MODELING MEDICATION MANAGEMENT PRACTICES:
The Coherence Theory of Medication Activities

by

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CERTIFICATE OF APPROVAL

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Modeling Medication Management Practices: The Coherence Theory of Medication Activities

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Abstract

Optimizing medication management is a low hanging fruit towards improving patient safety. However, while it is understood that medication errors are to be minimized, there does not appear to be any systematic method for thinking about exactly how we should go about doing so. Currently, there is not an adequate theoretical understanding of the medication management activities such that we may systematically conceive, discuss and test interventional strategies. This study examined a spectrum of medication management practices performed by various clinicians within a geriatric, long-term care setting.

METHODS

DESIGN: naturalistic observation

Setting: 5 settings in long-term care facilities on the Oregon coast (Lincoln City and Eugene) consisting of physician's office, skilled and unskilled nursing facilities, pharmacy and home health visits.

Subjects: 10 clinicians that performed medication management tasks including several nurses, physician, pharmacist, and pharmacy technician.

Sampling: Snowball Sampling - with a goal of identifying representative task types.

Data Collection: 14 sessions of naturalistic, non-participant observations and interviews conducted over 11 days (excluding travel), each session consisting of either one working day of each subject or the duration of the defined medication management task. Special attention was paid to the clinician use of cognitive artifacts. Documents were also collected for analysis.

Analysis: The observation data was iteratively analyzed, parallel to data collection, with the final analysis organized by individual settings and within them, thematically across all subjects. The themes derived were then synthesized into an explanatory theory drawing from the theories of Distributed Cognition (DCog) and Activity Theory (AT).

Results:

The study identifies the task types of correspondence and coherence tasks in terms of their distribution across the cognitive space, as well as special task features such as batching and flow, which have implications for how information tools should be designed. A novel theoretical framework is offered to explain these themes. It argues that clinical activities are well modeled as synthesis and propagation of coherence rather than simply information checking and that safety activities comprising of examining information representations for parity (correspondence) (Eg: Medication Reconciliation), form only a subset of the broader safety continuum that is better seen as a consequence of coherence activities.

This new theory fills an analytical gap, not fully addressed by existing theories; specifically, non-standardized professional activities distributed across both internal and external cognitive spaces, resulting in the synthesis of coherence from often heterogeneous representations often hosting only incomplete information, needing to be processed within local and general internal knowledge context. Given that this theory was assembled within the clinical informatics context itself, it holds promise as a native perspective for coming up with practical solutions that align well to clinical task realities.

Preface

The current study went through a somewhat atypical process. The goals of the dissertation changed through the process and the theoretical notions were significantly revised until coherence was ultimately constructed (pun intended).

The project was initially conceived as an engineering project aimed at creating a novel software tool for medication reconciliation tasks using existing cognitive theories as a guide. The early prototype was based on the concepts of Distributed Cognition (Hutchins 1995a) and its use of cognitive artifacts (Norman 1991) and an appreciation of the limits of human working memory (Miller 1956). The product result was expected to look something like the early prototype shown in Figure 1.

However, after the very first observation, it became clear that there were other similar tasks in the setting, that the model of the task was unlike anything expected in advance and that there was adequate richness to be explored within the tasks that making description and modeling alone to be project goals would to be adequate in scope and more valuable in contribution. The updated study is a qualitative study that produced a novel theoretical model of medication related activities.

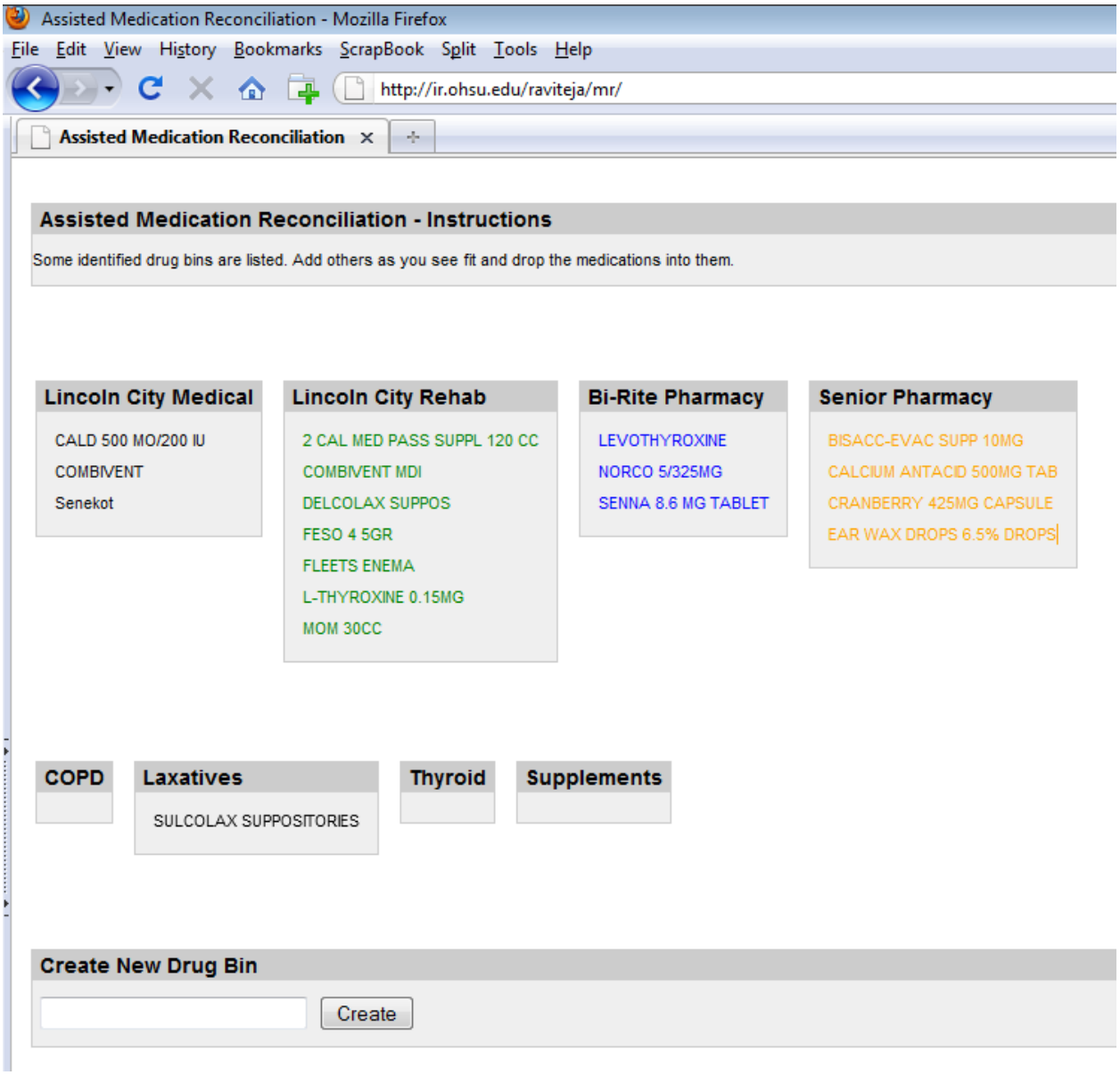


Figure 1: An early screenshot of the prototype implementing assisted medication reconciliation tool. The tool is a rich web application that presents a direct manipulation interface. Using "Drag & Drop" interactions, the user sorts the orders into logical categories (Bins) meaningful to h/er, creating them as necessary. The cognitive effects would be similar to those from the use of an Abacus or from simply using a writing surface for arithmetic vs. mental arithmetic unaided by artifacts. The future versions were to present auto-generated categories pre-populated with orders with the user processing the any remaining orders that could not be handled by the algorithm. The distinct colors cue the source site even when orders from different sites would be grouped under the same logical bin.

Chapter One: Background

A brief critique of informatics

Clinical Informatics aims to improve the quality of health care through information tools by both improving the efficiency of clinicians as well as the quality of their decisions. However, the information systems are still unable to deliver cost savings and only modestly improve process measures (Westat et al. 2009), add to the work of clinicians, are not eagerly embraced by the medical community (Hospitals shun life-saving IT | Healthcare IT News)(Hospitals shun life-saving IT | Healthcare IT News)(6), and sometimes even introduce new errors (Koppel et al. 2005) (Horsky et al. 2005).

The early enthusiasm began with attempts to create automated decision support systems that could produce clinical diagnoses. The goal of these systems was to model the knowledge and decision-making processes of respected experts. Ultimately, these efforts were abandoned. Early approaches used an Oracle model where the clinician would consult the expert system for advice, especially in perplexing cases. The expert system would query its knowledge base and use artificial intelligence techniques to provide advice. This kind of interaction was eventually found to not be what the clinicians sought and consequently did not garner the expected adoption (Miller & Masarie 1990).

The mismatch of informatics vision of these intelligent systems versus the ground needs was only to be a harbinger of things to come. Often, technological solutions would get prescribed to improve health care without an adequate understanding of the needs and settings. When the mismatches are eventually identified, substantial research efforts are then directed to evaluate the outcomes of such deployments. Attempts to introduce Alert and Reminder systems, Computerized Physician Order Entry Systems (CPOE) followed a similar course and will be discussed later in the document.

Similar results were encountered with the introduction of Bar Code Medication Administration Systems (BCMA). BCMA was introduced as a way to reduce errors in medication administration and has demonstrated its potential in some settings. Poon et.al reported that BCMA had reduced target dispensing errors leaving the pharmacy by as much as 85% and potential Adverse Drug Events (ADEs) by 63% (Poon et al. 2005). However, it was identified that

clinicians were not always following or were not able to follow the prescribed protocol in using BCMA and developed work-arounds. Carayon et.al identified several interruptions that hindered the clinicians (Carayon et al. 2007). Patterson et.al reports several instances of non-compliance that made the task seemingly more efficient for the clinicians, but negated some of the safety protections offered by the systems (Patterson et al. 2006).

In all these cases, interventions introduced as novel technological solutions presented and were found to be effective, but without substantive work into developing local theoretical foundations for the respective clinical tasks. While decision support systems did develop at the forefront, CPOE and BCMA systems were introduced with simple goals and perceived success in other settings. CPOE grew from the simple objective to improve the quality of the computer record (Sittig & Stead 1994) [1] while bar code systems were found to be effective in aviation, defense and automobile industries when healthcare took notice (Neuenschwander et al. 2003) [2].

The inevitability of "unintended consequences"

Clinical Informatics is a multidisciplinary domain that incorporates theories and innovations from its constituent disciplines. These include computer science, software engineering, anthropology, social sciences, cognitive sciences and many more. While most, if not all these disciplines possess their own theoretical foundations, clinical informatics itself does not possess a standard theoretical framework of its own that can serve as an anchoring foundation for specific, clinically tailored informatics inquiry, beyond those drawn from these contributing disciplines.

The closest that clinical informatics has come to in producing a theoretical framework is the recent postulation of a *"Fundamental Theorem"*. It states that *"A person working in*

[1] Sittig and Stead attribute the origins of CPOE to a 1970 enumeration by Morris Collen of the general objectives of the medical information management system that stated "Physicians should enter medical orders directly into the computer" as a means of ensuring quality.

[2] BCMA itself began as a spark of an idea when a registered nurse from the Topeka Kansas Veterans Administration Medical Center returned a rental car that was barcode scanned (Coyle & Heinen 2005).

partnership with an information resource is 'better' than that same person unassisted" (Friedman 2009).

Figure 1.1: Friedman's Fundamental Theorem of Biomedical Informatics (Friedman 2009).

However, this is less a theorem than a statement of what we wish to make true or assume to be true. Friedman himself recognizes this and presents it as an ideal that we strive for (constructivist ideal), rather than as a statement that has been found to be true (positivistic fact). But, the term theorem, by definition is a logical argument that rings true and more importantly, has never been proven to be untrue after substantial (but formally incomplete) examination. A theorem ceases to be a theorem when one instance to the contrary can be demonstrated. Unfortunately for our discipline, we have already demonstrated that we can indeed frequently build systems that can burden rather than assist (E.g. CPOE failures).

The lack of theoretical foundations condemns Clinical Informatics to simply react to trends in technology application; and to methods developed in other domains; and eventually, to be surprised when these tools and methods do not yield expected results. Research in Clinical Informatics is now often limited to evaluating the outcomes of the application of the contributions of foreign domains. Instead, a more progressive, assertive, self-aware and explicitly directed approach would be to develop a central intellectual platform[3] within

[3] The notion of an intellectual platform here is described as the theory + the data collected systematically by the community, using the theory. This leads to theory driven conclusions resulting in further implications to theory. The term framework may also be used in place of platform. The term framework signifies that major knowledge gaps are clearly identifiable to the community and co-ordinated research efforts may be directed at it, rather than having individual researchers having to come-up with new questions.

Informatics for design, optimized for goals that it can call its own; on which subsequent knowledge gathering would be predicated to either support or adapt.

Strategies for reducing "unintended consequences"

The impact on the introduction of new technology within any environment is difficult to predict. It becomes further difficult when formal descriptions of those environments are absent, and consequently cannot enable systematic predictions. However, formal descriptions can only be made in the context of explicit theory. Without such grounding, independent observations cannot be normalized. While it is true that observations are first necessary before a reasonable theory well grounded in experience can be proposed, an incremental effort needs to be constantly made.

Much of the current efforts on health systems are focused on evaluating the success and failure of the deployments but not enough to inform detailed design decisions. Further, CPOE and BCMA are abstract notions realized in actual implementations. Evaluations can judge implementations, but not the notions themselves. The abstract notions can only be refuted in logic: (e.g. CPOE with its rigid data entry demands could burden clinicians because clinical reasoning is not always explicit and formal) and not by inductive empiricism (e.g. CPOE must be a bad idea since the last 10 attempts failed).

While there is plenty of literature exploring success or failure of CPOE and BCMA deployments, there is little work on how the systems should be systematically designed. Towards that end, this study attempts towards the creation of a theoretical, descriptive framework upon which designs may be base upon.

Study Goals

Towards these over-arching goals, medication management and safety activities were picked as the focus of the study. Medication related information is relatively structured[4] when compared to the rest of the clinical chart and is easier to discuss than most other aspects of clinical information. Indeed, many of the technological interventions in clinical informatics (including the prior mentioned CPOE and BCMA) focus on medication related processes. Additionally, it is understood that improvements to medication activities can have significant impact (positively or negatively) on the outcomes. Much work on medication safety has focused on the information aspects of it i.e. ensuring information is meaningful in a machine context (Alerts and Reminders) and the factors that enable this strategy such as on information completeness of forms, standards, ontologies, (machine) information representations, interoperability concerns etc. Much less work has been directed at representational features of this information that affect the ultimate consumers/processors of this information - clinical cognition. LOINC (Logical Observation Identifiers Names and Codes) and other standards work that optimize clinical and laboratory information representation for machine sharing and interpretation are widely known and actively discussed within the community. However, efforts to optimize processing of laboratory information by cognitive agents, such as work on metaphor graphics (Cole & Stewart 1993) (Cole 1990) is much less widely known and perhaps never applied in production systems.

Beginning with the notion that clinical systems are primarily cognitive, now and for the foreseeable future, I will briefly review medication safety and the current cognitive approaches to clinical informatics.

[4] Laboratory data is another instance of well structured data.

Medication Safety

Situating Medication Safety

Medication safety is a subset of the broader concern of patient safety. Patient safety has been in the minds of the earliest doctors. The notion that doctors should foremost avoid causing harm as a result of their treatments (*Primum non nocere*, Latin for *"First, do no harm"*) is a time-honored aphorism. The notion (in its Greek form) dates back to the era of Hippocrates and Galen[5] and is a constituent of the Hippocratic oath[6], the maxim warns practitioners of medicine to, above everything else, avoid causing any harm to the patient, even if it means doing nothing at all (in cases of uncertainty)[7] (Smith 2005). Despite the prominent position of this primal warning within medical ethics, and despite best efforts and intentions to practice it, treatments still do cause complications and we continue to be concerned about iatrogenic injury - the harm caused by the physician.

The extent of iatrogenic harm is considerable. In terms of mortality, US estimates place iatrogenic deaths as high as 225,000 (Starfield 2000) with various estimates as follows …

- 11,900 deaths/year from unnecessary surgery (Leape 1992)
- 7000 deaths/year from medication errors in hospitals (Phillips et al. 1998)
- 20,000 deaths/year from other errors in hospitals (Starfield 2000)
- 80,000 deaths/year from nosocomial infections (Starfield 2000)
- 106,000 deaths/year from non-error, adverse effects of medications (Lazarou et al. 1998)

These statistics do not even address the arguably much more wide-spread distribution of morbidity. As can be seen here, medication related injury figures prominently into iatrogenic

[5] The authorship has not been ascertained with certainty. Hippocrates himself did not use Latin.

[6] A similar form that may not accurately reflect the maxim

[7] Note: *Primum non nocere* is not considered absolute, however. In the treatment of cancers (especially early stages of potentially aggressive tumors), *Primum succurrere* (first, hasten to help) takes precedence; when the only hope for cure involves significant risk.

harm and falls within a broader context of patient safety that includes practices with respect to reducing error in the context of infectious diseases, hospitalization, surgery, professional education and training, and patient consent. Medication safety is primarily concerned with the prevention of adverse drug events. Due to its significant contribution to error and its seemingly actionable information model, medication safety has attracted special attention from the clinical informatics community and the practice of medicine in general. Much effort has been devoted towards improving the processes and developing tools.

Drugs and Toxicity

Terms

Before we delve further into the discussion, a few terms need to be first clarified; beginning with the elementary definitions of drugs and medicines. *Drugs* are physiological change agents i.e. substances that when introduced into the body, alter physiological states in some way. However, not all drugs are considered medications. *Medications* are those drugs that are used for diagnosis and treatment. Stated differently, medications are used to treat or verify the occurrence of abnormal, undesirable conditions. This excludes drugs that are used to reach physiological states that are not considered normal. For instances, recreational drugs and performance enhancing drugs attempt to reach temporary states that may be considered as improvements by the consumer; but these will not be considered medications, at least in the above functional context. Drugs that create less desirable physiological states are considered poisons. However, the lines between these terms are often blurred. Dose can separate a medicinal drug from a toxin. Hence, the term medicine is largely a functional one.

Figure 1.2: Drugs and Physiology: Drugs can provide benefit as well as harm. The difference between medicines and poisons is entirely functional.

Role of dose in medication error

Dose related medication errors are by far the most common. The medication must be so administered such that enough medication is delivered to reach the clinical goals and yet low enough to not be toxic to the patient. The difference between the minimal dosages required to treat the disease and the dosage at which the toxic effects outweigh the benefits is termed as the *therapeutic window* (Oertel et al. 2007). Some drugs, such as cancer drugs, have a narrow therapeutic window requiring careful monitoring. The drug released into the system may be controlled, both internally and from outside. Skin patches and IV pumps introduce drugs into the patient's system at a controlled rate. Extended release preparations release the drug at smoother rates within the gastrointestinal system and avoid wide fluctuations..

Since the drugs produce changes in physiological states, they must only be used when *indicated*, not used when *contraindicated*, administered at correct *doses* and at the right *times* while monitoring the treatment with appropriate physiological data. Failing to do these can result in medication error.

Medication Error

Medication errors are errors resulting within treatments using medicinal drugs. Medication error has been a significant area of research in medical informatics since its conception in a pharmacy and other medical literature before that (Flynn 2005). This long trail has been somewhat overshadowed by the more recent IOM report which produced high-impact estimates of what these mean on a national scale.

Flynn traces medication errors to literature when they were used as a metric of safety with the development of drug delivery systems in the sixties. The concern at this time was mainly with the administration errors, from a machine standpoint. Later on, other forms of medication errors such as the errors of omission, and errors of commission, errors of dosage, route etc. were also subsequently included into this definition (Flynn 2005). Medication error was progressively seen later on as a human error and finally now, as a system error (Cheng et al. 2003) (Shojania et al. 2001).

If has the focus of medication safety shifted, so has the evaluation of it. The early understanding of the magnitude of clinical medication errors was only through incidence reporting. This was a voluntary process that was nearly always incomplete in its ability to document errors, as is common with most self-reporting methods. Medical error received renewed attention since the Institute of Medicine's (IOM) report which estimated from 44,000 to 98,000 preventable deaths due to medical errors (Kohn et al. 2000). However, not all medical errors are medication errors.

Adverse Drug Events (ADE)

Dean et.al apply the Delphi method, using a panel of 34 judges, to arrive at the following definition for prescribing error.

"A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective or (2) increase in the risk of harm when compared with generally accepted practice" (Dean et al. 2000).

Medication errors are a subset of prescribing errors since the later cover non-medication prescriptions as well (Eg: therapeutic procedures), resulting from improper prescription of medications. Not all medication errors result in harm to the patients. If harm does occur, it is then termed as an adverse drug event (ADE). However, adverse drug events occur even under appropriate use, for instance, as a rare side effect of a drug that is otherwise safe to use. The ADEs caused by medication errors on the other hand are termed as preventable ADEs. Some ADEs occur at normal therapeutic dose, while others do not. The ADEs that occur at therapeutic dose are termed as adverse drug reactions (ADR) (Nebeker et al. 2004).

Classification of Adverse Drug Events

Since adverse events have several characteristics, they may be classified across several axes for various purposes. Leape et.al provide a relatively comprehensive clinical classification for medical errors (cf: medication errors) (Leape et al. 1993).

1. Diagnostic
    a. Error or delay in diagnosis
    b. Failure to employ indicated tests
    c. Use of outmoded tests or therapy
    d. Failure to act on results of monitoring or testing
2. Treatment
    a. Error in the performance of an operation, procedure, or test
    b. Error in administering the treatment
    c. Error in the dose or method of using a drug
    d. Avoidable delay in treatment or in responding to an abnormal test
    e. Inappropriate (not indicated) care
3. Preventive
    a. Failure to provide prophylactic treatment
    b. Inadequate monitoring or follow-up of treatment
4. Other
    a. Failure of communication
    b. Equipment failure
    c. Other system failure

This scheme lays out medical error in terms of the various types of clinical intervention with respect to the occurrence of disease. AHRQ (Agency for Healthcare Research and Quality) uses a more process based classification that is irrespective of the outcome. The decoupling from the outcome means that even common omissions such as a prescription for Amoxicillin without the route specified qualifies as an error (Shojania et al. 2001).

1. Failures in ordering/prescribing
2. Failures in transcription
3. Failures in dispensing
4. Failures in administration
5. Failures in monitoring

Often, for an adverse event to occur to occur, there are failures at multiple levels that allow an error to pass through the chain of safeguards that exist in clinical care. Golz and Fitchett illustrate this at an individual level while offering insights into a mishap that happened in their watch (Golz & Fitchett 1999). They note the causes of their error as a combination of one or more of the following…

1. Failure of collaboration
2. Failure to double checking
3. Clouded thinking
4. Inadequate reference material

As a collaborative failure, even though knowledgeable persons who can help prevent a given error are available, they are not always leveraged. The causes range from access to a lack of pre-cultivated working culture between the potential collaborators. Various factors such as miscommunications, trust factors can influence whether double checking is performed. The missed checks are often justifiable by common sense and for efficiency. In other cases, missed checks do miss error. Clinicians are not perfect information processing units. They may perform a task at varying degrees of effectiveness at different occasions. A tired clinician after a long shift may be more likely to perform error. In other cases, the effectiveness differential may simply be difficult to explain. Errors may happen when clinicians encounter less common cases. Since they are unlikely to remember the procedures and low level details off-hand, they may need to consult external sources of information such as drug references. However, these sources may not always be up to date, and they are also task specific. A reference useful to brush up on a few key facts may not provide adequate detail for an uncommon case. Golz and Fitchett touch upon the important emotional aspect when clinicians make medication errors. No clinician wants to be a party to be medical mishap that causes injury or death and try their best to prevent them. When they do occur, they cause a great deal of emotional suffering to the care providers, along with the patients (Golz & Fitchett 1999).

Impact of Adverse Drug Events

Errors in medication management produce negative outcomes that cannot be ignored. Classen et.al estimated ADEs occur in about 2.43 per 100 admissions. The average hospital stay was estimated to have been increased by about 1.74 days; with a nearly two fold increase in the risk of death (Classen et al. 1997). While ADE may be unavoidable in many cases, they may not be always so. Preventable ADEs are of particular interest since they offer an opportunity to improve quality. In a 1997 study, Bates et.al estimate an average cost of $4685 for a preventable adverse drug event, adding an increase of 4.6 days of hospital stay. They further estimate a cost of $2.8 million for a 700 bed teaching hospital (Bates et al. 1997). Johnson and Bootman estimate a cost of $76.6 billion, due to drug-related morbidity and mortality in the ambulatory setting in the United States (Johnson & Bootman 1995).

IOM Report on medical errors

A major impetus for change came from the IOM Report of 2000 which estimated large number of deaths annually due to preventable medical errors, gathering media attention, placing medication safety into national focus, not just academic patient safety research, and provided the political will and resources to solve the problem on a broader scale. Identifying and quantifying the problem, as well as the resulting open debate, has slowly but surely led to several changes in health systems.

Impact of the report

Leape and Berwick note several improvements that have been made since the report changing the conversation about medical error, but feel that the progress has been frustratingly slow. Pay per performance initiatives as well as Medicare and Medicaid programs now require reporting of quality data and notification of patients in case of error. In case of surgical errors, ‘Sign Your Site' (SYS) initiative, which involves pre-operative signing of the operative site by the surgeon gathered wider adoption. The cause of error is now increasingly seen to be system error rather than human error; i.e. humans making errors in error-prone setups. Towards creating less error-prone systems, the Leapfrog patient safety program, an incentive system, began to encourage the use of Computerized Physician Order Entry (CPOE). Joint Commission

on Accreditation of Healthcare Organizations (JCAHO), a major accreditation provider now required prompt reporting of medical errors to the patients. In general, the open debate about patient safety certainly promoted the efforts for a culture of safety (Leape & Berwick 2005).

Interventions

A number of practices and technologies have been recommended by the clinical informatics community with an aim of improving medication safety. These include Computerized Physician Order Entry (CPOE) systems that try to minimize errors that result from poor handwriting and transcription, clinical decision support systems that try to assist and improve upon the inconsistent human decision-making abilities, alert and reminders systems that attempt to bring attention to errors of commission and omission and the inclusion of clinical pharmacists in rounds and reviews to improve upon the pharmaceutical expertise of the physicians. Further efforts have centered on minimizing dose-related errors including unit dose drug distribution systems, automated medication dispensing devices, dosing nomograms and specialized clinics and services for high-risk medications such as anti-coagulants (Shojania et al. 2002).

Unintended consequences

The best intentioned interventions can lead to unexpected and unwanted results. Efforts to introduce Computerized Physician Order Entry (CPOE), and Alert and Reminder systems into electronic systems are two exemplars in clinical informatics.

CPOE

For structured information to be available for interventions, it must first be placed into the system. Here lay the significance problem. While most physicians seem to appreciate the benefits of having electronic access to information, they are not always willing to pay the time and effort costs of physician data entry.

The introduction of these systems met with resistance from clinicians (Freudenheim 2004). Creating electronic records of information was cumbersome, while the clinicians did not perceive adequate benefits in return. The early success from the few early adopter institutions

such as those at the Veterans Affairs and Massachusetts General Hospital systems could not easily be replicated elsewhere. These institutions invested substantial resources including research funding and organizational effort in creating custom tailored systems. The organizations that employed turn-key systems met with much lower success. CPOE deployment is now seen as a complex social technical issue and attaining success with CPOE deployments became to be considered something of an art, skill and luck; with organizational heroes and champions (Ash et al. 2003).

Using unintuitive workflows, the systems required dose updates to be performed as separate steps. Unaware, the physicians sometimes gave orders for new doses of medications assuming that it implied that the previous dosing was cancelled. However, the system recorded it as separate orders effectively double dosing the patients (Koppel et al. 2005).

For a user to effectively use the system without such erroneous preconceptions, the user's mental model of the system must match that of the system's abstraction model. This may be attained in two ways. First, the system must be designed with a thorough understanding of the user's mental model. The interaction model design must then be designed to correspond to it. If this is not possible, the system designers must strive to make the users fully aware of the system's model of the task instead. Designing the system with the user's mental model is clearly preferred whenever possible since it requires fewer user modifications. User modifications are less under the control of the system designers when compared to system modifications. User behavior however can sometimes be modified in ways that systems cannot, although only through much more expensive processes such as training. For this reason, it must be reserved as a second line of adaptation towards designing human computer interactions.

Alerts and reminders

Alerts and reminders are the two common approaches used in electronic medical record systems, typically used in conjunction those with CPOE. Both alerts and reminders are system notifications. The alerts are system notifications that are provided to the user when a potential

error of commission has been detected. On the other hand, reminders are system notifications that are triggered when a potential omission is suspected.

Unlike the previous safe guards that were implemented as periodically conducted batch tasks, alerts and reminders integrate into the practice management tools in real time. Mistakes can be detected before they translate to undesired actions. As an example, errors such as drug duplication, a rare drug interaction, a forgotten screening exam could previously only be caught after a review, long after the medicines have been dispensed or after the task has been put off for too long. Alerts and reminders on the other hand offer real time assistance to the busy clinicians at the time of care, as the record is being updated.

Alerts and reminders have however not produced the desired results. They are inexpensive to trigger than their manual counterparts as safeguards (medication and practice reviews) and were eagerly used and perhaps abused. In a busy clinical setting, clinicians have shown low tolerance for frequent alerts with low value information and have been known to simply ignore them (van der Sijs et al. 2006).

Herbert Simon eloquently stated this aspect of *"attention economy"* as follows *"What information consumes is rather obvious: it consumes the attention of its recipients. Hence, a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."* (Simon 1996).

Errors from technology use

Alerts and reminders and CPOE are the two examples of efforts to improve patient safety that have resulted in unexpected outcomes. The original arguments offered to make a case for these interventions appeared to be as obvious in beneficence as motherhood and apple pie. However, the devil was, and will be, in the detail. The implementation of these simple abstract notions of cognitive support was found to be much more perplexing.

The problems listed above can be corrected by better designs or entirely novel solutions. However, such designs are difficult to conceive without a thorough understanding of

the tasks that users perform rather than attempting to patch the problems as they come by. Without a proper understanding of the deeper issues, our fixes to these problems are likely to result in further problems. CPOE has now been reported to cause entirely new errors. Recently, Koppel et.al reported 20 new errors facilitated by CPOE sparking much debate (Koppel et al. 2005).

New Errors Facilitated by CPOE

1. Information Errors: Fragmentation and Systems Integration Failure
2. Assumed Dose Information.
3. Medication Discontinuation Failures.
4. Procedure-Linked Medication Discontinuation Faults
5. Immediate Orders and Give-as-Needed Medication Discontinuation Faults.
6. Antibiotic Renewal Failure.
7. Diluent Options and Errors.
8. Allergy Information Delay.
9. Conflicting or Duplicative Medications.
10. Human-Machine Interface Flaws: Machine Rules That Do Not Correspond to Work Organization or Usual Behaviors
11. Patient Selection.
12. Wrong Medication Selection.
13. Unclear Log On/Log Off.
14. Failure to Provide Medications After Surgery
15. Post-surgery "Suspended" Medications.
16. Loss of Data, Time, and Focus When CPOE Is Nonfunctional.
17. Sending Medications to Wrong Rooms When the Computer System Has Shut Down.
18. Late-in-Day Orders Lost for 24 Hours.
19. Role of Charting Difficulties in Inaccurate and Delayed Medication Administration.
20. Inflexible Ordering Screens, Incorrect Medications.

