Writ large

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WORKING PAPER SERIES | NO. 5 | DECEMBER 2018

Collaborative Research Center 1187 Media of Cooperation
Sonderforschungsbereich 1187 Medien der Kooperation

Working Paper Series
Collaborative Research Center 1187 Media of Cooperation

Print-ISSN 2567–2509
Online-ISSN 2567–2517
URN urn:nbn:de:hbz:467–13903

Publication of the series is funded by the German Research Foundation (DFG).

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The cover image shows a modification of Figure 1 (right). Editing by Nicolai Johann Schmitt.

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This manuscript was written early 2011 for a Festschrift (in the form of a special issue of the journal Language Sciences) celebrating the work of Professor Roy Harris on the occasion of his 80th birthday, but for various reasons the manuscript could not be finished in time to be included in the special issue.[1] It is made available here as an unfinished manuscript. Comments are welcome.

Writ large

On the logics of the spatial ordering of coordinative artefacts in cooperative work

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Enter a modern workplace, look around and look carefully, and you will notice a profusion of inscriptions of the most modest and unassuming kind. We are not here primarily referring to the mountains of text produced and perused as part of everyday work (such as letters, emails, reports, contracts), which naturally typically are the center of practitioners' attention, but to an assortment of inconspicuous and mundane artifacts, such as fault report forms, folders, binder labels, part routing schemes, *kanban* cards, identification codes, that have been specially designed to facilitate the coordination and integration of cooperative activities. We call this vast and heterogeneous family of specialized artifacts 'coordinative artifacts'.

Though unremarkable, such artifacts play an essential role in enabling workers in modern work settings to get the work done in a reasonably orderly fashion. They provide a manifold latticework of signs by means of which distributed cooperative work activities are coordinated and integrated.

Based on a series of ethnographic and similar studies of cooperative work in different domains of work (manufacturing, software engineering, architectural design, oncology treatment, ICD pacemaker treatment), the paper will attempt to show that we can begin to identify and describe the logics of the practices of designing and using such coordinative artifacts.

Our interest in this phenomenon is not derived from a linguistic research agenda. It is rather derived from our participation in the research area named 'computer-supported cooperative work' (CSCW) that emerged in the late 1980s. Briefly put, the research program of CSCW addresses the variegated and growing family of coordination technologies such as document management systems, workflow management systems and scheduling systems, production planning and control systems, group calendar systems, project management systems, and a multitude of specialized systems. While indispensable to the work settings in which they are used, these technologies also pose enormous problems in as much as their practical integration, their integration in the practical flow of work, is hampered by the simple fact that these technologies have not been designed to be integrated in work practices.

These coordination technologies are carefully devised to address limited and specific issues of coordination, initially often issues of concern to certain work domains. conceptual foundation. As a consequence, they are mutually closed. Architects and engineers using a CAD application, for example, will find that it does not interface with the calendar system, the project management system, and the document or workflow management systems they are likely to also use. Nor can the functionalities of coordination technologies be integrated with other work tools (word processors, desktop publishing applications, process control systems). This limitation is fundamental and cannot be overcome simply by devising a few *ad hoc* 'application program interfaces'. The number of possible combinations grows exponentially with the number of systems to be 'interfaced' and defeats such a strategy.

The limitation is conceptual and is a limitation of current computing technology. Another level of abstraction is required in coordination technology. To put it in technical terms, to overcome this limitation it is necessary to identify a set elemental categories of coordinative practices as well as a set of rules of combination that would enable users to express and coordinate their interdependent activities from within any application.

An analogy may help here. A comparable challenge was addressed in the development of interactive computing in the 1970s and 1980s (Xerox Alto, Xerox, Star, Apple Macintosh). At that time, the required abstractions were achieved by the identification of object categories such as 'character', 'word',

1 The paper draws on our early work (Schmidt and Wagner 2004; Schmidt et al. 2007)

'sentence', etc. and operation categories such as COPY, MOVE, PASTE, DELETE, etc. Likewise, in the development of computer-mediated communication technologies such as electronic mail, similar abstractions were achieved by the identification of primitives such as FROM, TO, SUBJECT, etc. However, these efforts of constructive abstraction did not pose significant conceptual challenges, for the categories had of course already been abstracted and standardized in the course of thousands of years of development of script-based communication (Olson 1994), and they were of course quite familiar to the technologists from their own daily life. Thus, the development of interactive computing and computer-mediated communication technologies could proceed as a process of incremental refinement in the course of which already standardized categories were associated with computational behavior. For CSCW, the situation is quite different.

For CSCW that seeks to support specific coordinative practices in different domains the situation is quite different. While CSCW has to identify a similar set of elemental categories and coordinative techniques, it soon became obvious that this challenge is of a different order. Coordinative practices are fundamentally enmeshed with work practices and thus enormously variegated. The ordering principles governing coordination in one work setting (e. g., an oncology clinic) typically do not apply to another (e. g., an architectural office). The challenge thus—generally stated—consists in identifying the 'logics' of coordinative practices across a wide range of a different work domains: identifying a set of elemental coordinative categories and techniques and their rules of combination that have not been abstracted and standardized as yet in the course of the development of work practices.

Where technologists involved in the development of interactive computing and computer-mediated communication technologies could rely on their own quotidian practices, the CSCW research program requires systematic 'ethnographic' studies of professional coordinative practices in multiple domains of work (as well as experimental design and systematic evaluation, etc.), and since the late 1980s, research in CSCW has been driven forward by such studies. And while attention initially focused on studies of practices of coordination among co-located actors based on their heeding one another's 'bodily conduct', the crucial role of coordinative artifacts in highly distributed work in complex organizations has increasingly become a focal issue. Our work contributes to this line of research.

In this research effort, received linguistic theories of writing have been of little use, with few exceptions. While the surrogationalist dogma that 'written words are symbols of words spoken' (Aristotle) has been challenged (most notably by Roy Harris, 1986, 1995, 2000) and may have lost its respectability (cf., e. g., Coulmas 2003), it is still generally taken for granted that writing is identical to 'glottic writing', to use the term suggested by Harris. Florian Coulmas, for instance, agrees with Harris that writing cannot be reduced to speech but still cannot accept the consequences: 'unlike Harris I reserve the term "writing" to what he calls "glottic writing"' (2003, p. 17). This is particularly remarkable considering that Coulmas, in restricting 'writing' to 'glottic writing', knowingly excludes 'non-glottic systems such as musical and mathematical notations' (p. 15). What Coulmas also excludes from 'writing', perhaps unwittingly but certainly without arguments, are spatially arranged textual configurations such as lists (especially nested lists, etc.), tables, charts. That is, Coulmas excludes such phenomena as the table of contents, the footnotes, and the index of subjects in an ordinary book from being considered as writing. In other words, what in this way is excluded from 'writing' are large parts of such sophisticated script-based practices as composing music, mathematics, genealogy, accounting and bookkeeping, cataloging, inventory management, archiving, and computer programming.

Conflating writing with glottic writing goes hand in hand with another dogma, namely, that the function of writing essentially is that of retention, namely, the retention of speech in some durable form. While the mnemonic function is certainly important, the credence that this conception commands is predicated on the privileged status that certain select uses of inscriptions have been granted. After all, it would normally be considered quite odd if someone was to claim that the role of his marriage license was to remind the married partners of the name and identity of one another.

The uses of inscriptions are enormously variegated and cannot be reduced to any one function, not even that of serving as durable vehicles of linguistic communication. Inscribed artifacts can be arranged in all sorts of ways: a set of inscribed artifacts may be spread out next to each other on a desk or a floor for purposes of comparison, composing, editing, or they may be the object of attention for a group of workers (authors, musicians, architects, engineers) discussing issues by pointing to features of the inscriptions, by rearranging the inscribed artifacts, and so on.

This becomes strikingly clear as soon as one ventures beyond the samples and situations normally considered by linguists in their studies of writing: snippets of glottic writing, typically prose, inspected in isolation from the practical circumstances from which they have been extracted. To do so, one has to leave the confines of the office and venture into the field and investigates the practices in which inscriptions are actually being used.

