu was designed, prepared and presented together with Florian Keller, my long-standing collaborator in various cooking projects. We understood our task as if we were invited to be discussants at a conference, with the exception that the media for our comment was not restricted to words but included food. The food translated some of the talks back to the media and sensations that were subject of these talks. We reversed the translation chains, by re-opening the black boxes and re-arranging the contents and thereby creating bodily experi-

Figure 1

ences that allowed to experience but also to question the "data" to which the talks referred.

As a comment, the buffet was not proper research. We did not have the resources and the time needed to systematically vary the dishes and to record the experiences of the eaters. As a comment, the buffet posed questions to reshape the discussion and that allow to see how proper research in a sociology of translation could be pursued. Our menu asked questions and added further examples and illustrations to the talks. Some of these questions and comments directly addressed specific speakers, some were more general and raised theoretical and conceptual issues implicated by the workshop.

The program of the workshop was as follows:

20 March, 19.15
Feeding, Feeling, Thinking: Historical and Contemporary Dietetics (Steven Shapin)

21 March
09:30-9:45 Opening Remarks and Chair (J. Tanner)
09:45-10:15 Sensory Aspects of Food Processing (F. Escher/J. Nuessli)
10:15-10:45 Molecular Taste Physiology of Tongue and Gut (J. le Coutre)
11:00-11:15 Comment (S. Shapin)
11:15-12:15 Discussion
12:30-14:00 Lunch
14:00-14:15 Opening Remarks and Chair (G. Folkers)
14:15-14:45 Eating and Communication (A. Linke)
14:45-15:15 Food Fictions. Visions of the Past and Radical Trends (S. Siegrist)
15:30-15:45 Comment (J. Tanner)
15:45-16:30 Discussion

We prepared the following menu:

Spinach-Puree with Cream, Cima di Rapa Puree with Cream (one of them with Cannabis Sativa, announced, but not disclosed which one)

Four kinds of Pommes Duchesses

Rice-A-Roni® Spanish Rice

Chicken-Surimi-Terrine with Citrus-Walnut-Capers-Salsa

"Pflüdder und Glünggis": Veal Heart on a Bed of Swiss Chard Toppled with Pears Cooked in Syrup

Veal Tongue with Saffronised Letter-Salad on Salsa Verde

Veal Brain with Cauliflower toppled with Brösel

Rice Pudding with Plum-Compote and Pink Pepper

Some remarks on the presentation of the menu. The menu was served as a buffet. We brought one course after the other and showed them to the audience (see figure 1). This was accompanied by an explanation of the respective course. It is impossible here to recreate this setup and the many possibilities how presentation and talk interplay with the knowledge of an audience of a symposium. I therefore try to explain some of the links between what we cooked and the themes of the symposium.

3.1 Symposion, or: The History of Technology of Food Preparation and its Relationship to Scientific Meetings

The first theme of our menu refers to the setting of the menu itself, and the technologies used to produce it. As

argued above, using cooking as medium for sociology is unusual, but using cooking as medium for science is not. Both the meal for scientists and the use of technologies to produce such a meal refer to a defining historical location for STS and the sociology of translation. This history was embodied in one single dish: the cauliflower, which we cooked in a pressure cooker (figure 1). The pressure cooker allows to realign STS with its own rewriting of the history of science. First of all, it allows linking the very act of cooking and eating as a tool of translation back to the history of science.

The pressure cooker is the missing link between our buffet at the Collegium and a true "symposium". Originally, in Plato's time, the symposium was not a meeting of scientists giving talks, but a drinking party – sympotein literally means to drink together. The participants of a symposium would lie on pillowed couches, talk, be entertained by songs and dance, eat, drink and debate. That symposium has come to mean a purely scientific activity dates to 1784 according to an etymological source (etymonline 2010).

A hundred years before this shift of meaning, the Royal Society was founded as the first organization to discuss scientific experiments and thus as an organizational container to such symposia. Usually, a meeting of the Royal Society involved some scholars who would show experiments to each other. An assistant, whose name was Denis Papin, usually performed them. He was a French doctor, who moved with a recommendation by Huygens to London to work in the laboratory of the famous Robert Boyle. From the diary of John Evelyn we know of one special event at the Royal Society announced as a "philosophical supper." The diary entry for the 12th of April 1682 begins as follows:

> "I went this afternoon with several of the Royal Society to a supper which was all dressed, both fish and flesh, in Monsieur Papin's digestors, by which the hardest bones of beef itself, and mutton, were made as soft as cheese, without water or other liquor, and with less than eight ounces of coals, producing an incredible quantity of gravy; and for close of all, a jelly made of the bones of beef, the best for clearness and good relish, and the most delicious that I had ever seen, or tasted." (Evelyn 2009: 393)

The philosophical supper, in a curious way, brought the symposium back to its roots: men of science eating and drinking together and discussing experiments. However, what had changed in comparison to the Greeks was the fact that the philosophical supper used the cooking and eating as an integral part of demonstrating new experiments. Such a fusion of improving cooking technologies as demonstrations has not been repeated until the now famous "workshops", rather than symposia – on "Molecular and Physical Gastronomy" in Erice, Sicily that were started in 1992 by Harold McGee, Nikolas Kurti and Elizabeth Cawdry Thomas (McGee 2008).

The digester demonstrated at the supper was a precursor of the modern pressure cooker. It was a continuation of the experiments with the air pump, the central invention by Boyle. The digester used the air pump technology to seal a container against the surrounding air and combined it with a stove. The resulting machine allowed heating food and air in the sealed container to create higher than atmospheric air pressure. This in turn creates higher temperatures inside the container, because the boiling point of water increases with higher pressure, causing the food to cook much faster. From Steven Shapin's research we learn that Papin was an "invisible technician" (Shapin 1989); he is the only assistant of Boyle whose name has been passed on. At the time, experimenters such as Boyle only supervised work; they did not conduct it themselves. Papin was employed by Boyle and he did most of the experimental work on the air-pump, proving that the vacuum exists and he even wrote the papers that made Boyle fa-

mous. As Boyle acknowledged: "Some few of these inferences owe themselves more to my assistant than to me" (Shapin 1989: 560). As Shapin shows, the technicians were invisible, because the "order of experiment" in 17th century England required a gentleman, a credible person to be the one credited with discoveries, while handiwork did not count: "Boyle was the author because Boyle possessed authority" (Shapin 1989: 560).

The digester is the major invention by Papin. It turned him from an invisible technician into an experimenter in his own right. The philosophical supper allowed Papin to become himself a credible experimenter, an author with the authority to speak for his own experiments and his name on the cover of two books on his invention "A new Digester of Engine for Softning Bones, Containing the Description of its Make and Use in these Particulars: viz. Cookery, Voyages at Sea, Confectionary, Making of Drinks, Chymistry, and Dying with an Account of the Price a good big Engine will cost, and of the Profit it will afford" (Papin 1681; 1687).

More than four hundred years later, in the social sciences, we do not even have invisible technicians with regard to how we translate food and smell. By using Papin's invention to serve Steven Shapin some cauliflower, we made the step from invisible technicians to credible experimenters in the social sciences (we also worked as caterers for the Collegium Helveticum, doing 'normal' cooking for workshops and symposia, and most often, the academics treated us for what we were: invisible technicians).[4]

3.2 Translation and Popularization

Papin's story relates to a second set of translation problems. The sociology of translations, as it restricts itself to (academic) writing as an acceptable presentation format looses many people as possible audience. While the increasing pressure to reach "the population" and to popularize one's work can be met by writing for newspapers, a typical move by other sciences is to allow the public witness the translation processes they perform. This is usually done by public demonstrations of experiments, by exhibiting lab equipment or objects produced in labs, or open labs during science weeks. Sociology has difficulties of doing so, because of its lack of interest in its own translation practices. (Indeed: this is not because translation does not take place, but sociologists do not demonstrate in public how an interview is recorded, transcribed, coded and finally turned into a scientific article). Our buffet can be seen as one translation step to popularize the sociology of translation of eating and cooking. Again, we follow in the footsteps of Papin and his pressure cooker.

The digester not only made Papin an author, it was also a tool for popularizing his work at the Royal Society. Papin understood that Boyle's work – or should we say: his work undertaken in Boyle's name – remained within the confines of gentlemen, not least because "being writ in Latine, and not giving the Description of the Engine, nor the ways how to use it safely for want of sufficient Tryals." (Papin 1681, preface, no pages). His new book should be addressed to those who were excluded from the Royal Society and thus written "in the vulgar Tongue for the use of such Housekeepers and Tradesmen as may have occasion for it". (ibid.).

That the digester was a cooking device was only consequential in his quest for popularizing the new science:

"... cookery is such an ancient Art, the use whereof is so general and so frequent, and people have been so earnest upon improving of it, that it seems if any could be brought to perfection, this should be it: nevertheless no body can deny but it will be now considerably improved, seeing by

[4] Sometimes we were even given a tip by the guests. Although we were paid directly by the Collegium and we also held at the same time other, academic jobs.

the help of the Engine here treated of, the oldest and hardest Cow-Beef may be made as tender and as savoury as young and choice meat." (ibid.).

The digester allowed him to popularize his new inventions not because he believed in some abstract duty of popularizing science, but because he understood that cooking was the field where progress would immediately appeal to "Housekeepers and Tradesmen".

We have learnt from Shapin and Schaffer that demonstrations in front of gentlemen inside the Royal Society were central for the credibility of the new kinds of experimentation developed by Boyle and his invisible technicians. For Papin in his attempt to reach a wider audience such experiments in front of gentlemen could not be enough. In his second book on the digester, he complains: "Very few people have been willing to make use of it" (Papin 1687, "to the reader", no pages). Writing in English is not enough, Papin understood, thus he had to bring the demonstrations to the people:

"For my part that I may not be found wanting in promoting the engines treated of in these papers, I do not only explain as clearly as I can, all that I know about the same, but I undertake to let people see them try'd once a week, in Black-Fryars, in Water-Lane, at Mr. Boissonets, over against the Blew Boot; every Moonday at three of the Clock in the Afternoon." (ibid.).

But somehow, Papin did not really trust his own popularization; he feared, rather than a lack of attendance, being overrun and thus reverted to the authority of the Royal Society: "... but to avoid Confusion and crouding in of unknown People, those that will do me the Honour to come, are desired to bring along with them a Recommendation from any of the members of the Royal Society." (ibid.). Papin became one of the first popularisers and was, as popularization has been ever since, plagued by fears of being too popular.