(Koppel et al. 2005)

Challenges in understanding tasks

One of the key problems of designing good healthcare systems is the presence of tacit knowledge. The notion of tacit knowledge was first articulated by Michael Polanyi while challenging positivism and its purist claims (Polanyi 1958). Polanyi himself used a clinical education example to illustrate the concept. A clinician rounding with his students relies on bringing his students in direct contact with the cases. He is however not fully able to articulate the features of the cases through his teaching alone. These need to be gradually understood by the medical students through their clinical experiences so that they may eventually learn to diagnose independently. The key issue here is not just that the educator considers such direct experience of higher quality but rather that he is unable to completely articulate the features that describe a disease by entirely by explicit means.

The extensive presence of tacit knowledge in day to day clinical work greatly hinders attempts by non-clinical or even clinically trained system analysts attempting to develop a requirements document of the clinical environment. While no perfect solution is available to get past this challenge, systematic development of, and application of theoretical frameworks will at the very least provide a systematic approach (*method*) to such design. If the research community is able to standardize on a set of theories for a period of time, the frameworks can help grounded observations to a common intellectual platform shared by researchers of a domain. This allows for incremental and iterative improvement of the knowledge corpus while making sense of it as a whole.

The later portions of this document will emphasize the role of human cognition in healthcare as a keystone feature and I will argue for the importance of cognitive theoretical frameworks for this purpose. However, before frameworks can help design, we must first have frameworks that can be used to describe. A design oriented framework will then take into account the descriptive theory and the interventional possibilities and constraints of current technologies (we are able to store large amounts of structured data, transport it and analyze it; but we are fairly limited in our ability to provide machine support for unstructured verbal

orders, recognize hand writing reliably etc) to propose solutions. It is towards such a descriptive cognitive framework of clinical tasks that the current study aims towards.

Donald Norman argues that the tools we use to complete the task don't simply make us do it more efficiently, but that they fundamentally change the nature of the task itself (Norman 2000). This has broad implications since the safety aspects of the tasks will be changed when efficiency aspects are changed and vice versa. An example is Beuscart-Zéphir's examination of the impact of medication ordering and administration functions of CPOE on the communications and cooperation between doctors and nurses in different hospitals at different stages of CPOE adoption. They found that the paper-based systems were characterized by synchronous cooperation with distributed decision making with an extensive use of mobile communications for coordination. On the other hand, in the hospitals using CPOE, physicians and nurses work asynchronously.(Beuscart-Zephir et al. 2007)

Cognition centered design

The call of cognitively grounded design research is not new, although still lacking in its influence on clinical informatics. Zhang and Patel have emphasized the role of human cognition in health systems, especially with respect to medical error and have called for designing the future systems with the central focus on cognitive factors (Zhang et al. 2002).

Limitations in theory driven approaches

Designing usable systems is a challenging task. System usability issues arise when at least one of the components of the system function depends on a human. To be able to design a system with predictable behavior, one should be able to parameterize all the factors that influence the outcome. While the machine system properties are more readily quantified, cognitive properties of the users are less accessible and understood, with our current understanding of the human cognition. This makes the development of designs, basing entirely on theoretical models challenging, if not impossible. As a result, usability engineers have depended on empirical evaluations of each of the systems they have built, as much, if not more than on the theories that were used in design.

Some experts in cognition and CSCW (Computer Supported Collaborative Work) voiced low-optimism about the value of theories in the near future or even more generally, given the nature of the fields. Kuutti describes the science-first attempt as the *"Cartesian ideal"* and notes that historically the human factors research has not met this approach (Kuutti 1996).

Landauer is similarly pessimistic about what we may expect out of theoretical approaches with respect to developing usable software. He notes that good theories with relatively solid experimental support had little impact on the field with most of the value coming from direct empirical modeling which can only be loosely be termed as theoretical. (Landauer 1991). Engeström also cautions against using cognitive theories too rigidly and recommends local adaptations.(Engeström et al. 1999)(Engeström 2000)

This was the general stance that the present study has undertaken. Existing theories are used as a helpful toolbox to inform new theory grounded primarily in an understanding of a specific setting (phenomenological) under study. This has implications in that universally generalizable claims cannot be made with this approach. However, new insights can still be generated.

Cognitive Theories

Several novel perspectives have been introduced to the west in the recent decades most notably, distributed cognition, activity theory and situated action. I group these perspectives under the banner of *"holistic theories of cognition"*. They all add something more to the analysis, locating cognition beyond the classical confines of the mind of the individual. This may be stated as a general move from internal cognition to external cognition.

The role of cognitive artifacts and external cognition were discussed by Norman (Norman 1991). He notes that human cognition has always been dependent on external artifacts as a means to support internal cognition, for any non-trivial task. It is almost impractical to perform any complex calculation beyond simple arithmetic without using cognitive-aids such as paper. In this case, the paper may be used to extend the internal working memory.

Like the register space of machine information processors, the human working memory is quite limited. Artifacts are used as a buffer to offload for short or long term durations or as a direct working surface. New theories recognize that it can be insightful to analyze the information processing to be occurring entirely on the artifact itself, as opposed to treating it a mere temporary store.

Norman emphasizes the importance of the system-level perspective in which the user using the artifact is also a part of the system. This is in contrast to the more classical model in which the user is outside the analytical boundary as he uses the system. Ed Hutchins et.al developed the theory of distributed cognition. While Norman's model expands the boundaries of cognitive boundaries, distributed cognition seems to take the next logical step by stepping almost entirely out of internal cognition. It also further expands the cognitive boundaries from personal cognition to emergent cognition of systems. Cognition is now described as a phenomenon that is distributed across individuals and artifacts. In informatics, Horsky et.al explored CPOE using a similar distributed resource model (Horsky et al. 2003). Hollan et al summarize the distribution as across social, physical and temporal dimensions.

a.) members of a social group
b.) between internal and external structures
c.) through time

They list its core principles as follows (Hollan et al. 2000):

a.) co-ordination of different structures
b.) co-ordination has costs
c.) off-loading cognition to environment
d.) social load balancing

Rogers describes it as an integrative approach: *"distributed cognition is a hybrid approach to studying all aspects of cognition, from a cognitive, social and organizational perspective"* (Rogers 1997). The theory has been applied to a number of complex settings such as air traffic control systems (Halverson 1995) and ship navigation (Hutchins 1995b). In clinical settings, it was notably applied in ICU and heart surgery settings (Hazlehurst et al. 2003b)(Hazlehurst et al. 2007)(Hazlehurst et al. 2004)(Hazlehurst et al. 2003a).

The common theme across these settings is that all these are complex systems that engage a variety of artifacts by a number of professionally diverse individuals. The literature on distributed cognition does not seem to suggest any restriction in applicability to any particular kind of activities.

Not only does Distributed Cognition focus on the study of the use of artifacts, it also cautions against an analytical dichotomy between individuals (actors) and the artifacts they use to support their cognition. Thus it differs from Norman's notion of artifact supported cognition with its emergent model that manifests over a system in which actors and artifacts are both subsumed as components, with no special directionality of interaction accommodated by the theory, lest it discriminate against the artifacts that are considered equal parties to the actor components.

I was unable to transcend this clear expectation and instead saw the need for a motive force for the cognitive engines that we model. In some tasks, the motive force may be provided

by the actors, especially creative and intellectual work. Professional work on the other hand is more structured and predictable and artifacts, through their states can more readily be seen as the instigators of events that effectively drive the actions human actors (Eg: In an assembly line, the worker responds to tool behavior). Human Computer Interactions distinguishes these as user-directed dialog (between user and system) vs. system-directed dialog systems (Sears & Jacko 2007).

Activity Theory

Activity theory cautions against the walls between individual, society, and historicity (this notion in part motivated the inclusion of the long preface narrating the historicity of the project). A key concept in Activity Theory is mediation (of action). Engeström considers mediation to be the key idea *"that breaks the Cartesian walls that isolate the individual mind from the culture and the society"*.(Engeström et al. 1999)

While the theories (DCog and AT) aim for similar goals and use similar holistic strategies with similar primitives, the language of Activity Theory stands in stark contrast to Distributed Cognition and other cognitive literature. The key introductions often introduced the theory in loaded descriptions, detailing the multiplicity of nuances associated with its practice and the subtlety needed for its application. It also draws heavily from philosophy and sociology and consequently, the language of these fields. It would be difficult to discuss the theory in its full native language and concerns. What follows is a simplified account of Activity Theory. The reader is referred to the excellent discussions by Engeström and Nardi (Engeström et al. 1999) (Engeström 2000) (Nardi 1996).

Activity Theory emerged from the works of Lev Vygotsky and Alexei Leont'ev. The core unit of Activity Theory is the activity. It stresses the participatory perspective of activity rather than as a disembodied action. It includes the person(s) *doing* the activity as well as any tools or other artifacts involved in the activity. In this sense, it is similar to distributed cognition in that cognition is conceived within the observable world and includes not just the human mind, but rather as an emergent phenomenon that is distributed across individuals and artifacts.

The emphasis on the dynamic aspect of this cognitive system differentiates Activity theory from distributed cognition, which is more structurally focused, relatively speaking. Actors and artifacts are less important in themselves. In activity theory, what is more important is what happens between them.

Activity Theory has strong philosophical foundations and draws from Soviet theoretical perspectives in philosophy, psychology and sociology. These perspectives in turn have roots in Marxist philosophy of dialectical materialism, which in turn has roots in Hegelian philosophy of the dialectic. This steady intellectual lineage of the focus on the process rather than things makes the dynamic aspects central to its theory.

Distributed Cognition takes great care to avoid human insinuations, perhaps as a reaction to the aftermath of Cartesian dualism i.e. excessively mind/human centric explanations of cognition. Activity Theory on the other hand fully embraces human-ness of cognition. Perhaps, it can be said that it rejects dualism and only dualism, not the intellectual aftermath. It goes further adding culture and situatedness.

A basic activity occurs between a subject and h/er focus, the object. However, most activities are typically mediated through artifacts in the environment and are termed mediated activities. Vygotsky represents simple mediated activity as a triangle with the three axes.

1. Subject
2. Object
3. Tool

The notational system is better developed in Activity Theory, with largely standard schemes. The diagrams only differed in detail, but not in the meta-model itself. No standard notational system is used in descriptions of Distributed Cognition.

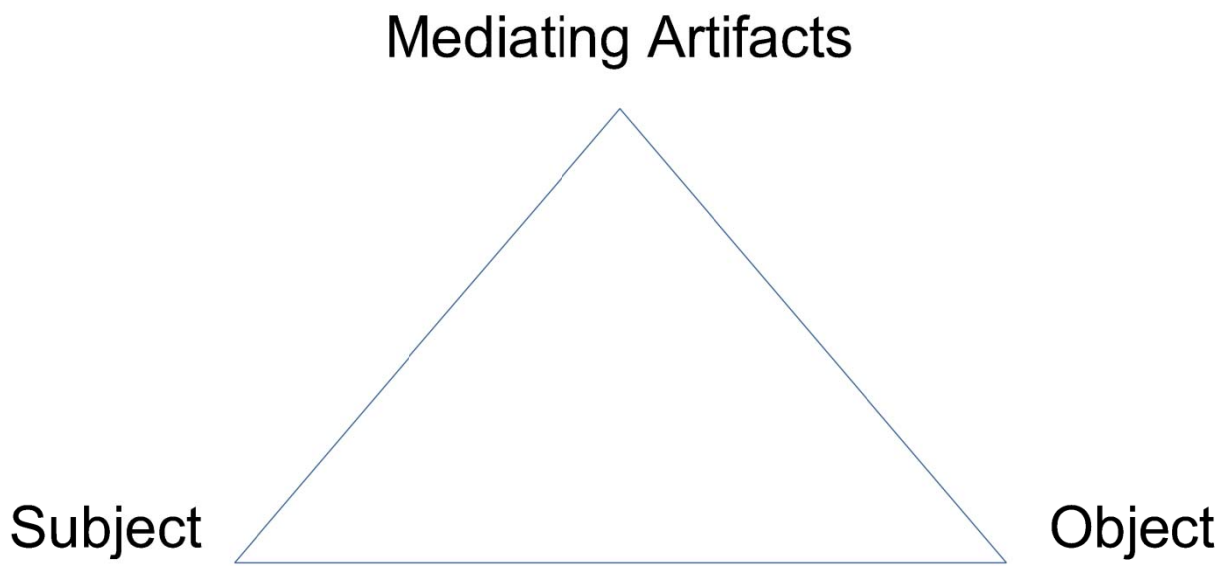


Figure 1.3: The basic scheme of mediated action. Subject focuses on the object through mediating artifacts.

Barab et.al illustrate this model with an instance of application in an astronomy course. The students use tools (3D modeling tools) to study astronomy. Their object is to study astronomy. However, the student's tool proficiency and the tool's inherent inconsistencies significantly alter the educational experience and outcomes. Likewise, the modeling tools must map to the object of the study well in order to be useful.(Barab et al. 2004)

Engeström expands the model by adding context elements namely

1. Rules
2. Community
3. Division of labor.

With the above example, the classroom rules and grade requirements, competitiveness and enthusiasm within the student body and how they take on larger projects and yet keep individual work manageable and equitable such that they all have more or less equal learning experience… all influence the educational experience.

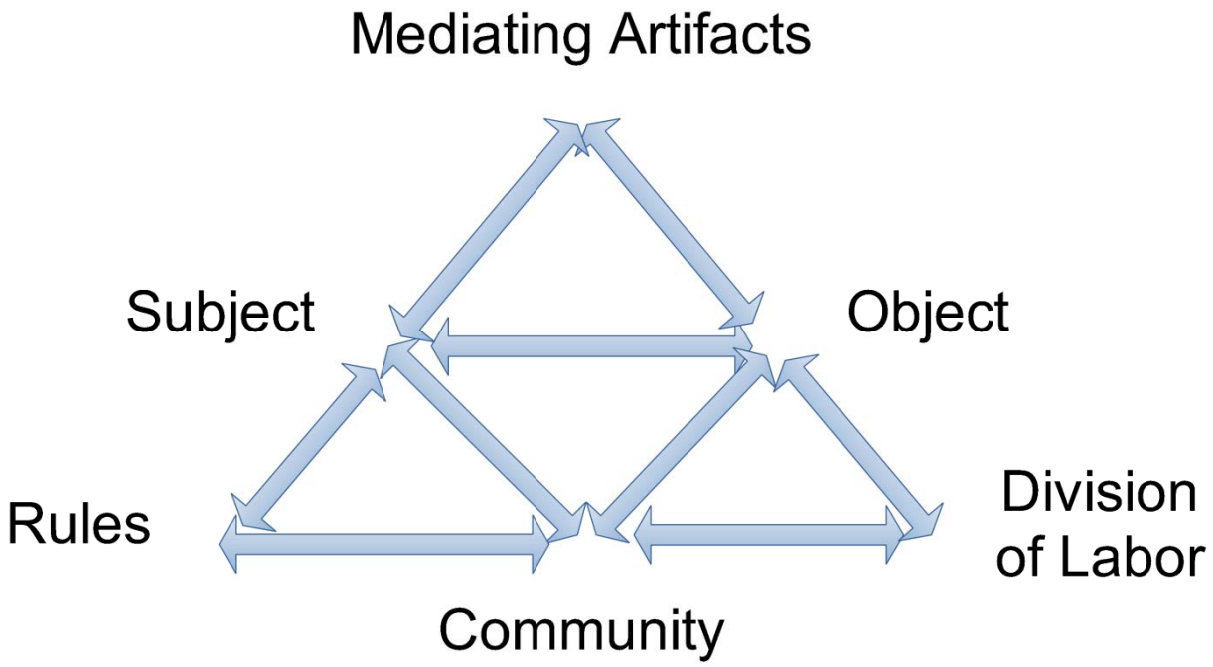


Figure 1.4: Engeström's expanded model of Activity Theory.

Activity theory has been widely applied. However, the key area of application seems to be in understanding learning settings which it well accommodated with its notions of historicity and participation. The key work in Distributed Cognition seems to be focused on understanding professional expert settings.

Medication Reconciliation

The present study focuses on medication reconciliation for two reasons. First, an ongoing, local, AHRQ-funded study of medication safety provided logistical support and convenience, with respect to mentorship, workload, travel, subject recruitment and scheduling. Second, medication reconciliation is a patient safety practice recommendation receiving great attention in health care systems and in clinical informatics, and is understood to be a cognitively demanding task..

Introducing Medication Reconciliation

One of the causes of medication errors is the problem of the prescribing clinicians not having full knowledge of the patients' medication profile. The problem of multiple medication lists arises as patients obtain care from multiple sources, each of which may document their respective treatments in independent medication lists. This fractured representation of the total medication profile makes it harder for clinicians to understand the full clinical picture of the patient. Without understanding the full medication picture, clinicians will be unable to identify drug interactions, duplicate orders and such.

Recently, much attention has been devoted to this problem and a standardized process, Medication Reconciliation has been mandated by the *Joint Commission on Accreditation of Healthcare Organizations (JCAHO)* to be employed during transitions in care, to resolve the discordance between lists. I will examine the problem, its roots and the proposed solution below.

Describing the problem

It might be assumed that care providers have an accurate picture of the medication status of their patients. However, this is often not the case. Hospital generated medical records are often incomplete. In one study in the Netherlands, Lau et al report that as many as 25% of

the prescription drugs in use are not recorded and 61% of all patients had one of more drugs that were not in the medical record (Lau et al. 2000).

Today, patients receive care from many sources. Doctors specializing in different sub-specialties treat different conditions of the patient.. Nurses, physical therapists and other skilled service providers address specific patient needs. Patients move from healthcare organization to healthcare organization as their needs or finances change. In this distributed care environment, it is more difficult to keep track of the patient's medication profile with a comprehensive and accurate list of current medications.

The medical chart is the common shared external representation that contains the knowledge pertinent to the patient's condition and treatments. However each institution maintains a separate chart that it creates for the patient as it delivers care. It is also a legal document that contains a record of the services offered to the patient. In the present circumstances, for organizational as well as technical reasons the chart is not portable. The physical limitations of the paper make it difficult to share the entire patient chart except by paper reproduction. An electronic chart potentially lends itself to sharing more conveniently. However because of varying adoption of the Electronic Medical Record (EMR) systems, a lack of a commonly employed data representation standard, and, importantly, organizational requirements and preferences of health systems, the electronic data is not shareable in practical terms today.

Each organization creates a discharge summary for the patient as he or she leaves the institution. This discharge summary is a concise representation of the patient's condition for which he has been admitted for in-patient services and enumerates the treatments that were provided for the patient. Not all patient conditions require institutionalization however. Many ailments simply require a visit to the doctor and a prescription that the patient gets filled in a pharmacy of his/her choice. Unless the patient is under a comprehensive health plan which can be expected to address all of patient's need, healthcare organizations do not have automatic access to medication lists so prescribed.

Currently, clinicians create medication histories, using patient interviews as the primary means of collecting this information. However, these interviews can be time intensive, especially in the elderly who take several medical as a norm. The patients cannot always be relied on to provide this information without a meticulous interview. For instance, patients do not regard some medicines, such as herbal compounds to be drugs and hence may not bring them up in an interview, unless specifically asked for. Nevertheless, these agents may have pharmacologically relevant properties. For example, garlic preparations can reduce anti-platelet function. The elderly, who may be suffering from cognitive decline, may forget to mention drugs when asked to list. They may not always know precisely what they are on either, remembering medicines only as *"heart pill"* or by their shape and color.

Not all clinicians are equally good at obtaining this information either. Physicians, who are often busy (and their time billed as more expensive), may not have enough time to conduct a meticulous interview for medical histories. Having a professional specifically assigned to this task was also suggested to reduce duplication of effort (Gordon et al. 2008). For these reasons, other professionals have been suggested for obtaining medication histories. Nurses, pharmacy technicians and pharmacists are considered the main alternatives. While the current nursing shortage in the US makes nurses a difficult choice, pharmacy technicians have been suggested a more cost effective alternative (Michels & Meisel 2003). Pharmacists are however considered the best option of these due to their domain knowledge advantage, cost not with-standing and had fewer errors than those collected by physicians (Hayes et al. 2007).

While physicians are aware of the incompleteness of medical histories, blanket orders such as *"resume all orders"* (after an operation or treatment of an acute episode) are not uncommon (Thompson 2005). Having an accurate picture of the patient's medication profile is intuitively critical to clinical decision making. There are several factors that contribute to both the need for generating an accurate medication profile as well as the complexity of the processes that address it.

Transitions in care are changes in setting, service, practitioner, or level of care (Ackley & Ladwig 2007). These typically include admissions, transfers and discharges. Transitions of care

are seen as both sources of medication errors, and consequently as opportunities to correct them and as many as 60% of medical errors have been reported to occur during these transitions (Rozich & Resar 2001). As we shall see later, JCAHO mandates are specifically targeted towards transitions.

Patients also complicate this picture by taking a number of medications on their own. Over the counter (OTC) medications do not appear in any clinically generated lists. These drugs may potentially interact with the hospital prescribed drugs. A common drug such as Aspirin could increase the effects of hypoglycemic agents, reduce the effectiveness of diuretics and reduce the renal excretion of certain toxic drugs such as Methotrexate and Digoxin.

However, in many cases, multi-drug regimens are a necessity, especially in the treatment of chronic conditions. Chronic care has become an important issue since the life expectancy rates have increased to magnitudes never before seen in human history. During the 20th century, life expectancy in US, which had already improved in health by then, rose by over 50%. As a comparison, it was just 25 yrs at the outset of the 18th century.

Chronic conditions are common in the elderly. In 2003, the population aged over 65 in the US was only about 15% (check). Yet this population accounted for a third of prescription medications and 40% of non-prescription medications (Werder and Preskorn, 2003).

Poly-pharmacy is a term that has been used to describe the practice of using multiple drugs in treatment. The term needs to be clarified before further discussion since it is associated with multiple applications. US usage of this word carries negative connotations by referring to inappropriate use of multiple medications. Fulton and Allen present the following definitions from literature (Fulton & Allen 2005).

1. Two or more drugs for 240 days or more (Veehof, Stewart, Haaijer-Ruskamp, & Meyboom-deJong, 2000)
2. Concurrent use of two or more drugs (Bjerrum, 1998),
3. Four or more (Bikowski, Ripsin, & Lorraine, 2001)

4. Five or more (Jo¨rgensen, Johansson, Kennerfalk, Wallendar, & Sva¨rdsudd, 2001; Linjakumpu et al., 2002)
5. Regular daily consumption of multiple medications as well as the use of high-risk medications and questionable dosing (Golden et al., 1999)
6. ‘‘Untoward iatrogenic sequela of the use of multiple, interacting medications’’ (Fillit et al.,1999)

The definitions are defined in terms of three axes – the number of drugs, the duration of such use and the clinical appropriateness. The authors observe that the European definitions were along the lines of number of medications used while the United States literature preferred to define along the lines of clinical appropriateness. These US authors unsurprisingly favor the later. The same definition will be used in the later discussion in this document.

Fillet et al. conducted a medication review in over a thousand patients with an identified risk of poly-pharmacy. As many as 35% of drugs were discontinued from this dataset, after a review conducted by physicians.

Proposed Solution

With all these concerns, it appears to make intuitive sense to create a definitive medication list for the patient from time to time. This process was termed as medication reconciliation. It is a process of creating the most current, complete and accurate list of patient’s medication.

Medication Reconciliation Challenges

While the notion of medication reconciliation has face validity, it is not without cost. Currently medication reconciliation is a pain-staking task. Electronic systems have shown promise in enhancing productivity. To assist with this process, Columbus Regional Hospital in Columbus, Indiana implemented an electronic reconciliation system (Groeschen 2007). The system reduced the reduced the number of steps that needed to be performed, from 42 steps

taken with the previous system to 7 steps in the new system. It also reduced the percentage of individual medications that were not reconciled, from 45.8% to 2.4%. The hospital lists the current process steps as follows.

- The nurse interviews each admitted patient at his or her bedside and enters the home medications and allergies into the electronic chart.
- The nurse prints two copies of the report with home medications and allergies; one copy is used by the physician for medication reconciliation at admission, and the other is used at discharge.
- The physician documents on the printed report whether to continue, hold, or discontinue each home medication as each patient is admitted to the hospital and, if necessary, writes orders for new medications; this marked-up copy is then scanned and included in the patient's electronic chart.
- If a patient is transferred to another area in the hospital, the nurse prints a report of the patient's home medications and current hospital medications and marks the report with a stamp to indicate the patient is being transferred.
- Before transfer of the patient, the transferring physician documents on the printed and stamped report whether to continue, hold, or discontinue each medication. This copy is scanned and inserted into the patient's electronic chart.
- The discharging physician documents on the printed reports of home medications and current hospital medications whether to continue or discontinue each medication; these marked-up reports are scanned and inserted into the patient's electronic chart.
- At discharge, the nurse updates the patient's medication list according to the physician's discharge orders and updates the home medication list to reflect any changes that were made during the patient's hospital stay. The patient is then provided a copy of the updated report at discharge, which serves as the new home medication list.

Medication Reconciliation is a relatively new term, coined circa 2004 (Barnsteiner 2005). However, the central theme of medication reconciliation, *"What is the patient on?"* is not novel to clinical practice. Rather, we are amidst a gradual move towards appreciating its significance and systematizing the process involved.

Appropriately, medication reconciliation is recommended to be an ongoing process just as the evolution of state of the patient is an ongoing process. Along these intuitive lines, it can also be argued that we need to understand how things stand with the implementation of medication reconciliation in care settings. The findings from such a study would give us feedback about the outcomes of our process modifications. Understanding the setting would also better inform us to enable creation of more optimal processes.

Pilot

Based on the literature review, the first foray was made into the setting to study the cognitive factors in an instance of a medication safety practice with a goal of creating a cognitive model of the task, enumerating the cognitive artifacts involved in the process, and describing their properties and purpose. The models that created these insights were expected to reconcile cognitive theory and actual field data, in order to inform the creation of informational tools that can improve the task performance of medication reconciliation.

The task was hypothesized, before the field observations, as a list management task. The clinician takes two or more lists of medications and checks for them for duplications, discontinued medications, changes in usage etc to create a final consolidated list that is accurate at that point of time.

A geriatric rehabilitation center was identified as the first target. The rehabilitation center has patients moving in and out, as their clinical condition changed. The medications would have changed in the interim and a consolidation of medications would be required after these transitions. When approached, the rehabilitation center confirmed the existence of such

a process that they simply called *recap*. However, the first day observation made it immediately clear that the task was much different from the one expected.

Paraphrasing General Colin Powell's quote *"No battle plan survives contact with the enemy" – Few pre-experimental models survive contact with data* captures the experiences here.

The recap task occurred neither in isolation nor was found to be a list-management task. Instead it was clear that it was situated in a broader goal of patient safety and intertwined inexplicably. While there was an opportunity to reframe the task and continue observation, an even more interesting phenomenon surfaced. Unlike medication reconciliation in literature, medication reconciliation, as understood by these clinicians was found to loosely refer to a broader set of medication safety tasks that both prevented as well as corrected error, were mediated by a variety of clinicians, each with their own unique contributions, examining different aspects of safety, at different stages of health care.

This integrated model of medication safety was not described in the literature and it was clear that it is this contribution that the current project could make. The research question was reformulated. Unlike the earlier proposal, the project no longer assumed a well established clinical task, but rather into to describe the existing tasks. These tasks would still be described, analyzed and modeled. However, since the scope of the project has considerably increased given that several tasks will be observed rather than a single task meticulously, the intervention component was removed.

Problem Statement

We can summarize the following from the discussion above. Medication safety has significant outcomes in healthcare. Yet, medication management practices are not properly understood. With a goal to improve the quality of healthcare, we aim to change the medication management practices, for the better. However, we know from past experiences, that a drive for change does not necessarily guarantee positive outcomes. There is much that needs to be

understood about what exactly medication safety practice means today to clinicians on the ground. One way to develop this understanding is to create a descriptive model of the medication management practices as they exist today.

Since the practices are currently cognitively driven, special emphasis will be placed on these factors. The goal is to produce a document that will both inform the system architects who need to understand where their specific interventions fit in the larger scheme of medication management, as well as the user interface designers who will influence the actual tasks that get performed towards these goals.

Research Questions

1. What are the different medication management practices in long term geriatric care with respect to the kinds of errors that they prevent?
    - The pilot observations suggested that clinicians perform several safety tasks to ensure that proper treatment was being provided. This question attempts to explore these tasks more completely, including:
        - What are the kinds of errors that the clinician is trying to prevent?
        - What are the information inputs and outputs used for the task?
2. How do clinicians who perform these tasks use artifacts and communicate with others? Since cognitive behaviors are given a special focus in this study and the theory of distributed cognition is taken up as the preferred model of cognition, special attention is paid to
    - Representations of information.
    - Transformations of representations to support a task.
    - Use of tools and artifacts, especially manipulation of artifacts that offer insights about underlying phenomena.
    - Environmental factors such as distractions, workspace organization etc.
    - Social interactions: eavesdropping, non-verbal communication etc.
3. What are the implications for improving task performance?

Chapter Two: Methods

Goals

The goal of the study is to understand the various medication safety tasks in practice. While it is tempting to see this as an opportunity for Task analysis, it is not so in this case. Task analysis often entails a detailed exploration of usually a single well defined task. However, our current understanding of medication safety tasks is below this threshold. First, the diverse distribution of medication safety tasks needs to be discovered. Later on, each task may be explored more meticulously using specific task analysis methods. For now, task discovery, rather than task analysis, is in order.

Since the nature of the tasks to be discovered is not known a priori, the method used to discover them must afford considerable freedom to adapt to circumstances on the fly; rather than be defined in stone ahead of time. Naturalistic observations are ideally suited for this task.

As an exploratory study concerning an enumeration of task types, the project will be a hypothesis generating study, not a hypothesis testing study. This entails that variability across samples be embraced rather than eschewed...

The approach should also be cognitively focused. Also, expert tasks become progressively more and more cognitively complex. This is because technology introduced into workflows automates repetitive aspects of the task; leaving behind creative, infrequent and fuzzy components of the task. In an automation assisted workplace, productivity may increase (assuming successful application of technology); often without making the tasks of the human agents any simpler (Woods 1996).

It should also take into account the tools that humans use to perform the task. After all, our ability to impact human cognition is limited and expensive, but our ability to impact tools is significant and more affordable. Finally, the method must take an integrative approach to all of the above.

The more conventional Cognitive Task Analysis (CTA) methods focus on the cognitive processes within the mind in isolation and consequently, do not offer an integrative framework for considering the environment around the human subject.

Experts in work settings do not function in isolation. They function cooperatively with other experts – from both their own discipline as well as others, to complete the tasks. A method that accommodates the discovery of this distributed cognition would also be welcome.

However, distributed cognition methodologies and frameworks currently do not specify standard methods. The experts in DCog lament that an integrated program for research had not yet been assembled (Hollan et al. 2000). This may simply be due to the essential complexity of the problem domain under consideration and the young age of the discipline than anything else.