At any rate, while a strict focus on the mnemonic function of writing may be of importance to linguistic

Fig. 1: 'Open-ended' spatial arrangements of inscriptions. Heart clinic: ICD patient folder with medical record (left) and folders with defibrillator data (right).

research programs, that focus would prevent us from understanding much about what makes coordinative artifacts effective. However, Roy Harris has suggested productive approach when he argues that 'the underlying formal substratum of writing is not visual but spatial' (Harris 1995, p. 45). For what we see when entering a modern workplace is not only an overwhelming abundance of inscribed artifacts in general and of coordinative artifacts in particular but also a variety of practices that are characterized by spatial arrangements of signs and discrete inscriptions. We of course see what is ordinarily understood by 'writing': signs that are fixed unto a surface in some spatial arrangement; not only prose text, the prototype of writing in linguistics, but also and especially lists, tables, charts. But we also, and especially, observe 'forms', that is, tables and charts in which cells or fields initially are left open, to be filled-in incrementally by different actors. Here the spatial arrangement is fixed and precedes the text to be added. These practices typically, in different ways, exploit that inscriptions and their spatial order can be made relatively permanent, in order to retain the record of an action or to stipulate an action to be taken. On the other hand, other coordinative artifacts are deliberately devised *not* to provide a permanent fixation of the spatial arrangement of inscriptions. In bulletin boards with work schedules, for example, discrete inscriptions are concatenated in *ad hoc* ways, fixed only by magnets or pins so that individual inscriptions can be rearranged or replaced incrementally. By contrast, folders and binders, which are also temporary arrangements of discrete texts that are open to additions and rearrangements, have the additional affordance of being potentially mobile. The medical doctor, for instance, can simply take the patient folder and bring it when making her round. More than that—and most importantly, perhaps—the spatial distribution of coordinative artifacts across the work setting is often used as a means of maintaining temporal order in the cooperative effort. Coordinative artifacts such as *kanban* cards, fault report forms, part process schemes, patient folders, etc. typically migrate and the location of a particular artifact with respect to other features of the setting such as other artifacts, work stations, offices, etc. and their arrival at a certain location at a certain time are then routinely taken to mean that a certain worker or team (located at that position) is now obliged or permitted to undertake certain action.

These practices go well beyond what linguistics will consider as writing, but they are anyway and most certainly literate practices and they are literate practices that are massively present. Without them our economy would grind to a halt instantly.

1. Spatial arrangements of inscriptions on surfaces

Harris' observation, that the 'underlying formal substratum of writing is […] spatial', first of all gives us a handle to begin to understand the subtle ways in which coordinative artifacts such as forms etc. are spatially formatted: the spatial arrangement of signs on the surface of the artifact (text fragments, boxed fields, etc.). A few examples will illustrate this.

Let us consider a couple of coordinative artifacts as one finds them in an architectural office.

In a modern architectural office, the central representational artifact is the system of CAD plans. They incorporate, as an ensemble, a project's trajectory from draft to implementation; they absorb and reflect all decisions taken and changes made, as plans are gradually detailed and modified. Typically, the CAD model of a large building is divided into 15–20 sections. Altogether about 30 plans, including 11–12 floor plans, have to be drafted and coordinated. Each plan in turn is decomposed into a large number of

layers, often more than 100, each devoted to the representation of one specific feature or set of features of the building (one for brickwork, one for concrete structures, one for windows, one for ventilation systems, etc.). All plans are stored on the central server, using a structured file system with different subdirectories for each project period and with predefined file-naming conventions. Print-outs of the CAD plan in A3 format are used for discussing design details and working out design changes. This is either done directly on the plan copy or on a blank transparent sheet of tracing paper that is placed over the printed plan and 'anchored' by positional markers. The tracing paper is then used for experimenting with design ideas. As planning progresses, more and more details have to be specified and filled in. A large building contains hundreds of details, which can either be left open, to be decided upon later by the construction company or craftspeople, or they can be carefully designed up front.

In doing their work, architects interact in a highly distributed manner, by changing the state of discrete items in vast heterogeneous and physically dis tributed collections: sketches, models, plans, drawings, calculations, specifications, etc. In the course of an architectural project many thousands of plans and drawings are produced, often in multiple versions, and are often submitted for comments and contributions to external stakeholders, such as local authorities and technical specialists, as well as to clients and prospective users. What is most striking is that the architects man age to interact in this highly distributed and mediated manner without succumbing to disorder and utter chaos. This is accomplished by means of a large variety of mundane coordinative practices and concomitant coordinative artifacts that are not simple at all. One of these is the so-called 'title block'.

The 'title block' (Fig. 2) is a template that gets 'stamped' onto each architectural plan at the bottom. (It used to be an impressed form, applied by means of a stamp and then filled in by hand, but is now integrated into one of the first layers of a CAD plan). This

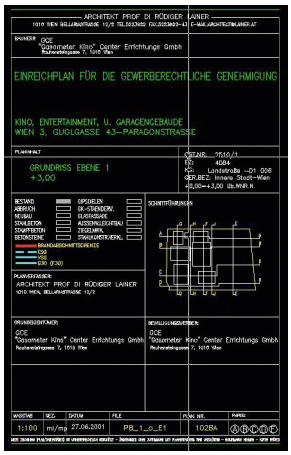

Fig. 2: The title block.

simple artifact illustrates a feature that we find in all coordinative artifacts: a *standardized format* (Harper et al. 1989, pp. 15 f.). The title block is, graphically, a chart, in this case a bounded space divided into fields of different sizes. Each field is dedicated to display a specific category of information. As noted by Harris: 'The chart relies on having the space divided up in some predetermined way, so that what a graphic form signifies depends wholly or partly on the particular division it occupies within that space' (Harris 1995, p. 123).

The spatial arrangement of graphical items in the 'title block' does not reflect a systematic grammar, nor does the 'title block' presume a particular reading path. Read from top to bottom it rather loosely reflects a certain order of priority (in conjunction with font sizes, styles, and colors): the name and address of the office, the name and objective of the project, the type of plan, the cross section represented in the plan, the name of the client, the authority concerned, and at the very bottom a set of identification codes.

The 'title block' can be seen as an example of what semioticians have dubbed the 'meaning compression principle', that is, 'a principle of economy whereby patterned multimodal combinations of visual and verbal resources on the small, highly compressed scale [...] provide semiotic models of the larger, more complex realities that individuals have to engage with' (Baldry and Thibault 2006, p. 19). The terminology is dodgy, however.

First of all, it is not 'meaning' that is being compressed here (whatever that might mean). Rather, a motley of graphical elements (text, codes, color notation) that relate to various aspects of a distributed practice (identity of stakeholders, organizational matters, notations used,) are concatenated in close proximity so that they, in conjunction, provide the competent reader with requisite information about the plan's identity, its origin and purpose, and its status, as well as keys to decipherment. Nevertheless, the observation that an artifact may conjoin inscriptions of various kinds that in a specific practical context are used to represent a host of otherwise disjoint factors, is an acute one and we see this kind of 'compression' by means of graphical proximity in many shapes and forms in coordinative artifacts. A prominent example of such compression is the 'flight progress strip' that plays a crucial role in the domain of artifact traffic control. This artifact has been the object of a series of incisive studies in CSCW (e. g., Harper et al. 1989; Berndtsson and Normark 1999).

We also have reservations with the use of the term 'model' in this context: we see no rules of projection or transformation. More importantly, the different graphical elements are routinely used in a variety of ways that cannot be simply reduced to that of 'a model of [...] realities' or any other singly specifiable relationship. In the case of the title block elements

stand (or are taken to stand) in relationships as different as that of naming, identifying, prescribing, encoding, and so on.

The 'title block' is part of *practices of identification and validation*. Each item in a collection of items has to be named or otherwise identified so that a potential user will know 'what' and 'which' it is. This may involve a more or less elaborate convention for naming items, from the usual way of doing it to a nomenclature, to a 'system of designation' involving a 'superimposed scheme' (Harris 1986). In our case, the architects' practices of naming plans are based on a systematic system of designation, namely the 'plan identification code' found at the bottom. Here, in the title block, the 'plan identification code' has two parts, the file name ('PB_1_0_E1') and the 'plan number' ('102BA'). Moreover, the type of plan at hand is specified, in this case a 'application for trade license, floor-plan, level 1'.

The title block also reflects a variety of *validation procedures*. It contains a date as well as information about the author (e. g., the architect), the client, the owner of the plot, the object (name, address), the authority to which the plan is to be submitted, and the legal authority to be addressed in case of a complaint.