We were not plagued by fears of being too popular. Our task was to cook for a select group of scholars. But we employed the same techniques as Papin to overcome the difficulties that texts in the sociology of translation pose by "being writ in sociology-slang" to make them understandable for an interdisciplinary group. We translated our contribution with the help of Papin's pressure cooker into something edible and therefore comprehensible.

3.3 Eating Physiology and Dietetics: Cooked Re-Entrées

A central translation problem for a sociology of translation concerns the embodied nature of emotions, and the difficulty to translate them into academic language. Although the sociology of translation has done a lot of work on how subjectivity and the relationship to one's body is mediated by technologies see for example (Cussins 1998), it has difficulties in doing such translation work because of the parallel jump from body to language and from observed to observer. This double problem is obviously also at play when researching emotions related to food. How do I know how it feels to eat an apple, a snail, or a mackerel?

The question here is how the (emotional) experience of food relates to theories about the body. Do I eat an apple differently if I believe that eating apples is good for my digestion because it contains a lot of vitamins or if I believe that eating an apple makes me more feminine? How can a sociology of translations get hold of these translations from theories of the body to eating experiences?

In our buffet we dealt with this question in two ways: First we related to theories about the organs that perceive food and create the emotions. Second we attempted to produce some of these emotions, specifically disgust, to comment on changing cultural notions thereof.

Steven Shapin talked in his paper about Galenic theories of dietetics. A central element of Galenic dietetics was the assumption that what one eats directly relates to emotions. For example, melancholic people should not eat dry and cold food since it would only exaggerate depressive moods. Food was also related to general personal traits, such as the idea that meat would create virility and vegetables femininity. English critiques of society implicated that humans eat meat to exert power over other creatures. Dietetics, as Shapin pointed out, were theories that closely linked theories about food with theories of a good life and emotions. Dietetics was comprised of one soul, one thing that had to be balanced, and that included the human body, its emotions and what it eats. Today, Shapin claims, the word diet merely relates to a very narrow understanding of food as composed of specific properties. Dietary programs of doctors are restricted to prevent very specific diseases (such as, for example, coronary heart disease). Humans are considered to be weak, suspect to addiction and eating the wrong things, but open to be persuaded by scientific results: We are expected to understand that scientists have found out that saturated fats lead to coronary disease and therefore we are expected to lower our consumption of bacon. The brain has become detached from the tongue and the heart, in terms of physiology as well as in terms of dietetics and metaphors.

In our menu, the three courses of heart (figure 2), tongue (figure 3) and brain (above, figure 1, between the cauliflower) related to these issues in complex ways. They were, first of all, cooked demonstrations of the organs involved in these issues. We cooked "re-entrées", to adopt the apt term "re-entry" of systems theory. A re-entry is a "re-introduction of the distinction between the system and the environment into the system" (Luhmann 1992: 83). A re-entrée is an eaten re-entry. The organs that create the difference between the body and the world, and at the same time open the body up to the world, the brain, the heart and the tongue, are eaten and brought back into the body. The organs also performed the shift from Galenic theories, which assume the bowels define on diets to modern theories that see the brain as central.

Figure 2

On a more general level, the whole buffet was a second level re-entrée: Academics who had just given talks about tongues and language, brains and thinking, sensory science and acidity, were now made to eat what they were talking with and about only a few minutes ago.

Figure 3

Second, the re-entrées also produced in the eaters very visceral sensations of repulsion and disgust. Some of our guests approached these dishes wearily; they checked on others if and how much they would spoon on their plates. They ate slowly and in small pieces, always ready to withdraw from the re-entrées. They constantly dis-

cussed whether and how much to eat from the dishes and how they smelled, as novices do when introduced to a new activity. These actions, or shall we say behaviours, are in complex ways related to the issues of Shapin's talk. Contemporary dietetics looks down on seemingly lesser parts of meat. Brains, heart and tongue, despite their relative fatlessness are rarely eaten. Dietetics, as a rational, brain-centred relationship to one's own body, is at odds with the body's emotional, bowel-centred impulses of disgust and the medium for this tension is exactly what registers the tension itself. The disgust strongly depends on a visual aspect. Nowadays meat and fish shall not look like its originating object. Many people find it difficult to look at whole dead animals. The "healthy" food that current dietetics advertises is very often food without form. It comes visually cleaned, as tablets, gels, powders and bricks.

3.4 Translating Modes of Perception: The Visual vs. the Olfactory

Another problem for sciences that only use the form of writing are shifts or incongruences between different media and senses. Sociology of translation approaches the problem in a one-sided manner: it takes writing as standard and relegates all other senses to a lower level. The saying "writing about music is like dancing about architecture" captures the translation problems in a more impartial way. Translation is always a problem. Not only is turning taste into language a very complex translation, but eating itself is a far less straightforward practice than we normally assume, because it is by no means restricted to one sense. The experience of what we eat is thoroughly informed and translated by other senses.

Such translations between different media and senses were a third theme of our buffet, focusing on the relationship between the visual and the olfactory. As Escher and Nuessli and also Le Coutre pointed out in their talks, the relationship between different modes of perception and the respective physiology is a complex one. First of all, taste and aroma perception can detect different smells and tastes for which a description on the molecular and physiological level is lacking. As Le Coutre pointed out, lobster and chicken taste similar, but can be differentiated. However, on the physiological level no explanation for these differences can be given. Similarly, as Escher and Nuessli explained, aroma intensity of increasing citric acid levels in candies is different for banana and citrus taste. The difference cannot be accounted for by measuring sugar or acidity levels (Nuessli/Escher 2009: 442). In short, there is a gap between chemical and physiological descriptions on the one hand and what we taste and smell on the other hand.

The situation is even more complex, because we are not only influenced by the taste and smell as recorded in our mouths and nose, but also by visual appearance. The same potato soup smells differently if it is coloured black or yellow. Escher and Nuessli point out that sensory science is increasingly turning to consumer studies, because neither chemical analysis of products nor professional sensory experiments can deal with the differences in consumer perception (Nuessli/Escher 2009: 443). Because the differences between people's perception cannot be found in chemical compounds, the people themselves have to become the subjects of research, but also the measure for the food industry.

What happens in sensory research is comparable with many other areas of science that have been widely described by Science and Technology Studies: experts judgments become replaced by those of lay people (Michael 1998). Taste and smell become less driven by standards defined by experts and seemingly universal aspects of physiology but by culturally highly specific consumer demands.

In our buffet we demonstrated this problem in various dishes. The chicken and surimi terrine is an invention of ours and we developed it in direct response to Le Coutre (figure 4). Terrines, composed of blended fish or meat, are well known in French cuisine. By combining chicken and surimi, we blended two tastes that are very close to each other and that result in two smells that are difficult to discern.

Figure 4

Furthermore, by combining poultry and surimi in the terrine, the dish played with cultural stereotypes of processed foods as unnatural and unprocessed foods as natural. Western kitchen has become obsessed with the idea of natural food. Despite Lévi-Strauss' dictum of the cooked as the origin of culture, we have come to believe that food should be as uncooked as possible. Testaments to this view are the countless diets that recommend eating raw products as well as the recent boom in sushi and carpaccio. Surimi, processed and cured fish stabilised with additives and often coloured red to resemble crabmeat, is an entirely natural product that has been invented in Japan in the 12th century. Because of the fact that it is industrially processed and often pretends to be something else than it is, it is suspicious to the Western value of naturalness.

On the other hand, chicken breasts appear to be entirely natural products. However, at least the ones bought in the supermarket come from beings optimised for food production with various technologies, from food to completely controlled living conditions to how they are killed and processed. The only difference in our terrine between the surimi and the chicken was that the former was processed after its death while the latter is processed before. Our terrine, finally, brought them to the same level of processing.

Second, our Pommes Duchesses were a little experiment in perception. We prepared four different kinds of pommes duchesses. Three of them came frozen from different manufacturers and only needed to be baked. One was handmade by us, by cooking potatoes, mashing them, blending them with butter and eggs, dressing the mixture on a baking tray and putting them into the oven. We tried as hard as we could to prepare them as evenly as the factory made ones (figure 5). This put the

Figure 5

eaters into the position of comparing and judging the different Duchesses, just as in a proper sensory experiment. But it also raised the question of which Duchesses are considered to be the standard to compare against. Duchesses are nowadays a product that is hardly ever home made. Duchesses are one of the most ubiquitous convenience products while they are comparably difficult to make by hand. It is fair to assume that only a minority of our eaters ever had home-made Duchesses. Our Duchesses test raised the question of whether we have come to take the convenience food as the

original and handmade food as the aberration.

Pommes Duchesses also featured prominently in the recent acrylamide scares. Acrylamide, a research topic of the panel member Felix Escher (Amrein et al. 2003, 2004), is a chemical compound, believed to be carcinogenic, which develops in baked and fried - but not in boiled – starchy foods, such as in French fries, chips or pommes duchesses. The acrylamide content of potato products rises if they are stored below a certain temperature and the longer the potatoes are cooked. Acrylamide cannot be smelled, which brings us to the next theme.

3.5 Knowledge and Taste

Even more puzzling than the incongruities between our visual and our olfactory senses are the incongruities between what we know and what we smell. We almost never eat without knowing what we eat. Not knowing what we eat poses a fundamental challenge to our bodies that is very difficult to deal with. Food is much more corporeal than any other thing we do and monitoring this intake is central to our wellbeing.

For sociology to translate the phenomenon, it has to get close to it by reconstructing it and it has to research how it operates among different eaters and with different kinds of foods. A written sociology has difficulties to do these kinds of translations since it cannot grasp the interplay of taste and knowledge. In our buffet we tried to reconstruct the phenomenon as a corporeal experience resulting from a difference between the food and our own verbal accounts of what we served.