Study Setting and Sampling

A representative selection of sites that provide long term care was chosen, using a combination of purposive and convenience sampling methods. The goal of the study was to observe as many uniquely different sites as possible. The study was conducted in the context of ongoing research into medication management in long term care,. Sites were then identified using snowball sampling method to identify likely candidates for additional observations (discussed later) through subjects' familiarity with other sites and processes.

Photo 2.1: Residential district for Home Health observation, coastal Oregon.

Sites

Samaritan North Lincoln Hospital

Samaritan North Lincoln Hospital (SNLH) is a JCAHO accredited non-profit facility, operated by Samaritan Health Services for the local rural health district. It is located on a 24 acre campus on Devil's Lake in Lincoln City and has been operational since 1967. The organization also operates 4 local medical clinics and a retirement and assisted living facility near the main hospital. SNLH is manned by a medical staff of independent and employed

physicians, and employs trained an array of health professionals including nurses, pharmacists, radiology technicians, physical therapists, nutrition consultants. The hospital also draws on the services of consulting physician specialists from larger cities who hold clinics at Samaritan North Lincoln Hospital on a periodic basis.

Lincoln City Rehabilitation Center

Lincoln City Rehabilitation Center is a skilled nursing facility that provides long term care services including rehabilitative therapy programs and community outreach services. It serves about 40 most of them covered by Medicare and Medicaid.

Senior Pharmacy

Senior Pharmacy, founded in 2000, specializes in providing medications and services for long term care and is located in Eugene. Senior employs 44 pharmacists, technicians, and administrative staff, with annual sales of $10.4 million. Its pharmacists travel, often on monthly intervals and provide various consulting services to rehabilitation centers and hospices.

Hillshire House

Hillshire house is an assisted living center providing supportive care and services for long term residents in varying degrees of independence, often on Medicare and Medicaid plans. When the patients develop acute conditions, they are moved to hospital or skilled nursing care, then returned when their condition stabilizes. Like other such facilities, costs are lower than skilled nursing facilities, and personnel tend to be young, low wage helpers who assist in chronic care. of the staff is minimally trained clinically and needs to be supervised for clinical work such as medication related tasks. They rely on the services of consulting nurses from SNLH to provide expert help.

Subjects

The exploratory, descriptive aims of this study are best served by sampling a range of experts performing a variety of related tasks in varying settings, which collectively represent a rich spectrum of medication management activities. Snowball sampling, a familiar sampling methodology was used to take advantage of each subjects' knowledge to identify additional subjects for study. (Goodman 1961). The population of, clinicians who perform medication reconciliation is rather large. Current JCAHO and other recommendations point to pharmacists, physicians, or nurses in in-patient settings. These categories provide a seeding sample. However, other subjects were suspected to be hidden in healthcare performing the reconciliation and other analogous tasks.

Data Collection

Naturalistic Observations

Naturalistic Observations are observations undertaken by the researcher in the subject's natural environment. This style of observation distinguishes itself from laboratory observations where the subjects activities are observed in a well focused (to the research question) but otherwise artificial setting. While naturalistic observations provide for a broader understanding, laboratory observations tend to provide meticulous details about a selected aspect of the activity. The current study is explorative. Hence naturalistic observations were chosen.

Naturalistic observations are similar to ethnographic studies in that both emphasize the natural setting. In qualitative research, the *Emic* perspective refers to the insider's perspective, while the *Etic* perspective refers to the outsider's perspective. Gathering the emic perspectives requires that the researcher fully immerse himself in the activity along with the subject. However, naturalistic observations differ in that they do not involve the extensive immersion that the ethnographer goes through to get at the *Emic*, rather than the *Etic* perspective.

Naturalistic Observations have a special place in clinical informatics research. Both the researchers and subjects come from a variety of backgrounds and settings. It is therefore important for the researchers to not make unwarranted assumptions about their subject's work conditions. Such precaution is especially important in this study. The subjects are expected to work in not just unfamiliar settings (to the researcher) but a variety of unfamiliar settings. Taking note of the unique characteristics of each of these settings is critical to gain a comprehensive understanding of the subject's task.

Naturalistic observations provide an opportunity to observe the subject in a (professionally) social setting as s/he works with other professionals. They provide an opportunity to observe and collect or record the natural artifacts in the setting. The deliverables from this method will consist of a narrative that includes these factors. However, observations are not perfect. A common concern is whether the subject during observations is behaving in the same way as when there is no researcher present, often referred to as the Hawthorne effect. In a hypothetical case, the subject may feel embarrassed to consult some knowledge resources that s/he might otherwise consult if she were to feel concerned about being judged by the researcher on competence. While these effects cannot be fully be eliminated, they may certainly be minimized by taking the subject into confidence, providing assurances of privacy and developing an amicable relationship in the early parts of the session.

Verbal Protocols

Naturalistic observations can only provide an incomplete knowledge of the task. Only those cognitive behaviors that involve external artifacts may be recorded using observations. While it is possible to draw some inferences on the internal cognitive processes of the subject through these artifact manipulations, without further examination, they are constrained by the effectiveness of interpretation on part of the researcher.

Verbal protocols give a closer look at these internal cognitive processes. Verbal protocols are the verbalizations made by the subject, on the task, as s/he performs the task. The subject is often asked to *think-aloud* as they perform the task. Or specific questions may be

directed about the task. The key is the immediacy of data collection in relation to the task. This ensures that the subject retrieves information from the short term memory rather than long term memory; where it might have been altered. The subject may simply forget much of the details if the subject was asked for information at a longer duration. In fact, much of the insights of observation studies come from the researcher's unique interpretation of events that appear to be banal through the subject's interpretation, which the subject is likely to skip over in describing tasks.

The information provided still may not be considered a transparent proxy that holds perfect correlation to the internal cognitive processes. It must be remembered that the narrative is still the subject's interpretation and is verbalized through a language affected by past cultural influences. Nevertheless, verbal protocols form an important component of task description techniques. Their reliability increases when the findings are corroborated with data collected from other methods such as observations.

Interviews

Interviews were conducted along with every observation. With the exception of one case (physician), all the interviews were conducted during the course of observations. The subjects were largely uninterrupted during the task. However, it became important to interrupt the subjects from time to time and clarify what they were doing (intent, internal structure of the task etc). This was typically not left to the end of the observations in order to take advantage of the freshness of task context in the memories of the subject as well as the investigator. The format of the interview was unstructured other than the obvious focus on the task. This was essential, given the exploratory nature of the study where items of interest simply cannot be pre-conceived.

Analysis

A framework of distributed cognition guides the analysis. While the framework classically eschews focus on a human actor and is more commonly applied to collaborative

tasks – usually but not necessarily local, the subjects in the current setting largely perform their tasks alone and only peripherally interact with other human actors. However, the model of distributed cognition still holds well as the subjects are seen as information components of a larger system, and interact with the environment to augment their internal cognitive faculties.

A constructivist approach was used. The researcher, as a learner, constructs knowledge from the data. There is no guarantee that such knowledge, constructed by two different researchers will exactly be the same, since the two researchers will in turn differ as information processing entities by virtue of differences in experiences, knowledge and several other factors. Thus it is not an attempt to discover truth in the positivistic sense, but rather to gain insight that can support sense making and hopefully theory- building. Much of the analysis will happen during the observations itself and the conclusions will be confirmed during intervening interviews, in an iterative, member checking process.

The field notes were later organized and structured using a generic task analysis template that addressed key items such as subject characteristics, task characteristics such as task environment, goals, tools and other information artifacts. Insights from the observations were listed and coded with a fixed naming scheme as follows:

(Subject abbreviation: Observation abbreviation)

This coding syntax was chosen to allow the observations to be re-ordered (non-ordinal) when logical grouping made sense and to recall the observation (nominal) without needing to cross check often. The analysis was first conducted on a setting by setting basis and later generalized across settings.

Chapter Three:

Observations

Residential Care Manager – Recap

Identifying the task

When the facility was asked whether they follow any distinct procedures to ensure medication safety they listed two tasks. The first was a task they called *recap* that was performed by the residential care managers. The second task was performed by a consulting pharmacist and was called *medication review.*

Setting

The facility was a skilled nursing facility providing geriatric long term care. According to the subjects, skilled nursing facilities differ from unskilled facilities in terms of the nursing resources they have available, both in terms of the number of nurses employed, as well as the training of the nurses, enabling them to provide more advanced nursing services. Skilled nursing facilities are also governed by a different set of federal regulations. This results in a different level of safety and in different documentation requirements.

Subjects

There were two Residential Care Managers (RCMs) employed in this facility and observed for this study An RCM is a Registered Nurse who provides oversight of nursing care in a skilled nursing facility. They equally divided the 40 residents present in the facility into two groups of 20 each. 9 of the 20 residents that were reviewed by the subject RCM availed skilled nursing services. The charts of these residents were grouped separately.

Two RCMs were observed over the course of three days in order to understand the recap task. The observation of the first residential care manager was critical in the sense that it fundamentally altered the nature of the study. While the initial intent had been to conduct a user centric design process, initial observations led to a much richer descriptive study since the task observed did not appear to match the 'medication reconciliation' process that was expected. The observation of the second subject helped in consolidating concepts and processes. For this reason, the observations will be presented as that of the first RCM since the

later subject observations mostly repeat the former. A few differences were however noticed. These will be mentioned at appropriate sections.

Goals

The subject stated goal was as follows. First, she wants to make sure that the orders on the new Medication Administration Records (MARs), a document used to track the administration of medications (and performance of other tasks) were accurate. Second, she would like to see that there are precautions in place to keep residents safe, and third, to recapitulate the care that has been provided to the residents during the last month.

Secondary goals

The recap task is not a formally specified task i.e. the task is performed with local variations. The RCM provides further goals when probed after the above activities have been encountered during observation.

The first goal is to know the medications that the patient is on. This is not limited to simply knowing the name of the medication but also about knowing what it is for. Generally, most of the medications will be familiar to the RCM, given her experience (RCM's are almost always experienced nurses). In the event that the RCM does not know a particular medication, she will look it up. She does not however need to know everything about it. She does not need to check the correctness of the dosage (although she will do that implicitly when dealing with family of medications) or look for drug interactions. But she does intend to know the reason why a particular medication is being given.

The second goal, as articulated by her, is to ensure that the drugs match the problems is perhaps an extension of the first. Both these goals are concerned with ensuring that the data is meaningful.

The third goal is to ensure that the MARs are easy for the med-aides to understand. Even a new med-aide should be able to simply *"walk-in and read"* the MAR, and understand what each individual resident needs from the detailed instructions of administration.

Environment

The two subjects worked in somewhat different settings. The first worked in a common room with other nurses. Notably the room had all the patient charts in shelves. The second subject worked in her own room. Despite the differences in locations, both the subjects demonstrated similar task characteristics. Both took steps to not be disturbed during the task by other nurses (see rcm: interruption-avoidance later).

Photo 3.1: The workspace of the second RCM. The arrows show the flow of documents

1 – MARs and TARs to be attended

2 – New MAR and TAR forms

3 – Completed MARs and TARs

Photo 3.2: The workspace of the second RCM. The arrows show the flow of documents

The facility uses a combination of electronic and paper based medical records. However, since the electronic system is used to print the Medication Administration Record (MAR) that is used by the nurses to document care, they interact with it indirectly. The employee who managed the electronic system came into the room from time to time to pick up charts and return them. The subject took this opportunity to pose questions to her with regard to potential discrepancies.

Task (rcm: holistic)

The RCMs primarily reviewed the nursing documentation (orders and administration documentation) to ensure that proper care is being delivered. However, the nursing

documentation was reviewed in context of the rest of the patient chart i.e. the RCM would flip through the chart to improve her understanding when discordances were encountered. This task as a whole is a comprehensive review of the patient chart and is performed monthly (typically in the last few days of the month). The subjects called the task *"Recap"*; and as the name suggests, this task is concerned with the **recapitulation** of recent patient care.

The RCM describes her task as ensuring that the care ordered for the patient is properly being delivered. Broadly speaking, the RCM compares the new MAR with the previous MAR and other information in the Patient chart. Comparing it with the old MAR helps her identify the changes in the treatment. She compares the changes in the new MAR with other information in the chart (orders, treatment notes etc) to ensure correspondence of information. She also examines the documenting entries made by the nurses and med-aides in the old MAR to ensure that the care is being delivered as ordered.

Tools

The tools consisted of documents and annotation tools.

Documents

While any component of the patient chart may contribute the documents necessary for the task, she primarily focuses on MARs (Medication Administration Record), TARs (Treatment Administration Record) and Injection Sheets. While these are the documents under review, the work itself is performed on a freshly-printed, empty, up-to-date MAR created by the medical records department. This form is printed from a computer system that has been updated with new entries that have been entered onto the ongoing MAR. The entries themselves are generally added from the physician orders which in turn, come in as transcribed phone orders and fax orders that get signed off at the next physician visit or by direct orders created during the visits.

MAR

The MAR is the worksheet for nurses, composed in a tabular, spreadsheet-like format. It is generated for every patient on admission and the beginning of every month, by the medical

records department. The MAR is a tabular sheet that contains recurring medications and procedures on the vertical axis and the dates of the month on the horizontal axis. This allows the nurses to use this as a checklist for the medicines and treatments that they have to provide. It is also a documentation system. After administering medications, the nurses enter their initials in the cell corresponding to a specific medication on a specific date.

Injection Sheet

Medications administered by injections are recorded separately in this form.

TAR

A TAR is identical to a MAR except that it records treatment procedures rather than medications.

Wound Care

Documentation for treatment procedures and wound management are managed on separate forms.

Annotation tools

Ball point pens and highlighters were used as annotation tools.

Process

Batch task (rcm: batch)

The Recap task is a batch task in the sense that several records are examined at once. As with the other batch tasks observed (pharmacist, pharmacy assistant) the subjects preferred to not be disturbed. Clinical batch tasks are repetitive information manipulation tasks (second RCM referring to the need for repeated signatures - "*By the time I am done, I hate my name*").

There were still distractions despite this. During the first observation, a patient with dementia wandered into the room. The subject got up, gave him a snack from the refrigerator, and sent him away. The staff nurses had a few essential questions from time to time for the first RCM subject, and she herself had a few questions for the employee in charge of medical

charts (who has created the forms that the Recap was being performed on), who happened to come in from time to time.

Interruption-avoidance (rcm: interruption-avoidance)

Despite the occasionally observed interruptions, these batch tasks were largely solitary tasks. Many clinical environments have been described to be interruption-rich, and even interruption-driven(Brixey et al. 2007b) (Grundgeiger & Sanderson 2009) (Brixey et al. 2005) (Brixey et al. 2007a). The recap tasks seem to represent the just the opposite class of tasks – solitary and interruption-avoiding. The first subject joked that the other nurses found her to be *cranky* on the recap days and stayed away from her. The second subject RCM turned down a staff nurse's request to take a look at some documents since she was busy on recap days. The other nurse found the reason familiar. She also worked with the doors closed so that she may focus better. This was despite the fact that the small room tended to get very warm due to this.

Preparatory configuration

There is a distinct stage of preparation that precedes the recap task (or may be considered the first stage of the task). This stage has been discussed in a distributed cognition literature as a stage of preparatory configuration (Gorman et al. 2000) (Hazlehurst et al. 2003a) (Hazlehurst et al. 2007). It consists of the subject(s) configuring the workspace with the necessary artifacts (writing tools, files and other document stacks) in specific spatial arrangement, in order to promote productivity i.e. making it more ergonomically optimal and for safety i.e. setting it up so that mistakes are less likely to happen.

The RCMs' preparatory activities are often driven by the affordances and constraints of the representational mediums and tools. Subjects configure the workspace to maximally productive configurations that they can conceive. Any number of other factors such as environment, cultural factors may play a role. For instance, a small desk will influence the layout of papers and certain documents may be regarded as secure information and may not be always available.

Paper is the primary representational medium in this task. Since the document resources are locked by the RCM during the task, the task needs to be performed such that the inevitable unavailability for other staff nurses needs to be predictable (i.e. performed at approximately fixed time of the month), without taking longer than necessary and at a time when new errors may just have been introduced (i.e. when new forms printed at the end of the month). The recapitulation task is a long task, taking 1 to 2 days to complete. The patient charts are the primary information resources in this task.

This need for concurrent availability was met differently by the two subjects. The first RCM located herself in the chart room and worked directly with the charts so that only one chart is locked at a time (cf: record level locking in transactional databases). The documents that she needs for this task are also the documents that the other nurses might simultaneously need since the documents in question are still considered live documents (as opposed to archival documents). The other subject worked primarily on the copies of an essential subset of documents (MARs, TARs and Injection Sheets) and did not run into resource locking concerns (cf: pass by value in programming).

Each had its own advantages and disadvantages. The first approach offered a broader availability of information when questions of coherency arose. The later permitted a much more focused and uninterrupted task. During interruptions, the subject placed her arm on the chart. She explained that this prevented the chart from being taken away while she was not looking. Such subtle cues point to the process of artifact sharing (much like resource sharing and synchronization in multi-threaded application). This enables the first RCM to safely make changes to the record itself. The first RCM added different kinds of information helpful to the CNAs (later discussed as propagation of coherence). On the other hand, the second RCM used copies and did not make similar changes to the chart. Although, both the RCMs performed the *recap* task, there were subtle, but significant differences between them.

As we shall see later, the Pharmacist would be unable to work without the chart. The RCMs are aware of patient context from their local presence and experience on site, while the

visiting Pharmacist who consults several facilities would be less familiar and have greater need for the chart. This makes the RCMs less dependent on documentation to create meaning.

In an excellent instance of preparatory configuration, before she began her task, the second subject arranged the MARs, TARs and Injection Sheets in binders, as orderly as possible with each set of documents is organized in the same order of patients, who in turn are organized by room numbers. This prior resulted in a more homogeneous artifact flow.

Photo 3.3: A clinician working through information organized as bundles. This organization helps us understand her logical categories of the information representations being used in the task.

Is it has to be noted here that the documents are bound by document type, not by patient. This is a representational transformation that is not immediately apparent. It is quite possible that even if it is possible for the RCM to have full access to the patient chart, she would still benefit from organizing them in this way. She was able to simultaneously view each of

these documents for the given patient without having to flip back and forth (Gorman et al. 2000).

Document flow

To fully understand the information and artifact context within which the RCM performs her task, the overarching documentation process as a whole must be understood.

Physicians provide orders in a number of ways. While visiting at the facility, they provide orders directly. More often, physicians provide orders while they are away, based on the messages that the nurses provide. These orders are transmitted either as telephone orders or fax orders. A telephone order is transcribed using a relevant form by the nurse receiving the phone call. This is subsequently signed off by the physician at the next visit. Interestingly, these telephone order slips are used for other purposes by the nurses as we shall see later. The medical records department records these orders.

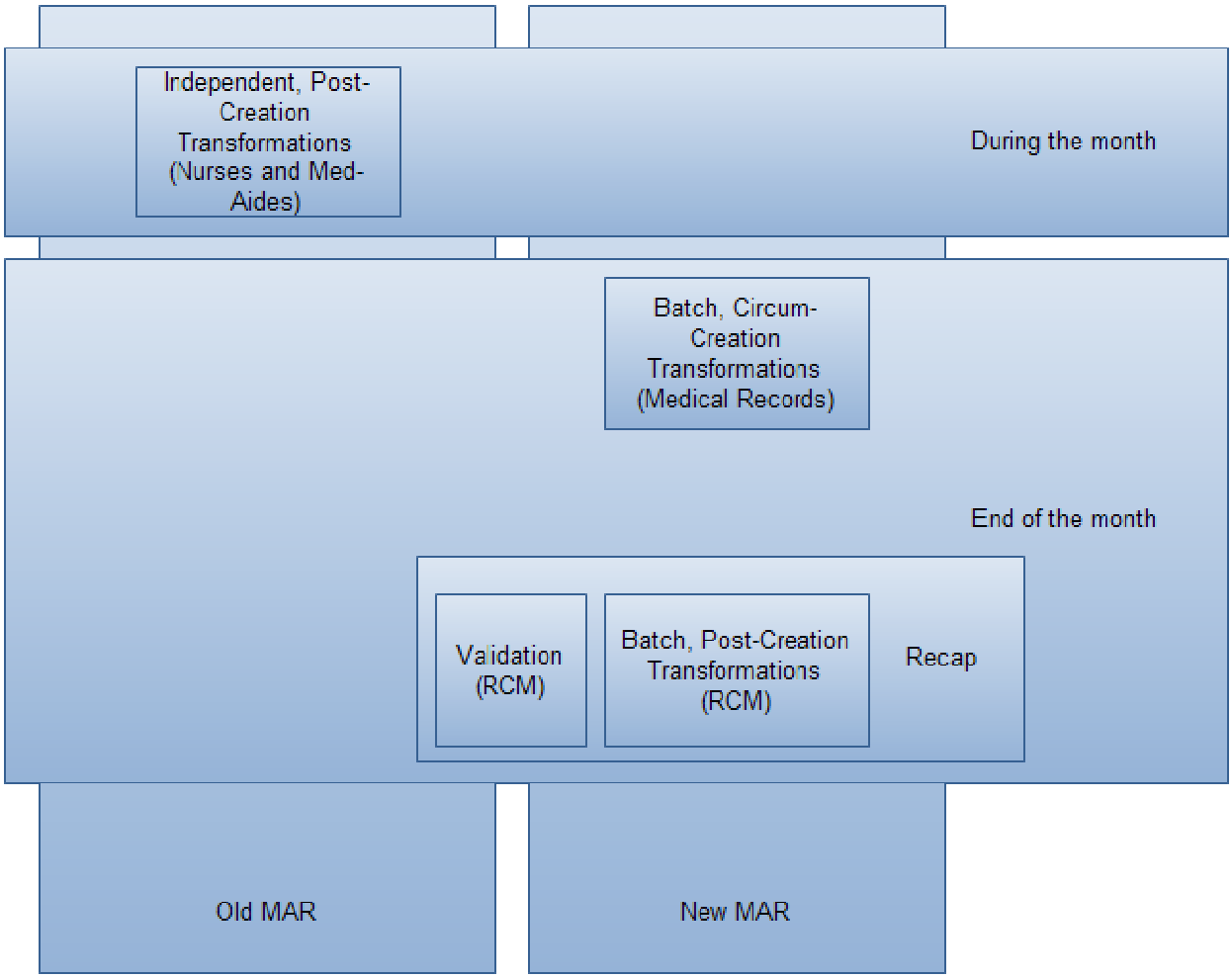


Figure 3.1: The information flow through the documentation.

These administration record forms are printed at the beginning of the month. However, since the orders change the medications and treatments during the course of the month, the changes are handled as annotation on the ongoing sheets. In the end of the month, the medical records department creates a new MAR based on the changes during the month.

Recap

The RCM is tasked with ensuring that the new MAR is consistent and adequate. However, this is only the part of the picture. It addresses only the first goal.

The structure of the administration records is primarily intended to serve the purposes of the nurses including the nursing assistants (CNA) that the facility hires from a contracting

agency. Even when the care is being provided by the nurses within the facility, the same nurse may not consistently be assigned to a patient due to logistical issues. As a result, the CNAs may not know everything that is taking place in the care of the patient. To use a computer science metaphor, specifically a web request processing analogy, care is provided in the stateless context for scalability reasons since this simplifies the task and therefore may be assigned to a commoditized (units with well-defined skill set that may be added as needed) employee resource. This model further exaggerated when the CNA is involved. Since the CNA's are contractually hired from outside, they are likely to have a less comprehensive understanding of the patient. In other words, care will have to be provided by those who may not have the complete patient care context.

Patient context is relevant for the nurses while performing routine tasks. For instance, if the patient has difficulty in swallowing, the tablet must not be administered in full. Physician orders do not provide the operationalization details. It is the nurses' responsibility to work those things out.

The RCM informs that the physician's office keeps a separate patient chart. However, physicians may not always have the patient chart in front of them as they provide telephone orders. While the physician discusses the patient's condition with the nurse, this may allow for some errors.

Artifacts and Annotation

This brings us to the goals to two and three. The RCM attempts to ensure that the nurses and CNA's are less likely to make errors. Additional information about giving the medication will not be present in the order. She will add it to the MAR. She is also familiar with common errors with reading and recording on the MAR. She tries to ensure that these are less likely to happen using special annotations. For example RCM may add specific times at which a medication should be administered, though the order only notes the number of times per day that it should be administered (Photo 3.4). The RCM uses different strategies for this. By default, she simply calculates them along the lines of even time spacing between dosings, and to align them with scheduled medication rounds. Further, she may need to adjust it based on

known aspects of the patient such as h/er bed-time, meal-times, effect of medication (precise timing is much more important for insulin than a vitamin supplement), impact of the medication on sleep etc.

Use of color (rcm: color)

Different colored paper is used for different types of information. The RCMs noted that this varied by facility. The following is the list of colors used.

- Injection sheet - Pink
- MAR - Blue
- Treatment sheets - Green
- Coumadin – Orange

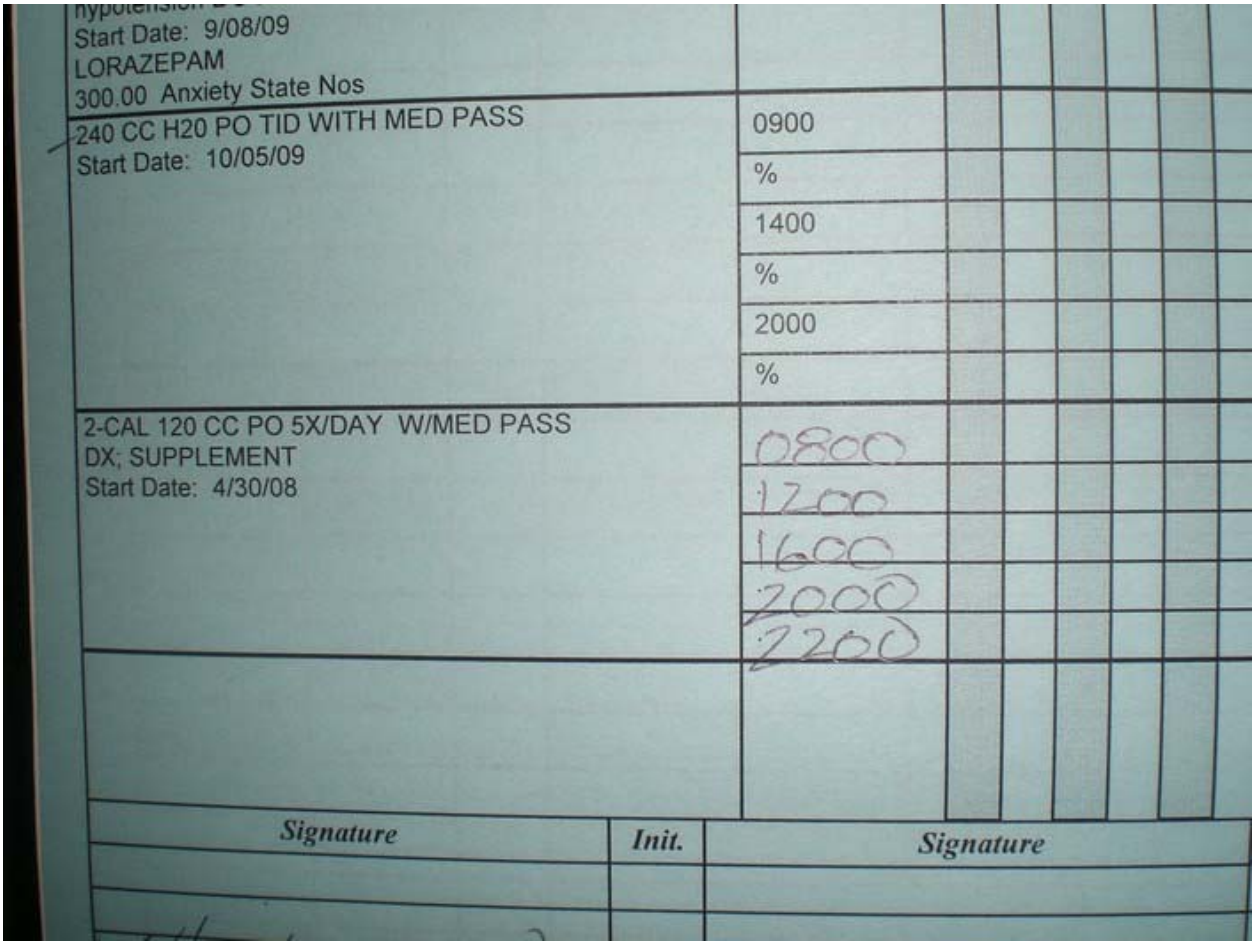


Photo 3.4: The RCM adds specific times at which the drug should be administered.

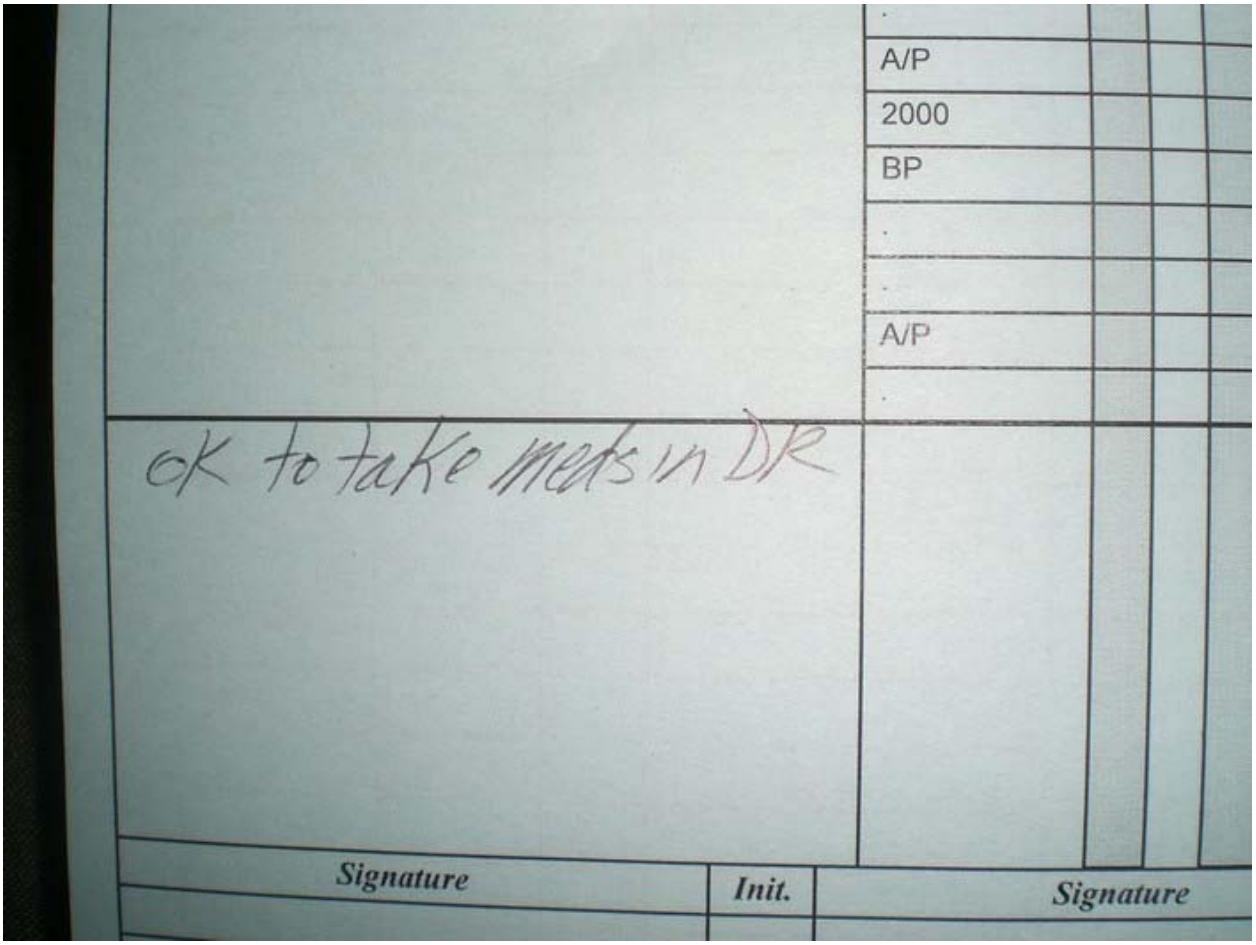


Photo 3.5: Transferring the approval of the physician that medications may be taken in the dinner room, into an actionable location (i.e. the approval note placed in the chart will not be seen by the person admininstering the medications. But placing this information in a place guaranteed to be seen by that person, and at the time of administration ensures action).