1.1. Tables

As noted above, the elements of the 'title block' are not arranged in any systematic way and no particular order is presumed and imposed. This feature is quite common. As pointed out by Pierre Bourdieu (1980), there is a strict 'economic logic' to practice: no more logic (consistency, rigor, etc.) is required than to get the job done with an acceptable level of effort and uncertainty. However, in many practical contexts it is of overriding concern to ensure a systematic order in work activities and to achieve this some very sophisticated coordinative practices and concomitant artifacts have been developed.

For example, in a vast family of coordinative artifacts we find that a grid structure of the 2D space of the artifact, often in the form of a table or matrix, is used to express and impose a strict relationship between tasks, roles, time, tools, documents, etc. The position of individual inscriptions relative to the grid of the table assigns meaning to the inscriptions.

We find this exploited in the simple staffing plan from a power cable plant (shown in Fig. 3). Here the columns indicate the different shifts while rows indicate work stations (by number). The assigning of a worker to a particular workstation (e. g., '32255') on a particular shift (e. g., 'Shift 1') is indicated by the inscription of the worker's name in the cell in question. In this case the inscription is made by placing the magnetic tag with the worker's name attached in the appropriate cell.

Fig. 3: Power cable factory: Staffing plan on bulletin board with fixed row and column headings and (magnetic) inscription elements.

The non-permanent nature of the inscription is noteworthy. While column and row headings as well as the grid lines have been inscribed with permanent ink, the tags are movable and can be reused, from one shift plan to the next, in such a way that the shift coordinator only has to move tags affected by staffing changes. The work organization of the cable manufacturing plant was based on advanced 'delegation of responsibility and competence' in terms of planning and coordination to shop floor workers organized in 'autonomous working groups'. Among the tasks delegated to the groups was the task of staffing shifts and workstations. The design of the staffing plan board supported this task quite well: the worker acting as coordinator for a given group could express his proposed plan by placing name tags in the matrix in a manner that was publicly visible and amenable to modifications. It was straightforward to modify the plan, and, in principle, any of the involved workers could make changes that would then be publicly visible. The durability of inscriptions in coordinative artifacts is not a defining feature but a requirement that sometimes is non-essential or even unwanted.

The staffing plan is a *chart*: 'A system which makes semiological use of absolute locations in a given graphic space'. In the application of a *script*, the 'forming and processing activities involved in dealing with letters, numerals, syllabaries, etc. […] are based on the recognition and relative sequencing of the members of an inventory of characters, differentiated not by their absolute locations in a given graphic space but by their form'. Filling in or reading the chart is a quite different technique: 'Filling in the grid correctly requires the exercise of spatial skills and associated mapping procedures which are not demanded at all in setting down a string of characters' (Harris 1995, p. 93). However, the staffing plan is somewhat different than a simple chart: the inscriptions in the indi-

vidual cells are not merely identical marks or tokens (") but name tags. That is, the staffing plan employs what Harris calls 'a mixed system' similar to modern musical notation: 'mixed systems which employ features of both script and chart, but in such a way as to separate out different kinds of information in the message' (*ibid.*, p. 94).

Let us briefly look at the syntax implicit in the format of this artifact. The location of a particular name tag in the array can be 'read' as follows:

> {person_name} is assigned to {workstation_no.} in time period {shift_no.}

This might of course just also be expressed in the form of an ordinary prose command: 'Hansen is assigned to workstation #32255 on the 1st shift the coming week; Petersen is assigned to workstation #32256 on the 1st shift the coming week', and so on. However, the table format has some obvious advantages over glottic writing. Firstly, it does not impose a particular reading order. The staffing plan can be read by row ('who'll be operating workstation #32255 next week?') or by column ('has the 3rd shift been fully staffed?', 'who's on the 2nd shift this week?'). That is, the play is immediately surveyable from the point of view of practitioners in different work contexts.

Secondly, the two axes are lists, i. e., discrete items in a certain order; this allows for the superimposition of a formal order such as a hierarchical grouping. The list of workstations on the vertical axis, for example, is a nested list, expressing the conventional categorization of workstations in the plant.

Thirdly, the tabular format makes it immediately visible if a cell has been filled in (or left blank) and thus if anybody has (or has not) been assigned to a workstation on a particular shift.

Jack Goody's observations on the affordances of lists and tables are relevant here:

> 'The list relies on discontinuity rather than continuity; it depends on physical placement, on location; it can be read in different directions, both sideways and downwards, up and down, as well as left and right; it has a clear-cut beginning and a precise end, that is, a boundary, an edge, like a piece of cloth. Most importantly it encourages the ordering of the items, by number, by initial sound, by category, etc. And the existence of boundaries, external and internal, brings greater visibility to categories, at the same time as making them more abstract.' (Goody 1977, p. 81)

Similarly, 'the formalized graphic arrangements in matrices' provide precise spatial locations for items:

> 'they not only extract, codify and summarize a great deal of information otherwise embedded in the flux of experience, but they also make it possible to manipulate, reorganize and reformulate this information in a manner that is virtually inconceivable in the purely oral context.' (Goody 1987, p. 276)

More specifically, the formalized graphic arrangement in the matrix highlights omissions and inconsistencies: 'The table abhors a vacuum' in the sense that 'anyone composing a matrix is almost forced to fill all the gaps, to leave no "empty box"' (Goody 1987, p. 275 f.). As a result, by virtue of their specific graphic format, matrixes can be instrumental in expressing and imposing a strict organizational order.

Spatial arrangements of discontinuous inscriptions such as matrixes (but also diagrams of hierarchies, flow diagrams, etc.) also conjoin graphically, in what Antoine Augustin Cournot aptly calls a 'synoptic' format, what is otherwise spatially and temporally disjoint and distributed, thus suspending and canceling time and space:

> 'We try to correct [the imperfections inherent in discourse] by constructing synoptic tables, trees, and historical atlases: types of tables of double entry, in the outlining of which we are more or less successful in representing two dimensions of an extended surface, so as to indicate systematically relations which are difficult to disentangle within the concatenation of discourse.' (Cournot 1851, § 243, p. 357)

1.2. The open table

The affordance of the 'synoptic diagram' to make us 'apprehend simultaneously and in a single glance' 'meanings that are produced and used polythetically' may be employed as a means to impose order on local activities. A recurrent feature of coordinative artifacts is the use of tables that are successively filled in by several actors, in step with the progress of the work process in question. To members this not only serves as a record of events (retention) but also as stipulations of what to do now.

The production order and report form (Fig. 4) is a simple example of this. One such artifact is created

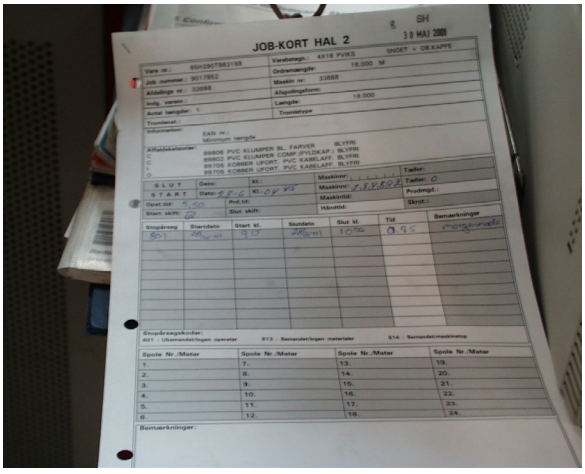

Fig. 4: Power cable factory: Production order and report form to be filled in as the work is performed.

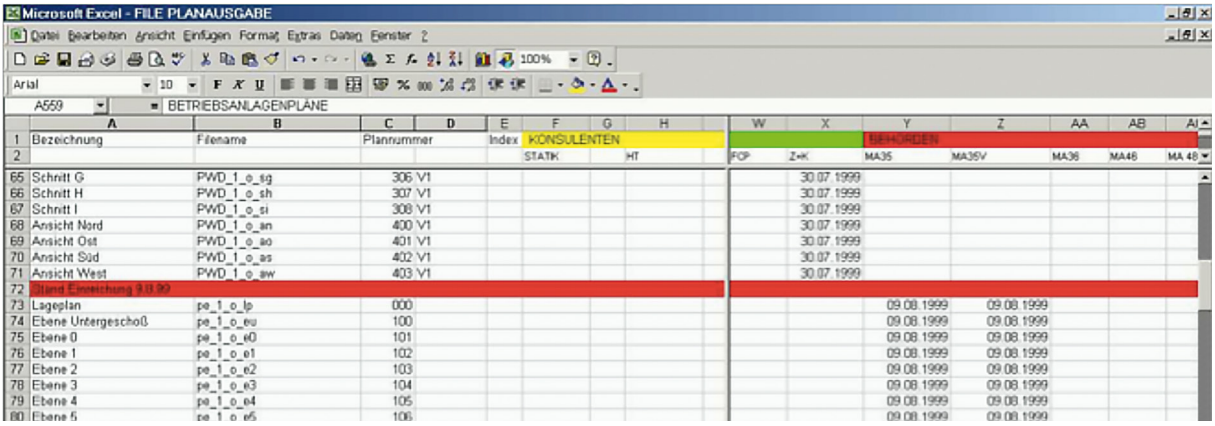

Fig. 5: The plan circulation list (fragment).