Traditionally, monitoring what we eat was regulated by tradition, habit and the fact that for most of history only a small variety of foods have been available. But trade and the industrialisation of foods, the research subject of the commentator Jakob Tanner, have changed this (Tanner 1999). Food is most often understood today, both in the food industry and in everyday life, not as dishes, menus and ingredients, but as an assemblage of chemicals, nutritional values and additives. The media are full of research results showing that ingredient x causes or prevents cancer, cardiovascular disease or obesity. A whole industry of advice books caters to these fears. The regulation of what we eat has become a complex and constantly changing game of adjusting to the latest products, research results and food fashions. Furthermore, the difference between food, medicine and illegal drugs is fluid. Many culturally accepted stimulants, such as cannabis, tobacco and increasingly alcohol are illegalized. The boundary between food and medication has also become blurred with the food industry inventing the category "functional food" as a form of preventive medicine.[5]

In all these cases the relationship between food intake and bodily effects is difficult to grasp. It is only possible to understand in the very long run and through statistics. Individuals do not know how they relate to the statistics. I may not die from cancer if I have eaten enough spinach. But how will I know, once I die, whether I would have lived longer if I had eaten more spinach? Our food choices are thoroughly guided by science-backed advice and science induced fears without a direct way to experience these dangers and benefits.

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[5] I have explored the relationship between advice and intake in two other research and exhibition projects: "Straight from the heart. Prevention indices and divinations of researchers" by Bernd Kräftner, Judith Kröll and myself explored how people relate to prevention and advice (Guggenheim et al. 2008. "Self-Service. Luncheonette for Advice and Other Experiments" surveyed the relationship that people have to intake of foods, drugs and medicaments and where they got their knowledge about (Guggenheim et al. 2006.

Figure 6

In our menu, this complicated relationship between food and knowledge was a theme of two dishes. The first was the spinach and cima-di-rapa puree, where it returned twice (figure 6). First, as children, many of us had been forced to eat pureed spinach because it contains a lot of iron. Popeye was sold on this idea. A whole popular culture was based on an invisible and inodorous ingredient that was difficult to imagine. Popeye was a 20th century version of popularization: it needed a comic figure to popularize a fact that could, unlike Papin's digester, not be demonstrated in public. In fact, as it turned out, spinach does not contain that much iron. The claim that spinach contains a lot of iron was based on an error. The physiologist Gustav von Bunge measured the amount of iron in dried spinach and the results were later wrongly applied to fresh spinach (Bunge 1892).

What is noticeable about this from the perspective of a sociology of translation of eating is not so much the error, but the fact that (not) knowing about the measurement error has also changed the perception of eating spinach. We can only speculate about this, but children probably came to hate or love the *taste* of spinach because they liked Popeye or hated their parents' enforcement of eating spinach, both based on an error. Nowadays Popeye is gone for good and spinach has turned from a pureed sludge into a delicate salad ingredient. This is why we put a cima di rapa puree to the side of the spinach. Rather than upgrading spinach we downgraded cima di rapa, a vegetable that has a slightly bitter taste and is a kind of yuppie version of spinach. Other than spinach, which seems to have existed in puréed state only for most of its western culinary existence, cima di rapa is usually eaten intact. Puréeing cima di rapa made it indistinguishable from spinach and the eaters needed to guess which purée was which.

Second, we added a pinch of Cannabis Sativa to one of the purées. We announced that we added Cannabis, but we did not tell the eaters to which purée. Eating the two purées became a sensory experiment for detecting Cannabis. The eaters could be frightened and not eat any of the purees (which nobody did). The eaters could also just eat from one and hope that it does not (or does) contain the cannabis. Then the choice would become a gamble. Or they could eat from both and try to find out, which one contains the Cannabis. This could happen by smelling the Cannabis, which would require the eaters to have a very good nose, made even more difficult because the purées were from different vegetables. It could also happen by experiencing the effects rather than taste. However since the effects of orally consumed cannabis are very slow, the detection also operated on two timescales.

Our eaters, quite predictably, after the first daring subjects made a try, all tried a small amount of both purees. Like this, they neither ran the danger of sleeping through the afternoon's conference programme nor of being seen as timid eaters in a test situation.

The second course in which knowledge and olfaction featured prominently was the Rice-a-Roni dish. We had Rice-a-Roni delivered from the USA by a friend, Andrea Westermann, who was then a visiting scholar in San Diego. She had to smuggle Rice-a-Roni to Switzerland, because Rice-a-Roni is made from GMO-rice. GMOs are forbidden in Switzerland and the public is highly critical of it. Even in the US, Rice-A-Roni does not advertise on its packaging the fact that it contains GMOs. One needs to consult specialist consumer awareness guides such as Greenpeace's "How to Avoid Genetically Engineered Food" to find out (Greenpeace 2010). By telling our eaters that we cooked Rice-A-Roni for them (the one dish that was more difficult to source than to prepare), we alerted them to the fact that, depending on whom they believed, they would eat something illegal and dangerous. Again, nothing in the visual or olfactory appearance of the dish could have told the eaters about the potential harm. None of our eaters seemed to care.

3.6 Knowledge, Food and Class

If we give up writing as our sole translation device, we can also return in a more reflexive way to Hennion's critique of critical sociology. The move of critical sociology to reduce taste – both in its sociological and culinary meaning – to class does not take taste seriously. But undeniably, a defining feature of taste is class, so how is it possible to introduce class into a sociology of translations? Rather than describing the effect of class on taste we propose to perform it and render it observable in the wild.

The starting point is again the fact that one needs to know food to taste its social meaning. The olfactory and haptic difference between caviar and salmon roe or between a bottle of Château Pétrus and a bottle of Chianti from the supermarket is far smaller than the different status indicated by them. For an uninitiated person there may be no difference at all or she may honestly prefer salmon roe or Chianti.

These status and food indicators obviously vary by group, place and epoch. To cook these indicators properly is quite difficult, not because it is difficult to find such indicators, but because they are so ubiquitous. Every meal unavoidably is such an indicator, whether it is fish and chips, a pizza with horsemeat salami or fugu. It is the interpreter, not the cook, who turns food into a status indicator. Furthermore, food becomes a status indicator as much through the eating situation as through the food itself. Fried calves brain in a cheap eatery in a hidden corner next to the slaughterhouse is something different from fried calves brain in a Michelin-starred restaurant.

Since we could not vary the eating situation in our buffet, the only possibility to discuss food and class was to speculate on what would be understood as indicators of different groups and classes in our menu. One goal was to choose ingredients and dishes that changed their status over time to indicate this issue. We were both interested in cases of "gesunkenes Kulturgut" (Naumann 1922), dishes that sank from high status to low status as well as the opposite.

A case for the latter, as already indicated, is spinach: it has turned from deep frozen pseudo healthy junk food to a fashionable salad. Another though much more complicated case are the brains, tongue and hearts. They all have led a life on the lower end of the meat quality until they were recently re-discovered as lean and healthy kinds of meat and now enjoy considerable success in high cuisine – although they never really disappeared.

A case for *gesunkenes Kulturgut* is Pommes Duchesses, an invention of classical French cuisine, usually served as a side dish to roast beef and other fancy meats. It descended from haute

cuisine and lost its appeal as a leftovers dish, or even, as described in cookbooks of the early twentieth century, as a means to elaborately save time and money by first cooking whole potatoes, using them the next day for mashed potatoes and finally for Duchesses. Finally, when freezers became available for ordinary households after the Second World War, they started a career of middle-class modernity par excellence.

The social status of a food also relates very much to how and where and by whom it is prepared, and these facts again vary with time and place. The 1950s and 1960s were a time when factory made food was considered to be modern and healthy. The category of junk food did not yet exist and the standardization of such things as fish fingers of pommes duchesses was seen as good. Since the cuisine nouvelle and the global trend towards "health" food, freshness and handmade have become fancy again, while fabricated food and the food industry has gained a bad reputation. Today, prefabricated food in western countries is an indicator of the lower classes. In our menu, this topic was played on with our pommes duchesses that were hand made and opposed to the factory made ones. It was also a theme in the Rice-A-Roni dish, since the packaging of

Figure 7

Rice-A-Roni, the least handmade dish of our menu, features both industrial standardization by printing "same great taste" as well as phantasies of rural hand made cooking with a photograph of a potentially Spanish village (figure 7).

4 Towards a Sociology of Translations with Cooking

I have outlined an argument for why the sociology of translation – as sociology in general – should not refrain from using cooking as a medium and I have discussed an example for doing so. I have started with the observation that the sociology of translation has a policy of mechanical reproduction when it comes to other media than writing. Interview recording is accepted, as is photography and video recording, but drawing and cooking is not. The only way in which the sociology of translation can communicate about food, cooking and eating is in writing. But thereby it translates it into another medium while ignoring the underlying translation problems.

My suggestion was to include cooking as a medium into the sociology of translation. I have presented the case of a lunch buffet as a workshop comment. The buffet addressed various issues of the workshop with dishes invented specifically for this occasion. Among the themes were the history of technology of cooking, physiology, the difference between the visual and the olfactory and the relationship between knowledge and taste and class.

This was nothing but a first exploration, along with some other similar events. It was a workshop comment, not a proper research project. And it related to a variety of papers given at the workshop, trying to cover a wide ground rather than systematically addressing a specific question. For future projects, other researchers aiming at an extended sociology of translations might venture into more detailed and more focussed cooking. Also, future research could integrate cooking and researching the reactions of eaters more closely and researching the latter in much more detail.

A possible list of research questions to be cooked could include: What is the relationship between cultural taste perception and the development of food and cooking technology? An obvious case in point here is the question how the pressure cooker, but also the microwave change taste perception. This can also be analysed from the opposite direction: How are cultural taste preferences, say for tastes such as umami, or textures such as jellies or foams linked to preparation technologies and the inventions of the food industry?

Another line of inquiry would be to research how (legal) food categorizations are linked to technological changes and taste preferences. For example, the change of Cannabis from a food additive and stimulant to an illegal drug would be an interesting case at hand. Also of high interest would be the definition of what counts as edible and inedible, including cases of pica (MacClancy et al. 2007) – eating what has no nutritional value – and its relationship to food technology and the food industry.

I do not merely propose to do historical and sociological studies on these issues, but to investigate them by systematically cooking this relationship and testing it with eaters and to systematically vary dishes and eaters. I also suggest to invent new dishes based on such investigations and test them with various eaters. By doing so, sociology could learn a great deal about how cooking and eating relates to taste, class, law, science and technology. It would also become a bit more true to its material and it would become a harder science.