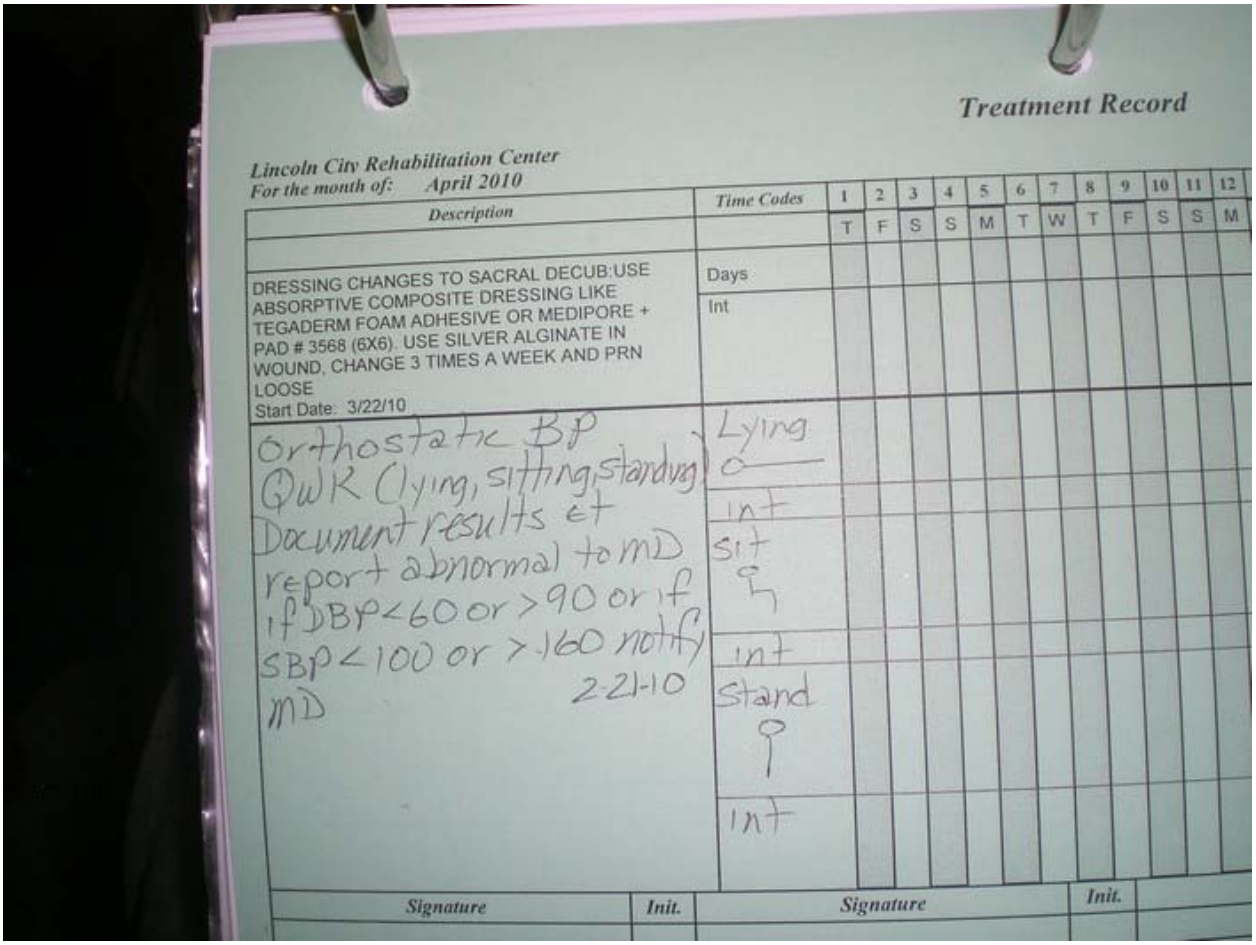
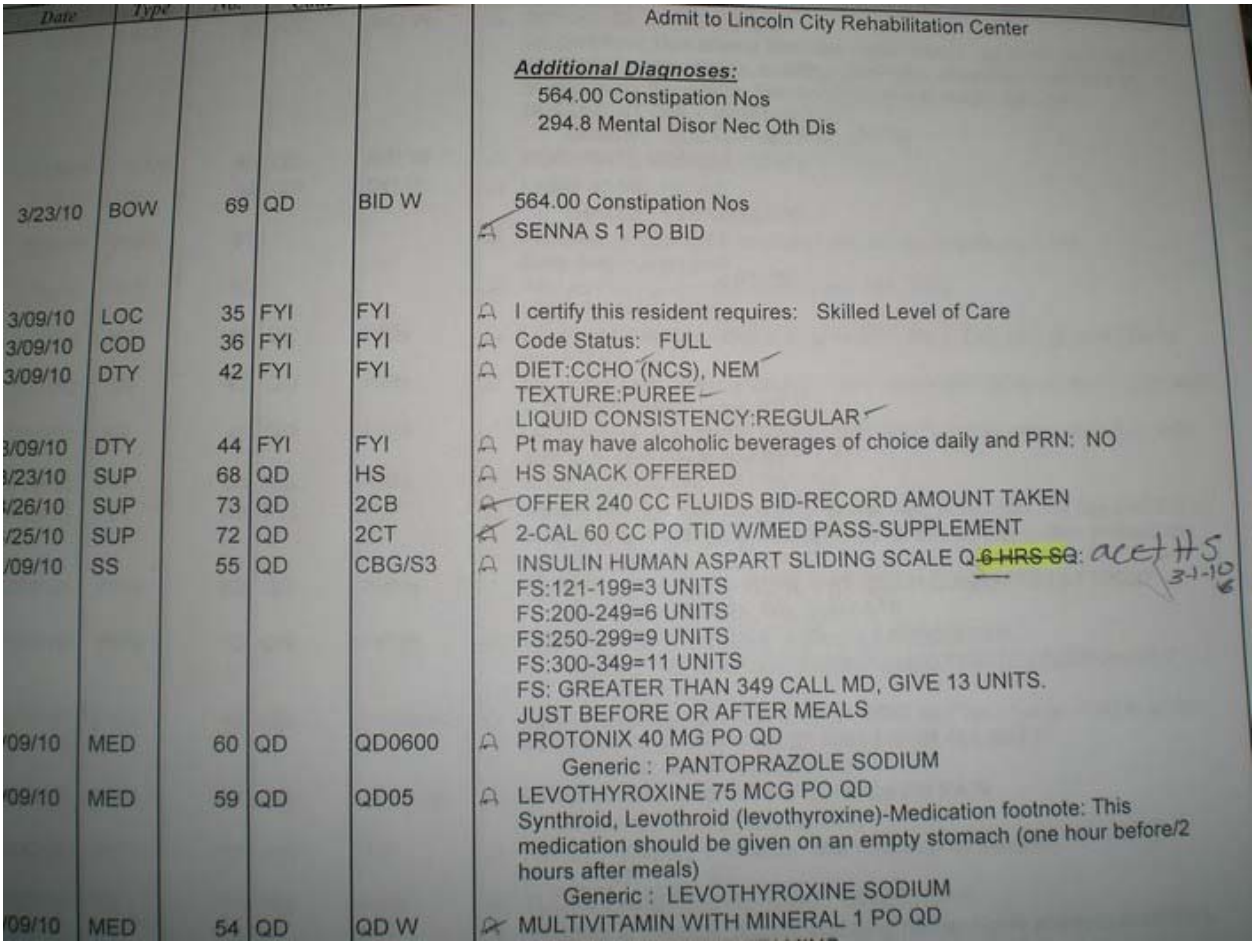
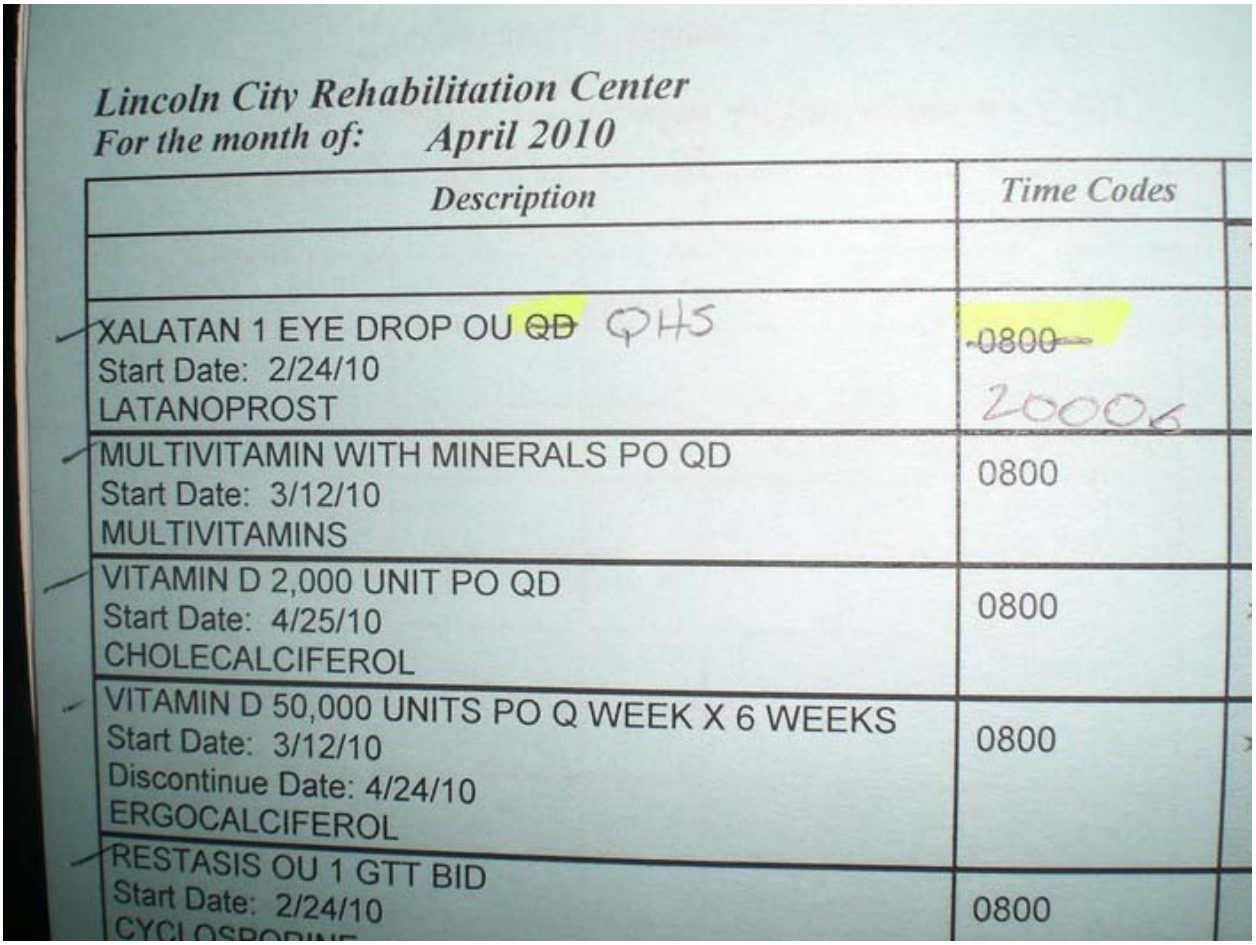


Photo 3.6: RCM adds structure for noting three separate blood pressure values. These representations are not created by general purpose templates. In this case, the entry was manually added and so could not have been provided by the template to begin with. The order was for weekly measurements (QWK). Note that the RCM did not strike out unnecessary days. Strike-out annotations were generally limited to medications (safety risks).



Date	Type				
					Admit to Lincoln City Rehabilitation Center
					Additional Diagnoses:
					564.00 Constipation Nos
					294.8 Mental Disor Nec Oth Dis
3/23/10	BOW	69	QD	BID W	564.00 Constipation Nos
					SENNA S 1 PO BID
3/09/10	LOC	35	FYI	FYI	I certify this resident requires: Skilled Level of Care
3/09/10	COD	36	FYI	FYI	Code Status: FULL
3/09/10	DTY	42	FYI	FYI	DIET:CCHO (NCS), NEM
					TEXTURE:PUREE
					LIQUID CONSISTENCY:REGULAR
/09/10	DTY	44	FYI	FYI	Pt may have alcoholic beverages of choice daily and PRN: NO
/23/10	SUP	68	QD	HS	HS SNACK OFFERED
/26/10	SUP	73	QD	2CB	OFFER 240 CC FLUIDS BID-RECORD AMOUNT TAKEN
/25/10	SUP	72	QD	2CT	2-CAL 60 CC PO TID W/MED PASS-SUPPLEMENT
/09/10	SS	55	QD	CBG/S3	INSULIN HUMAN ASPART SLIDING SCALE Q ~~6 HRS SC~~: ac et HS 3-1-10
					FS:121-199=3 UNITS
					FS:200-249=6 UNITS
					FS:250-299=9 UNITS
					FS:300-349=11 UNITS
					FS: GREATER THAN 349 CALL MD, GIVE 13 UNITS.
					JUST BEFORE OR AFTER MEALS
/09/10	MED	60	QD	QD0600	PROTONIX 40 MG PO QD
					Generic : PANTOPRAZOLE SODIUM
/09/10	MED	59	QD	QD05	LEVOTHYROXINE 75 MCG PO QD
					Synthroid, Levothroid (levothyroxine)-Medication footnote: This medication should be given on an empty stomach (one hour before/2 hours after meals)
					Generic : LEVOTHYROXINE SODIUM
/09/10	MED	54	QD	QD W	MULTIVITAMIN WITH MINERAL 1 PO QD

Photo 3.7: Correcting dosing information using conventional abbreviations “a.c. + h.s.” which means – after meals and at bedtime. Check marks imply that concordance with orders has been verified.

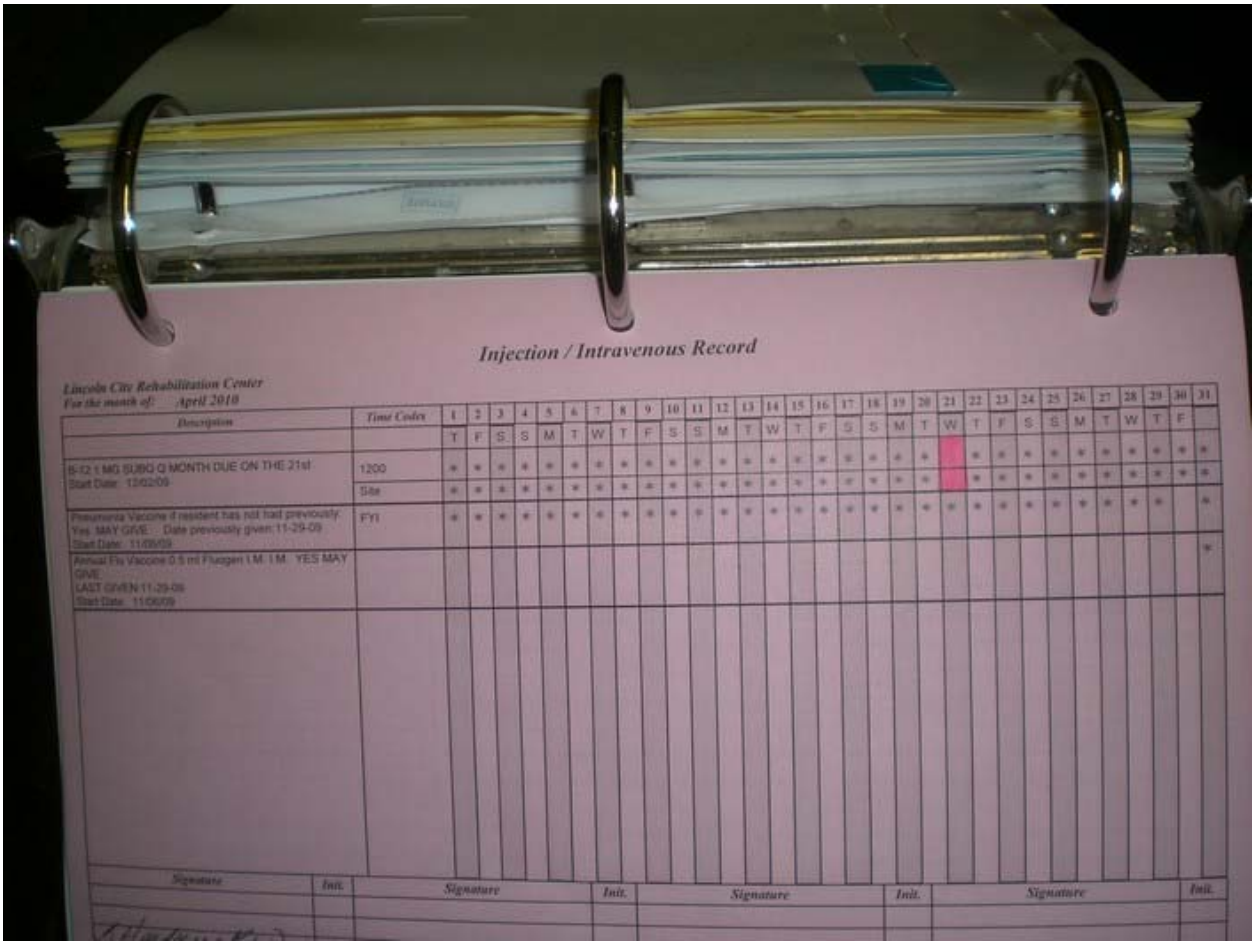


Lincoln City Rehabilitation Center
For the month of: April 2010

Description	*Time Codes*
XALATAN 1 EYE DROP OU ~~QD~~ QHS Start Date: 2/24/10 LATANOPROST	~~0800~~ 20006
MULTIVITAMIN WITH MINERALS PO QD Start Date: 3/12/10 MULTIVITAMINS	0800
VITAMIN D 2,000 UNIT PO QD Start Date: 4/25/10 CHOLECALCIFEROL	0800
VITAMIN D 50,000 UNITS PO Q WEEK X 6 WEEKS Start Date: 3/12/10 Discontinue Date: 4/24/10 ERGOCALCIFEROL	0800
RESTASIS OU 1 GTT BID Start Date: 2/24/10 CYCLOSPORINE	0800

Photo 3.8: Correcting an error. The eye drops are to be given at 8 PM, not 8 AM. QD means once a day, but does not specify what time of day. QHS means give at bedtime, a more precise instruction. Handwritten font and color highlighting draw attention to the correction.

Photo 3.9: The blood pressure monitoring should be on the TAR, not MAR. The RCM uses yellow to note that it need not be executed by the nurse passing medicines and clearly states that it had been moved to the TAR (Tx).



Injection / Intravenous Record

Lincoln City Rehabilitation Center
For the month of: April 2010

Description	Time Codes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	
5-FU 1 MG SUBQ Q MONTH DUE ON THE 21st Start Date: 12/02/09	1200	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*
	Site	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*
Pneumonia Vaccine if resident has not had previously. Yes MAY GIVE Date previously given:11-29-09 Start Date: 11/05/09	FYI	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*
Annual Flu Vaccine 0.5 ml Fluogen I.M. I.M. YES MAY GIVE LAST GIVEN 11-29-09 Start Date: 11/06/09																																*

Signature	Init.	Signature	Init.	Signature	Init.	Signature	Init.

Photo 3.10: Annotation which emphasizing that the medication was instructed to be given only once a month on a specific day.

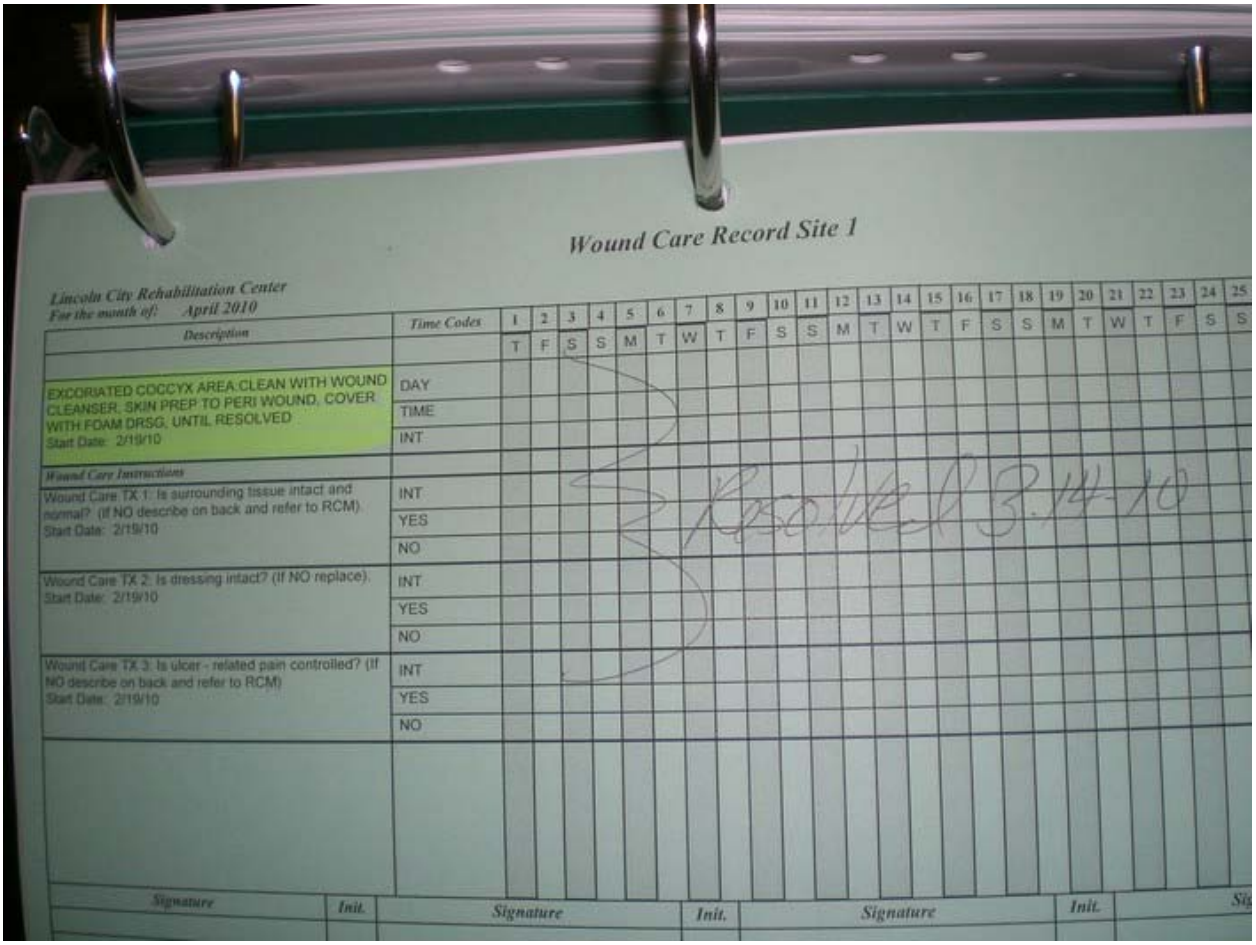
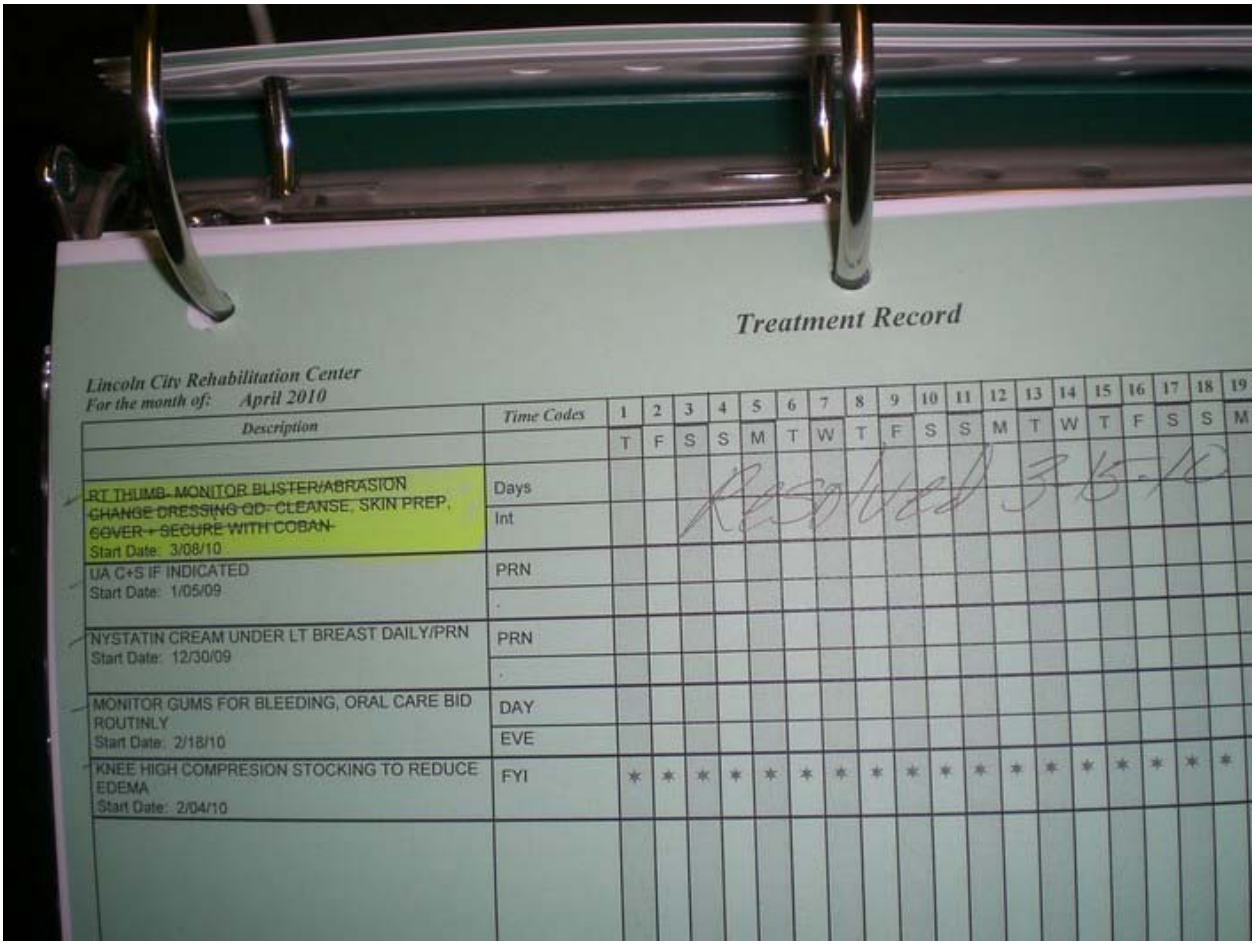


Photo 3.11: The wound had healed and further care need not be provided. The RCM uses the color yellow, which is locally understood to indicate DC (discontinuation), and writes on the entry section of the document stating that the wound has been resolved.



Treatment Record

Lincoln City Rehabilitation Center
For the month of: April 2010

Description	Time Codes	1 T	2 F	3 S	4 S	5 M	6 T	7 W	8 T	9 F	10 S	11 S	12 M	13 T	14 W	15 T	16 F	17 S	18 S	19 M
~~RT THUMB- MONITOR BLISTER/ABRASION CHANGE DRESSING QD- CLEANSE, SKIN PREP, COVER + SECURE WITH COBAN~~ Start Date: 3/08/10	Days																			
	Int																			
UA C+S IF INDICATED Start Date: 1/05/09	PRN																			
	.																			
NYSTATIN CREAM UNDER LT BREAST DAILY/PRN Start Date: 12/30/09	PRN																			
	.																			
MONITOR GUMS FOR BLEEDING, ORAL CARE BID ROUTINLY Start Date: 2/18/10	DAY																			
	EVE																			
KNEE HIGH COMPRESION STOCKING TO REDUCE EDEMA Start Date: 2/04/10	FYI	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

Photo 3.12: The RCM uses the color yellow to indicate DC (discontinuation) and writes on the entry section of the document stating that the wound has been resolved. Additionally, she strikes out the entry. All these unambiguously and redundantly communicate the RCM's intent. Also note the check marks to the left of each row. These indicate that the RCM had checked for the presence of orders and had located them.

Process

The recap process consists of the following comparisons

- Physician orders are compared to treatment orders.
- The new physician orders are compared to the old physician orders.
- The new MAR is compared to the copy of the old MAR
- The new TAR is compared to the copy of the old TAR

However, these comparisons are only the part of the picture. It simply addresses information congruency.