(by the planning system) for each production job, specifying product ID code and name, work station, and amount of cable (in meters). The grey fields are left open, to be filled in by the operator: date and time of start and finish, and time and duration of possible stoppages and their causes. These inscriptions are made by hand. The coordinative scope of this artifact is rather limited: it is a simple written command that merely stipulates what is to be done and the table structure is used to ensures that the job report provides required information about stoppages and is in a format that is reasonably surveyable.

The 'plan circulation list', which we find in the architectural office, on the other hand, illustrates that such techniques can be quite powerful for coordinative purposes (Fig. 5). As already mentioned, architects engage in exchanges of plans and calculations with external stakeholders. For example, layers of the CAD plan, e. g., layers pertaining to the heating- and ventilation system of the planned building, are extracted and sent to relevant stakeholders, *in casu* heating engineers, for their contribution or comment. since the number of plans and plan layers and versions thereof runs into the thousands and since these transactions typically are subject to a strict temporal regime of time limits, architects are concerned with managing these transaction. Hence the 'plan circulation list': it is used for keeping track of plans as they traverse the network of consultants, local authorities, and of course the client.

The 'list', which is graphically a matrix, itemizes vertically all CAD plans with their identification code (type_of_plan/file_name/plan number/), and horizontally it records data about who received and returned which plan at which date. Color is used for distinguishing different categories of external actors. The matrix, a computer-based artifact (Excel spreadsheet), is not printed out but checked online and resides on a central server, accessible via computers from different work stations in the office.

Let us now turn to the uses of coordinative artifacts in three oncology clinics in which we carried out extensive fieldwork (Schmidt et al. 2007; Tolar 2008).

The work performed at these clinics, as is typical of oncology clinics, roughly consist in the administering of chemotherapy, in multiple cycles, and the taking of blood tests for the purpose of monitoring the state of the patient. Oncology work in these clinics can be conceived of as the delivery of care at three levels of intervention, represented by the outpatient clinic, the day clinic, and the ward.

Patients will visit the outpatient clinic for clinical examinations before, during and after treatment. That is, they will visit the clinic for the purposes of planning and monitoring therapy (or if they have acute problems). Patients are referred to the outpatient clinic by general practitioners or specialists, with a more or less specific question. A diagnosis has already been formulated and patients will now seek advice as regards therapy; or equivocal laboratory results make doctors suspect an oncology or hematology problem and the doctor will then send the patient to the clinic for clarification. Some patients are referred from other hospitals, e. g., after breast surgery, with the question as to whether they need after-treatment or, in case they are metastasized, what kind of treatment they need. At the outpatient clinic, decisions are furthermore taken as to how to further proceed with a patient and if s/he is sent to other departments or further examinations. In the course of this, all kinds of clinical examinations are performed, from auscultation to physical examination and biopsies. Blood samples are routinely taken and sent to the laboratory for analysis.

The day clinic and the wards, by contrast, are where the treatments are actually delivered. Patients are admitted to the day clinic for chemotherapy and other infusion therapies that last a few hours; and for some treatments that may last for a couple of days they will be hospitalized in one of the wards.

Oncology work involves massive paperwork. As suggested above, cancer treatment typically requires lengthy therapy, delivered in multiple cycles, accompanied by regular check-ups before, during, and after therapy. All these interactions need to be carefully documented so that they can be reproduced at later stages. Furthermore, oncology work is safety-critical work. Patients are given aggressive chemicals with taxing and possibly damaging side-effects. All clinical measures taken thus have to be carefully recorded. On top of that, although the clinics under study are specialized units devoted to chemotherapy and associated clinical interventions, oncology is highly interdisciplinary. As also noted above, the clinics need to cooperate with other clinical specialties, such as departments of surgery, urology, and gynecology; with radiology, nuclear medicine, and the laboratory; as well as with the pharmacy and radiotherapy. In short, the clinics are embedded in a network of institutions and have to maintain relationships with them, and keeping track of and recording the various requests and results that are exchanged is a crucial issue. And finally, the oncology clinics under study have a considerable and increasing throughput of patients. In ONC1, for example, one of the clinics included in this study, there are 4.500 to 5.000 admissions to the wards per year, plus 5.500 to 6.000 patients in the day clinic, and about 10.000 visits to the outpatient clinic. The sheer volume of care being delivered of course only exacerbates the load of documentation work. As a result, the documentation work of the clinics is arduous work.

In ONC1, a 'therapy sheet' (Fig. 6 left) was developed by the head nurse at the outpatient and day clinic to facilitate work:

> "For chemotherapies there have always been special forms. For all other therapies like for example bisphosphonate or blood bottles there were none. We had a documentation in the patient folder. The problem was that the doctor who gave the therapy to the patient could not see who gave the order. As in the day clinic we often have 40 or 45 admissions and to prepare therapies with 40 or 45 patient folders was difficult, almost impossible. For this reasonthe therapy sheet was developed. From this sheet you can see what the patient has received continuously. You can take it with you to the patient. And the actual order becomes traceable" (INT1.8, p. 5).

In order to ensure that it can be identified, in this case connected to a particular patient, the therapy sheet, as all other artifacts in the clinic, carries a unique identity code in the form of the 'patient label' (Fig. 6, right). The label is a laser-printed adhesive label produced by the clinic's patient-administrative information system and combines a barcode with information about the patient: name, sex, social security number, name of hospital unit, insurance company code, admission number, data registry number.

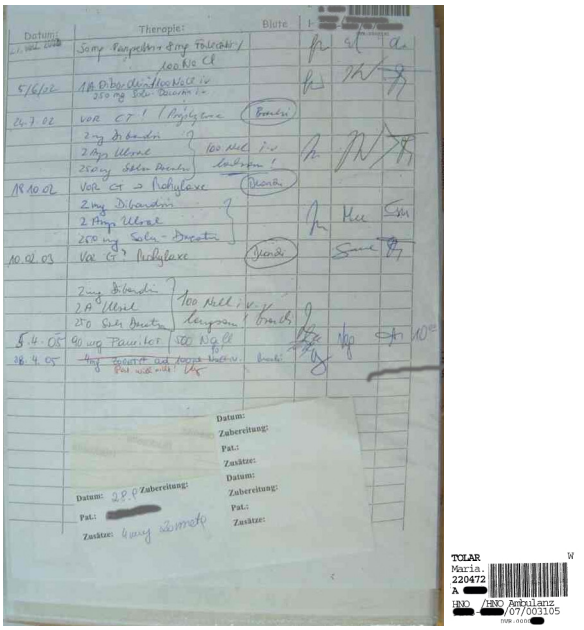

Fig. 6: Therapy sheet (left); patient ID label (right).

The graphical format of the sheet is that of a matrix (using a spreadsheet as a template). In the left column the date is entered, then the therapy and the blood tests to be administered. In the remaining columns there is room for the signatures of the doctor who orders the therapy, the nurse who prepares it, and the intern who administers it to the patient. The reason for this personal form of validation of the entry is straightforward: the ethical and legal issues involved in administering toxic substances to patients.

The form is filled-in by hand. Colored ink is used for particular interventions (e. g., chemotherapies are indicated in red). The sticker at the bottom indicates the next chemotherapy with some specifications (date, additional substances). We can say that the 'therapy sheet' supports a variety of central coordinative practices: identification ('what' is documented about 'whom'), validation ('who' has ordered, performed, validated particular actions), and temporal ordering ('what' has been administered, 'when', in which sequence).