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Sense and Security

A Comparative View on Access Control at Airports

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Abstract

In case of doubt, in which sense do we trust? Is there a dominant (visual, haptic, gustatory, olfactory or acoustic) culture of evidence? The present contribution approaches the applied side of sensory research. Looking at the case of airport security it reconsiders a number of changes carried out during the last decade. Envisaging the production of security as a matter of sensory perception, it goes beyond a polemical appreciation of these modifications. Instead of debunking some unspecified *false sense* of security, it shows *multiple senses* of security at work. Describing how sensory data are isolated, amplified, transformed, and re-combined during the process of security screening, special emphasis is given to the actual location of control activities and to the issue of storage of information. As a result, two modes of access control are found to persist and termed "laboratory check" and "biometric guardianship". While the former, isolating sensory data, is local and allows for reversibility, the latter, blending local sensory practices with biometric information captured elsewhere (and stored), is irreversible.[1]

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[1] This contribution extends a topic discussed in two previous papers, available in German (cf. Potthast 2010a) and English (cf. Potthast 2010b). It has improved thanks to questions and criticisms raised at a number of workshops and seminars in Siegen (Locating Media), Paris (CSI), Freiburg (Sicherheit und Gesellschaft), Tübingen (GWTF), Marne-la-Vallée (LATTS) and Jena (BMBF Sicherheitsforschungsprogramm). I am particularly indebted to Stefan Kaufmann who attended almost three of these presentations, to Dominique Linhardt, first reader of the first draft, and to Cornelius Schubert, last reader of the final cut. The ultimate version is still underway (Gefährlich unauffällige Passanten, Wiesbaden: VS/Les passagers extraordinaires, together with Dominique Linhardt). The motto on Doubting Thomas and a more substantial interpretation of it can be found in Chateauraynaud (1996; 2004).

> So the other disciples told him, "We have seen the Lord"! But he [Thomas] said to them, "Unless I see the nail marks in his hands and put my finger where the nails were, and put my hand into his side, I will not believe it."
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> A week later his disciples were in the house again, and Thomas was with them. Though the doors were locked, Jesus came and stood among them and said, "Peace be with you!" Then he said to Thomas, "Put your finger here; see my hands. Reach out your hand and put it into my side. Stop doubting and believe." Thomas said to him, "My Lord and my God!" Then Jesus told him, "Because you have seen me, you have believed; blessed are those who have not seen and yet have believed" (John 20: 26-29).

1 Introduction

Since 2006, at many airports, passengers are no longer allowed to carry liquids with them. Before boarding a flight, liquids exceeding a certain quantity have to be sorted out. Regardless of their quality and without a trial, liquids have been put under a general suspicion. Passengers ready to advocate the case of their liquids were not allowed to do so. With regard to liquids, a tightened security regime came without a procedure of testing. Unsurprisingly then, passengers felt to be exposed to arbitrary judgements. The current practice of controlling for potentially dangerous liquids continues to defy common sense and to produce sensory confusion: How to distinguish between liquids and non-liquids? Is this a matter of visual, of gustatory or of haptic expertise? Provided these uncertainties and weakly instrumented, judgements on toothpaste, soft cheese or chocolate bars will remain contentious.

As illustrated by the liquids' case, airport security has recently undergone a number of modifications. This prompts a set of questions highly familiar to scholars of science studies, and particularly to sociologists and historians of medicine. First, what are the consequences of laboratorisation, that is, the increasing instrumentation of scientific and other professional practices? For instance, how to defend a professional monopoly while depending on new technologies and their experts? Second, if laboratisation has extended and partly replaced human senses (by using sensor technologies), does it follow a main trend towards a sensory *dominance of the visual* (cf. Daston/Galison 2007)? The opening observation on the treatment of liquids seems to question this twofold assumption. Neither does it confirm the idea that access control closely follows a laboratory model, nor does it support the claim for a control revolution built on visual technologies. Rather, it points in the opposite direction of sensory if not *sensual confusion*. This is why the contribution attempts to review a broad range of recent changes, highlighting the ways in which classification relates to sensory practices. Following the basic layout of contemporary airport terminals, it is organised in two main sections on changes, first at the departure level (3), and second at the arrival level (4), followed by a discussion on similarities and differences (5). Providing a close and continuous description of how security works in both sections of airport terminals, I attempt to re-situate and maybe reformulate a fundamental discontinuity in terms of institutional logics.

Recent reconfigurations of access control have not gone unnoticed and have been sometimes picked up by mass media. This attention, however, has remained ephemeral and superficial, two omissions being similar to those displayed by John's account of Doubting Thomas. First and more generally, the narrator focuses on personal identification, and depicts its procedure in detail. On the other hand, while it is stated that Jesus came into the house though the doors were locked, modalities of access are left without further detail or comment. A second omission occurs, when it comes to the moral to be drawn from the story: "Blessed are

those who have not seen and yet have believed." This statement points to a *visual bias*. Evidence is assumed to be a matter of visual perception while the haptic trials described in some detail are simply left out (cf. Chateauraynaud 1996: 3-4; 2004).

Putting modalities of access control centre stage and avoiding a sensory bias, the present contribution seeks to further specify what may be termed a "resilience turn" in the social studies of risk and safety. To recall and briefly re-introduce, recent studies have been guided by an interest in resilience, responsiveness or preparedness as a property of social institutions.

> "If we cannot know the risks we face, how can we cope with unknown dangers? Taking the focus of the debate away from risks and safety to the choice between social institutions, we can suggest the qualities necessary for dealing with risks" (Douglas/Wildavsky 1982: 195).

According to a founding contribution to the cultural study of risk, institutions built on "control by anticipation" are likely to fail as they lack "the capacity to cope resiliently" (ibid.). It follows that it is "our responsibility […] to create resilience in our institutions" (Douglas/Wildavsky 1982: 198). "Searching for safety", a later book by Aaron Wildavsky (1988) returns to the distinction between "anticipation" as opposed to "resilience", specifying that "anticipation is a mode of control by a central mind. [...] Anticipation attempts to avoid hypothesized hazards; resilience is concerned with those that have been realized" (Wildavsky 1988: 77). Once more, the author reaches a clear-cut conclusion on what is the more efficient way of dealing with the unexpected: "Thus, under considerable uncertainty, resilience is the preferable strategy. Under substantial certainty, anticipation [...] does make sense" (ibid. 79).

While the notion of "resilience" remains to be associated with the field of safety, similar concepts and distinctions have emerged in the domain of security and guided research on responses to the 9/11 terrorist attacks, though reaching different conclusions.[2] According to Birkland (2004), institutional responses in the field of airport security have displayed a remarkable capacity of learning from and adapting to the varieties of terrorist action. Focusing on the immediate response to the terrorist attacks, Knorr Cetina (2005: 225ff.) argues that, faced with flexible terrorist cells, large and hierarchical organisations have been exposed as being slow and inefficient. Among the studies that take a critical view on the rise of surveillance society (cf. Lyon 2007) some have come to agree that control by anticipation should not be overstated (cf. Agre 1994; Krasmann 2003). Instead of presupposing a vantage point which would allow for full observation and total surveillance, a more careful analysis is called for in order to cover (or uncover) a greater variety of control activities. So far, however, this call to go *beyond anticipation* came without a researchable concept of resilience in positive terms.[3] While there is a broad agreement that abandoning a static panoptic model will allow for a more fine-grained empirical description of control activities, it is still waiting to find support in a sound research framework. Therefore, to opt for a (more) situated analysis is to look at the *sensory cultures of evidence* as implied in control practices. Probing the assumption of a single dominant mode of visual control, attention is devoted to distributions and redistributions among multiple senses of security at work.

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[2] While both safety and security relate to (the absence of) accidents, common sense insists on different concepts of causality. In the case of security, accidents are produced by an external threat and are related to malign intentions. Safety threats, in turn, are intrinsic to and specified in terms of technical systems.

[3] This failure has occurred both in the safety (cf. Potthast 2007: 53-59) and in the security camp.

n the case of mobilities and the ways in which they are controlled, airport terminals host two intersecting logics of access. Providing access to political territories at arrivals and to technical networks at departures, they suggest themselves for a comparative analysis of control activities. If there is a turn towards a single mode of anticipation (or away from it), it needs to be grasped on both sides and on the ground of sensory practices. If there is a new (control) regime of visibility (cf. Hempel et al. 2010), this claim needs to made without a methodological bias. Hence, sharply contrasting the account of Doubting Thomas, the ways in which sensory data are generated will be put under sustained scrutiny.

Concentrating on multiple senses and of practices of control that combine and switch between different senses, I seek to side-step a current strategy of interpretation practiced by surveillance and critical security studies. In my view, work in this area often suffers from a visual bias the symptom of which is easy to grasp. Take the following comment: "Another reason why the screening changes […] were accomplished quickly is that they were very symbolically important measures designed both to add some measure of security (although not of course total security) while at the same time reassuring the traveling public that something was being done – and the urge to do something or anything is often quite strong after focusing events" (Birkland 2004: 358). Drawing this conclusion is to discourage further and more continuous empirical work. To extend on the critique of the visual bias and its genealogy, one has to account for the appalling loss of microfoundation. Contrasting the standard set by the investigation that lead to the "control revolution" hypothesis (cf. Beniger 1986) countless studies have reflected on how (bureaucratic) technologies of control have emerged as a response to (railroad) accidents. At the same time, however, they have neglected the everyday operation of technical systems. The reception of Crozier's work on technical failures (cf. Crozier 1964; Potthast 2007: 72-79) illustrates this point. Taking little interest in the mechanisms of transforming technical uncertainty into a resource, the "bureaucratic phenomenon" (Crozier 1964) is, above all, taken as a product of symbolic action. Undeniably, both risks and responses to risks may be used for the public staging of power and control (cf. Gilbert 1992). In the case of recent terrorist action, there was plenty of opportunity to observe both the reaffirmation of state power and marketing strategies of industrial suppliers (cf. Ceyhan 2007). But this is no excuse for stating nothing but the obvious.

Ronen Shamir (2005) argues that emerging technologies of profiling are responsible for social stratification at a global scale. He claims that creating and linking large databases for personal identification has a double impact: It may speed up mobilities for some, while it produces effects of containment for others.