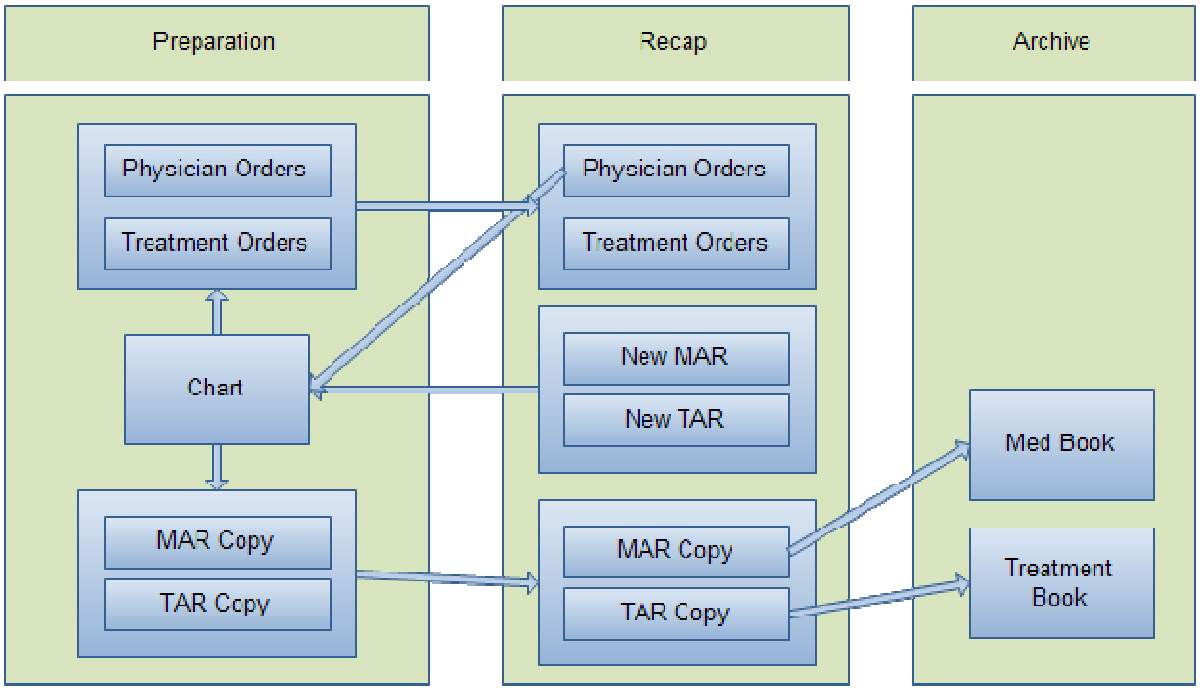


Figure 3.2: Recap process

The RCM's knowledge of the patients, her professional education, and her understanding of the culture and the setting play a significant role in the task. The RCM may find errors within data that appears congruent across artifacts.

When we discussed the actions within the setting in a representational framework, we may frame them as follows. This facility performs a representational transformation of orders

into administration records. This common practice is performed with the intention of representational effect, although it is not discussed as such. When the orders are written by the physicians or transcribed by the nurses, the format is appropriate for the record of singular information. However, when the medications are being administered, it is impractical to consult every single order to understand which medications should be given at what time. The representational transformations required to be performed in such a determination are performed in advance, resulting in the creation of a MAR. Any complex representational transformation is however prone to error. Given that this transformation is repeatedly used throughout the month, it is especially important to ensure that it is fully correct. This necessitates congruency checking.

However, this is not a simple case of transform and check. The RCM also adds transformations of her own. It would be naïve to suggest that all transformations must occur in advance and then be verified. The order-to-administration-record transformations are automatable. Even when not automated, they do not require special professional knowledge because verification alone does not require external knowledge or expertise (nor can it identify an accurately transformed but incorrect or inappropriate order). However, the RCM begins with this preprocessing and adds transformations based on individual determinations and special cases. Her transformations are based on her professional knowledge. Some of these however, may be automated. For instance, the RCM highlights the first cell of the month in the MAR when the order states that the medication should begin from the first of the month. However, the MAR is created at the end of the last week. Actions such as these do not require the special nursing training. However, recognizing the necessity of such actions does require nursing training. We can propose that if a taxonomy of representational actions was to be created, clearly delineating which common, non-automatable actions may be performed more clinically, some of the burdens of the task may be offloaded to less trained staff or to machines.

Perhaps, we may better understand the creation of a MAR into unskilled and skilled phases. The unskilled phase involves largely automatic transformations or transformations by

nonclinical personnel. The skilled phase validates the unskilled phase, and completes transformations that require clinical expertise.

The skilled and unskilled phases are different in the context of informational/representational consideration. The unskilled phase is only capable of dealing with homogeneous data involving relatively isomorphic transformations. The skilled phase is additionally able to deal with heterogeneous data the connections across which require special training to identify. In this sense, it is the nurse who is able to connect treatments to the patient needs. This network of heterogeneous clinical information comprises clinical meaning. Performing a meaningful synthesis of the clinical picture of the patient is the overarching theme within the recap task.

Later on, we shall see how the pharmacist engages in a similar synthesis of meaning. The RCM differs from the pharmacist in the kind of information she brings to bear. Specifically, the RCM has a good context of the patient's history, which she can draw from her immediate memory based on personal history of the care of the patient. The pharmacist is not able to do this. Additionally, given her professional duties, her focus is on ensuring that the medication and treatment administration functions are accurately and appropriately carried out. The pharmacist on the other hand is better able to focus on the connections between the patient's condition and the medication activities including laboratory tests.

Informal (rcm: informal)

The RCM explained to me that as far as she knew there was no formal process for her task. She learnt it from her senior; when she herself was a junior nurse, and that the process differs from organization to organization. Even within organizations, she observed different individuals performing this task slightly differently. The particular setting that I was observing the RCM in had one other RCM. The subject notes that her partner performs this task slightly differently as well. However, she feels the task is the same overall.

Skilled first (rcm: order)

The subject chooses to begin the task starting with the skilled (higher acuity) patients. When probed, she said that she always begins with the skilled patient charts since they take more time. She estimated that skilled patients typically take about 40 minutes to review while the unskilled patients take only 10 minutes. (Note: These subjective estimates may be wrong. Objective estimation however is not worthwhile. The relevant information here is that skilled patients take significantly more time)

Sign first (rcm: sign)

The RCM curiously begins the review of the MAR by signing a blank template (freshly printed for the patient without any nursing markers). When asked if this order was also a consistent pattern, she confirms it and says that it is simple *("a no-brainer"*) and that she would like to get it out of the way.

Early check off (rcm: checkoff)

She then continues by taking a completed physician's order sheet and works with it by checking off each item on it and the corresponding entry on the MAR. She uses her thumb to represent her progress through the task. Later, I would notice that she would no longer use her thumb to mark the progress after going through a couple of charts.

Adding to MAR and safety (rcm: safety)

The orders are represented on the MAR. She meticulously examines the orders to ensure that the entries on the MAR accurately reflect the orders. If she finds incomplete information that she deems necessary for its execution, she fills that information in on the MAR. However, it was not just missing information that she adds to the MAR. She also adds administration instructions such as HS (bed-time) and PRN (as needed) even though that information is already present on the MAR. When probed for her reason to be doing this, she says that the nurses may sometimes make a mistake and not notice these instructions. She says that she would like to make sure that they are less likely to miss them.

Reviewing content (rcm: bp)

The RCM was not reviewing just the medication information in the patient chart. She was looking at nearly every document in it. She looks at lab reports and event alert orders from physicians. The event alert orders are parameters that the physician specifies. If these parameters are met, the physician would like to be notified. In one instance she notices an event alert order that says SBP < 150 in the MAR. This implies that the physician should be notified when the patient's systolic blood-pressure goes below 150. She finds this instruction odd and begins to search for the record of the order in the patient chart. Eventually, she locates it and finds that it was indeed as she had suspected - a typing error. It was intended to be SBP > 150. She collects the entry on the MAR and makes a note to the records department. During my session, the records department employee entered into the room several times and the RCM took the opportunity to update her on the discrepancies that she found.

Discord between systems (rcm: discord)

The orders from the physician come through multiple channels. The order may be written in on a form at the facility, faxed-in, or provided orally over the phone. The RCM must find documentation for the orders in the MAR in any one of these forms. She laments that when orders get changed, the physicians do not always update their records and re-send orders in their older form. Correcting these and notifying the physicians of this, adds work to her.

Detecting incomplete information (rcm: incomplete)

She finds that some of the orders on a MAR are incomplete. Certain orders (either on the MAR or in the physician orders) are not specific enough without accompanying parameters. For instance, she expected to find parameters with which she can generate the alert for, for an order to monitor blood pressure. She searches through the patient chart to find a previous order that had the parameters included.

Correcting mistakes (rcm: correct)

She finds orders that were inaccurately transcribed onto the MAR. In one instance, she sees instructions as b.i.d. However, the actual order specifically ordered for 12hr

administration. She notes that the current nursing rounding places this at 10 and 14hr administration. She corrects this in the new MAR such that it is to be exactly filled by the hour.

Too specific and wrong (rcm: incorrect)

The errors and can go the other way as well. In case of a diabetic patient, the physician ordered insulin before meals. However, the MAR template came printed with specific times and these did not correspond well with the mealtimes (much too early). She suspects that the computer automatically calculated these times.

Wrong DC (rcm: dc)

In the older MAR, she identifies erroneously continued drugs by the nurses. In a specific instance, she is unable to find an order for an antibiotic. She searches beyond that month's orders to finally locate an order that called for a limited 7-day administration.

Better with own patients (rcm: context)

The RCM is able to be even more meticulous when a patient was someone who she personally provided care to previously. In one case, she is aware that the patient went through a short-term medication change for infection. She carefully looks in the MAR to make sure that the drug being administered has indeed been discontinued.

Emphasizing DC and colors (rcm: dc)

When she finds orders for the discontinuation of a routine drug in the middle of the month, she takes a yellow marker and clearly marks the cells corresponding to the dates during which the drug should not be given. When probed, she says that this will prevent accidental continuation of the medication and that the yellow marker is a standard color for denoting discontinuations in nursing. She did however say a few places where multiple colors were used. She feels that this is undesirable since it encourages the nurses to ignore medications not belonging to a shift. In fact, she says, she had to make nurses break that habit in a previous facility where she worked. I did however find a brick colored fluorescent mark in one of charts. She says it was not hers and that it was likely used to denote a nightshift. She stresses once again that she does not like multiple colors.

Emphasizing infrequent orders (rcm: infrequent)

When the RCM encounters a weekly psychotropic order with instructions to administer on every Wednesday (Wed), she carefully examines the MAR. The MAR has indeed clearly translated this order by placing an asterisk in every cell except Wednesdays. The RCM still takes her pen and writes *Wed* explaining to the investigator that she would like to reduce the chance of an error.

Marking completion (rcm: tracking)

Once she completes reviewing a patient chart, she takes a blank phone order form, writes the date on it, and in large letters writes *"Recap Completed"*. She says this will help her remember the point in the chronologically organized chart until which the previous recap has covered. She looks for similar notes in every chart that she picks up.

Labs after marking completion (rcm: labs)

Curiously however she had not completed checking the lab reports by the time she writes "Recap Completed". When probed for a reason, she is initially unsure but later says that the object is a much simpler task where she simply has to ensure that the lab report has been documented and does not have to worry about its content. The lab sometimes gives them a hard time with receiving orders and they have to keep following up.

Missing crumbs (rcm: crumbs)

She says that her partner has newly joined the job and is still learning the ropes. She does the task a little differently. In one instance, a partner has forgotten to leave a marker of completion and this confuses the RCM briefly making her wonder if it was a patient that she was responsible for (from her half of the recap charts, at the time) and had forgotten to review.

Outbox/Generating a TODO list (rcm: todo)

Throughout this task, the RCM maintains a pad where she maintains a to-do list of items that she has to follow-up letter on. However, most of these tasks were not pending by the end of the day. In many cases, the tasks were directed with the medical records department and

whenever the medical records employee walked into the room, she had the pending questions resolved through her.

Recurring errors (rcm: recurring)

In a few cases, errors that she had collected in the previous MAR reappeared in the new one. She believes that the electronic system was not updated and thinks that the records department only looks at the order sheet for requested corrections. I asked her if there is a protocol for updating the system with the corrections. The RCM was uncertain.

Detecting un-restored meds (rcm: unrestored)

She describes how she wishes that the reasons for medication changes are made known to her. She describes the case of an Alzheimer patient who had an acute episode of pneumonia and was moved to the hospital. On return, she found that he was on two drugs for his Alzheimers disease. In another case, a patient with schizophrenia had his medications discontinued during his acute episode. She feels that the orders might not have been restored because he might not have exhibited the signs of the condition during his stay. However, he began manifesting them after his return to facility.

Un-administered order (rcm: unadmin)

She shows me a suppository order in the last patient chart that was placed on the treatment record when it should really have been on the MAR. When she probes further, she quickly finds that it actually had not been administered. She investigates to find the reason and finds that he received a stool softener and concludes that it might have taken care of the problem and that the suppository might not have been necessary, as a result.

Medicaid reimbursement and its effect on recap (rcm: medicaid)

While speaking of her other duties, she mentioned that one of her key tasks is reviewing the services provided to the patient for purposes of Medicaid reimbursement. She says that since payment to the facility hinges upon this task, it is considered important. She says that it is a “structured task” and she estimates that it takes as much as 1.5 hours for each patient. She says that performing this task keeps her up to date on the state of her patients. When I asked

her on what aspect of her recap she finds most hard, she says that instances where the orders are in the chart but have not been processed are the hardest, since she really has to scrutinize if these orders have indeed not been followed up on, or documented elsewhere or were undocumented. However, when asked to estimate the time for such cases, she only estimates about 2-3 minutes. She feels that the medication component of the task (MAR review) is the most important and the task is mainly concerned with ensuring that the orders have been properly transcribed into the MAR. She feels that it is relatively easy for her since she has been doing it for the past 10 years.

What would help? (rcm: wish)

When I ask her about what she wished for the most that would make the job easier, she says that making the chart remotely accessible from the facility to the physicians would help. As she talks to me, one of the final charts that she was waiting to review was away with a staff nurse and it arrives. She takes it, leans on it to make sure that no one else will take it away, while she completes our conversation.

Snowballing to next subject

She talks about the pharmacy involvement in this task and says that the extent varies from place to place. The pharmacy does not manage their facility completely but they do about 12 hours of review every month checking for interactions and such. This part of the conversation provided me with the lead for identifying the next subject… the Pharmacist who consults at this facility.

Pharmacist

Identifying the task

During the observations the RCM mentioned that a pharmacist from the pharmacy to which they have a contract with periodically visits the facility to review medications. When the RCM was asked on how that task differed from that of the pharmacist, she noted the pharmacists' task was more focused on medications than her recap task.

Subject

The subject is a consulting pharmacist employed by a pharmacy to provide medication review services to the facilities that request them.

Goals

The pharmacist is ensuring that the medications are appropriate for the patient's condition. Since this is understood to be the physician's responsibility, I asked my subject on what she believes to be different about her process from that of a physician. She feels that her task is different, since she does not actually see the patients… but that she is able to catch some errors because she spends more time with the chart.

"I might be able to suggest… since they see so many patients.. they don't sit down with the chart, things just fly by"

"But it's paperwork. But I am not seeing the residents".

Task

At the broadest level, the pharmacist reviews the chart of each patient and makes a note of concerns, if any. She forwards these to the physicians. Below, I will explore this task in further detail.

I asked her to describe what she perceives as her primary task at the site. She enumerates the following.

1. Review meds
2. Do they have a diagnosis for each one (medication order)?
3. Are they monitoring with proper labs?
4. Are they making the effort to reduce psychotropics?
5. Should they be increased for any?

Tools

Since there was considerable distance between the pharmacy and location of the skilled nursing facility and other such clients and because her task spreads over a couple of days, the pharmacist is a travelling professional. She travels with luggage and stays overnight at a hotel. Aside from clothing, she carries a portable workstation with her. It consists of a small laptop computer, a printer, a thumb drive with a copy of the relevant pharmacy records for the patients at the facility and some stationary. This copy of the pharmacy database is more important when she visits unskilled facilities since they do not have complete records of the patient. However, she finds occasionally use for the data even at the skilled nursing facilities.

Besides this software, the laptop is also equipped with an electronic drug reference and a report authoring software that she describes as *"a glorified word processing program"*. It can load the off-line patient data from her thumb drive and shows her the new residents that have been admitted since her last visit. The reports that it generates are also more elegant than what she could do manually.

Pharmacy

The same skilled facility that employs the RCM also subscribes to the consulting services of a professional pharmacist from their pharmacy, included in their contract along with the other medication services. The pharmacy also employs several other consulting pharmacists and consulting nurses. The subject and her colleagues visit the different nursing facilities that have contracted with the pharmacy. The skilled and unskilled nursing facilities have different needs and pharmacist performs slightly different duties across these locations. Notably, since the unskilled facilities do not have a direct equivalent of an RCM, the pharmacist fulfils some of the RCM roles. The pharmacy additionally employs several pharmacists to work at the

pharmacy itself, to review incoming medication orders, in real time (as opposed to the periodic review that the subject performs).

The Visit

The pharmacist visits the facility about once a month. At the skilled nursing facility where I observed her, her task was two-fold. She 1.) reviews the patient chart for medication information and 2.) participates in the routine morning nursing meeting of the day, at the facility. However, the pharmacist did not end up participating in this meeting during the visit of my observation as the meeting on that day got postponed. The observations detail her medication review task, exclusively.

Process

Location advantages (pharm: location)

The pharmacist was asked on how her task at the site was different from the task her colleagues perform the pharmacy. She says that performing the task locally is more *"proactive"*, or as she puts it, "*more proactive than retroactive",* and that the on-site pharmacists do not get to see as complete picture of the patient as she gets to. She can ask more questions because she can check the chart. She can point to a medication and say - *"Can we stop is now?"*

Some facilities have *"frequent flyers"*. Frequent flyers are those residents move in and out of the hospital for treatment of acute conditions, and back to the skilled facility, frequently. The subjects often have their routine medications discontinued during the acute episode. However, the medications are not resumed after the stay in all cases. She can raise questions on whether those orders need to be restarted or just tries to understand why a particular medication is now missing from the list. Many of these do get caught by the time of her visit however and she identifies the rest.

At the site, she is able to take advantage of the full chart with the lab data and the MAR. Since the MAR is the actual administration data, she could compare and detect an occasional transcription error (something that needs to be given twice a day but entered as only once-a-day). When asked to compare with the similar check that the RCM performs, she says she only

"glances" at the MAR while the RCM is more particular about it. She feels that the new pharmacists do not do this is much. MAR checks take a lot of time and "*they only have so much time for the visits*".

On the other hand, the pharmacists at the pharmacy only have access to medication data and can only check such things as drug-drug interactions. Additionally, her presence at the site allows the nurses to draw upon her expertise. "*Hey. What could we use for this patient… for their behavior*". She usually meets with the nurses on the second day. She would have completed all or at least, most of the reviews by then.

Holistic (pharm: whole)

Like the RCM, the pharmacist was found to be not simply looking at a small set of inputs that is her task description had suggested. But she finds minor mismatches between the orders and the MAR.

She says that the pharmacists are trained to look at the whole profile (not just medications) during the *"Medication Review Process"*. "*Drug Utilization Review*" (DUR) is the other name for this process.

Information under review (pharm: pt_triage)

The pharmacist reviews only the "*snapshot"* of the patients at the time of her visit. Those residents who have been admitted after her last visit and have been discharged by her current visit would not be reviewed by her ("*in and out between pharmacist visits*"). All medication orders are however reviewed by the on-location pharmacists at the pharmacy as they are faxed in. The pharmacy has records of the rest of the medications that the residents are on. This allows them to detect some errors. For instance, a pharmacist may question why a patient is on two scheduled anxiolytics.

Drugs under focus (pharm: drug_triage)

The pharmacist is particularly interested in certain drugs, more than others. These drugs include

1. Mental health drugs
2. Cardio-vascular drugs
3. Other drugs with high toxicity

Drug accumulation (pharm: accumulation)

The significant component of her task is the reduction of psychotropics; to avoid conveniently chemically restraining patients.

"*Less is better*." "*We just add on so much. They have that? Lets put them on an anti-depressant*." "*They are not being nice? They are hitting their care givers? Oh. Add Depakot. You just keep adding medications. I guess we are here to go - Well. Can you take some away? You know… Can we do something different? Its' tough. As you grow older as you have these adults… who are now children… mentally*"

Without such periodic re-examination, she feels that such drugs are otherwise added more easily than taken off.

Connecting the dots (pharm: connecting)

In one instance, she finds that a patient on antipsychotic does not have a record of AIMS (Abnormal Involuntary Movement Scale), which is necessary to detect tardive dyskinesia, a side effect that develops on the long-term use of antipsychotics. She makes a note.

With blood pressure medication, she would like to make sure that the pulses, BP, CBG, A1C etc are being monitored in case of beta-blockers. She looks at this monitoring data in an attempt to find any trends that tie together, drug usage to the lab values.

Tracking progress across visits (pharm: tracking)

Like the RCM, she goes by the dates and looks at only those documents that have been added since her last visit. Her software also cues her about the medication changes since her last visit.

She looks for *"Pharmacist Consultant Drug Regiment Review"* in the chart, the document recording her last visit and works from there chronologically. If it is a new patient, she goes to the physician's orders to see what meds they are on.

MMR (pharm: mmr)

She goes to the history to see if they have a diagnosis for each medication. Sometimes, the admission orders don't have them but the history may have it even if it is not verbatim (h/o Colitis, GI bleed etc) and she can infer why a drug was given. Sometimes, it does not match and there remains a question - Why. If she cannot determine herself, she will ask the nurse or ask the nurse to query the physician.

Once the diagnosis is figured out, she looks at medications that need monitoring and see if the labs (Dig, A1C, blood sugar etc) are available to base them on. Some patients have some values on MAR, other may not and may have their own methods. She has to look it up based on the setting.

She sometimes glances at nursing notes since they have justifications for psychotropics. She also looks at other documents such as the dietician's report in which case, she is mainly looking for weight. Sometimes dieticians ask for medicines such as appetite stimulants. They have dietary goals and have their own processes but she want to know why. They have a meeting in this facility called *"Nutrition at risk"*.

On seeing that she is going through many different document types, I ask if there is any document in the chart that she does not look at. She says that she does not look at physiotherapy documents. But rarely, she might look at them as well, to check if they are ambulatory if they are heparin therapy so that it may be stopped. She looks at MDS as well from time to time.

Cleaning med lists (pharm: clean)

The pharmacist tries to make sure that the medication regimens that the patient is on continue to be valid.

"Sometimes the medications get started but never get re-evaluated and that's why people end up with too many meds. I mean… that is just over-simplifying how we look at it. We would like to clean that up. I have a concern.. they travel from point A to B and then to C… are we understanding why things have changed between those? That's what I am curious about."

"I don't know.. maybe there is a valid reason but I can't discern why (from the documentation)". "A lot of times they come in from outside living from their home… they don't know what they are on… they don't have a complete list…unless you have access to the pharmacy they went to… maybe they went to multiple pharmacies…hopefully not… there will be just one. You know… they don't have a list.. it is kind of hard to recreate… I don't know what they do in the hospital in terms of finding out exactly what they are on if they don't bring in their little pill bottles. Were they taking all those… you don't know… perhaps… there are checks and balances in the real world too… they may have all these… 3 different anti-depressants… and maybe they are not taking all of them…do they know which one they are taking.. hope they do".

"We have physician orders and we have to keep up with what the new orders are when you are gone and find out why something happened and sometimes you can figure that out by a descriptor… fax or by the physician's actual thought process… because you want to know why… you don't just take it at face value because it helps complete the whole picture".

This is a cumulative task with these components.

1. Identification of changes since last visit.
2. Determining why the changes occurred.
3. Raising issues if the changes are not deemed reasonable.

Q[8]: Do you compare medication lists? I see that you are working with only one list.

A: "*I do when they are first admitted*". "*Or when they are readmitted…*" "*With admission… that is the primary med reconciliation*"

[8] The following convention was used in this section.
Q: These are the investigator's questions
A: And these are the subject's answers.

Inferring (pharm: why)

She starts taking notes about meds of a resident who looks like "*he is going to be there for a while*". She says she will note down everything except the PRN medications. She starts looking at the other documents in the chart and starts reasoning out loud.

The pharmacist's task appeared to be cognitively demanding. This might make purely observational data inadequate for understanding her thought processes. I explained the think-aloud protocol to her and asked her if she would be willing to follow it. However, she felt uncomfortable with the idea at firstand I did not press further. Much later in my observations, she spontaneously began to think out loud. The transcript provided much insight into the issues she considers and the uncertainty that goes along with them.

> *"See they stopped the protonics which she was on… and then… in the hospital… because that might have been a formulary item… and then we are gonna start the Prilosec… I mean… tells you some information.. but I still don't know why the Potassium… why the Potassium… I don't know. But anyway, that's not what I am looking for. I was looking for a… they had a…some medlist somewhere in here. But I don't know… see… I don't know."*
> *"This is closer to what she is taking now. Yeah… see that doesn't. This doesn't have Potassium on it. So I am wondering if it was something they found in the…Yeah… see… she was low when she came in. Is that an artifact… from her disease state? Or is it something that is chronic? Well! It can't be too chronic cause she is not on it prior to coming in… so. Sometimes… I am gonna go… why?"*

At this point, she becomes self-conscious and says

"So that's… that is your med reconciliation (laughs)".

This resident is on 20+ meds. She says that federal guidelines instruct to watch when there are more than 9..

> *"There is not much data to go through. Huh. So I don't… I have to ask about the Potassium down the road. Well… Its not something that critical but we need to find out why."*
>
> *"Its says.. with meal. That's potentially quite a bit. Hmph."*
>
> *"2 times…2 times… 20 yeah.. that's quite a bit. In my book that's 40 meq/day. Hmm..And I would not have known that if I did not have this data here. Didn't have this visual blah blah blah… if I had access to data in the hospital… lab data… I would know. But I always… sometimes don't get that. Hmph" This is what is in their… med… chart… in their hospital… sometimes… maybe…yeah… its kind of useless… sometimes you can figure out stuff but… (If) I wanna ask, I will just write… why the Potassium… Hmmm. Maybe we recheck… I donno.. maybe we stop… it's a supplemental thing. That where if you had access to a discharge summary… that would be nice". "Sorry. It is kind of bothersome. Because they are asking for a referral. I mean she is kind of old. Oh look… this is their MAR… from the hospital that we can actually see what they were doing here". "Hmph… strange. ooo..k".*

The matter does not get resolved at that time. She makes a note of it and decides to raise this question the next day.

The pharmacist and the physician (pharm: physician)

I asked her about her recommendations. Recommendations are directly addressed to the physicians. Since most of the physicians round weekly and because they do not want to get faxes, the facility aggregates the recommendations and shows it to them. However, not all physicians respond positively to recommendations.

"A lot of stuff we do is for survey… cause you want to make sure you are doing everything by the letter of the law."

"I am more here the flag waver.. Hello, do you want to look at this? (laughs). A lot of people come in with even shorter time than I do… The blood pressure in this one day looks good when the physician came through but really it was elevated…"

The pharmacist shows me a recommendation form from the previous visit where she noted that she did not see any laboratory monitoring for potassium for certain medications that warranted it. The physician wrote down - "*Sure*". The potassium test results came back and the results were indeed high. While the results did not warrant discontinuation of the medicines in the instance, they were significant.

"That's something to watch out, I guess".

In another note, the pharmacist had recommended a decrease in the dosage of supplemental Iron given to the patient. The physician wrote - "*Sure. Why not?*"

Sometimes she is less successful. She feels that occasionally, the physicians get irritated when they feel that the pharmacist does not fully understand the patient's needs and feel that the advice and recommendations are naive and unhelpful. This is evident to her from the kurt responses she gets.

"You are hitting on what others do. But it is that second pair of eyes that maybe… you can catch something they missed".

*"Sometimes it feels like a thankless job… at the front lines… you are there to patch things that are… you know***… a low rumble***".*

Overall, she feels that the success rate with her recommendations is not bad.

"Oh! I don't know. It's not bad. Between 50 (percent).. I don't know… 80 (percent)"

Knowing the site (pharm: site)

The pharmacist knows what to expect from the nurses at the site. She felt that the AIMS scores by a previous RCM were very high, unlike the current one who assigns lower scores. She attributes the source of this difference to the clinician rather than the patient.

Uncertainty in judgments (pharm: uncertainty)

In an instance, she makes a complicated judgment (*"I am sitting on a fence now", "it's a grey box for me"*) before making a recommendation to withdraw potassium. There is only a "smidgeon" of (elevated) potassium. Although the patient is on Lasix, the patient is on drugs that elevate potassium. She thinks that there is a possibility that this may be normal (reported renal sufficiency) but she does not have the data to go back and look for. She would ask the physician to stop the potassium and recheck. *"I hate to do that. Its' another cost for the resident. Why give something if you can get by without it". "Its' borderline. Maybe they have more data than I do. They could say no or yes. My thing is to get rid of medications".*

I ask why she thinks the physician did not catch this. She thinks they might have if the difference was larger but she does not see any documentation to explain that.

When she finds that a resident had a seizure, she begins to ponder about its cause. The resident had a fever at that time which might have precipitated it. She also feels that the antiepileptic drug level in the patient's system is slightly low.

Rummaging through the chart (pharm: rummaging)

I frequently found the pharmacist looking for information that she precisely could not define, but would know when she saw it. This often happened when she was trying to find why a certain drug was given. While I generally made a very conscious effort to not use analytical terms while conversing with the pharmacist that imposed my model beyond what I saw, I accidentally used the judgmental term *"rummaging"*. The subject was quite amused by it and came back to use the term. When asked, she assured that the term was indeed appropriate.

Rummaging

Q: “You are not going to let me get away with that. Are you?”

A: “*I know. It is hilarious. It is kind of like… what its.. very appropriate for what we do. It does feel like you are doing that. Rummaging often connotates that you almost don’t have a clue. You are just digging you know. That’s very appropriate*”.

Decisions, decisions (pharm: grey)

The pharmacist was not always certain on where she should be making the recommendation.

“I am sitting on a fence now”, “it’s a grey box for me”

In one instance, the patient was on Lasix, a common diuretic. Potassium supplementation is advised for patients on diuretics and this patient was on one. However, his potassium levels were slightly elevated (*"only a smidgeon"*). This could be normal but she does not have previous laboratory data to verify that. She decides to ask the physician to stop the potassium and recheck since her goal is to reduce unnecessary medications.

“I hate to do that. It’s another cost for the resident. Why give something if you can get by without it”. “Its’ borderline. Maybe they have more data than I do. They could say no or yes. My thing is to get rid of medications”

She wonders why the physician did not catch the elevated potassium. She thinks it might have been caught if the difference was larger.

She says that Thyroid medications are another example of medications routinely given, even when they are no longer necessary, and even when the labs clearly indicate that.

"Sometimes I think thyroid levels go by and nothing is done.. either they did not get notified…" "…it was missed. We got the data but nobody is doing anything with it. I could be that messenger that says by the way, we did do those labs …"

Notes (pharm: notes)

The pharmacist writes down information from the patient chart in her own notes. It helps her see things more cleanly at a glance, both at the time of the review as well as in the subsequent visits, without having to wade through the patient chart again.

Task model (pharm: model)

During the course of this observation, I had iteratively developed a model of her task and member checked with her at each instance. In each successive attempt, I would try to refine it further.

1. Reviews med lists, makes a list of concerns, checks the chart and notes her findings
2. The subject looks at what has changed for the patient in the medication profile, generates a series of *"why"* questions and attempts to answer them by looking at the chart. In the some cases the specific information is not found but she needs to make inferences or contact the nurses for clarification.

Member Checking

Q: "Would it be a fair assessment to say that your principle task here is to match not just medication lists, but to match the physiological profile, the laboratory profile and the pharmaceutical profile".

A: She eagerly agrees - "Yeah… I like that. I like that idea.. Yeah.. I like that. Thank you"

Q: "That's a summation of what you do?"

"Yeah.. I guess so. Thank you (laughs). Wish I could have thought of that one."

Report (pharm: report)

She calls the report she generates the *Pharmacy review sheet*. The periodic pharmacist review is federally mandated and this report serves as the documentation to fulfill that obligation. The report is addressed to either the doctor or the nurses, depending on the recommendations. When created for the nurses, it is addressed to the DNS (Director of Nursing Services). However, the RCM is usually the one to look at it.