1.3. The 'ward chart'

Let us now move from the day clinic to the ward. At the oncology ward the key artifact is the 'ward chart', a large sheet of paper (about 3 times A4, folded twice to A4 format). The basic format of the 'ward chart' is a chart or rather a collection of multiple charts, with space for additional information (Fig. 7, left). On top of the 'ward chart' (just below the patient ID) is space for the diagnosis and main observations.

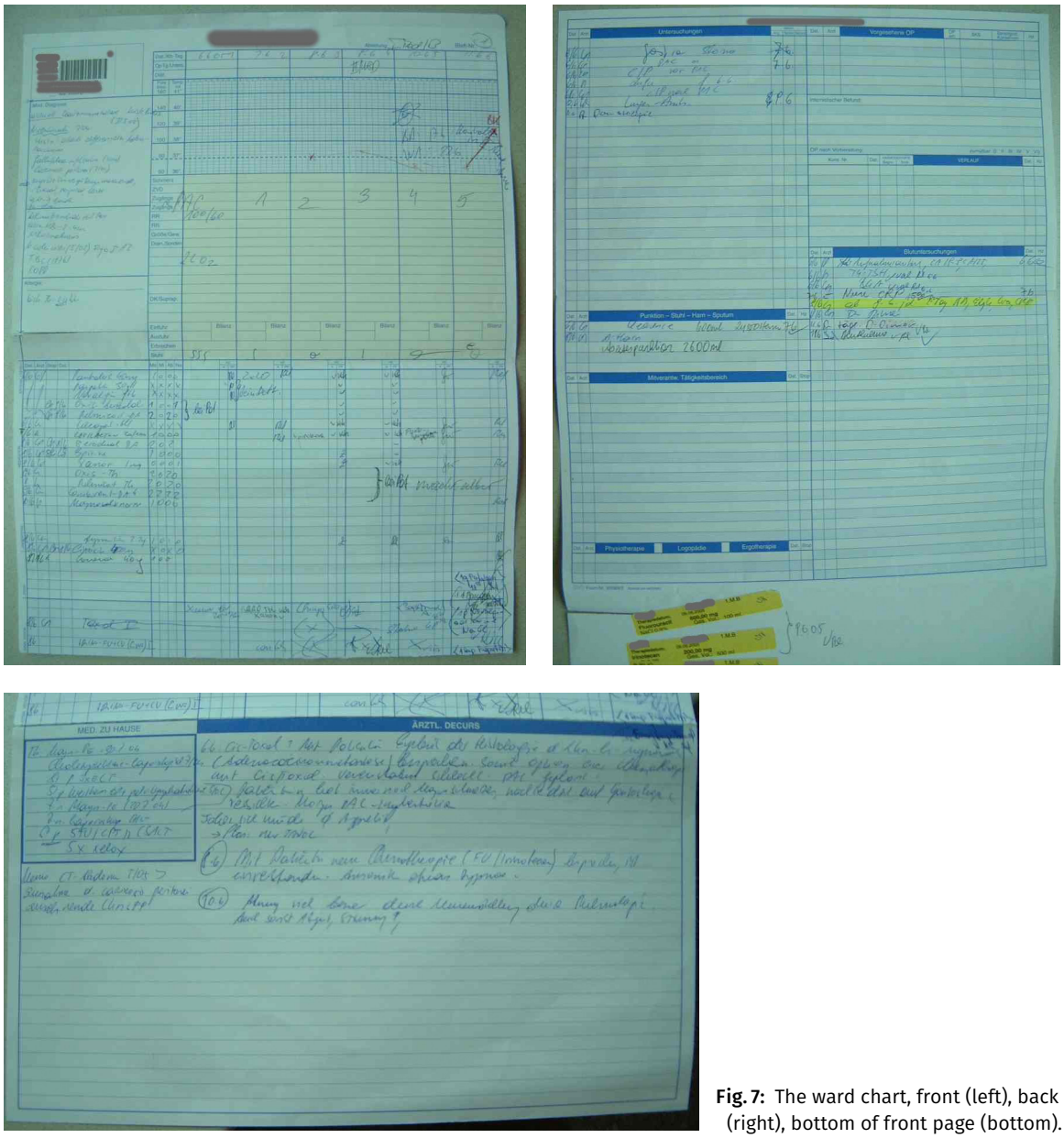

Fig. 7: The ward chart, front (left), back (right), bottom of front page (bottom).

During the stay of the patient at the ward, it is kept with all the other documents that together make up the medical record in one of the two trolleys that are used for the ward rounds. The ward chart describes the *'daily course'* of actions and the condition of the patient at a high level of detail. That is, each time they see a patient at the ward round or in between, doctors use the 'ward chart' to document their observations and note orders of medication, therapies, examinations, and nursing interventions. Also the care personnel make their daily entries in the ward chart: temperature, blood pressure, and excretion.

One nurse explains how she 'reads' the chart. She starts with the front page, which contains one column per day. The most basic information is in the upper half of the front page. At the top is the temperature curve. In this particular example we see a rise in temperature, which is signaled by a thick red line (in the upper right of Fig. 7, left), which in this particular case resulted in an extended stay of the patient. We can also see various annotations around the red line. The figures 1 to 5 in the section below denote the number of days the 'port-a-cath' (a small device under the skin to give chemotherapy and take blood) has been installed. This is important, as the needle has to be changed after 10 days. She finds the medication for the patient on the front side in the left column for different kinds of application (enteral / oral, parenteral, perfusion), including the daily dosage. There is a note if blood pressure and weight have to be measured daily. These entries are completed by progress notes in a section ‚below', i. e.

at the end of the front page with lines for free text (Fig. 7, bottom). The progress notes give explanations for decisions so that they are comprehensible for doctors who later on try to reconstruct the medical history of a patient.

The nurse then looks for examinations and punctures. They are noted on the backside of the chart (Fig. 7, right), with sections for blood tests, other examinations (diagnostic imaging like x-rays or computer tomography), etc. The doctor who gave the order notes the date of the order and signs it. Ointments and the like are to be found under what is called 'jointly responsible area of activity' where all the actions are noted that have to be done by care personnel in their own responsibility. In a column on the right of the back page the blood tests to be ordered are listed. Results from examinations are usually not entered in the ward chart but added as printouts to the medical record. But sometimes they are also noted in the progress notes section or written down as an additional diagnosis; or, as is the case in ONC3, results from the laboratory are provided on labels that are stuck onto the chart. Also on the back page of the chart in the free area at the bottom there is room for sticking the yellow barcoded labels from chemotherapies or other drugs.

When looking at this very particular organization of graphic space we can identify elements usually highlighted by semioticians: 'framing' (the use of various visual devices to connect or separate different elements on the page), 'salience' (assigning visual 'weight' to elements on the page) and 'information value' (the meaningful positioning of content) (Kress and van Leeuwen 2006). The problem with this kind of analysis, however, is that it is implicitly taken for granted that the meaning of an inscription is somehow intrinsic to the inscription, as opposed to inherent in the practice to which the inscription belongs and in which it is routinely used. This becomes a critical issue because the 'ward chart', as well as the other coordinative artifacts we analyze here, is an integral part of a sophisticated professional practice—not a front page of a newspaper or an advertisement and similar inscriptions that are so familiar to the reader of semiotics textbooks that author and reader alike can presume that the meaning is somehow intrinsic. The design of coordinative artifacts reflects complex coordinative practices of heterogeneous sets of professionals who have adopted templates that can be found in any hospital setting or architectural office and adapted them to support their specific needs. The reading path of professionals through these documents depends on their particular organizational role, their preferred conceptualizations and reasoning strategies, the particular urgencies of the situation at hand, etc.

The graphic space of the 'ward chart', which may look messy to an outsider, is organized around professional roles, responsibilities on the one hand, around specific medical and nursing practices and standards on the other hand. Due to the complexity of practices and the richness of relevant data, the use of the graphic space reflects a compromise between affording an easy overview and providing as much information as possible in one artifact.

The 'ward chart' combines the loose 'compression' principle of the title block with the rigorous order of the matrix. That is, it obtains compression of temporally distributed observations, events, decisions, and interventions by means of a loose concatenation of charts (forms, diagrams) on three consecutive surfaces that, like the 'title block', does not presume or impose a certain reading path.