> "[T]he differential ability to move in space – and even more so to have access to opportunities for movement – has become a major stratifying force in the global social hierarchy. […]
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> [P]rofiling emerges as a more discrete technology of intervention that facilitates and complements the regulation of mobility by legal and disciplinary means. Moreover, while laws and regulations may formally enable governance through profiling, they nonetheless lack the instruments and *the type of gaze that allows profiling to function as a mode of spatial containment* that is able – on the ground – to maintain the selectivity of boundary-crossing and to effectively distinguish those who are licensed to move from those who are not." (Shamir 2005: 205, 210; my emphasis).

According to Shamir (2005), responses to 9/11 have resulted in a new global order of access. Portrayed as depending on a new "discrete technology", these changes appear supporting a distinctive "type of gaze". Actually, the present paper does not select a single

discrete technology but seeks to trace changes all along the journey of passengers and their luggage through the terminal building. It attempts to depict security in action.

2 Sources

Unsurprisingly, access control at airports is a field which is difficult to study.[4] Standard procedures of generating qualitative data may therefore be simply inadequate. Empirical investigation on airport security rests upon research strategies that are hard to reproduce. Morgane Iserte (2008), for example, doing research in the restricted waiting area at Paris-CDG airport, reports that she was not allowed to talk to the persons whose legal status was uncertain, and that she was permanently accompanied by border police officers. Furthermore, she had to join a non-governmental organisation allowed on site in order to carry out her research. Provided these conditions, the state of the art in social studies on airport security has remained rather deficient (cf. Adey 2004). There is no study which would be based on a fully comprehensive research strategy and a consistent and coherent body of observations. Among the few studies available, there is a noteworthy analysis of passenger screening at the departure level of Paris Orly based on fieldwork before 9/11 (cf. Linhardt 2000; 2001; Jobard/Linhardt 2008). Finally, there is a more recent article on security screening which combines the analysis of publicly available documents from various sources with a series of crises experiments the author has carried out at several airports (cf. Parks 2007).

In addition to the work just mentioned, there are three more continuous sources of information and research I will draw on in this contribution. As a first source, I will use reports provided to members of the US Congress by the *Congressional Research Service* (CRS). Within this large collection which has recently been made available online, there is a number of reports dealing with air transport security and related issues. A second source is *Passenger Terminal World*, a monthly commercial review that serves as a show-case for airport terminal technologies and services. For the purpose of this article, I will refer to contributions by major design and architecture studios. Their authors often take a comprehensive view on airports, reflecting on new technological devices in the context of "old technology" and the spatial layout of terminals. Finally, there is a French academic journal, *Cultures & conflits*, which has closely followed the topic for more than ten years. Within these three sources, I will trace the sensory cultures of evidence. Combining the three sources mentioned I will compose an empirical study of the ways in which airports have been equipped with and make use of security technologies.

The present article has two main sections reviewing recent changes of access control at departures (3) and arrivals (4). Providing a close and continuous description of how security works in both sections of airport terminals, I attempt to re-situate and maybe reformulate a fundamental discontinuity in terms of institutional logics. In the case of departures, access control is related to threats specific to air transport. In the case of arrivals, threats are defined with regard to the current doctrine of domestic policy which is applied to territorial boundaries in general, regardless of

[4] Following Bigo (1998: 5), studies on security and terrorism merit highest standards of methodological reflexivity. Surprisingly, therefore, reviewing 10 studies on terrorism and security published after 9/11, Neidhardt (2004: 263) finds that none of the authors has taken care to reflect on the methodological aspect of their research. For a succinct methodological discussion which is instructive beyond the problem of understanding suicide missions, see Gambetta (2005: 259-300).

the mode of transport. Terminal architecture can be said to draw a distinction between security related to the safety of a technical system and security related to issues of national sovereignty. The strict separation between departing and arriving passengers has remained a stable feature of airport layout that has not been affected by recent changes. This is reflected by the organisation of the present inquiry. Building on the separate documentation of changes of sensory practices at departures and arrivals, it will address the following questions: Have changes taken in both sections affected each other? Has the relationship between arrivals and departures been transformed? The inquiry will be sensitive to both local and to translocal change: It will ask for distinctive features of terminals as a building type, and elaborate on issues which account for the fact that one airport's arrivals section is another airport's section of departures.

The author of this paper partly draws on observations taken as a passenger. More importantly, though, I have carried out ethnographic research on the crisis of baggage handling related to the introduction of hub-and-spoke operational schemes at the airports of London Heathrow and Paris Charles-de-Gaulle (cf. Potthast 2007). I do not claim that responses to both types of crises (lost bags; security after 9/11) can be analysed within a common framework. However, both studies are complementary, both in a spatial sense (after check-in, passengers and bags are processed separately) and in a historical sense (fieldwork on the bag crisis has been conducted before 9/11 and therefore eclipsed the current concern for terrorist prevention).[5]

[5] Further studies focusing on crises and transformations within the large technical system of air transport include an analysis of public responses to the Swissair 111 crash in 1998 (Potthast 2003) and an ethnographic account of the uses of paper strips in air traffic control (Potthast 2008).

3 Departures

On a cynical note, one could say that airplanes have been designed for taking hostages as they are difficult to invade and almost impossible to evacuate. What is more, for fear of crashing, passenger resistance is unlikely. Planes are spaces that are *easily controlled* – for good or for evil. This is why it has become so important to control access to them. These control activities have to be carried out in spaces which are particularly *difficult to control*: airport terminals are anonymous public spaces (and sometimes crowded). In this sense, these buildings offer a perfect hideout for terrorists as they cannot be distinguished from ordinary passengers (cf. Linhardt 2001). While this is a salient observation for public places and buildings in general, the specific vulnerability of airport terminals is obviously related to the fact that they are access points to planes.

To deal with this problem, a number of spatial boundaries have been erected. First and foremost, departures are strictly separated from arrivals (cf. Phipps 1991). Second, within the departures area, passengers are separated from and later reconciled with their bags. Separation of passengers and bags takes place at a considerable distance from the aircraft. *Separation* is a key term to describe security procedures at airport terminals: separation of persons (to be checked individually); of persons and their bags; of persons and carry-on luggage; of bags and bags. Finally, in case of doubt, various items within carry-on luggage are given a separate check. In short, the whole process is designed to transform a heterogeneous crowd entering the airport terminal into components identifiable by corresponding sensor equipment.

Entering the airport terminal and finding their way towards the correct check-in desk, passengers are welcomed by security announcements

reminding them *not* to engage in an operation of separation without assistance: They are requested to never leave their baggage unattended in the terminal area. At many airports, this announcement is combined with a warning: Objects left unattended are considered dangerous and "may be destroyed". To destroy unidentified bags has been an ongoing practice even before 9/11. Alertness to it has certainly risen after these events. In addition to the invisible announcement, an increasing number of security agents serve, among other functions, as a permanent visible reminder of the security announcements.

Passengers have to present themselves at a check-in desk. At this point of their journey, they will be identified by airline operators and will have to leave larger bags. To describe the bulk of actions taken to disrupt terrorist travel after 9/11, I will now go on to the security checkpoint.

One of these actions is to screen passengers for explosives. To this purpose, technological equipment has been made available at airport security checkpoints (cf. Shea/Morgan 2007). There are two ways of screening called "explosives trace detection" and "detection of bulk explosives" the latter of which has been introduced earlier. Trace detection is carried out using ion mobility spectrometry. Usually deployed with portals, it targets traces or small doses of explosives on airline passengers themselves. One of the questions raised during its implementation was whether to use trace detection as a primary or only as a secondary check. If used as a primary check, would it allow for appropriate "passenger throughput"? What if too many "false positives" slow down the process in unacceptable ways? What if, for the purpose of mass (false) detection and disruption of airport operation, explosives are disseminated on commonly touched objects at the airport? Finally, what if new explosives are used which are not (yet) detectable (cf. ibid.)? Up to now, trace detection devices and portals do not provide visual or other clues which would offer a starting point to use operators' intuition and experience in case of doubt.

Following significant investments into trace detection,[6] the issue of liquid explosives (which escape trace detection) was brought up in 2006. Dangerous liquids were added to the list of dangerous substances – dangerous liquids which are difficult to distinguish from harmless liquids such as water or toothpaste. The consequences are well known. As passengers have to leave larger quantities of liquids at the security desk, the current situation remains challenging both for operators and passengers. It defies common sense that a reliable method for discriminating dangerous liquids is not available. Instead, in the absence of a criterion to determine what is a dangerous substance, security staff uses "liquids" above a certain quantity (which is controversial in itself) as a proxy. The current treatment of liquids both mirrors and points to the limits of a prior mode of extending the control process at departures: in order to respond to a new security threat, (further) isolate components and generate reliable sensory data; replace human senses by sensor technologies if possible.

As exemplified by the handling of liquids, screening hand luggage has been given particular attention. Passengers have to take off their coats and jackets, or even their belts and shoes. Together with their hand luggage, these items are put on a belt for security X-raying. Laptops must be unpacked. Passengers have to check their pockets for metal objects, and they have to hand

[6] In the US, the system for explosive trace detection has been implemented at 400 commercial airports. When implemented in 2005, the cost per portal was 160,000 Dollars (cf. Shea/Morgan 2007). In order to estimate the overall cost of this measure, operation and maintenance expenses have to be added (cf. ibid.).

over mobile phones, and they are requested to put liquids (which are not allowed to extend a maximum limit) into a separate transparent bag. Substances and objects considered dangerous may be confiscated. Finally, a passenger may him/herself be denied access to the plane. The tightening of security procedures has been accompanied by countless complaints by passengers, and many of these complaints appear perfectly justified. Some complain of having missed their flight due to longer queuing time. Others complain of the loss of private property classified dangerous. Another set of complaints is directed at search practices judged too intrusive. A rare but particularly severe case is presented by those who have been refused from boarding the aircraft due to misidentification (cf. Krouse/Elias 2007, 8). Throughout these complaints, it is rather difficult, if not impossible, to identify a common line of critique. Neither is there an abstract concept of privacy behind the variety of indignations, nor is violation of privacy the only controversial issue. A great number of critical remarks suspects security checks to lack efficiency. Sometimes, security is not only questioned but clandestinely tested.