When she recommends the discontinuation of a couple of medicines to a physician, she prints it as a form where the physician can simply check the boxes when he approves.

Pondering duplications (pharm: dup)

She notices duplicate orders and begins to wonder if there could be a good reason for the duplication. She feels that physicians sometimes asked to prescribe without having access to the full information and this may result in duplications.

"Mrs. Smith is depressed. She is not on anything. Well maybe she was. And then they started an anti-depressant and now she has two. Sometimes they pick up. Sometimes we pick it up". "We ask - are you sure?".

Differences from RCM task (pharm: rcm)

At this point, I mention that the RCM performs a similar check. She says *"Oh Yeah. It is the reconciliation process that they do. That's not my focus"*.

Now I ask her about what she believes to be the difference between her task and that of the RCM. Also, since she named the RCM's task, I asked her if her task has a name as well.

"What do I call it? (ponders) (laughs) I dooon't know"

"Satisfying the federal guidelines for having a pharmacist… you know. That's why we are here every month to make sure you glanced at the medication regimen"

Since it is a federal requirement, I ask if the requirement has a name. She says that it is called MMR but does not readily remember what it stands for (she is using it as a routine word rather than as an abbreviation). I later look it up (Medication Management Review).

Importance of documentation (pharm: documentation)

She feels that task is even more difficult in and assisted living setting. Even though the patients here are less ill, the pharmacist does not know what happened during the doctors' visit. Since the regulations are tighter on skilled facility, the documentation is more complete in this makes the job much easier.

However, when the patient returns from a hospital, she would not have access to the hospital medical record. She is often able to look for reasons on why a drug was added; but has a much harder time trying to find documentation on why a drug was taken off the list.

Not all the notes that the pharmacist makes are forwarded to the physician. In one instance, she notes that the creatinine level is somewhat high in a patient on digoxin. However, she is uncertain if this one-time event warrants an alert since it simply could be that the patient was not taking enough fluids at the time. She keeps this note to herself to remind her to alert the physician if the levels persist.

Inferring under uncertainty (pharm: infer)

When she finds an antibiotic prescription but does not know why it was given, she begins looking for tell-tale documents. She suspects it to be either for a respiratory infection or a unitary tract infection. The dose helps her to some degree. She looks for a chest x-ray is a clue for a respiratory infection. When suspecting a unitary tract infection, she expects to find documentation for Urinalysis.

The pharmacist provides a lead about the nurse also provided by the pharmacy who visits the facility on a quarterly basis to make sure that the nursing medication practices are in order. She feels that this nurse is more hands on and finds errors such as *"an insulin vial that has been open for a month and half"*.

Similarities to RCM task (pharm: rcm)

Occasionally, I see the pharmacist catching errors that my previous subject, the RCM was focused on. She catches problems of mismatches between orders and MAR. This is not common and usually these are small things. They don't specifically look for these though since the facility has checks for them. But some duplication of effort helps.

Report Sample

Case 1 - To Nurses

1. Resident taking Resperidol and needs an AIMS placed in the chart. Since resident was re-admitted this year, there is a current AIMS, done within the last 6 months in the previous chart. You could make a copy and place it in the current chart.
2. Concerns about AIMS=8 done last November. This was increased from AIMS was done in August, although did reflect the scores done by the last RCM, suggest redoing AIMS evaluation to determine if the score is 8 is an accurate reflection of the movement disorder.
3. Please ensure that the behaviors are documented after starting Suprexa. Will need baseline AIMS done as well.
4. Resident readmitted in October and continues with Roxillin injection. Please do an AIMS evaluation. Place under assessment section. Previously requested AIMS evaluation.

Case 2 - To Physician

1. Resident's medications include KCL 20 microeq BID, no diuretic but is tapering off prednisone over next week (may decrease Potassium). History and physical indicated low K in hospital. Suggest checking BMP to determine whether need to continue for Potassium supplementation.
2. Resident's medications include protonix 40 mg and Iron Sulphate BID since admit at the end of November. Labs from November showed H&H = 12.8/38.6 with CBC results pending (were requested in Jan but not done yet)
    a. Depending on latest H&H results, consider decreasing iron supplement to once daily for chronic therapy

        Yes/No
    b. To consider decreasing Protonix to 40mg once/daily

        Yes /No

Pharmacy Technician

Subject Identification

The prior subject, the pharmacist informed the investigator of the safety task that her pharmacy performs using the pharmacy technician.

What does a Pharmacy Technician do?

The Occupational Outlook Handbook (2008-09) describes the work of pharmacy technicians as follows.

Pharmacy Technicians help licensed Pharmacists provide medication and other health care products to patients. Technicians usually perform routine tasks to help prepare prescribed medication, such as counting tablets and labeling bottles. They also perform administrative duties, such as answering phones, stocking shelves, and operating cash registers. Technicians refer any questions regarding prescriptions, drug information, or health matters to a pharmacist.

Pharmacy technicians who work in retail or mail-order pharmacies have varying responsibilities, depending on State rules and regulations. Technicians receive written prescriptions or requests for prescription refills from patients. They also may receive prescriptions sent electronically from the doctor's office. They must verify that information on the prescription is complete and accurate. To prepare the prescription, technicians must retrieve, count, pour, weigh, measure, and sometimes mix the medication. Then, they prepare the prescription labels, select the type of prescription container, and affix the prescription and auxiliary labels to the container. Once the prescription is filled, technicians price and file the prescription, which must be checked by a pharmacist before it is given to the patient. Technicians may establish and maintain patient profiles, prepare insurance claim forms, and stock and take inventory of prescription and over-the-counter medications.

In hospitals, nursing homes, and assisted-living facilities, technicians have added responsibilities, including reading patients' charts and preparing the appropriate medication. After the pharmacist checks the prescription for accuracy, the pharmacy technician may deliver it to the patient. The technician then copies the information about the prescribed medication onto the patient's profile. Technicians also may assemble a 24-hour supply of medicine for every patient. They package and label each dose separately. The packages are then placed in the medicine cabinets of patients until the supervising pharmacist checks them for accuracy, and only then is the medication given to the patients.

The observations were scheduled for a day when the pharmacy assistant was to perform the periodic (monthly) review of medication lists from unskilled facilities. Consequently, the observations do not include details with regard to the dispensing and supporting tasks that the pharmacy technicians have been formally described to perform.

Setting

The Occupational Outlook Handbook (2008-09) describes the work environment of pharmacy technicians as follows…

Pharmacy technicians work in clean, organized, well-lighted, and well-ventilated areas. Most of their workday is spent on their feet. They may be required to lift heavy boxes or to use stepladders to retrieve supplies from high shelves.

Even within the specific scope of my observations, this description mostly fit the task of the subject. One exception was that the subject spent most of her workday at her desk than on her feet, given the nature of her task on that day. She still needed to lift moderately heavy boxes and used stepladders to retrieve supplies from high shelves.

Task - *"Doing the Yellows"*

The pharmacy technician refers to her task through an informal name - "*doing the yellows*". The pharmacy prints the MARs for the unskilled facilities (The skilled facilities in this setting manage their own). These MARs have a yellow back copy. The unskilled facilities note

the administration information on these MARs and return the yellow carbon copies to the pharmacy. The pharmacy technician then checks the MARs for changes and compares them to the orders received in their system for parity, following up with the facilities as necessary. Since the pharmacy technician works with these yellow documents, the task is named as such.

Tools and artifacts

The pharmacy technician used the following tools

1. Florescent marker – to mark and queue items.
2. Workstation – to retrieve the data from the pharmacy system.
3. Phone and Fax– To follow up on discrepancies.
4. Card board boxes and files – Archive of older orders.

Process

Use of ambient sound

A radio was playing in the background. The programming changed through the course of the observation but the station was never changed. According to the subject, the radio helps break the silence that is otherwise very common. She was not really paying attention to the content of the programming.

Workspace

Photo 3.13: Shows the document flow during the task.

1. Yellows files from each facility
2. Yellows to triage
3. Yellows that passed the triage
4. Yellows needing follow-up
5. Archival box
6. Dumb terminal to the server hosting the pharmacy information system
7. Monitor displaying (character based) local records of the patient

The photograph shows the desk of the pharmacist. Here, one can see the thick files containing the medication lists of the patient's from each unskilled facility. At her left-hand lies the stack of medication lists that the subject is yet to review. On the right-hand side is the stack of medication lists that have been addressed. At this point, they contain those lists where she did not find any discrepancies worthy of further attention. Above it is a small stack of medication lists that were set aside for further review. This stack will be merged with the previous stack after follow-up, returned to its file and put away for archiving. A cardboard box similar to the ones used for archiving can be seen in the corner of the photograph, on the floor. The workstation and the phone were used extensively through the task, and can also be seen on the desk.

Document flow

The pharmacy technician has the stack of thick files, each containing the yellows of one site. She takes each yellow and locates the patient on their local electronic system through her work station. The patients may have some medication changes during this time and they are represented in the MAR. The subject checks to see if they have a record of all the orders for these changes. The pharmacy system highlights the changes and new orders since the last review. She will remove these highlights after she has gone through the yellow. If the pharmacy has received all these changes, she types them into a Word document. She marks orders on the MAR with a diagonal stroke to note completed verification of the change from their system. If she identifies a potential discrepancy, she marks it with a circle using a fluorescent marker and sets it aside in a different stack. Once enough yellows for follow up have been stacked, she contacts the facility by phone to clarify the discrepancy. She continues to work as she waits on the phone.

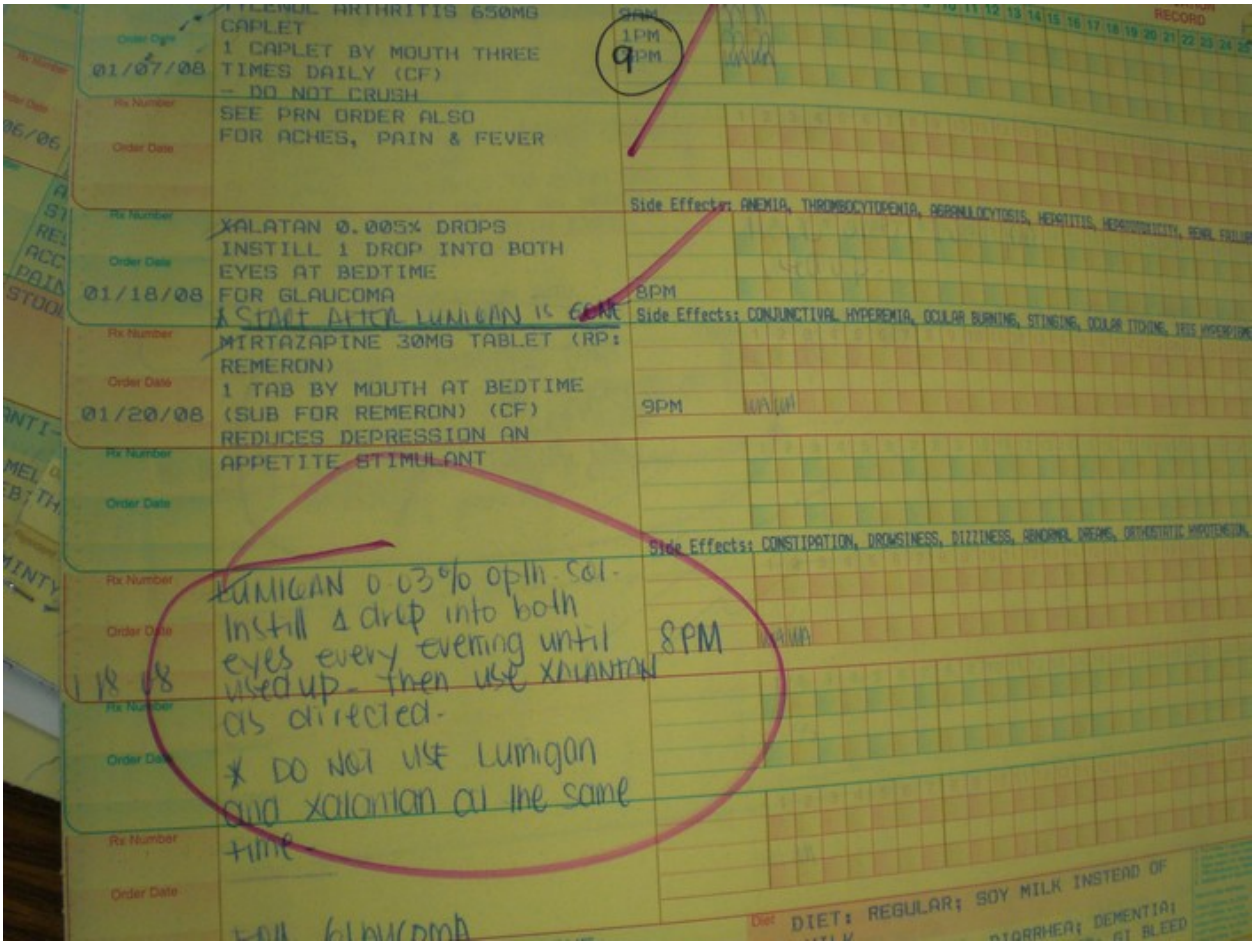


Photo 3.14: A *"yellow"* marked for further review after the triage phase. The diagonal strokes denotes that a corresponding entry was found (i.e checked successfully). The circled item needs to be checked (i.e **not** checked successfully). Note the drug side-effect info. The pharmacy adds this information to the MARs to improve medication safety.

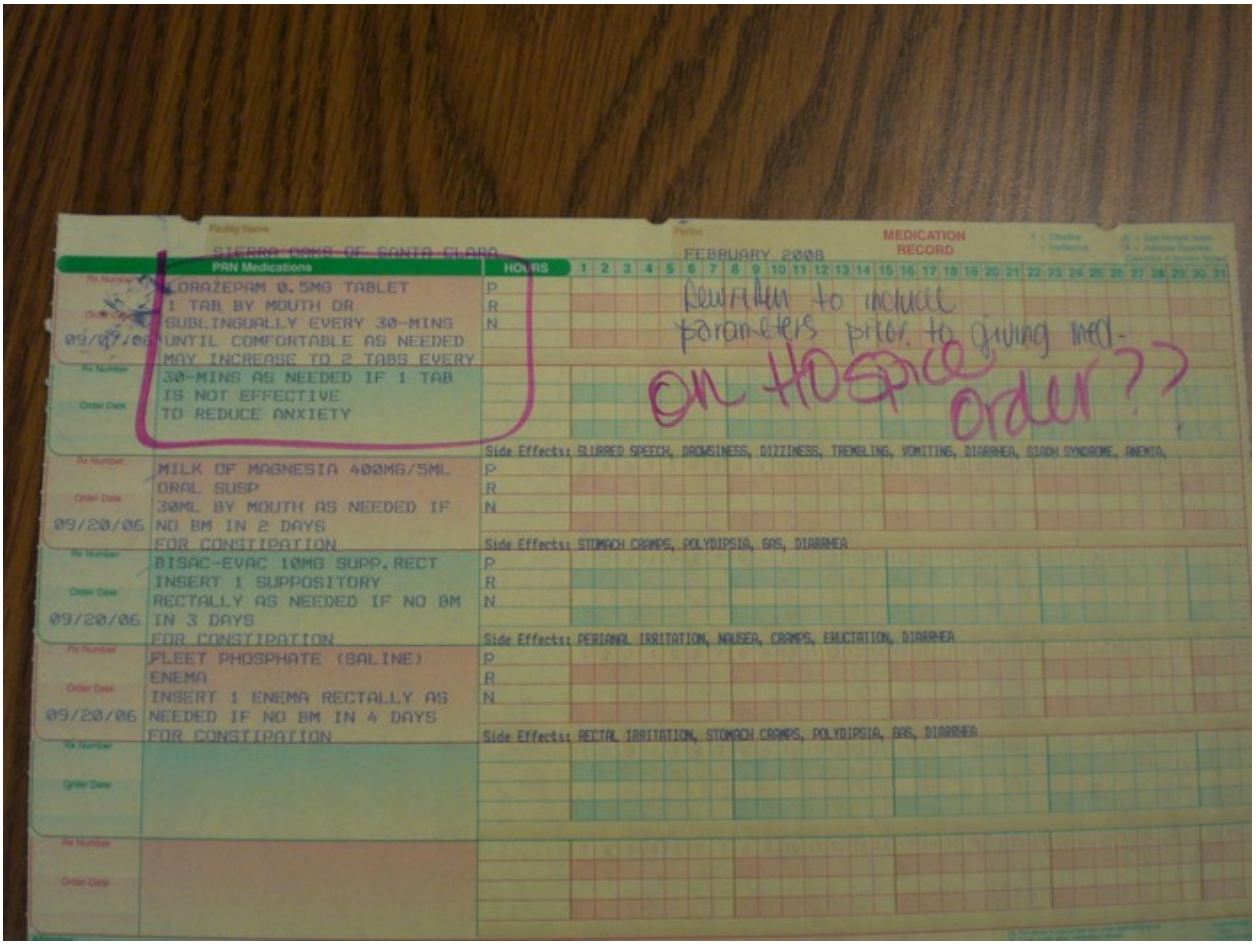


Photo 3.15: The pharmacy assistant did not see the order for this item in their system. She suspects that it was a hospice order that would not be transmitted here. She will confirm this over the phone.

Verifying with archives

She says that the facilities do not typically like it if she asks for orders that they have already sent. In some cases, the order is old and would not be in the file. If she suspects that the order was accidentally not entered into their system, she visits their archive room. The archive room contains the old files of the patient's, catalogued in cardboard boxes. She fetches a ladder, retrieves the files and searches for the order.

Photo 3.16: The older yellows (previous month and past) are stored in this repurposed hangar close to the office. The rolling ladder used to retrieve the appropriate archival boxes is seen to the right.

Identifying discrepancies

In one instance, she notes that the nurse has written PRN on the MAR. However, that has not been specified as such in their order. She marks it for follow-up.

I ask her if she checks the content of the orders, or just their presence. She replies that she does note some errors with common medications but otherwise mostly only checks for their presence in their system.

Nurse Consultants / Home Health

SNLH offered nursing consulting services much like the pharmacy I had visited earlier. In this peripheral setting, aside from hospitals, care was provided at different levels. The very sick patients were housed in skilled nursing facilities. The less sick were cared for in unskilled nursing facilities. Others received care at home. The nurse consultants catered to the nursing needs of the patients at each of these.

The skilled nursing facilities had adequate nursing resources for most part. However, they still needed help in some “special cases” and the nurse consultants provided the “special services”, on a contract. They also have some specialty equipment that their clients can benefit from (such as nebulizers).

The unskilled facilities have less nursing resources. Much of their work force is minimally trained teenagers, supervised by a nurse or two. This reduces costs and is generally adequate for the routine care of their residents. A consulting nurse at this kind of setup would support the nurses there as well as provide special services.

The nurses also visit the patients at their home and provide nursing support for the patients. Also, as one nurse described it, they act as eyes and ears of the patient’s physician; making sure that the patients are following orders and notify the physician of any additional information that they feel should be communicated, as well as the changing health of the patient.

The nurses travel to the site and provide services on location. The administrator at the facility was asked to suggest opportunities to observe every major kind of visit that the nurses perform. The administrator suggested four observations in three different settings. A different nurse was the subject in each of these observations and each observation was about half a day, including preparation for the visit - if any, travel, the visit itself and post-visit documentation. The skilled and unskilled facilities were within a walking distance of the nurses’ office. The patient homes that were visited were about a half an hour drive away.

Tools

All the nurses mostly worked off paper (with one exception – the nurse at the skilled facility used her laptop on site). They used their laptops before the visit to look up their patient's documentation before the visit and to create reports after returning from the visit. The laptops were compact and light and well suited for travel.

Consulting for the Skilled Facility

Task Description

Skilled nursing facilities have well trained nurses at hand as required by federal law. However, they still contract out for some special cases. The subject performed the medication safety task before providing patient services. The task comprised of comparing the medication list in her system to the medication records at the facility.

Environment

The safety task was conducted at the nurse station – a large desk. The chart room is adjacent to the station (this is the same room where the Residential Care Manager was observed) and she fetches the charts relevant to her from there. It is morning and the facility is bustling with activity as the nurses and other staff moved across the station.

Tools

The subject uses her laptop. The pharmacists have read-only access to the physician's record at their office, but the sites do not provide that locally. Much like the pharmacist observed earlier, she syncs up her laptop at their office before she heads off to the sites and this enables her to access the record offline. On query, the subject described herself as *"enthusiastic"* about it.

Process

An ongoing process (hh: ongoing)

She says that Medication Reconciliation is an ongoing process. It has to keep going because even if the patient's med lists are brought up to date and the patient is only visiting select facilities, they will still continue to fall out of sync as the medicines get changed during the course of the treatment. The subject feels that the *"organizations do not communicate well with each other"*.

"They don't tell you about the changes" (hh: changes)

When asked whose responsibility reconciliation was, the subject feels that the clinicians who really need the reconciled medication lists are the physicians. But the actual reconciliation is done by nurses. In this setting, the physicians have their offices separate from the care facilities to which they provide services. They periodically visit the sites to check the patients. They have their own record system that is different from the care facility systems. During the visits, the physicians make changes to the patient's medications. However, the physicians do not update the lists in their system, even when they make the changes at the facility.

Processing the lists (hh: lists)

The subject goes through the record, item by item, to identify the medications that have been changed recently for the patient. She marks each item in the list as she find the corresponding item in the other. She remarks that this facility keeps the drug orders in different places (standing orders, regular orders, narcotic orders etc) *"just to make life harder"*.

Updating (hh: updating)

As she works with the lists, she cancels a DC'ed order in her record. She is also annotating items in her list. Orders that need further attention are circled. Question marks are added to items that needed a follow up with the local staff. A check mark is used to denote that the order is OK.

Holistic (hh: holistic)

As I observe her, it becomes clear that she is using not just the med lists. She is also using other information in the medical record. Like the RCM, she is also reviewing the rest of the record in order to understand the patient.

Local knowledge (hh: local)

The subject sees that some standing orders are crossed off and checks the reason for this from a passing nurse. The nurse tells her that they were duplicate orders.

Consulting for an Unskilled Facility

Task Description

The subject provides nursing assistance to the unskilled facilities. She ensures that the orders match the treatments being delivered.

Environment

The unskilled facility had 2 floors and the nurse moved between them. There was a nursing station where the nurse resolved the medication discrepancies in the documentation, in conjunction with the local nurse at the facility. Much of this task was performed standing.

Tools

The nurse used her laptop and the local paper documentation at the site. She mainly looked at the physician orders.

Process

Monitoring

During the observation, the nurse provided care to one patient. However, according to the subject, the primary task of the nurse consultant in an unskilled facility is the monitoring of care, not providing it.

Modified orders (hh: modified)

The subject wants to make sure that the medications being administered match the orders. However, this is not always easy. For instance, the patient says that s/he can self adjust the dose and would not follow the order. The doctor, when informed about this, would say - *"OK"*, but does not follow up with an order to that effect.

Med-aides (hh: med-aides)

The subject explains the situation with the med-aides. The med aides are low cost resources, employed by these facilities to take care of the patients. They are young, often have

only barely finished high school and do not have the clinical skill sets. Their training is just 4 hrs. They need to be instructed on everything.

The subject gives an example of morphine preparation, where dosing is very important. The use of dropper to determine the amount to be administered needs some calculations based on the prescribed amount and the drug concentration in the preparation.

Med-aides do not feel comfortable with this and want the nurses to perform the transformations that they can follow. Likewise, they cannot assess PRN (instructions to administer as-needed) needs. Med-aides often have only 4 hours of medical training. They are even confused about things such as mg and ml. She says that nurses also need the specifics and like well parameterized (specified) orders.

Missing orders

Upon visiting a patient she finds that the patient is being administered oxygen. However, the order for oxygen is missing. The physician ordered it and the nurse records have it but the local records at the facility don't. These kinds of record mismatches are a concern but she says that they do not deny care as a result.

Load

When asked on what she perceives to be the load of medication reconciliation (as a broad category), she says that she has a 20 yr professional nursing experience and would estimate that about 15% of her time was spent on medication reconciliation.

Home health – Trailer

Task Description

The subject was providing post-operative care to a patient who had just been discharged from a major medical center.

Environment

This observation took place in the subject's home, a trailer in a trailer park, about a half-hour drive from the subject's main office. The patient was a heavy, double amputee whose surgical wounds required attention. He was in pain and needed help to even move in his bed. His ex-spouse was assisting him. They were both in grief for having to put down their dog that they have had for a long time. There was considerable grief in the atmosphere. His ex-spouse was quietly in tears.

The patient was on many medications. The medications were mostly organized within a large, transparent, plastic shelf box. But there were also medications that were littering the couch and shelves. In general, the trailer was cluttered and had more stuff than it could cleanly accommodate. It was not adequately cleaned (given the difficult circumstances that the patient's family was enduring).

Tools

The nurses used a variety of information tools. Notably, they carried a laptop on their trips that contained from their system. At the sites, they always worked with the paper based records. In addition, they used annotation tools such as pens and markers to compare lists.

Process

The subject began by reading the patient his rights and got his signature for consent to the procedures that she would perform.

Verifying medication use (hh: verify)

She went through his drug box, asking the patient and his spouse about whether he was on them. She also specifically inquired about the details such as how often he took them and

whether they were helping. The patient was visibly in discomfort and answered in short responses. The patient's ex-spouse occasionally assisted with some answers.

Ensuring supply (hh: supply)

The subject found out that they patient did not have enough diabetes strips. She would later notify this to the caretaker.

The subject then proceeded to take the patient's vital signs. She opened the bandages to check if the surgical incision was healing properly.

The patient's Medicare benefits provided a caretaker. This caretaker had arrived during the observation. The subject informed the caretaker about the diabetes strips and the caretaker agreed to take care of it. With the help of the care taker, she redresses the wound.

On returning back to the facility, she uses her electronic system (Horizon Homecare System). It has a clinical explorer module that is used to browse the patient documentation. The clinical explorer also has an interaction checker that can show warnings when drug interactions and side effects are detected.

Assessing documentation trustworthiness (hh: documentation)

However, the med-list in the records she got from the facility which treated the patient does not match their discharge summary. She remarks that the discharge summary is not accurate at all. It was hand written and unsigned. She feels that it might have been written in a hurry since the patient did say that they had to leave in a hurry, in about 25 minutes when the van to transport the patient became available.

Communication link to the physician (hh: physician)

She notes questions for the physician. She uses check marks while comparing across lists. For some medication entries, she wonders why the patient was on them.

Monitoring and reporting (hh: monitoring)

She updates the patient state documentation in her system. This form - OASIS MO780 measures the patient’s ability to take their medications. With forms like these, the federal

Medicare mandate requires the assessment of each facility by their patient's performance with respect to the national average (along with risk adjustments).

Educational support (hh: education)

Using her system, she prints some teaching material for her patient. She would give it to him in the next visit.

Home health – Tracing Side Effects

Task Description

The subject visited a patient who has recently been discharged from the rehabilitation facility and is being currently care for in her house by her spouse. The subject has concerns whether adequate care is being provided to the patient. The patient is currently on a large number of medications. Recently, the patient has developed a new complaint. The subject suspects that it might be drug-related.

Environment

The patient's house is a proper home, a far cry from the trailer where the previous observations took place. There are several parrots, in cages, in the room that functions as an entry-way. They greet us with loud squawks but calm down after a while. A small dog is also disturbed by our visit and keeps barking for the duration of the visit.

The house is somewhat unkempt - notably pill-bottles, littered on tables and counters. Otherwise, the house is clean. The patient was seated in a sofa and remained there through the entire session. She was very thin, weak and anemic and spoke in a low tone. Her husband aided with the answers.

Tools

The subject only works with pencil and paper during the visit. After the visit, he uses his laptop to enter the information into their system.

Process

Medication analysis (hh: analysis)

While driving to the subject's house, the subject mentions that he suspects that her new symptom might be drug-related. In an attempt to identify the cause, the subject has gone through the list of the patient's medications and had earlier looked up side effects and interactions among them, from a reference source in preparation for the visit. With a pencil, he had scribbled this list, in the margins of the medication list of the patient that he had printed

from their system. He says that he wishes to review other medications that the subject might be taking.

Note: I waited on the subject as he said that he had something to finish before the visit. It turned out that this prior information collection was not considered by the subject as part of my observation and I had assumed that it was an unrelated task until the subject had mentioned it during the travel.

Ensuring medication access (hh: access)

After greeting the subject and the spouse, the subject proceeds to take her vitals. He proceeds to go through the list of side effects that he has created earlier to rule them out. After giving some diet advice, the subject runs through the patient's med list to make sure that she is taking them as per orders. He then checks her *medi-planner* and *pill-basket*. He finds that a medication is missing while checking the medi-planner. The patient confirms that she has run out of some pills and the subject makes note.

Identifying pills (hh: identify)

The subject finds a pill outside a container that he is unable to identify. It does not seem to fit the profile for any medication that the patient should be on. In another case, he finds a white round pill in the medi-planner while he was expecting a white oval pill. He makes a note of these and we take leave.

Transient Representations (hh: transient)

During a conversation, I mentioned an earlier pilot study of mine in trying to understand clinical representations and mediums. The subject immediately resonated when I mentioned transient mediums and showed me a joke gift that her colleagues gave her. It was a notepad created entirely of paper napkins. The subject had the habit of preferring paper napkins and other scraps of paper as a note taking medium which her colleagues found amusing. The subject was surprised to hear that such behavior was previously documented. She had assumed that it was her own peculiarity.