2. Spatial arrangements of coordinative artifacts: Beyond the inscribed surface

Spatial communication by means of inscriptions, that is, fixed concatenations of signs attached to a surface in some (more or less) permanent manner (ink on paper, magnetic tags, digital arrays, etc.) affords transmission of not only signs but their spatial arrangement. In the case of prose texts, the spatial concatenation—apart from the linear order of signs, of course—may be of only marginal concern, but with other kinds of inscriptions the spatial order may be of primary concern. For instance, as we have shown, with open-ended charts (forms), the content is added over time while the graphic arrangement remains fixed from the outset (the grid). Indeed, with matrixes on surfaces such as whiteboards, the structure may be fixed while the content may vary. What we have in such instances may be seen as a two-dimensional positional syntax: the position of the individual inscription relative to the two axes of the chart (matrix) determining the meaning of the individual inscriptions.

For many purposes, however, a fixed spatial concatenation of inscriptions may not be beneficial, for instance where the relationship between individual inscriptions is variable. In fact, a ubiquitous phenomenon in modern work settings is that work relies upon often vast arrays of mutually complementary documents. That is, to perform a given task, workers typically have to identify and assemble a range of documents.

The work of architects, for instance, depends on multiple CAD plans that in turn are subdivided into a large number of 'discrete layers', as well as detail drawings, component drawings, etc. (Schmidt and Wagner 2004). Similarly in health care work. In giving care to a patient, clinicians have to align a large number of documents concerning the past and current state of the patient: doctors' notes, test results, medication plans, etc. Geraldine Fitzpatrick refers

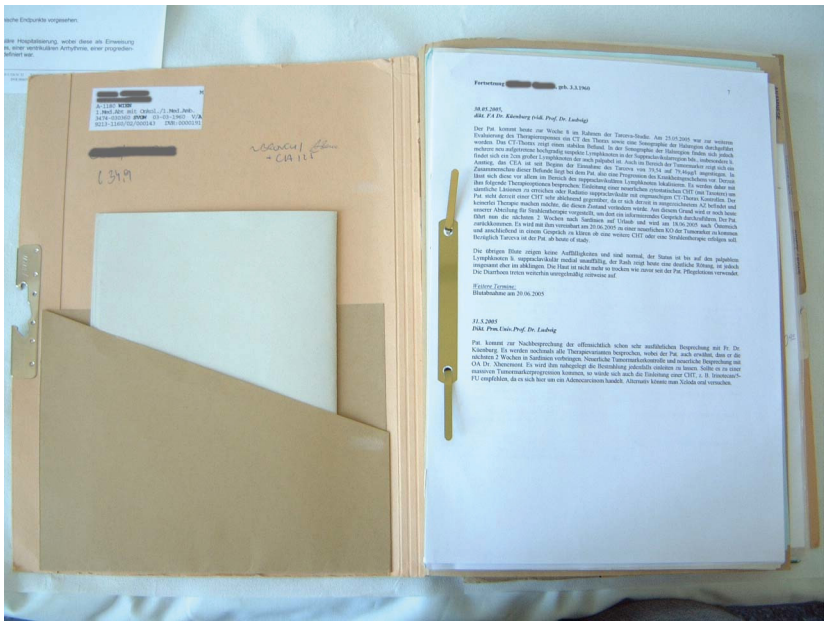

Fig. 8: Medical record, patient folder (ONC1): Open-ended arrangement of inscribed artifacts.

to the complementarity of distributed clinical documents as the 'working record' (2004) while Jakob Bardram and Claus Bossen use the term 'a web of coordinative artifacts' (2005).

The work of maintaining order in these vast, distributed collections and of identifying and assembling pertinent documents is facilitated in a variety of ways. One will, of course, find simple cross references, pointers, or 'links' in documents to other documents (indicated by highlighted graphical elements, titles of related documents, and so on). While highly economical on a small scale, such techniques do not scale up to handle a large number of interdependent documents, nor do they provide an economical method for ensuring that all relevant documents have in fact been identified and assembled.

As alternatives to *ad hoc* pointers, a host of more systematic techniques are used, such as the use of ID-codes that identify documents relating to a particular case: in the clinical work, the individual patient's ID-code (citizen code, social security number, etc.) is often sufficient, but with patients with chronic diseases, especially when patients suffer from multiple diseases (diabetes and heart failure, say), the distributed collection of documents often needs to be subdivided according to medical specialisms, which then needs to be reflected in the way individual documents are identified (for instance by using the name of the clinic to supplement the patient's ID-code). In architectural work, as in engineering, the techniques of systematic identification of documents are advanced and sophisticated. As noted above, in architectural offices we find designation systems based on (superimposed) classification schemes (expressing the division of labor in the office, the structure of the building, the formal stage structure of projects, the conventional structure of CAD plans, etc.).

Somewhere in between these techniques, between *ad hoc* pointers and global schemes, we find a family of techniques that all involved some kind of container to assemble what pertains to a particular case: folders and binders. The medical record is a case in point.

The medical record represents a special kind of spatial concatenation of signs. The individual document is an ordinary inscribed artifact, fixed inscriptions in fixed arrangements on a surface. All reports generated as a result of the patient's visits are collected in the patient folder. It may be doctors notes and discharge letters (in ordinary prose) as well as laboratory results (often charts with texts and diagrams) and records of administered treatment (often forms filled in by hand). In so far, the folder can be seen to adhere to the compression principle: it collects in some loose order a motley of discrete items that represent what would otherwise be distributed in space and time. However, in contrast to the 'title block' the spatial concatenation of items is not fixed. Individual artifacts may be added and replaced, they may be removed permanently or temporarily, and they may be rearranged. The arrangement is open-ended. On the other hand, what distinguishes this assembly of artifacts from the stack of papers on a desk is that the artifacts are assembled in a folder and, hence, that they, as an organized collection, can be treated as a unitary coordinative artifact.

The order in which the individual artifacts are placed in the folder may vary. Typically, in medical records, the order is inverse chronological, with the most recent on the top, in accordance with the reasonable search heuristic that the most recent is probably the most relevant. However, folder contents is typically subdivided by means of sheets with inscribed tags such as, in the case of ONC1, 'Anamnesis', 'Day clinic', 'Consultation', etc.. Within each subsec-

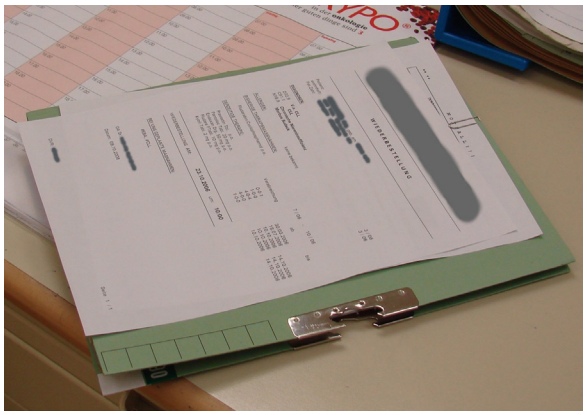

Fig. 9: ONC3: Patient folder with appointment sheet attached to the front.

Fig. 10: ONC1: Archive of patient folders.

tion, the order is again inverse chronological. Often patient folders are equipped with pockets for items to which readers need access irrespective of the time of production and inclusion ('ram access' in computer science jargon). The surface of the folder will of course also carry a conspicuous inscription identifying the patient in question. In ONC1 the ID-label of the patient is attached to the folder, whereas in ONC3 the patient's appointment sheet is attached to the outside of the folder (Fig. 9), as a way to uniquely identify the patient as well as to summarize the state of affairs.

Since the individual artifacts in the folder are produced in a distributed manner, by different actors at different places and at different stages in the treatment, before being assembled in the folder, and since they can be removed again, they are all equipped with a patient ID-code.

Because of the folder, the assembly can be treated as a unitary coordinative artifact. This is exploited in different ways.

First of all, folders can be archived and retrieved again while retaining the particular arrangement of discrete items, as if they were fixed inscriptions in a fixed arrangement on one surface. The folders of all patients who have visited the outpatient clinic in the current or preceding year are stored in the archive located in a small room behind the counter (Fig. 10). Older folders are located in the basement.

Locating folders is one of the main tasks for the nurses in the outpatient clinic of ONC1. In this clinic patients may arrive without an exact appointment. So, upon arrival the patient presents his or her patient diary (*Patiententagebuch*) and possibly also external laboratory test results to a nurse manning the reception, who then fetches the patient folder from the archive, checks if all relevant information is available, enters the arrival of the patient in the administrative information system, enters services in the 'care sheet' (*Pflegeblatt*), sends the patient along to have a blood test taken or directly to one of the consultation rooms, and places the patient folder wherever it is needed next, namely, at the 'blood work station' [*Blutarbeitsplatz*] where another nurse prepares the tubes, or in the consultation room.