Security staff is exposed to critique – not just in an abstract sense. Taking passenger complaints seriously is to stay close to the everyday worldly encounters between security staff and passengers and to the problems to generalise from these particular experiences. While airport security is composed of a stable sequence of operations, checkpoint encounters, mediated by technological equipment in multiple ways, are the object of considerable tensions.[7] A clear indication for this tension is that, at some airports, security checkpoints have been explicitly declared joking-free zones. It further adds to the ritualistic dimension of security procedures that, when approaching the security checkpoint, passengers are shown the following warning:

> "All comments regarding bombs and guns are taken seriously. Please no jokes." Or: "Making any jokes or statements during the screening process may be grounds for both criminal and civil penalties. All such matters will be taken seriously. We thank you for your restraint in this matter."

Besides carrying out work that is physically challenging (cf. Parks 2007), security agents are inundated with complaints. They are trapped by receiving contradictory complaints: On the one hand, they are criticised for taking their security mission too seriously; on the other hand, they are insulted for not taking their job seriously enough. They are confronted with resentment for both following and allegedly neglecting rules. Constantly interfacing with passengers and exposed to their moods and critiques, they need protection from joking and ambiguity.

To mention a further change post 9/11, security checkpoints at departures have been equipped with more sophisticated technologies of visualisation. Suspicious objects may be zoomed in and shown in contrasting colours. These devices have not replaced but rather complemented manual searching. Having screened passengers' belongings by means of visual analysis, some passengers and their belongings are selected for a second stage of manual search. The deployment of new technology has allowed for extending the process of screening, but it has not replaced a procedure that relies on training bodies (for manual research). Both vision and tactile senses are deployed to deal with a doubtful passenger or piece of luggage. In a recent instance, the multiplicity of senses has become fairly obvious. As body scan equipment is currently reconsidered for implementation in many countries, manual search may

[7] Of course, similar tensions arise in a number of customer service work settings, both within and beyond air transport. Cf. the early study on emotionally securising passengers before and during the flight (Hochschild 1983).

lose importance. In Germany, however, the announcement of this technology was not welcomed but regarded as highly problematic. One of the headlines read as follows: "Politicians terrified by the announcement of a *Nacktscanner*" (Spiegel-Online, 23.10.2008). Raising objections against a *scanner that reveals the naked body* is to question a further extension of the visual mode of control. Contrasting the case of medicine which has evolved towards a visual dominance[8] (and marginalized other modes of examination; cf. Pasveer 1989), privacy claims are founded on a cultural sense of visual integrity. On the other hand, would not body scanning allow for substituting practices of manual search to be considered (even) more harmful in terms of privacy? Would not visual search by machines be more democratic as compared to manual search carried out by operators following dubious and maybe racist stereotypes of what constitutes a "dangerous person"?

As pointed out earlier, the separation of luggage and passengers is at the basis of the current mode of controlling access to aircrafts. Having processed, on separate paths, both passengers and their bags, there has to be reconciliation before take-off. Two failures of reconciliation may occur: Either the person or his/her luggage is not on board. While the first event is classified a threat for security, the second is considered as a technical failure.[9] Therefore, in case of a missing passenger, the departure of a plane has to be postponed until his/her bag has been identified and unboarded. While this may cause disruption, its impact on overall flight delays is low.[10]

Assuring reconciliation is the last step in a sequence of security operations at departures. Reviewing responses to terrorist threats targeting air transport, the preceding observations confirm that airport security is a matter of incrementalism. A pre-existing set of trials has been extended by adding up a number of operations. Having undergone the modifications depicted in the preceding paragraphs, the process of controlling passengers and bags is still homologous to a scientific trial. According to the (pre 9/11) description by Linhardt (2001, 85), the aim of this process is to transform a worldly object into an epistemic one or to reduce a complex object to readable traces which can then be processed by laboratory-like technologies at the security checkpoints. By and large, changes have confirmed a pattern well established by science studies to be summarised as follows: Laboratorisation implies the dominance of the eye, the idea of objectivity being closely associated with a hierarchy of the five senses with vision at the top.

For the sake of simplification, changes at departures may be said to have evolved along a *laboratory-like mode of control* and given more weight to modes of visual control. But how then about arrivals?

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[8] Leading to the marginalization of other modes of examination, as stressed by Pasveer 1989, Dommann 2003, Burri 2008. For a contrasting case, see Johnson 2008 on the haptic-enabled surgery simulator.

[9] In the case of a lost bag, there is no formal imperative on how to proceed (cf. Potthast 2007).

[10] According to the US air travel consumer report covering the period of March 2007, 73 percent of all flights at 32 airports in the US have been on time. Among those delayed, only a small fraction of 0, 06% has been delayed by "security reasons" that are defined as follows: "Delays caused by evacuation of terminal or concourse, reboarding of aircraft because of security breech, inoperative screening equipment and long lines in excess of 29 minutes at screening areas" (Office of Aviation 2007: 26). Among the future "gridlocks" of air transport, "security" does only appear as a marginal problem (cf. Elias 2006).

4 Arrivals

Video screening, combined with profiling based on biometric data, has been ready for introduction at the gangways of major airports since 2002.[11] This is a specific application of CCTV systems which contrasts with the generic use of video cameras elsewhere in the terminal building (including the departure section). Many airports have multiplied the number of video cameras in response to the terrorist attacks. For instance, as decided in 2003, 6,800 cameras have been deployed at Paris-CDG (cf. Iserte 2008, §18). At the exit door of the aircraft, the use of video taping and software for facial recognition serves a specific purpose, related to this particular location. The average time required to walk through a gangway is long enough to find potential matches in a biometric database. A person classified as being dangerous may then be identified and sorted out by security forces at the end of gangway. In terms of sensory practices, this way of sorting out is primarily based on visual data and recent technologies of detection and storage. Throughout the section on arrivals, visual technologies and their electronic extensions will stay in the limelight.

Access control at the arrival section has moved up to the door of an arriving aircraft. For the rest of it, there is no stable sequence of control activities. The absence of it is reflected by passenger experience. To arrive is less of a ritual as compared to the much more structured procedure of separating and filtering at departures. Obviously, passengers will have to go through passport control (if boarding on international flights) before recollecting their bags and then passing the line of customs control. The arrivals section is divided up into various zones, too. One of these zones is "reserved" for arriving passengers that are refused to enter the country or even the transit zone. By definition, this zone is not linked to any sequence of standard operations applied to the entire public.

Access control at the arrival section is selective from the outset. Since 9/11, the focus on national identity has been renewed. Determining the country of origin is paramount. At Paris-CDG airport, passengers originating from one of 34 countries that have reached the highest numbers of asylum seekers in the recent past are given particular attention (cf. Iserte 2008, §30). If selection by nationality fails, border police units have to deal with persons of "unknown origins". In order to reduce their number, some incoming flights are controlled directly at the exit door of the aircraft. This action has become a regular practice and serves to sort out passengers on the basis of intuition. Trying to identify those who might not be tourists, border police seeks to reduce the number of persons "losing their origin" between the aircraft and the transit zone. Tracing both official projects and more unofficial practices related to access control at Paris- Charles de Gaulle, Iserte (2008, §§40ff.) claims that this airport has become more "securised".

Moving further through the catalogue of changes, one will notice that some control activities related to the arrival section are carried out at a distance. Locally, departing and arriving passengers continue to be strictly separated. At the same time, territorial boundaries have become more flexible. Stated in another way, sections for departures and arrivals have gotten closer to each other.

Among the activities even *prior to* the control of passengers and luggage at departures, one has to mention the listing of dangerous persons and descriptions of dangerous items that

[11] CISCO manager, personal communication, Passenger Terminal World Conference (Hamburg, 2002). This personal communication came with a demonstration of the time needed to capture and transform visual data.

should not enter the plane. The task left for the various points of control at the airport then consists in finding matches between those persons and objects listed and those to be checked at the gate. Since 2001, *screening* passengers has been intensified and complemented by an activity called "pre-screening". US authorities have put 20,000 persons on a "no fly" list. Airlines flying to the US are obliged to check passenger lists against this "no fly" list *before* take-off and to contact US authorities in case of a match. In addition, there is a second watchlist which is estimated to name about 325,000 "automatic selectees" who are given particular scrutiny at airports (cf. Krouse/Elias 2007: 5). Collecting, storing and sharing large amounts of detailed passenger information have been the subject of controversy; also, there have been serious concerns about the quality of these databases, following the misidentification and mishandling of passengers. The notion of "pre-screening" is interesting in itself. From a passenger's perspective, it does not make sense, because screening has always been pre-flight (at departures). The operation referred to as "pre-screening", however, takes the destination of a flight as its reference point. Pre-screening involves the transmission of passenger data from the airport of departure to the Transport Security Agency (TSA).

Every day, an average of 30 matches with the "no fly" list is reported to this agency (cf. ibid.). In case a passenger list is incomplete or has been incorrectly transmitted to the US authorities, flights heading for the US might be diverted. This has occurred on a few occasions. As a consequence, among the measures taken to increase security, pre-screening has been widely discussed and criticised for "extroverting" (US) borders (cf. Cuttitta 2007; Kaufmann 2006). Extending border control, persons classified as suspect are identified before entering US territory. They are "located" at a distance. Listing, checking and (pre-)screening activities do not necessarily require the introduction of new technologies. Making use of databases, however, has not only led to the extension of territorial boundaries. It has also extended towards a new type of visual data, notably biometrical data. During the last few years, technologies of collecting, storing and comparing biometrical data have been developed, tested and widely deployed.

Access control at arrivals no longer takes place in a single location. Instead it has developed towards a spatially distributed activity that comprises collaboration between several parties. To mention one example, cooperation between border police services with embassies and airlines in the country of origin has been intensified. This cooperation is built upon heavy constraints. Airlines that carry passengers without documents are fined penalty payments reaching 5,000 Euros. In 2004, airlines flying to Paris-CDG airport have been fined on 1,033 occasions (cf. Iserte 2008, §36). In official documents the practice of shifting boundaries is depicted in terms of growing efficiency and accompanied by the following series of figures: Each year, some 12,000 persons arriving at the airport of Paris-CDG have been refused access to the French territory. In 2005, this was about half of the total figure in France. In 2006, more than 14,000 persons were placed in the restricted waiting zone at the airport. During the same year, almost 3,000 persons asked for asylum at Paris-CDG airport. Since then, this figure has decreased. Another figure presented as a key indicator to a successful migration policy regime is average "waiting time" in the restricted area (at Paris-CDG airport) which has gone down from 5 days in 2004 to 1.89 days in 2006.[12] Moreover, the French administration

[12] "Waiting time" does not refer to departures here. The concept has migrated to the "reserved waiting areas" at arrivals.

has celebrated itself for having speeded up the treatment of asylum requests. In 2006, 86 per cent of requests were handled within 4 days (all figures quoted from Iserte 2008).