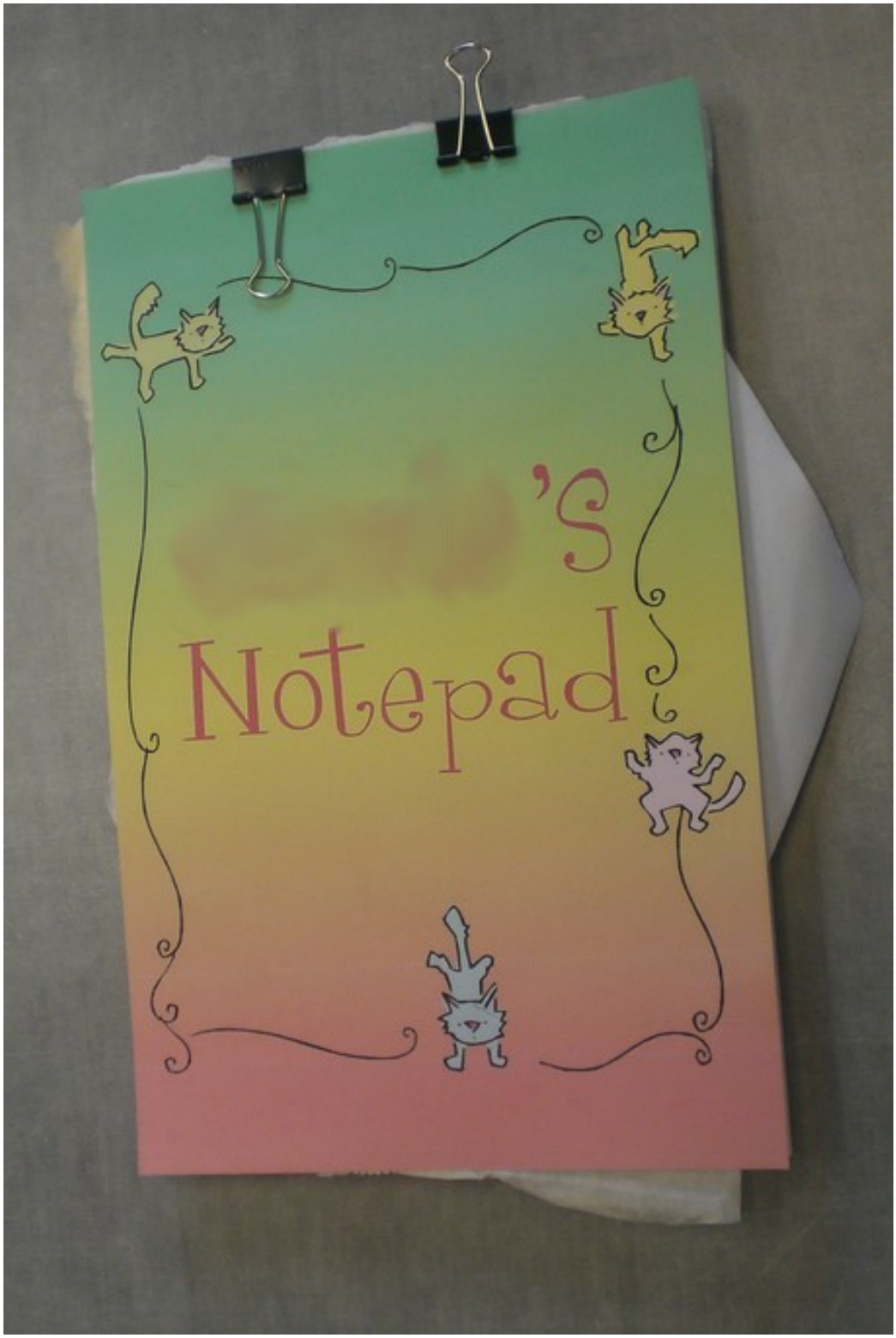


Photo 3.17: A notepad gift made of paper napkins. Tacit acknowledgement of the preference and utility of trancient artifacts.

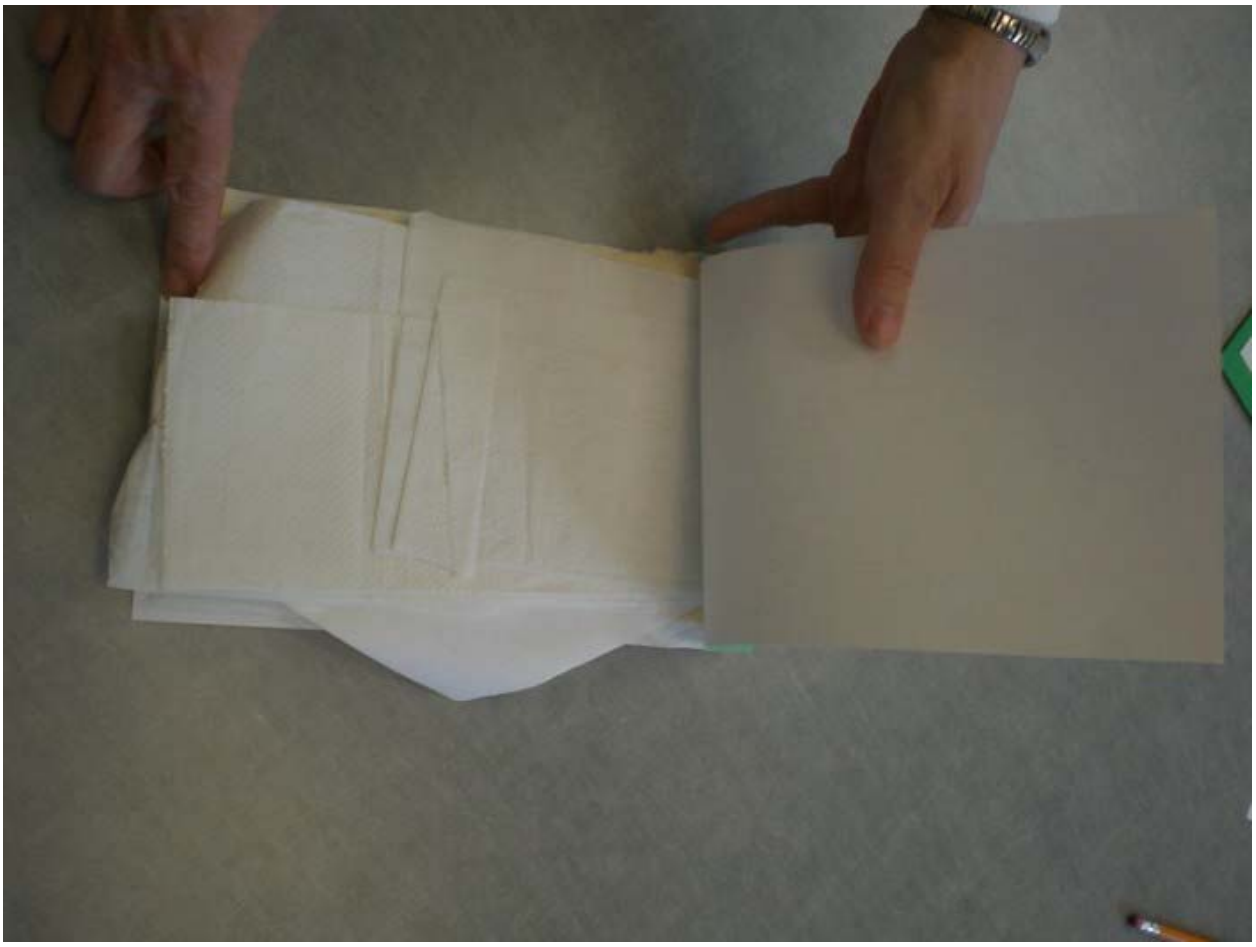


Photo 3.18: A notepad gift made of paper napkins. Tacit acknowledgement of the preference and utility of trancient artifacts.

Prior literature described the use of transient representational mediums by clinicians. The figure shows a back of the envelope/back of the napkin style use of representational mediums. A gauze pad is shown with several numerical entries (Gorman et al. 2000). Further, the information is largely indecipherable for an individual who is not familiar with clinical settings. However, most clinical professionals can make sense of it. The use of a transient medium relieves the subject from being required to use formal representations and instead entirely use those recognized by h/er professional community. The representations are created in the rich local context that the subject is aware of and is confident that h/er colleagues share.

The use of non-standard representational medium ensures that the intent of the representation not being a part of the official record is communicated.

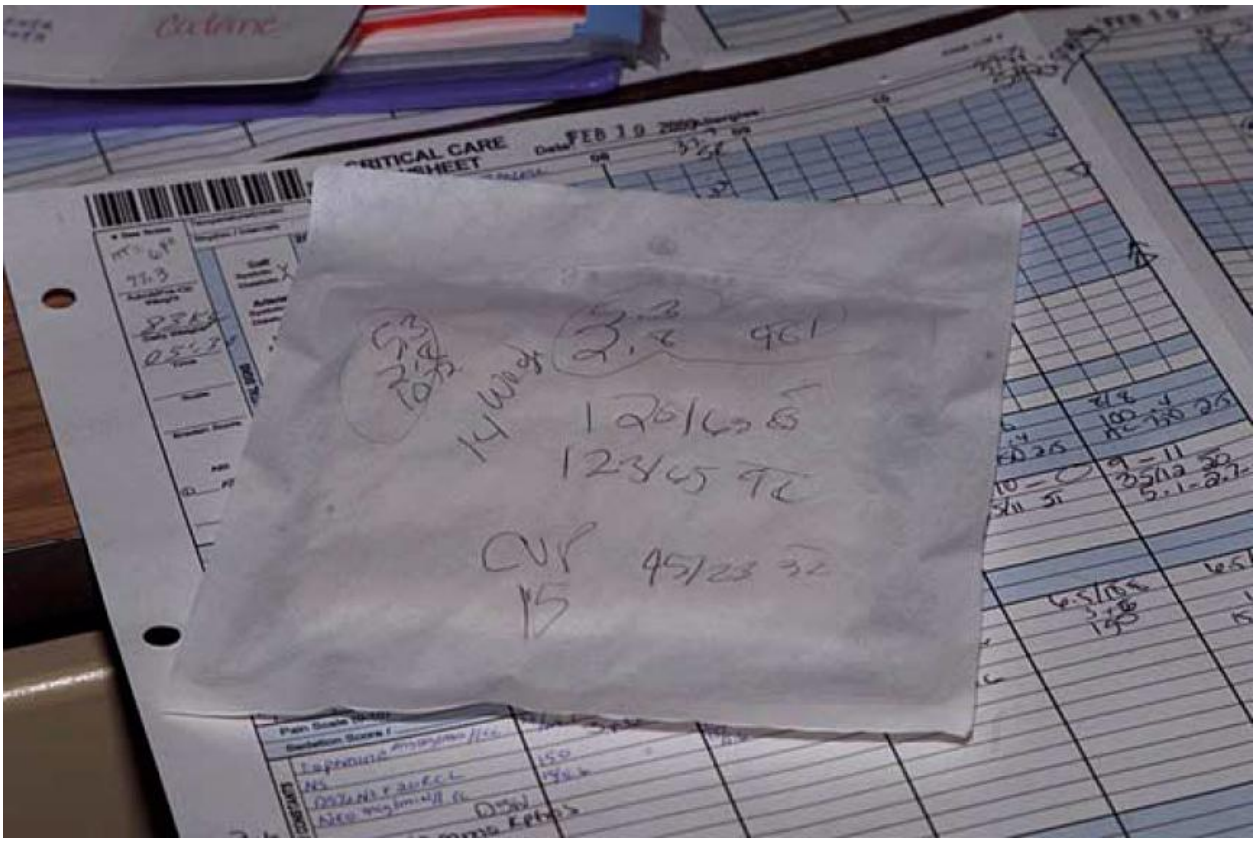


Photo 3.19: A *Messy Bundle* demonstrating the use of transient clinical representations (Gorman et al. 2000). Reproduced with permission.

Representations are used for three primary purposes in clinical activities

1. Communication
2. Cognition
3. Record

Only the record component is primarily addressed by the contemporary EMR (The R in EMR). Communication features exist, but simultaneously force record aspects onto it. This is acceptable for formal communications but informal communications are not addressed.

Subjects might communicate with more freedom when they have the ability to destroy the message (transience). Since a good deal of clinical decision making happens under uncertainty, it may be essential to acknowledge the importance of such non-formal mediums.

The Physicians' Office

The physician and his office nurse were observed and interviewed on 3 days, first with a day each, and after reviewing the observations; a follow-up session was conducted with both, on a single day.

Task Description

The physicians' office as a cognitive system attempts to gain an understanding of the patients' medication profile before acting on it.

Environment

The physician shares his practice with other physicians. The entrance to the facility is provided with a waiting area adjacent to which non-clinical staff operates. They take care of setting up appointments by phone, receiving the patient and creating the preliminary paper work on arrival. Additionally, billing and technical support staff is also located here. The waiting room leads into a corridor that leads into the clinical area. At the entry to the corridor, a folder is located on the wall which contains the admit paper work placed by the non-clinical staff upon receiving the patient. The clinical area consists of a small room where the physician and nurse work from in between visits. There are four exam rooms where much of the activity happens. There is a large weighing scale on the way to the exam rooms. The nurse picks up the admit documentation, call the patients' name, receives and leads them to an empty exam room, measuring the weight on the way. There are also some procedure rooms.

The exam room consists of an examination bed and a workstation providing access to their EMR. The clinician typically faces away from the patient while interacting with the machine. However, the interaction time is not significant since the manual data entry is kept to the minimum through the use of templates in the EMR. A common printer is located outside the exam rooms, along with the weighing scale. Each room has a folder attached to the door where the nurse places the paper documentation after completing here part of the consultation.

Tools

A combination of paper and electronic tools are used in this setting. EMR is used as the primary local information source while paper remains the exclusive cognitive medium. Paper acts as the information source as well, especially for the information that the patient brings with him.

Process

The task was medication management that occurred as part of patient consultations, a series of which comprised the activities of the Physicians' Office activity. During most consultations, patients were diagnosed, followed up, or both, during a same visit. In fewer instances, procedures were prescribed that were either performed during the consultation (cleaning wax, removing a papilloma) or referred elsewhere (Barium swallow).

The primary focus of observation was on medication management that occurred during the visit. Many patients in the long term setting are seen by multiple physicians. In most cases, the physician observed was the primary physician of the patient. The other physicians were the specialists that took care of specific problems on referral.

Since the patients' use of medications might have changed during the time in between the visits, either due to the changes made by other physicians or by the patient himself, they are reviewed at each visit.

The patient's medications are checked by comparing the local records and patients' account, or in some cases, additionally with the records that the patients brought in with them. Medications may be modified or added during the end of the visit based upon patient interview or laboratory data that was fed directly into the EMR. The physician's office, as a collective unit attempts to understand the patients' medication profile in context of the patients' diagnosis, treatment and investigations.

The entire task, and specifically, the medication management task, was performed as a collaborative, multi-stage activity, by both the nurse and the physician. In most cases, the

physician and the nurse do not concurrently attend the patient (except for procedures locally performed). However, the do interact through artifacts.

The nurse sets up the patient session on the EMR and enters the patient's vitals (Weight, Pulse, Blood Pressure etc). She reviews medication information with the patient, creating a report for the physician, as needed. When the physician visits the patient, uses the same patient session in the EMR is used. This means that the EMR is not able to distinguish between the information entered by the nurse vs. that entered by the physician apart from being recognized by local convention. The distinction can be argued to be functionally unnecessary for the medical record (although imaginative or exceptional instances may be cited to the contrary), especially since the EMR did not seem to specially support one from the other. The physician, nurse combination can be seen as a single cognitive unit.

The physician's office was unique among the observed settings since it involved significant sharing of responsibilities in a relatively concurrent task flow.

- Nurse picks patient sheet
- Nurse calls and receives patient
- Nurse leads him to exam room
- Nurse takes weight outside exam room
- Nurse takes patient into exam room and brings up the chart (later?)
- Nurse enters weight
- Nurse takes rest of vitals
- Nurse enters vitals
- Nurse opens drug list
- Nurse print drug list if it is long
- Nurse goes through the list with the patient checking if meds changed.
- (Asks for selected meds, generally does not ask for dose changes except when obvious concern, looks up meds when necessary)
- Nurse writes changed meds on printout (if no printout?)
- Nurse checks CC (from scheduler)

- Nurses places papers on the door
- Physician walks in
- Physician talks to patient
- Physician enters orders (occasionally performing procedures)
- Nurse schedules procedures if any.

After noting the vital signs including weight, blood pressure and heart rate, the nurse brings up the patient's medication list. If the list is short, she directly checks, with the patient to see if he agrees with the list of medications. If the list is long, she prints out a copy and checks it off as she checks for the patient. Is the patient says that he is on any new medicines, she writes them down on the printout to be shown to the physician. During this check, only the drug names are verified; not the dosage or frequency information.

After this interview, the patient is left in the room with the paperwork placed in the box attached to the front door. When the physician emerges from one of the other three examination rooms, this paperwork cues the physician that a patient is in this room.

Goals

When the physician was asked to list the goals of his medication related tasks, he provides the following list

- Deciding which medications the patient should be on discovering whether the patient is complying with the medications prescribed.
- Tracking changes to the medications.
- Follow up with the patient on efficacy and side effects i.e. checking whether the medications are working out for the patient.

Observation later showed that these tasks are not entirely performed by the physician himself. Both the office assistant and the physician query for compliancy. Tracking medication changes is primarily done by the office assistant. The physician exclusively tends to prescribing medications and following up on them for efficacy and side effects. He says that the process he uses is developed by both his academic training, and his experience.

He gives instances of noting side effects of medications. ACE inhibitors cause cough, while statins cause muscle pains. Since he knows to expect them, he's able to attribute the problems to the medicines.

On a query on memory, he says that it actually improved with regards to remembering the patient record. He feels that his experience consolidated his education. Some of his

patients' problems are not accessible by medications. In this case, he says that his role is primarily to hold hand and support rather than solve.

Chapter Four: Analysis

Analysis of settings

Residential Care Manager – Recap

If the recap task can be described in one sentence, it would be – *"comprehensive, periodic, nursing-oversight task that builds and disseminates coherence within the facility"*.

The RCMs' term recapitulation implies a cognitive phenomenon. The nurse is recapitulating the clinical events in one sweep, effectively forming a meaningful picture of patient care. The recapitulation process consists of reviewing, transforming and creating representations on the artifact. Some of the transformed artifacts are specifically intended for other clinical staff such as shift nurses and med-aides. As a result: although the Recap task itself is bounded to a single subject, it can still be seen as a distributed task.

This is a more complex task setting rather than a case where the RCM is simply examining documentation for errors. The RCM was ensuring that the artifact network is coherent i.e. there are orders for all the medications, treatments etc. Additionally, she is also ensuring that her own understanding (posited as the internal network of information) about the patient continues to be coherent while considering new information from the artifacts. This means that if she finds any information in the chart inconsistent with her understanding of the patient, she will explore further till a state of coherency is regained. Finally, she further makes the record more coherent by propagating her coherence that was generated using her patient context to the other nurses who might not have as much patient context, by introducing new representations that make it easier to understand and mitigate the chance of error.

Her goals may be stated as 3 Cs

- Correction
- Caution
- Coherence

She corrects errors (rcm: correct, rcm: incomplete, rcm: dc) of transcription, places safe-guards in place to prevent errors by other nurses (rcm: safety) as well as make the MAR easier to understand (rcm: annot), makes sure that the record is meaningful with her understanding (rcm: unrestored, rcm: context) while simultaneously improving her own understanding of the patient status (rcm: medicaid).

Over-sight

Oversight is important since patients are taken care of by different nurses at different times of the day and different periods of their often long stays at the facility, for logistical reasons. This can create a fractured understanding of the patient's condition. The RCM provides an oversight to compensate for this. She reviews all the information on the patients, not just the information necessary for her shifts and reviews all patients assigned to her for oversight, not just the ones she is providing nursing care for, during that period. This positions the RCM as a unique resource in the long term nursing care setting, much like a classical family doctor who keeps tabs on all care received by his patients.

Patient Model

The striking feature in the recap task was the comprehensive, pre-existing and evolving model of the patient that the RCM brought to bear. On the surface, the RCM compares the information in the MAR with the information in the patient chart. However, she was more importantly comparing it with her understanding of the patient. She is not simply performing a clerical information comparison task; but rather a higher intellectual task of assimilating new information into a coherent body of patient specific information while simultaneously validating against it.

The model comprises of the past medical history of the patient, an understanding of his condition, his response to prior treatments, his family history, habits and personal preferences etc. This comprehensive awareness allows her to think much more deeply than the information

in the patient chart alone would support. She is able to think whether the treatment information in the chart makes intuitive sense given what she knows about the patient.

A patient model is difficult to externalize outside the neural boundaries of the subject's cognition (cognition itself is a conjectural concept). It would be an interesting question to measure task performance between two groups of subjects of identical training (same knowledge based information) but differing in patient model (patient specific information). One group would be familiar with their patients, and the other group would not be and works exclusively from documentation (crossover design). Recognizing the role of the patient model means that individuals possessing such models need to be leveraged explicitly to performing tasks that benefit from, or just plainly require the model. When the hospital management intends to maneuver these model hosts (clinicians) within an organization, for organizational reasons, the implications need to be carefully considered.

Task Space

	Knowledge	Local information
Internal	Nursing Training	Patient context
External		Patient Chart

Table 4.1: Information resource distribution within the RCM's abstract task space.

Tacit task specification

The recap process is a tacitly specified, informal process. It has several subtle aspects that need to be well understood before systems that can support the process can be built. We may not hope to create tools for processes that we have not described first (describing before prescribing). Explicating such tacit behavior facilitates system designers to explore novel error prevention aides using the descriptive framework. As an instance, the current EMRs do not support annotations. This may deny clinicians their earlier tools in communicating, notifying and alerting the other team members. This will have implications in safety. But, unless the fact

that annotations are routinely used is first understood and gamut of their application is described, the designers cannot be expected to appropriately support the existing process or systematically propose alternatives. Unless the finer aspects of the annotation use are described in detail, designers will not be able to create the architectures that may support such functionality.

Unbounded task

The recap task is not the only major documentation task that the RCM performs. She also performs a similar task concerned with reporting services provided, for Medicare/Medicaid reimbursement. Similar to the recap task, this task also influences her patient model. Both these task generate as well as utilize patient model (rcm: medicaid). Modifying one task will have impact on the other task. It is important then, for system designers, to have a more holistic understanding of the gamut of tasks performed by clinicians rather than address them in isolation.

It may be necessary to design keeping in mind – information comprehension, cognitive side-effects, working memory, long-term memory. Different information representations will likely have different cognitive effects. A visual representation that aids long-term memory will be different from an interactive representation that aids short-term, working memory. Designers will need to be explicitly aware of the effects they need to produce i.e. Representational Determinism, before designing artifacts (Zhang & Norman 1994).

Bounded task

While the task has dependencies and implications that challenge a naïve confinement of convenience, it nevertheless was bound quite clearly in time and space. It was performed in a specific room (with good access to patient charts) and during a time period when the RCM does not attend any other tasks and devotes here attentions exclusively to it. The task can also be well delineated into sub-tasks.

1. Examination of the new MAR
2. Comparison with the old MAR
3. Identifying changes
4. Validating changes using order documentation, along with content inspection
5. Examining lab orders and reports

The way in which the RCM begins and ends the recap task is especially interesting. Recap is a cognitively intensive task requiring much focus and attention. A tell-tale indicator of this aspect is the note made by the subject that she is considered to be cranky during the task. She appeals to the bounding the hardest portion of the task concerned with fuzzy interpretation (E.g. why did they put him on that medication?) and model generation, with the noticeably easier subtasks. The acts of signing the MAR and writing “Recap completed” are in themselves not significant in scale to attract attention. It is however their logical displacement that begs enquiry. Documents are typically (and rationally) signed at the very end, not in between. The RCM might be recognizing the daunting task ahead and picking relatively easy tasks. There are two lines of questions that emerge – behavioral (descriptive) design (prescriptive).

On the behavioral plane, does performing a simple task warm up the subject's cognition to the more daunting load at hand? Does such consistent partitioning enable the subject to see the task as more manageable and with a sense of progress? Are the simple tasks at the end considered as rewarding moments? Without a more thorough examination, we can only speculate.

On the design plane, there should be further explorations on whether clinicians engage in this behavior elsewhere. If further corroborated, such data may warrant thinking about the cognitive need and impact of such behavior. Are the electronic systems supportive of such behavior? Do they allow completing the tasks as separate units at the user’s discretion, or do they enforce a particular sequence to completion? If they enforce process sequence, are such controls justifiable? What should be the guiding philosophy in process design? Should the systems protect the users from themselves or should they trust the users to know best?

Arguably, both approaches can result in problems. But which approach can be empirically shown to be the least problematic? What should the metrics be for comparing these approaches? Can there be a balance between the two approaches? If yes, what would be the operational framework to derive it?

Batch task

The RCM performs the recap task as a batch process i.e. she examines all her patients at once. However, she does not batch the subtasks within each task (as will be seen with the pharmacy technician). This could possibly be because the task requires recalling a rich patient context from long term memory, something that the pharmacy technician is not able to do. The costs of switching patient context is likely much more cognitively intensive than those incurred by not having a homogeneous stream of sub-tasks.

The RCM initially used her finger to remember her progress through the chart. Later on however, she did not. Physical cues such as these are the external artifacts that humans use to augment their cognition. It is likely that the RCM no longer needed this assistance as the task progressed along. This could mean that the task has become simpler. However, the RCM was still reviewing complex charts of residents using skilled services. The other explanation is that the subject is now able to focus better than the early phases of the task. The phenomenon is colloquially referred to as *"in the groove"* or *"in the zone"*. Cognitive Psychology literature refers to this as flow. Flow states are hyper focused states where the subject is fully immersed in the activity. Productivity is increased in such states. This brings up several questions worthy of exploration. How often do clinicians enter the state of flow? Is the distribution similar across different clinician classes? What is the role of batch tasks in promoting flow? Do all batch tasks favor flow? Are there any exceptions? What are the performance differences (time, error, satisfaction) between tasks completed in flow vs. without? Do the electronic systems take the incidence of batch tasks and provide supporting tools for them? If so, are there any design-patterns that can be extracted from these tools? Can we improve them with further theoretical foundations?

Representational determinism

As seen above, the two RCMs used different organizational strategies in the preparatory configuration phase. Since this changes the information availability and representational affordances, it is possible to hypothesize that the two tasks were different at some level. It is possible that these organizations are consequences of differing professional experiences and would result in somewhat different task outcomes (even if slight) due to representational determinism (Zhang 1997). However, this was not further explored in this study.

Catching Errors

In describing the task, the staff (and the RCM) simply presented it as a documentation verification task. However, the RCM did not just ensure correspondence of documentation artifacts but also evaluated their content to the best of her abilities. The RCM was observed to correct several content errors as well. She also mentioned other kinds of errors that she identified in the past during the interview. These are as broadly as follows:

- Errors in transcription – the content of the orders are not accurately transferred
- Errors in discontinuations – medications being administered longer than ordered
- Errors in resumption – Long tem drugs for chronic conditions that are withdrawn temporarily during acute episodes are not resumed.
- Orders without adequate (parameters) information.

She was able to notice errors, potential errors and inadequate information by medical records department, other nurses and even physicians.

Preventing Errors

The RCM simply does not correct errors that have already occurred; she actively attempts to prevent common errors from occurring in the future. The RCMs are always experienced nurses and the current subject is no exception. This experience makes her

sensitive to the common errors that nurses make. These errors largely appeared to be concerned with improper reading of instructions, especially when there are slight variations over common orders. The human mind is understood to recognize patterns in written language, rather than to meticulously interpret character by character (Giere 2002). To prevent such errors, the RCM brings extra attention to error-prone orders (one drug was prescribed to be given only on a specific day, but was listed along with daily medications) by using visual aids (highlighters and adding emphasis to printed text). There is an opportunity for the informatics community to identify common error-prone information representations (accidents waiting to happen) within busy clinical settings. Common base representations and their problematic variations need to be enumerated. If ethically possible, the role of these *safety representations* in reducing error rates should be explored and measured.

Comments

A user interface that works well at a desk with a mouse does not necessarily work well in an environment where there user is walking, has only one hand (or just a thumb) free. In the former, the user interface may accommodate a busy design with a rich display of information giving the user freedom to drive the task in any way s/he chooses. In the later instance, the user interface needs to be more focused, clean, process-driven, presenting the user with a smaller set of choices for easy selection.

Similarly, if we are able to identify and acknowledge the tasks that are expected to be performed in high-focus scenarios vs. those that are performed in high-distraction scenarios, we may be able to provide better aligned information experiences.

Pharmacist - MMR

Pharmacist as a coherence generator:

Like the RCM, the pharmacist examines not just the medication lists (local list at the facility against the pharmacy list) but also much of the medical record (pharm: whole) and attempts to ensure that the diagnostic profile, pharmaceutical profile and the laboratory profile are in concordance with one another (pharm: model). Since each of these profiles is subject to change during the course of care, it is performed periodically and incrementally. The pharmacist uses her own information tools to track the reviewed state of the medical record (pharm: tracking).

The pharmacist's task may be compared to that of the RCM's in that she periodically reviews the specific elements of the medical record to ensure that is meaningful from perspective. She differs from the RCM in the uniqueness of her perspective, the particular information components that she evaluates, and in the outcome of her task (pharm: rcm).

Her perspective is unique in that, she participates as a special pharmaceutical resource (her knowledge base and experience). Both the RCM and the physician do possess differing degrees of pharmaceutical knowledge. However, since the pharmacist is particularly trained in this domain and performs a special medication focused task, she is able to bring a new level of coherence to the system (pharm: physician).

The pharmacist had to look for information without being certain what it is that she was looking for until she felt that the information was adequately coherent to move on (pharm: rummaging). A more standard and connected representation of information would have made this unnecessary

Since the pharmacists visit several facilities, they also need to pay attention to the various local variations in documentation. A standardization effort in terms of both the content fields as well as the visual presentation across health systems could benefit clinicians who work

across them. Like the pharmacist, the physicians and some nurses in the setting also worked across several facilities.

I felt that the pharmacist was not suitably served by the structure of the current medical record system. It was not uncommon for her to feel the need for information that was either difficult to locate in the chart or was simply absent. In these cases, the pharmacist had to infer the information indirectly from other pieces of information (pharm: infer). Predictably, and not uncommonly, such inferential information existed in uncertain form (pharm: uncertainty, pharm: dup) and such decision making appeared cognitively burdensome.

The inferential process however seemed to consume significant cognitive resources. If coherence is understood as a meaningful association between individual information elements, the association information was often natively lacking within the chart. Medication orders are not associated with diagnostic information that necessitated them. Similarly, laboratory results do not provide the information to associate them with diagnoses, clinical events, medications etc. It should be noted here that this observation is not special to this particular facility. I spoke to clinicians elsewhere and from my own experience; this is simply information that has not been traditionally persisted in the record.

So, should this information be required by the physicians who are assigned to be the primary clinicians who establish these relationships? Grudin's law (Grudin 1994) (Norman 2000) (Gorman 2006) states that *"When those who benefit are not those who do the work, then the technology is likely to fail, or at least be subverted"*. The physicians likely would not readily see themselves as beneficiaries of such information since they have a relatively well developed context of the patient (at least of their own patients). While they do have their own coherence, in today's distributed health care delivery, this coherence needs to be propagated somehow without being too burdensome to the contributors. This document cannot assert an ideal solution but can attempt to speculate on some approaches.

- Small cues can go a long way (a short, perhaps even a 1 word statement could help)
- Digital record systems need to consider novel interactional schemes that allow such specification with a few key strokes. However, they must refrain from ambitious highly structured formal data representation utopias. Excessive formalisms do not work well (Shipman & Marshall 1999).
- The system should provide some sense of value. Perhaps a pilot test could show that physicians would derive benefit from the representation themselves.
- Some of the relationship information may be authored by the less expensive nursing resources. Although not the primary generator or meaning in the record, they have the next best grasp of it. The RCM was in fact acting in this way, although she had a very specific audience for her coherence contributions i.e. the nurses who perform administration duties. If more general purpose, yet well defined representations could be formulated that improve the overall readability of the chart, the RCM could engage in a formal, compensated coherence generation/consolidation task that could enhance the overall coherence of the health system. This will need to be evaluated for costs and benefits.

How do clinicians currently interpret meaning from such a record (without relationships)? Typically, they are expected to possess the knowledge and experience that makes such relationship information redundant. When an antipyretic is seen in the chart, it is inferred that the patient likely had a fever at that time. The inference however becomes difficult when the drug is uncommon or multiple uses are present, or when a diagnosis cannot be located in the chart. We see this in the case of an antibiotic order (pharm: infer). Was it for a respiratory infection or a urinary tract infection? The pharmacist looked to see if a chest x-ray or a Urinalysis report to resolve ambiguity. Note that finding one of these will only increase her confidence in her speculation. Without an explicit representation, it cannot be asserted.