In the consultation room the doctor will look through the documents in the patient folder, checking results from different kinds of tests, and take a decision about the next step in the treatment. He or she enters the next appointment, e. g., a regular examination after, say, about three months ('mid June'), into the patient's diary and hands it over to the patient. If any immediate measures are planned, the patient takes the updated care sheet back to the nurse at the counter who then takes care of the doctor's orders, e. g., for lab tests. When the patient has left, the doctor dictates a short progress report into a dictaphone which is then transcribed and added to the patient folder.

When a patient is scheduled for chemotherapy, the patient folder is transferred from its customary location in the outpatient clinic to the day clinic.

For example, one prevalent principle of organizing work in clinical work are stacks or piles of patient folders, with piles on desks, in boxes underneath a table or on the couch (Fig. 11), and everyone knows who is responsible for processing them and what the tasks are. The amount of folders in a pile gives a good estimate of the number of patients for that day, with their position in the stack indicating expected sequence. For example, some patients may call to learn about the results of a recent examination because they live far away or have difficulties walking. The responsible nurse places these folders in a pile on the couch in the physician's room, with a yellow post-it note attached to it with a symbol of a phone and "pat. calls" on it. Sometimes they write the time and date of the call on this post-it. There are other post-its for other types of recurrent activities.

How these stacks of patient folders are spatially arranged may vary due to variations of work practices. In ONC3, for example, where patients arrived by appointment only, the secretary uses the list of appointments to retrieve the folders of patients the day before. The nurse in the consultation room then puts the folders on a sideboard in the order of the patients' arrival times (Fig. 11, right). However, she

Fig. 11: Stacks of folders in ONC1 (left) and ONC3 (right).

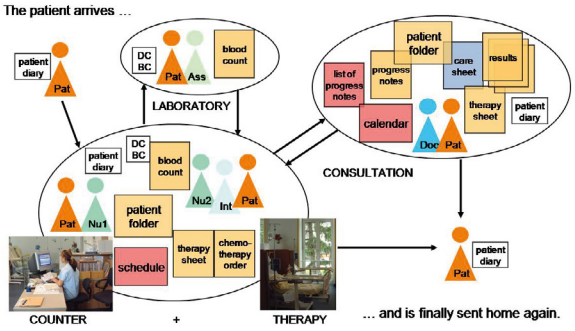

Fig. 13: The spatial distribution of artifacts and workplaces in ONC1.

Fig. 12: The binder system in an architectural office. The binders in the photo on the left all pertain to one project, identified by the color of the binders (blue).

Fig. 14: Spatially arranging tubes for blood tests to be performed the same day (left), the next day (right).

puts those folders towards the wall in the back where patients still have to do a blood test. Each of the folders is directly accessible for nurses to search through them or put in additional sheets. Current examination results (e. g., from a blood test or from nuclear medicine) or a form stating the patient's 'informed consent' for chemotherapy and the appointment sheet are attached to the front cover of each folder with a paper clip. The nurse attaches the latest report to the front sheet. Here the spatial arrangement not only supports a anticipated sequence but allows an 'at a glance' overview of things to come.

While the archive at ONC1 is organized so as to account for patients that undergo recurrent treatment in a (largely) diachronic cooperative effort, the organization of documents in an architectural office reflects the need to collate documents produced as part of a cooperative effort unfolding (largely) synchronically. The 'binder system' (Fig. 12) is a heterogeneous collection of documents ranging from plans, drawings, sketches, correspondence (faxes, letters), to contractual information, legal documents, and product specifications, often arranged in inverse chronological order within each binder. Binders for different projects have different colors. Standard labels adapted to the nature of the project are produced and printed out. The subdivisions of the filing system reflects the architects' interactions with different professions—consultants, client, local authorities, and companies—and the domains these represent.

3. Migration of artifacts across space

Coordinative artifacts are located across the physical space of the cooperative work settings and in the course of the work artifacts may migrate across that space (Fig. 13).

We already saw that patient folders in oncology clinics are retrieved from the archives in order to be to hand during the consultation. More than that, we saw that retrieved patient folders are positioned in the consultation room of the respective doctor and, in ONC3, stacked in the order that patients are to be received. That is, the location of a particular folder relative to the layout of the setting (rooms, desks, tables, etc.) as well as relative to other folders is not only a practical matter of making relevant resources available but is taken to signify that the doctor assigned to that particular consultation room that day will be in charge of treating these particular patients in this specific order. It is equivalent to a written request in the inbox, only that the positioning of folders in this way is highly economical: instead of two flows (written request and distribution of folders) that would have to be aligned and synchronized, only one is needed.

To take just one more example, consider the work stations at which blood tests are prepared. Figure 14 shows two different ways of ordering tubes and associate requests. One is the arrangement of tubes together with the requests on a trolley from where they

are picked up and brought to the laboratory on the same day; the other one is in carton trays on another shelf for blood tests to be taken from patients who are expected to arrive the next day.

These observations of mundane practices are of course bordering on the trivial. But then again. There is an obvious system to these practices that we, for our purposes at least, need to work out.

We probably do not want to stretch the concept of 'writing' to include these examples of routine significance of the *location* of inscriptions. But these examples do seem to give rise some conceptual issues. It is assumed that writing requires a suitable surface to carry the inscription (Harris 1995, 2000), which is hardly problematical. But how do we semiologically deal with what happens at the boundary of the surface, and beyond? It is clear enough in the case of a postcard or a letter: when the surface has been filled it can be posted. But what about, say, a book? It is, materially, an assembly of printed sheets and thus can hardly be considered a single surface. We nevertheless, unproblematically, consider it one integrated semiological artifact because the sheets has been glued (or stitched) together to form a virtually continuous surface, provide one turns the pages. For ordinary linguistic purposes, considering books and magazines and the like as inscriptions on one surface may be quite legitimate. But when it comes to the literate practice in modern work settings, we need to consider the huge variety of techniques by means of which discrete inscribed artifacts are spatially concatenated in meaningful ways, all the techniques of assembly in between the stack of loose sheets on the desk on one extreme and on the other the glued-up sheets in the bound volume: paper clips, folders, folders with flaps, spring-back folders, vertical suspension folders, boxes, staples, binders, etc.

We are of course not advocating going into the office supplies industry, The point is not the materiality of staples and folders but the logic of their different uses: the spectrum of different degrees of durability of the arrangement of individual inscriptions. We consider these logics a semiological phenomenon of obvious interest.

Let us, to support this point, wrap up by mentioning a coordinative artifact of the most mundane sort that plays a strategic role in modern industry: the *kanban* card. It is used as the baton semaphore in a relay race to coordinate distributed production activities. The idea of using cards for horizontal coordination of activities originates from retail trade, e. g., supermarkets and bookstores. For each type of product on the shelves of the store, (at least) one preprinted card has been prepared and attached to the last item to be picked. When a customer picks up this last item, the associated card is transferred to the storage in which steps are then taken to refill the appropriate shelf space or procure a new batch. The idea of using cards as semaphores for coordinating complex just-in-time production in manufacturing operations was developed by Taiichi Ohno at Toyota after the Second World War (Ohno 1988) and is now used globally in the manufacturing industries (Schonberger 1982; Monden 1983). The *kanban* card is a coordinative artifact with a preprinted inscription that specifies the part number and number of parts to be produced per batch (and perhaps other items of information). When the batch of parts has been produced the card is attached to the container or pallet with the parts and is transferred to the next station in the workflow where they is then used (whether further processed or as parts in a subassembly). When the batch has been used, the *kanban* card is sent back to the work station from where it originated. It is placed in the stack of (similar or different) *kanban* cards in the in-tray of the workstation, and it is then, by the operator, routinely taken to mean that he or she now has to produce another batch of the part in question. That is, as parts are moving down the line and are used, *kanban* cards move up the steam in the same rhythm. The simplicity of this coordinative artifact can be misleading, for setting up a *kanban* system requires a careful analysis of the operations involved in the production of each part at each stage (set-up times, processing times, etc.). Anyway, what is interesting in our context is that a number of cards with different but fixed inscriptions can facilitate the horizontal coordination of enormously complex and distributed manufacturing operations simply by the significance assigned to the changing location of inscriptions (for a discussion, cf. Kaavé 1990; Schmidt 1994, 1997).