While these figures are meant to be evidence for good policy, they have raised serious concerns about the ways in which they have been achieved. As stated before, the French administration celebrates itself for reducing "waiting time" of passengers while clarifying their legal status and their admission to French territory. However, the reduction of waiting time is partly related to questionable practices. For instance, arriving passengers suspected not to satisfy admission requirements are not informed about their rights, actively discouraged from officially notifying their status and told to return as quickly as possible to their origin of flight. In turn, public announcements and appraisals on the speeded-up treatment of passengers of uncertain legal status or of "unknown origins" and an increasing rate of refusal may further encourage these practices (cf. ibid., §40). Clearly, though, a control mode largely based on visualisation does not indicate gains in objectivity and transparency.

While a thorough discussion on whether these concerns are justified is beyond the scope of the present paper, its comparative framework allows for highlighting the following difference: At departures, a stationary sequence of trials has been supplemented by further technical equipment. Its clear-cut spatial layout corresponds to a concise definition of institutional responsibilities. At arrivals, things have evolved in the opposite sense. Notwithstanding the speeding-up and reduction of local waiting time, access control has become more diffuse, both in the spatial and in the institutional respect.

Changes at departures are exclusively related to security issues that may affect flight safety. At arrivals, security is inextricably tied to migration policy (cf. Carter 2008). "Establishing alienage" (Wasem 2008, 15) is a prerequisite to deny illegal entrants access to "federal benefits" (ibid. 1). For this purpose, arrivals have been equipped with various technologies of verifying identity and citizenship. Speaking of "federal benefits", what are the costs related to false claims of citizenship, and how do they compare to the costs of fighting false claims by technical and organisational means? Without specifically referring to airports, many observers estimate that the latter approach is simply ineffective (cf. Romero 2007) and contest that new technologies (for instance, more sophisticated identification documents and document control systems) will provide a durable technical fix. This assumption is doubtful at best, provided the scale and the social complexity of the issue of "illegal immigration" and "alien residents".[13] Without going deeper into the details of immigration policy, it is obvious that security concerns, whether founded or not, have been an important political resource for restrictive migration policy doctrines in many countries.

Looking back to the previous sections, there is a displacement of attention shifting from departures to arrivals. This is remarkable for a simple reason: on the morning of 11th September 2001, all terrorists had checked in for domestic flights and never reached the scheduled destination. Responses to the terrorist threat, however, have not been limited to departures. On the contrary, the US and other countries have redefined their territorial bounda-

[13] For a brief illustration, the estimated number of illegal alien residents in the US is 11 million. How many of these persons live in families of mixed status? And how to deal with these families that are partly composed of legal residents, for instance children born on American soil (cf. Wasem 2008)?

ries and modified access control at arrivals.[14]

The objective to "disrupt terrorist travel" has led to refining and intensifying passenger control both at departures and arrivals. In addition to screening up to 150,000 daily passengers, access control also applies to airport staff, a workforce that cannot be divided up between the two populations of departing or arriving passengers. In 2005, Paris-CDG airport received 63,000 requests for badges authorising airport staff to work in sensitive zones.[15] At many places, these employees were chosen to pioneer access control technologies based on biometrical screenings. Biometrical information collected at all access points allows for tracking and tracing movements of staff members in real time throughout the airport. In addition to the shift to a new technology of identification, checkpoints used by airport staff have been equipped with machines designed to prevent tailgating. These devices consist of two doors, the second of which will open once the first door is closed, and the person has been successfully identified. In the meantime, checks of weight are being carried out to make sure that only one person is allowed to enter the sensitive area. With regard to these check-points, biometric control takes place without local human assistance. Yet it can be noted that visual control (matching biometric data) is complemented by a different type of sensory detection (haptic devices for weight control).

Whether assisted by humans or by technical equipment, control of arriving passengers and of airport staff is of a mixed status. While new technologies of control have been implemented that primarily deal with visual data, access control continues to rely on multiple senses. To characterise the composite and compromising nature of access control at arrivals I suggest speaking of "biometric guardianship" (see table 1). As illustrated by the preceding example (prevention of tailgating), controlling access by biometrical means does not equal with miniaturisation but has prompted investment into heavy mechanical artefacts and is therefore bound to a specific location.

5 Departures/Arrivals

As illustrated by the previous sections, research and new applications in sensor technology have changed and reshaped practices of security screening in important ways. Obviously, there is more technology in the pipeline of research and development that is considered for introduction to the airport environment. Although the account presented so far may be short-lived, it allows for evaluating the impact of sensor technology on empirical

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[14] *Cultures & conflits* has closely and critically accompanied this development, including a number of thematic issues on "security and immigration" (issue 31-32, 1998), "critical approaches to security studies" (54, 2004), "identification and surveillance" (64, 2007), "circulation and the archipelagos of exception" (68, 2007), and "confinement of foreigners: between circulation and arrest" (71, 2008), "borders and the logics of crossing everyday transgressions" (72, 2008).

[15] The rate of refusal was between one and two percent. Total staff at Paris-CDG airport was 83,000, employed by some 700 companies (cf. Smolar 2006). Security staff, including customs, gendarmerie, border police and private security firms at both Paris-CDG and Paris-Orly was 10,000 in 2002 (cf. Smolar 2003). In France, discussion on the security of airport staff has been fuelled by a right wing politician's book on "the mosques of Roissy" (Villiers 2006; cf. Boltanski 2006). Shortly after the publication, a number of baggage handlers have been refused access to the airport as they were suspected to belong to islamist organisations. Elsewhere, the discussion was not dominated by the issue of racial profiling. In the US, for example, status and training of airport security workforce have been a major concern. Security staff has been federalised in the aftermath of 9/11. As reported by Parks (2007), however, turnover rates continue to be alarmingly high reflecting difficult working conditions and a failure to continuously build up and train a well skilled security work force.

grounds.[16] Extending and replacing human sensory capacities, the rise of sensor technology has prompted a control revolution hypothesis (cf. Shamir 2005) that is now ready for specification and critical re-examination. To what extent do sensor technologies challenge the spatial organisation of airport terminals? Does the sequence of spaces characteristic of passenger air transport further persist? Does sensor technology make terminal buildings disappear? Are mobilities to be controlled in seamless ways, according to a single abstract logic, irrespective of architectural devices, of spatial division, zoning, and walls (cf. Mitchell 1995)? Defending that the 2001 terrorist attacks triggered a control revolution, it is not enough to suggest airports as its major host. Rather, it has to be shown that departure and arrival levels have been affected in the same ways. Having built up separate inventories on both, the present section will turn to this issue,

Table 1: Differences with regard to departing and arriving passengers persist. Changes in airport security do not add up to an all-encompassing control revolution. Differences between countries have been neglected.

Changes in airport security since 2001	at DEPARTURES	and ARRIVALS	with respect to SENSORY PRACTICES
Equipped with technology	- document authentication - identity check partly based on biometric recognition - detection of trace explosives - technologies of visualisation, including body scan	- document authentication - identity check partly based on biometric recognition - facial recognition based on video footage - control activities	- sensory data isolated, amplified, transformed and stored - primacy of visual data
weakly instrumented	-check for liquid explosives - police and security increased in staff numbers	- extended to the flight's origin (delegated to airlines and embassies) - practices of reducing waiting time ("render inadmissible")	- blend of sensory practices with no hierarchy
Evolution of spatial and institutional setting	Stationary agglomeration and incremental change: new features of control are added to a locally confined process. The last instance of control is manual research.	Increasingly diffuse in both spatial and institutional terms: recombination of remote and local control practices.	Highly instrumented and spatially confined, allowing for replication and refinement (DEP) vs. weakly specified local control activities linking up with storage and use of biometric data (ARR).
Mode of control	Laboratory check	Biometric guardianship	Recent transformations do not converge.

[16] Maybe short-lived and certainly not exhaustive: It has captured major changes regarding access control all along the journey of passengers and their bags, but it did not present a full matrix of objects considered dangerous and related means of sensory detection.

inquiring about the future of the terminal as a building type.

To begin with, terminals are very large buildings. Major airports receive up to 80 million passengers per year. As passenger flow is unevenly distributed, and often split up between several terminal buildings, terminal design is based on the expected number of "busy hour passengers". A UK-based airport designer has presented the following calculation: Adding up 20 square meters for public use, 20 for non-public use; 6 for public commercial use and 1.5 for non-public commercial use, airport terminals should provide 50 square meters per busy hour passenger (cf. Stewart 2004). The built space per passenger ratio varies with different terminal layouts. Horizontal layouts are less space-consuming than vertical layouts. However, in the case of horizontal layouts, passengers will have to walk longer distances. To give an example, Terminal 2E in Paris Charles-de-Gaulle extends over a surface of 220,000 square meters. It was designed to handle 11 million passengers per year and 7,500 departing passengers per busy hour (cf. Salat 1998: 264). As to check-in queue areas, the "congestion standards" released by the International Air Transport Association recommend 1.4 square meter per occupant as the "minimum design objective" (IATA manual, 1992). If it falls beyond 1.0 square meter, this is qualified as an "inadequate level of service; condition of unstable flow; unacceptable delays; inadequate level of comfort." These figures might suffice to remind of the fact that all revisions with regard to access control take place in a built environment of considerable scale and complexity. Under these circumstances, airport terminals appear to be unlikely hosts of a "control revolution".

If we are not to expect the end of the terminal, how then to characterise airport terminals as a building type, and is this building type affected by current changes? What is the role of the revised security regime as compared to other factors?

Much like railway stations, airport terminals are run by more than one organisation. This is hardly worth mentioning unless these organisations have to coordinate their activities – as in moments of emergency. In critical situations, they have to collaborate without already having agreed on a common mode and common rules of coordination. The studies conducted by Isaac Joseph and his collaborators (1995) focus on "situations perturbées". In their understanding, to keep large railway stations "accessible" is to manage all sorts of crises that may result in leaving spaces of flows decoupled from spaces of communication. Focusing on situations of crisis, they find that horizontal modes of coordination between various actors prevail, while hierarchy and anticipation, apparently, are no option in complex spaces such as major railway stations.