4. Concluding remarks

Our analysis of coordinative artifacts and practices has led us to the notion of 'ordering systems' (Schmidt and Wagner 2002, 2003, 2004). They are based upon the combination of specialized coordinative practices and coordinative artifacts and their main purpose is to manage interdependencies that transcend local interactions, such as those involved in taking care of an oncology patient over many years of treatment and examinations or developing the construction plan of a complex building and overseeing its construction. Essential to such practices is the management of vast distributed collections of artifacts, such as for example patient folders and the documents they contain (e. g., appointment sheets, results of laboratory tests, therapy sheets, doctors' notes, prescriptions of chemotherapy).

A major practical and intellectual challenge here is to grasp and face the enormous variability of ordering systems and coordinative practices in general. We investigating these practices we have, for instance, come to appreciate the huge variety of different

'syntactic' systems: the loose logic of association by proximity (the title block); the discrete containers; the positional syntax of ID codes, the assignment of meaning to inscriptions by relative and absolute position in lists, tables, and charts; the assignment of temporal order by positioning artifacts and folders in stacks.

In the uses of these artifacts, elementary categories of coordination and integration of work activities can be distinguished. For example, a list or a stack is composed and read as a way of expressing certain types of relationships. We have focused on relationships such as task assignment, timing, sequence, and priority. But other types of relationships can be detected: authorization or attestation (by proximate initials), relevance (also by proximity), allocation (by location), identification and validation (conspicuous position on cover of patient folder). Coordinative artifacts assist in identifying individual artifacts and versions of artifacts; they afford specific validation procedures; they support keeping track of and providing access to the vast and perpetually changing collection of artifacts; they support the accomplishment of temporal order (sequence, cycle) and or priority; they document that actors, including external partners and authorities, meet agreed-to or statutory deadlines; and so on.

4.1. The dance of time and space in coordinative practices

Coordinative artifacts are, of course, first of all inscriptions. Or rather, what we have at hand is a data structure attached to a discrete object by some method. It may be ink applied to paper or carbon powder fixed thermo-mechanically. Or for that matter electromagnetic patterns in the memory of a digital computer and projected onto the screen. Whatever the method of inscription and irrespective of the nature of the object that carries the inscription, the key feature of such coordinative artifacts is that the configuration of signs is sufficiently durable. Coordinative artifacts would obviously be of little use if they were likely to disintegrate spontaneously or if letters began to jump about as soon as the inscription has been made. In so far, coordinative artifacts can be considered trivial, primitive, and uninteresting phenomena from a linguistic point of view.

Very often coordinative artifacts are 'open' to addition and have been deliberately designed in such a way that the space for later additions is marked, e. g., by empty cells in a matrix. That is, such coordinative artifacts are designed in such a way that the spatial concatenation of significant groups of signs is fixed in advance and can be retained as the artifact migrates over the cooperative work arrangement and is being filled-in step by step. That is, while it in some cases is crucial that the inscription, as fixed upon the surface, is maintained in the immaculate form of its inception, in other cases this is not at all the case, but it is, rather, crucial that the coordinative artifact is amenable to a process of incremental inscription.

It is of significance, however, that the issue of durability is entirely relative to the practical context. In the context of keeping records (for purposes of accountability, documentation, etc.), the durability required of inscriptions may be years and more. Here the mnemonic function is predominant and all kinds of effort are being made to ensure the integrity of the inscribed artifact (use of acid free paper, control of humidity of storage facilities, etc.). However, other inscriptions are of merely transient use and it may even be required that the inscription can be deleted easily without destroying the writing surface (the use of whiteboards for scheduling, shift planning, etc.), when the inscription in individual cells is more or less frequently updated while the overall system of relationships is fixed.

However, what is perhaps particularly remarkable is what goes on beyond the horizon of the surface of the individual artifact, in the relationships between artifacts. We are here not just referring to the ubiquitous *ad hoc* spatial ordering of discrete coordinative artifacts and other inscribed artifacts: the concatenation of artifacts on a desktop or a bulletin board, for local and temporary needs. We are rather thinking of the systematic concatenation according to some ordering principle (chronology, categorization) that we find in the form of stacks, folders, binders, filing cabinets …

A fixed and durable spatial concatenation of signs (or of complexes of signs) is crucial for some purposes but for many other purposes it is important, if not essential, that the individual artifacts remain detached and thus that these discrete artifacts can be spatially combined and recombined, in different ways, to form different organized complexes.

Last, but not least, coordinative artifacts are distributed over the work setting, located where they are most likely to be used. That is, the location of a particular artifact at a particular place can be taken to indicate that a certain action is to be taken. This is a very economical way of assigning tasks. Instead of taking two actions—instructing A to do *x* and at the same time provide A with the resources (blueprint, process chart, medical record) required to do *x*—the relocation of the required resources to A's work station can be routinely taken to be the instruction.

4.2. In lieu of a conclusion

The aim of our interest in these practices is not to contribute to linguistic theory. Our aim is, rather, to identify, in these semiotic practices, elements of co-

ordinative protocols, 'primitives', that are combined and recombined in coordinative practices. However, a critical step in the process of identifying such primitives is to survey the semiological techniques employed in the huge variety of coordinative artifacts and their different roles in coordinative practices.

What we see when entering a modern workplace is a continuum of techniques of ordering of which glottic writing is only one element, a continuity with other forms of spatial concatenation of signs (as inscriptions on surfaces as well as arrangements of artifacts in the workspace at large).

A major obstacle is here posed by linguistic dogma: that such techniques are not linguistic and therefore not interesting.

Coulmas gives a clear expression of this when he states that writing came much later than speech. There is of course no record of glottic writing until around 4000 BCE—but does it not seem odd to use the archeological record to argue for the precedence of speech over writing? Anyway, the tacit assumption is, again, that writing is equivalent with glottic writing. But if we step back from that highly problematic assumption, the pictures becomes far more differentiated. If we take the archeological evidence, there are indications of the use of abstract patterns in Paleolithic cave painting that may have served as clan emblems. There are Paleolithic inscriptions on bone that indicate inscriptions for counting. And if we consider the ethnographic record, finger counting is ubiquitous (Ifrah 1994), and is there reason to believe that finger counting and sign language in general is not as old as speech? Is there any reason to believe that counting by arranging pebbles in rows or piles is a recent invention? There is indeed ethnographic evidence of uses of everyday objects in sophisticated spatial arrangements to keep track of the phases of the moon:

> 'He told them to take three coconuts from the bush and to break them on their elbows. The six half-shells represented lunar months, popu (lit. "moons"); they were strung on a tong-like stick or piece of bush-vine so that they could be moved to mark the months. At the start of aoro nari, the six shells all faced upwards on the west or "sunset" side of the string, suvugavosso. This was the season of plenty. At each new moon (tale popu), the keeper of the calendar would move one shell over to the east or "sunrise" side of the string, ghasangavosso. When all six coconut shells were turned downwards on the "sunrise" side, it was the time of scarcity. When the first shell was turned back to the ‚sunset' side of the string, aoro vino began.' (Burman 1981)

It is somewhat ironic that another sign of the tacit assumption of discontinuity can be found in studies of the semiotic techniques that preceded glottic writing and, in Ancient Mesopotamia, seem to have evolved into writing.

The use of such assemblies seems to have played an important role in the development of writing in Ancient Mesopotamia (Schmandt-Besserat 1989; Nissen et al. 1990; Schmandt-Besserat 1992). However, as soon as historians have discovered and reported the practices of making impressions of the content of *bullae* onto the surface container and later other forms of inscriptions to denote the content, practices of significant concatenations of discrete artifacts falls under the horizon of linguistics. It is as if such collections of artifacts are not relevant to the history and theory of writing.

'Before writing'—as if spatial concatenation of signs ceases with the emergence of glottic writing, and as if spatial concatenation of signs is overall more primitive or less expressive!

The point is that we observe routine and highly regular uses of spatial concatenations of signs, that these sign systems are immensely diverse, and that these diverse sign systems are amenable to systematic study. They may be uninteresting from the point of view of linguistics but the techniques are hugely important for the settings in which they are applied and understanding them is critical for developing computational techniques for cooperative work settings.

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