To underline this point, and to better understand airport terminals as a building type, they may be compared to the contrasting "model of castles" (Phipps 1990: 1). For obvious reasons, organising access to air travel cannot follow the example of defending a castle. To apply this model would be to create a clearly defined closed or controlled area and to impose severe limits both with regard to the temporal dimension (short period of service; limitation of visiting hours) and the social order of access (staff and visitors limited to personal acquaintances). While this may be a standard for good practice with regard to castles, it is inappropriate in the case of airport security management facing:

"[1. v]ery large workforces with high levels of individual responsibility spread over a complex and widespread organisation. 2. An increasingly intimate involvement of the general public within the work places and operational areas of the industry. 3. An increasing spread of highly valuable tangi-

ble and non tangible assets outside protected areas of operation. 4. An increasing dependence on the continuing function of sophisticated electronic systems, equipment and communications in order to be able to operate." (ibid.)

In short, managing access to castles is a matter of buildings. Faced with multiple uses, access control to airport terminals cannot rely on the (passive) quality of a building. Rather than being achieved by design, "access" needs to be (re)conceived of as a capacity. This is where the introduction to airport security management (cf. Phipps 1990) joins the analysis by Joseph et al. (1995). However, similar to castles, and unlike railway stations that have often fused with surrounding urban spaces, access to airport terminals is limited to a few points.

For its methodological limitations, the present study cannot offer microscopic observations on crisis management and the related forms of coordination.[17] Instead, it has taken an organisational structure as given that is inscribed into the basic layout of terminal buildings: the separation of arriving and departing passengers. Contrasting castles and railway stations, airport terminals have to cope with the dynamic evolution of a global technical network. This is why, from an architect's point of view, terminals are regarded as a building type which is particularly short-lived (cf. Moore et al. 2004: 55). On the other hand, a complex building type (airport terminals) is more unlikely to host an all-encompassing control revolution as compared to a simple building type (castle). Therefore, again, did recent responses to security threats affect the basic layout of terminal architecture?

Airport terminals have been equipped with additional security devices prompting the extension of security areas for both passengers and staff. By consequence, terminal spaces have been reorganised and further extended. In the same way, more space was made available for queuing. New control rooms have been set up and existing control rooms have expanded or merged. Despite not being exhaustive, the list of spatial adaptations mentioned so far does not affect the separation between arrivals and departures. Moving backwards from security to check-in, the introduction of biometric identification has an effect on the spatial organisation of terminals. However, biometric identification has not yet replaced check-in desks. Due to the increasing use of biometric identification, check-in halls may be significantly transformed and, therefore, cease to be the icons of terminal buildings (cf. ibid.). But still, even if check-in halls were to disappear, this would not be the end of terminal buildings and their major principle of spatial organisation. Pointing to the arrival of technologies capable of tracking and tracing passengers, one should not conclude that the guiding vision of creating a continuous flow of passengers has already been accomplished (at the expense of previous ways of ordering).

Next to refurbishments and extension related to security innovations, airport terminals have gone through a number of changes. As a result, the building type has differentiated rather than developed towards the single form of a large and integrated terminal. Both the introduction of new (especially larger) aircraft and the increasing diversity of aircraft have imposed changes on terminal architecture. Speeding up this

[17] See Parks (2007) for a little more detail on how new technologies of security have been appropriated by their users. Waiting for more systematic studies, the following questions should be addressed: Has new technology led to higher levels of complacency? Has developing and implementing new technology been accompanied by sufficient efforts to train operators and users? Has the introduction of new technological systems devalued competences relevant to the achievement of security? Has it affected the users' sense of controlling their immediate environment of work? If so, what are the consequences?

sort of trend, airlines have adopted divergent business models that are unlikely to be realised under the roof of a common terminal (cf. Moore et al. 2004). Nevertheless, the shifting and diversifying commercial logic of airport terminals does not entail the end of this building type. Airport terminals continue to provide a stable context for organising departures and arrivals.

6 Conclusion

The current debate on surveillance society is framed by huge questions. After the age of panoptism, what awaits us next? Are we now entering the age of resilience, distributed power and traceability? Or is it that the apparatus is back in and preparing for a more disguised version of panoptical control? Analysing shifts in control and surveillance is a difficult task, even more so if one seeks to distinguish between action and talk, between real and symbolic policy, or between more or less symbolic actions taken to disrupt terrorist travel. In various domains of security, it is evident that policy change is influenced by a logic of "staging" and of "symbolic matching" (Hitzler/Peters 1998). For the purpose of the current paper, however, I have adopted as a methodological guideline not to distinguish between real changes and symbolic actions. In other words, while I cannot claim to have presented an exhaustive review of the recent refinements of airport security, I have not only stopped at the most *visible* changes. On the other hand, I refrained from denouncing security actions for being *nothing but visible* (in the sense of symbolic action). Against a visual bias, I have presented evidence to support the persistence of multiple senses and of practices of control that combine and switch between different senses. Following ordinary passengers throughout the entire journey, I have noted and located changes at both arrivals and departures. This has enabled me to include a range of technical devices and to depict ways in which they relate to each other, thereby providing descriptive breadth.

Faced with the problematic sequence of terminals (difficult to control) and airplanes (easy to control), access control at departures has erected a number of spatial barriers. First and foremost, sections for arrival and departure are strictly separated. Within the departure section, passengers and luggage are separated and processed on different paths. "Separation" turns out as a keyword to describe security at airports: Separating passengers (to carry out individual control), separating passengers and their hand luggage, separating various pieces of hand luggage. The whole process is designed to transform an obscure crowd that may contain problematic connections into identifiable elements (cf. Haggerty/Ericson 2000, 612).

The history of airport security (at departures) seems to be easy to write. The process of controlling passengers and their bags has been organised in a sequence of operations of separations which have been more and more fine-tuned. Separating persons from their belongings and objects from objects, airport security is about producing more traceable objects that can be compared to a list of dangerous persons and objects. A history of airport security had to concentrate on the classification of dangerous persons and objects in order to account for the constitution of the lists and their updates. Finally, a history of airport security would have to integrate various technological devices that have been implemented to support analytical operations of separation and identification. This is where the historical account is unlikely to pursue a linear path. For certain, airport security is no candidate for automation.[18] This is

[18] With the exception of the sub-process of sorting and screening bags which offers a show-case example of the limits of automation (cf. Potthast 2007).

most obvious as all steps of separation are heavily assisted both at check-in desks and at security checkpoints.

If the analysis was restricted to departures, airport security would feature with a record of political incrementalism. Undeniably, there is some path dependency and a process of learning enacted and structured by interactions between terrorists and national and supranational authorities. Fully subscribing to this perspective, one author is keen to emphasize that the 9/11 attacks were only a minor innovation: "The only new aspects were the use of the seized aircraft as weapons and the prior acceptance by the hijackers that they [...] would die" (Wilkins 2007, 43).[19] As mentioned earlier, policy analyses have come to a similar conclusion (cf. Birkland 2004), resonating with a founding text on "resilience" quoted in the introductory section (cf. Douglas/Wildavsky 1982). Once noted in passing (cf. ibid., 192) proverbial knowledge has gained evidence: airports are constantly under construction. Sharply departing from Wildavsky's (1988), however, the present contribution has not taken a polemical stance against some "false sense of security" (ibid.: 82, 90) but explored the multiplicity of senses and sensory equipments.

On the other hand, it would be inaccurate to subsume observations taken at the arrival section under the same headline of incrementalism. In order to account for these changes, one has to present a different story. Most significantly, various technical elements (including video taping, database technology and a software for pattern recognition) have been combined to establish an operation of surveillance next to the opening door of an arriving aircraft. Looking at this particular site, controlling access from technical networks to political territories has been changed by new technical means.

Even though this example should not be considered in isolation, the following conclusion is to be drawn: As regards arrivals, the availability of biometric data has reshaped access control. Linking up with weakly specified local control practices and recombining remote and local operations, it has resulted in a mode of control that is increasingly diffuse in both spatial and institutional terms. To capture its distinctive features, it may be called "biometric guardianship". On the other hand, access control at departures is highly instrumented and spatially confined, allowing for replication and refinement of trials. In this sense, access control at departure gates resembles a "laboratory check". Contrasting the case of arrivals, it follows a pattern of stationary agglomeration and incremental change: new features of control are added to a locally confined process. Provided that the distinction between both modes of control persists, airports are unlikely to host an all-encompassing control revolution.

Airport terminals continue to be a distinct type of building at the encounter of two different spatial logics. On the one hand, they are tied up with

[19] Sketching a short history of terrorism, Wilkins (2007) puts centre stage its "interaction" with airport design and operation, and the resulting effects of learning. Prior to the 9/11 attacks, he accounts for two moments of close interaction, followed respectively by stages of security refinements. A first wave of actions to secure air transport has been triggered by a number of hijackings in the 1970s and early 80s. These actions were based on the assessment that terrorists were ready to die for a political goal. As a response to this threat, special forces were set up and trained to invade planes once landed. Learning from this response, terrorists did not change their target (namely planes) but their strategy. The second wave is marked by the use of explosives and includes the Lockerbie crash in 1986. As a response to this renewed strategy of terrorism, airports changed their process of handling hold baggage. Most significantly, separation and reconciliation of bags and passengers was made mandatory. This response to the second wave of terrorist attacks has once more been followed by a renewal of terrorist strategy, displayed on 9/11.

bounded territories and closed worlds, on the other hand, they are connected to a global network of transport. Both types of spatial orderings appear to be irreducible, leaving articulation work carried out between territories and networks as a promising subject of study. To invest in this line of research is to prepare for a complement to a more conventional type of analysis as practiced by political sociology. Without this complement, the present inquiry would have been guided by a different set of questions: Who were the relevant actors in the field of airport security? How did they manage to impose their actions? How did these actions feed back on the relative power of actors? This analysis would have concluded that the US Homeland Security Department has been a winner while the Department of Transport and international authorities have lost influence (cf. Mariani 2005, 32). Comparative analyses, possibly based on ethnographic fieldwork, offer a potential for reformulating these constellations, making use of categories rarely used but highly familiar to all parties involved.

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