If the relevant portions of the patient chart are rendered into an at-a-glance visualization across appropriate dimensions, the pharmacist's task could be greatly simplified. Timeline representations are potential candidates for this (Bui et al. 2007) (Allen 2005) (Plaisant

et al. 1996) (Plaisant et al. 1998). The pharmacist should be able to filter to the last one month of medication and select the axes relevant to her (medications, labs, diagnosis etc).

Zhu et al. note two classes of uncertainties that often occur when reviewing medication information (for medication reconciliation) – temporal uncertainties and clinical uncertainties. Temporal uncertainties refer to incomplete information with regards to the time parameters. An example is a history where a note provides the history of use of a drug but not the exact time and duration for which it was used. A clinical uncertainty may be when a class of the drug is specified (Painkillers) but not the specific drugs that were used (Zhu et al. 2009).

Since the review task is a safety task, the goal of the pharmacist is not to simply assume that an antibiotic is being given for some infection but to actually check for the diagnosis such that she can make sure that the medication is appropriate and that it is not being given over an inadvisable duration.

The temporal uncertainties are less significant in the skilled facility setting since meticulous documentation is present with regard to medication administration through a MAR for recent medication. The standard medication reconciliation process would have been completed at the time of admission. The particular type of uncertainty seen in this setting is a diagnostic uncertainty i.e. what diagnosis necessitated this medication? This uncertainty may be considered a sub class of clinical uncertainty.

The pharmacist is largely an outsider to the facility. This has two interesting implications - in reducing medications and in understanding the medical record.

The patients in these facilities are old and often suffer from chronic conditions that result large medication regimens. Since medications are added over time and because the prescriber may not have the full medication profile at hand and may be relying on the incomplete information of an interview, medications may be added inadvertently alongside existing ones. Similarly, the impetus to discontinue medication is a less active one when compared to prescribing them.

The pharmacist brings in an explicit will to reduce medications. Note here that while the medication prescribers and medication administrators are motivated to promote use of certain medications due to their contact with the patient (eg: anti-psychotics, pain-killers), the pharmacist who examines the data as an outsider does not have these motivations and is able to examine the medication profile more critically (pharm: accumulation). As a result, she is able to present a detached evaluation and remind the local clinicians on whether the medications need to be reconsidered.

Being an outsider, she has no additional context of the patient other than what she can obtain laboriously from the chart. Her information is limited to what she can read from the chart. The chart typically does not contain every piece of relevant information about the patient. Even when the information is present in the chart, the pharmacist is only able to assimilate a part of it. This makes it harder for her to make confident judgments about the patient's medications.

The pharmacist was understandably cautious in her suggestions, since they were often based on uncertain, inferred knowledge. Adding to this, the physicians show their annoyance from time to time when the recommendations are not coherent with their clinical context. Conversely, the pharmacist was encouraged when the physicians responded positively and approved recommendations (pharm: physician).

It appears that the physician’s appreciation for the services that the pharmacist provides may be improved by making them aware of the cognitive processing she performs. This may motivate them to include relationship information in the chart as well as be less annoyed when her suggestions were not based on complete context despite her best efforts. This failure may happen due to the following reasons.

- Physician's decision making context was incompletely documented in the record
- Pharmacist was unable to determine when she had enough of it (pharm: uncertainty)
- Pharmacist was unable to formulate a successful strategy to acquire it (pharm: rummaging)

Task Space

	Knowledge	Local information
Internal	Pharmaceutical Training	
External	Pharmaceutical Reference	Patient Chart Pharmacy Medication List

Table 4.2: Information resource distribution within the pharmacist's abstract task space.

Recommendations:

Chart comprehension

The pharmacist task may be more abstractly defined as that of a clinician who is attempting to make sense of a new patient. It is likely that a similar activity occurs when a physician looks at a new patient's chart. This chart comprehension is unnecessarily difficult.

I propose that we rethink the way information is structured in the modern electronic health records systems. The current systems often present the data as documents, similar to their paper counterparts. However, this structure is potentially grounded historically in the physical characteristics of the paper medium.

When coherence is being expensively generated by the actors within the clinical system, much of it is simply discarded and only a small summary of it is persisted and propagated through the system. In the absence of reuse, this is an ill-exploited cognitive investment. In a virtual information space, this need not occur.

It has to be noted that it is certainly desirable to not cause further information pollution by further adding to the already large clinical charts with additional information burdens to the clinicians. Nevertheless the utility of such information vs. the costs need to be explored. The costs will likely be cognitive as with the benefits and associated with authorship and distraction (effort needed to filter out while attending to a task that does not require this information).

The new conception of record structure should take into account, the novel affordances of the electronic medium. The representational affordances continue to evolve. Highly graphical displays should replace today's form based user interfaces. Novel representations should be specially built to facilitate coherence i.e. show how the data is inter-related semantically.

The increasing display resolutions should also be taken into account. The large displays allow us to design representations that can give a comprehensive overview of the patient's condition within a single view.

Very large displays can be driven by the modern, powerful yet inexpensive GPUs. Large displays are generally associated with increased productivity as well as satisfaction. This allows the designers to create very large logical representational spaces that can be navigated within. Large displays have been shown to improve performance and satisfaction of users (Czerwinski et al. 2003).

The successful ideas of hyper-linking that led to the modern web and the more modern notion of the semantic Web should similarly be exploited by the EMR designers to create a meaningfully connected patient record that allows easy navigation through relationships. Contemporary designs largely use hyper linking only to navigate between content-types (move from displaying a medication screen to a labs screen) rather than between them (move from a medication to a specific lab test ordered to monitor it).

The potential collaborative nature of the electronic system also means that the relationships of meaning can be constructed gradually and incrementally by various clinicians that interact with it. The designers should create the tools that make the specification of

relationships between information elements, effortless. Such a workspace should not only provide value through representations that are generated through it but also generate value by promoting clarity to the contributors through the very activities of constructing such a coherence network.

Determining what interactional models would most exploit the available technology and provide the most benefit to the clinicians would be a significant research undertaking. Aside from the technology itself, the representational models that would best serve the cognitive needs, both in the context of specific tasks as well as general principles need to be explored. Before this may be done, we ourselves must develop a coherent understanding of clinical cognition.

Pharmacy Assistant - Yellows

The task of the pharmacy technician was the simplest and the most well defined of all the subjects observed. This subject neither had the patient context like that of the RCM (works remotely) nor any pharmaceutical context (knowledge context) like that of the pharmacist (although, she was still able to think in terms of medications by her work experience). This meant that there was much less in terms of internal cognitive context that needed to be accounted for. All the information that she was considering could be directly observed over external artifacts.

Task Space

	Knowledge	Local information
Internal		
External		Yellows Pharmacy medication list

Table 4.3: Information resource distribution within the pharmacy assistant's abstract task space.

Batch task

Like the tasks of the previous two subjects (RCM, Pharmacist), the pharmacy technician's task was a batch task. The most distinct insight gained from the observation of the pharmacist task was about how she restructured her task to optimize it.

Unlike the previous subjects, she does not deal with one patient at a time. Instead, the task is divided into three distinct phases, where all the patients remaining under consideration are dealt with in each phase.

- Triage
- Double-check

- Follow-up

In each of these phases, some patients are set aside since they need no further review. It is only the patients in the last phase that typically necessitate corrective actions. During the triage task, the pharmacy technician compares the medications list, item by item. This is most in contrast with the RCM who seemingly compared it with the internal context and to a much lesser degree with the pharmacist. The coherence model allows us to postulate that the likelihood of a clinician to perform an item by item comparison is indirectly proportional to the internal context that the clinician processes with respect to the information in question. The pharmacy technician behaves accordingly.

The large majority of the yellows received from the unskilled facilities will have changes that would match well with the orders received into the pharmacy system. The triage task is simply concerned with filtering these away. When the yellows do not match, the pharmacy technician uses annotations to focus in on the discrepancies in the next phase. In certain cases, additional information is added (partial coherency preservation).

This can be viewed as a two-stage problem space reduction.

- Across document reduction
- Within document reduction

Once, the number of yellows meaningful attention has been substantially reduced by the triage task, the pharmacy technician proceeds to ensure that in those cases where she suspects of possible transcription error, usually concerning missed entry into their system, she does not bother the nurses at the facilities by checking with their local paper document archives. Her trepidation is similar to that of the pharmacist, who did not want to raise false alarms for the physicians. In both these cases, the other party was considered to be busier than the subject and their time, more valuable.

Since all the subjects observed had the freedom to modify the task to improve their productivity, and assuming that with the given amount of experience that all the subjects possessed, they would have had ample opportunity to devise appropriate strategies to optimize

their tasks within constraints, we must theorize why it is that only the pharmacy technician chose to slice and dice her task this way and not the others.

The activities performed by the pharmacy technician were well defined and much more predictable than those of the other subjects. The spectrum of discrepancies encountered by the pharmacy technician was much more limited. She did not need to operate under too much uncertainty. This likely allowed for a systematic planning and reorganization of the task.

Now we need to theorize how this particular task structure, may benefit the pharmacy technician but not the other subjects. It might have to do with the relative preponderance of internal cognitive context necessary for each of the tasks. We can imagine that constructing an internal representation with inferences on uncertain information within our knowledge context is expensive. Once such an internal task context is constructed, dismantling it away too soon, to make way for another patient, only to having to return to it in the next phase would be wasteful. Along these lines, we can imagine that those subjects who need to consider the information at hand, with much more complexity within a task space (this should also mean that a similar complex task space construction in the external cognitive space should also be desired to be preserved whenever possible) would rationally favor to take maximal advantage of it before having to dismantle it. This way, we can find it coherent that the RCM and the pharmacist had little benefit to be gained by this behavior.

On the other hand, the pharmacy technician benefits from the same phenomenon by the opposite behavior. Since her subtasks are homogeneous and predictable, she can set up an internal task context (frame of mind) and an external task context (organization of documents and the class of activities performed on them) only once per phase. In other words, the task space reconfiguration is meaningful only at a phase level since each individual instance within the phase is otherwise too small.

While this theory could not be put to test within the constraints of a broader descriptive study, a later confirmatory study could yield new insights. That study should be perhaps be conducted using relatively inexperienced subjects in order to avoid the bias of comparing against a workflow that the subjects are already very familiar with.

Recommendations:

The contemporary EMRs do not permit restructuring of the tasks by users. Unlike the case with paper based systems where the user has much flexibility in reorganizing the system, EMRs are typically not typically constructed to accommodate user controlled workflows. Novel, modular, user-composable, interactional models need to be explored rather than limiting users to pre-defined workflows. The exact kind of interactional modularity that would be optimal is difficult to speculate at this stage and should be considered a topic for later exploratory work. Although, we could posit that such designs will likely involve some kind of loosely-coupled, interactive architecture.

Not all clinical activities require such flexibility though. This study identifies batch tasks as a candidate to take advantage of such design. Further work is needed to identify similar task variants and other instances of batch tasks.

Nurse Consultants

The home health nurses were observed in three settings

- Skilled nursing facility visits
- Unskilled nursing facility visits
- Patient home visits

Skilled Nursing Visit

The primary medication related activity that the nurse visiting the skilled nursing facility performed was identifying the medications that had changed since her last visit and updating them on her system. Not being able to quickly identify what the significant changes was the primary concern of the subject (hh: changes). She needed to know the changes before she can deliver the care services to the patient. This list updating can be regarded as coherence maintenance. Qualitatively, it is similar to the pharmacist activity since both the home health

nurse and the pharmacist intend to meaningfully examine the updated medication list. The pharmacy technician also updates her medication list. However, since she does not truly evaluate the meaning of the contents, that task should not be regarded as coherence maintenance but rather as concordance maintenance.

The subject compared the medication lists, carefully, item by item, using her finger as the guide. This subject does not have as strong patient context is the RCM who sees the residents every day throughout their visit. Her internal patient context was however expected to be superior to that of the pharmacist since she had personal contact with the patient while the pharmacist knew h/er only through the chart. However, this did not seem to produce any noticeable difference in the comparison activity relative to the pharmacist.

The timeline-based overview system that provides a quick overview that was recommended for the pharmacist would also likely benefit this subject.

The notable difference was that unlike the pharmacist, the subject did not attempt to infer the reasons for medication changes from the chart. She simply marked the changes using annotations to query the local nurses for the information.

This different choice of a strategy could be explained based on the following factors.

1. The subject was not performing a batch task while the pharmacist was. It is not practical for the pharmacist to interrupt the local nurses every time she had a question. However, if she had left many questions for later follow-up, the partial state of coherence that she generated for each of the patient would likely be lost by the time the questions are answered. So she needed to answer them on her own without assistance. Since the subject had just one patient on that visit, it was much more practical for her to directly and interactively obtain the information.
2. The pharmacist has a much stronger knowledge base with regard to the medications. Given the medication, she is more ready with the associated information that she would expect such as the labs that need to be present, the other medications that might be co-prescribed, the particular diagnoses associated with the medication etc. This knowledge better equipped her to interrogate the patient chart and deduce the clinical condition.
3. This subject worked across the street to the skilled facility. Consequently, she had personal familiarity and relationships beyond the professional familiarity that the pharmacist had with the local nurses. This would make her more likely to feel comfortable in interrupting them for information. The common professional status might also contribute.

All the above factors could explain the observed differences in behavior from that, which would be postulated by the coherence model.

Unskilled Nursing Facility

The activities of this subject differed from the previous one in that, although she did provide some care services, her primary goal was to professionally support, the unskilled care providers in conjunction with the local nurse. Since the med-aides are likely to make mistakes with interpreting the physician's orders, she engages in two kinds of activities. She retroactively examines the MAR changes since her last visit and inspects them for concordance with the

physician orders. Acting proactively, she assists in constructing coherence by performing dose calculations and other activities that the med-aides are not able to perform. In representational terms, these are both isomorphic representational transformation activities. The subject is attempting to validate/ensure that the transformation is indeed isomorphic. The nurses making these visits also attempted to motivate the med-aides to develop more complete understanding of the disease processes and to become more invested in the patient outcomes.

Patient Home Visits

The visits to the homes of patients were also quite distinct from the other nurse visits.

Notably, the nurses attempted to ensure concordance between the medication lists and the actual medications in the patient's possession (hh: verify). They also checked if the patient was indeed taking the medications according to the instructions their records indicated.

In one case, using an electronic drug reference, the nurse looked up the side effects of all the medications that the patient was taking trying to establish whether the particular symptoms that the patient was experiencing could be a result of one of the medications (hh: analysis); a task typically considered to be a physician’s concern.

The subjects promoted medication coherence of the patients. They explained medication related issues to them (hh: education), answered their questions, assisted in identifying unknown medications (hh: identify), noted missing medications (hh: access), ensured that they had enough medications (hh: supply), transferred patient questions for the physician (hh: physician)

Physician's Office

Co-authorship of the record

The patient's record was being edited collaboratively by both the physician and the office nurse. There is no form of authentication for each. There is a tacit understanding of which information elements are entered by whom and can be treated as a co-authorship. The nurse enters the vital signs, sets up the SOAP (Subjective, Objective, Assessment and Plan) note and updates the medications. The physician continues with the rest. Once again, we see the task being performed by the office unit (system perspective). In a paper based setting, the identity of the person might have been implicitly addressed by the handwriting. Here, there is no such distinction; nor does it appear to be necessary.

The creation of the patient visit artifacts are similar to how the MAR is created for recap. In both cases, the initial contributions to the artifact are by a non-expert. This person follows relatively predictable procedures, acting on well-defined information. Later, the professionally trained participant continues in the creation of the artifact, drawing upon the information suitably collected and processing it further in a professional knowledge context. As such, this stands as a clear distributed information processing context with an appropriate delegation of resources to sub-tasks.

Analysis across the settings

The previous section individually analyzed each setting. In this section, the cross-cutting themes that emerge from the entirety of the observations will be explored. A novel framework that further synthesizes these themes will be presented.

Importance of context

The pivotal concept that demarcated the two categories that distinctly emerged was the processing of information within context - particularly, how medication information was processed in the absence of context and how it was processed within rich context. The role of context in clinical settings has been described within clinical informatics by Evans and Gadd (Evans & Gadd 1989). Their description of the context is focused on discourse and language; and is curiously, a negative definition i.e. they describe it in terms of its absence - *"we see the effects of context whenever we attempt to interpret language out of context"*. Such linguistic/discourse context is less useful for this study since many of the tasks are performed in solitude. While there was still discourse within the setting, it was characteristically different, given the task selection – it primarily occurred through representations i.e. not in real-time.

The definition and description of context has always been troublesome (Dey 2001). No standard definitions are available. Since the particular kind of context that is being addressed in this study is that of task context, additional definitions were sought. Schilit et.al (Schilit et al. 1994) defined it in terms of - where the subject is, who the subject is with, and what resources are nearby. Pascoe defined it as the subset of physical and conceptual states of interest to a particular entity (Pascoe & others 1998). While the former is *objective* (as in Activity Theory), the later is framed in a more classical cognitive analytical context. Both these perspectives are useful for the current study.

In the study, it was noted that some subjects who had a very rich context either in their deeper and more comprehensive understanding of the patient (RCM - patient context), had a richer professional context (RCM, HH - nursing training or pharmacist - pharmaceutical

training), or had a strong cultural context (RCM-1). These subjects performed the task differently from those subjects who did not have such a context.

The presence or absence of the context (and task goals) is a more useful *discriminant* than the professional description of the subject. For instance, a residential care manager who has worked for several years in a care facility would have a rich context of the residents (rcm:context) and would leverage it visibly; while a new residential care manager with the same training would work without the benefit of such context. This made the task of the former RCM more similar to the pharmacist's task, while the task of the later was more similar to a pharmacy technician's task. Similarly, a home health nurse consulting from outside the facility, with similar training, would work with even less context than the second RCM during her visit.

The pharmacist and the pharmacy technician observed during the study were both employed by the pharmacy and they both verify the medication lists. However, the pharmacist has a strong professional context from her education, which the pharmacy technician does not. The pharmacy therefore engages both these clinicians in very different tasks. While the pharmacy technician focuses entirely on the medication list artifacts and compares them directly, without significant interpretation and analysis, the pharmacist goes to the facility and examines the medication list in the presence of two additional contexts - the professional context that she brings along and the patient context, which she lacks but can draw from the patient chart available at the nursing facility.

Coherence

The subjects were initially approached with an assumption that they engaged in tasks consisting of verification activities that would consist of comparing two or more information representations. However, many subjects seem to be engaged in a much broader activity of sense-making. More formally, this was termed as coherence. Unlike representational verification, coherence is a much more fuzzy activity that brought several complex considerations into play. Coherence activities were constructive activities i.e. subjects inferred new meaning (to them - might be known to other clinicians) and then attempted to ensure that

this meaning is compatible with their expectations of meaningful states their training and experience.

Coherence may be regarded as a connectionist activity where relationships between discrete information representations were discovered. The nature of these discrete information nodes, as well as the types of relationships inferred varied from setting to setting. The RCM primarily focused on the relationships between orders and administration while the pharmacist made sense between the diagnostic profile, the pharmaceutical profile and the laboratory profile.

Once created, a number of things may happen to this coherence. The pharmacist created a report from the state of coherence. This report was quite sparse given the amount of effort that was put into inferring the current state. The rest of it seems to be simply lost. The RCM propagated coherence to the nurses administering the medications through the use of culturally recognized representations. This can be seen as she creates diagrams for text orders. She ensured that the MAR was directly coherent (i.e. coherence can be perceived rather than having to be constructed once again) by also adding further annotations that lowered the risk of errors. This can also be stated as, the RCM predicting potential states of incoherence and taking steps to prevent the emergence through the use of representations. Often, the additional representations were simply isomorphic representations in that they did not contain any additional information other than making them cognitively easier to consume through representational transformations.

The home health nurses educated their patients and care providers. This may also be seen as further propagation of medication coherence. The patient coherence of medications was enhanced by the connections made by the nurse to their condition. The care provider coherence was improved by giving them educational activities since the med-aides that well understood the disease were more likely to identify findings. The aides that have a better coherency of patient's condition can become better perceptual organs of the care organism (Distributed Cognition). One nurse stated that she attempts to increase the investment of the aides in the patient outcomes.

The tasks that were performed for coherence nearly always occurred in the presence of strong context of one form or the other. While coherence tasks have some structure, it is not uncommon that they deviate from it. When a state of incoherence is reached, the subject has to formulate strategies to resolve it. The full coherency state on a single patient case may consist of accumulated sub-coherencies. However, ambiguity or incomplete coherence may need to be accommodated in more than one sub coherencies. The subject uses judgment to determine whether the case is incoherent enough to warrant consultation with another subject or regarded as adequate.

Batch tasks

The residential care manager, the pharmacist at the pharmacy technician engaged in batch tasks i.e. they addressed in multiple patients in one sitting. Note that the batch tasks do not line up into the preceding two categories. The pharmacy technician's task was neither highly contextual nor did it involve any coherence activities. Most instances of the batch tasks were associated with the following characteristics.

All the subjects performing these tasks needed high focus environments. One RCM reported that she was understood to be *"cranky"* during this task. Another closed herself in an uncomfortably warm room for the solitude. The pharmacy technician was allotted an independent room. She used the radio to break the silence but otherwise never paid any attention to it. In all these cases, the colleagues of the subjects knew that they were not to be disturbed until very necessary.

All the subjects used external representations or simply artifacts to keep track of their state within the repetitive task loops. The pharmacist looked for her previous report in the chart. The RCMs did not need to file a report at the end of their task and so instead repurposed telephone order forms that were simply marked "Recap Completed" to track the documents since last recap. The pharmacy technician used the organization of the artifacts themselves, as well as superimposed annotations to track the state.

Some of the subjects restructured their tasks. This allowed them to cognitively and economically optimize their task by decomposing them into subtasks and attending to the subtasks in a group rather than attending to them that patient. This seems to be an additive effect between relatively context-free tasks and batch tasks. In line with this claim, the pharmacy technician was most prominent in restructuring her task while the newer RCM restructured her task to a much smaller degree. She had set up a stage of preparatory configuration where she makes copies of all the documents and organizes them by document type, and in the same patient order within each document group. The more experienced RCM did not seem to restructure her task at all.

Types of representations

The information representations utilized by the subjects can be functionally categorized into three - representations for communication, representations for cognition and representations for record. While the use of representations for record is prominently considered, the role of the other two needs to be stressed. In each of these two cases, they can further be categorized based on who they're addressed to - either to oneself, or to others. Two strategies were seen to achieve these effects - superimposed layers of information and transient representational mediums.

The pharmacy technician’s use of annotations is the use of superimposed layers of information to both cognitively reduce the problem space by circling items of interest and dismissing verified items with a diagonal mark. She also communicates to her future self using succinct notes.

The RCM used annotations to cognitively assist the nurses in understanding the MAR. The pharmacist uses a notepad to keep track of her work. Her report may be considered a representation that is both a communication as well as a record.

Communication (and cognition) representations seem to become increasingly informal, depending on whom they are directed at. Self-directed representations are the least formal. Those that are directed at the colleagues at the same professional level or below are also

relatively informal. Understandably, those that are directed above in the professional hierarchy are more formal.

Transient representations encode one piece of information very clearly. It is that they are not record representations. The gift of napkin notepad best illustrates the preference of some clinicians to such mediums.

Chapter Five: Synthesis:

After collecting a good amount of data and recognizing local themes, I began my attempt to more systematically analyze the data using distributed cognition primitives. However, I felt that the terms were not clear enough for my expectations. This was in part due to my concept of modeling were in the spirit of software modeling i.e. *strongly typed*. As it became clear that obtaining non-intersecting definitions, for instance, how does one distinguish between a resource and a tool. I wished to find an underlying enduring meta-model even if the model elements can only be applied as descriptors to the same physical entities under different contexts. For instance, we may regard a person as an actor at one time and resource in another. While this transmutation is acceptable, the need for formal definitions for both the terms: actor and resource are still necessary. After being unable to locate candidate definitions from literature, I attempted to create my own meta-model for the theory of distributed cognition with a focus on ontological clarity. While some progress was made, the meta- models still seemed incomplete to be applied to my data. At the same time, I was also attempting to find or create an adequate representational notation to depict my models. A review of the literature with these goals seem to indicate that no such ontologies or notational schemes exist and that it was common to use one's notational schemes, just as it was acceptable to use one's own interpretation of the boundaries of conceptual primitives.

While looking for the alternatives, I then came across activity theory. My recent inclinations towards philosophy drew me towards the interactions of this theory, given similar inclinations by its proponents and its own philosophical intellectual roots. Further, the theory also offered a lucid notational scheme, with clear definitions of the components, and even enumerated specific interactions between these components. The clarity of these specifications was so simple and straightforward, that I was able to create an automated tool that took in a data structure that represented hierarchical task analysis and generated a series of notational diagrams for the steps. I was finally pleased with having a clear methodology for analysis.

However, after completing the analysis for some subjects, I was surprised to find that I was not generating any novel insights into their work. My diagrams seem to encode the findings adequately, but were not providing any meaningful transformations and thereby novel perspectives, by themselves. However, unlike the case with DCog where I was certain that the

chief problem was the clarity of terms, I was unable to identify an explanation with Activity Theory.

After a period of uncertainty, first methodological and then analytical, I was able to create a novel theory that fit my data better. The Hegelian perspective on dissertations or simply the dynamics of emergence of any novel thought, offers a framework of thesis, antithesis and synthesis. Within this framework, my attempts to adopt well established and respected theories constitute the thesis, while my eventual rejection of the applicability of these theories for my particular purposes constitutes the antithesis, and the ultimate emergence of a novel theory out of this chaos and conflict of ideas constitutes the synthesis.

The findings discussed so far are now reduced into a categorical scheme that was arrived at by a phenomenological derivation: by organizing the findings for coherency (pun intended), providing definitions and explaining the observed phenomena, using existing theoretical models when possible.

Scheme/Model/Theory

The organization that will be offered here can be considered either a scheme, or a model or even a theory. The appropriateness of each of these terms can perhaps be only be determined by the ultimate utility. For the purposes of this discussion, the terms are locally distinguished as follows.

The term (categorical) scheme is used to stress the conceptual simplicity of the high-level products of the synthesis which offers just two major categories. Only conceptual primitives are discussed in this form. The term model implies a finer specification. Models additionally specify the relationships between the conceptual primitives. The model in question here is empirical and phenomenological. The term theory is used in the later parts of the discussion when the model is presented as a more general description of clinical activities, as a whole. However, since those theoretical claims have not yet been empirically validated, the propositions are primarily provided to demonstrate the ability of the model to at least attempt axiomatic extension and to specify falsifiability.

Correspondence and Coherence

This scheme states that the medication management activities may be categorized into correspondence activities or coherence activities. But before we go further, a framework of analysis that was used for this synthesis is presented.

A framework of analysis – for synthesis

A good theory or a model must be able to explain the findings, predict for the outcomes when applied to other settings, and finally should be able to provide actionable advice. A good theory, Bardram argues, is less about whether or not it provides an object a representation of reality; but rather whether its application can give form to the object it is applied to and in the process, delivering insight (Bardram 1998). In other words, a good theory must be able to organize the data well, and from that organization should new insights emerge. Halverson terms this as descriptive power and offers three additional attributes (rhetorical power, inferential power and application power) that are important to theories (Halverson 2002). A theory with a good rhetorical power should provide with a well structured conceptual framework that maps well to concepts that can be expected to be well understood by the community that applies it.

While, Halverson states that the concepts should map to the real world, this perhaps is not always necessary. While previous scholars have similarly argued that concepts that ultimately do not map to any non-conjectural entity are literally nonsensical (A.J. Ayer), there are good arguments to the contrary. Euclidean geometry forms one example by providing an entirely closed system that does not specifically map to any particular real-world objects. Wittgenstein argues that *"meaning is use"* (Wittgenstein et al. 2009). The particular caveat here is that if the community lacks a common dictionary for its terms, confusion will result.

What this means to this analysis is that while it is permissible to use abstract and conjectural conceptual primitives, it is necessary to define them with clarity. This unfortunately somewhat goes back against "meaning is use" argument by constructing novel and normative definitions that may not include the entire rich diversity of use associated with the terms.

However, this problem cannot be avoided since many of the terms that will be used later on can be considered as *loaded*, making synthetic clarifications necessary.

The problem of definitions and their boundaries was a concern that was often revisited in this study. In the early stages, the demarcation problems between classical distributed cognition notions such as actors and resources needed to be resolved. In the eventual analysis, the clarity of terms such as coherence was the subject of debate.

The inferential power of a scientific theory is extremely important. A theory with the good descriptive and rhetorical power, but lacking inferential power is limited. While it provides a communication platform for the participants, it is not methodically generate new insights. In order to construct a theory with inferential power, it is necessary to specify not just the concepts well, but also how they interact. Axiomatically specified systems have good inferential power; the perfect example being mathematics. While such pristine frameworks are impractical in qualitative model building, a realistic attempt will be made.

The final attribute is the application power of the theory, which according to Halverson is based on what we want the theory to do. Halverson argues that we must be aware of what the theory might be predisposed to do, as well as, what we wanted to do. The design and historicity of this study tacitly took this consideration as a major concern. The observations were conducted with the implied goal of generating insights that may inform design. Thus, what we explicitly want this analysis to do is to provide a model that is actionable by system analysts, examining medication management settings with the intent of introducing well reasoned interventions. However, the models generated by this analysis will only partially succeed in that. Since this is an early exploration, the conceptual primitives offered and the interactional concepts specified between them will be framed at a high-level. This introduces operational issues, since it will be difficult to directly map the domain models to implementation models. In this way, what the models actually are predisposed to is to encourage scholarly debate towards the validity and refinement of the models. The future validated and refined models can be expected to better serve the needs of the analysts in the trenches.

Defining the terms

The core primitives are drawn from Norman and Zhang's framework for distributed cognition. In this model, the total cognitive space is distributed across internal and external representational space (Zhang 92) (Zhang 1992). Zhang illustrates this model in context of an Emergency Room (Zhang 97) (Zhang 1997) distinguishing between the perceptual components and context components (learned knowledge and biases). A fundamental precept of distributed cognition is the emphasis on representations rather than process (Zhang 92) since in this perspective, the causal proposition is that representations necessitate processes and not vice versa.

The chief general proposition of this analysis is that tasks that are primarily performed chiefly in the perceptual space are different enough to warrant a nominal/taxonomic distinction from those that are chiefly performed in the context space.

As a more specific proposition, the tasks that were observed to be performed in the perceptual space were those of correspondence. The clinicians mainly looked for the existence of representations across artifacts that corresponded to one another (typically, a one-to-one cardinal relationship). Since even when the representations are isomorphs, they may not exactly be the same. This will necessitate some internal cognitive processes. However, to be categorized as a perceptual, correspondence task, these elements must be in preponderance. A representational activity is a transposition of representations. In perceptual tasks, this transposition is seen directly between external representations.

The tasks that chiefly occur in the contextual space were termed as coherence tasks. The context space may consist of patient models, knowledge models, cultural models and other models derived from prior experience. The transposition of representations here is between external and internal representations as well as entirely between internal representations. To be coherent, the new representations must be accommodated into the existing representational models.

Illustrating with data

The pharmacy technician and the pharmacist form the best contrasts between correspondence and coherence. The pharmacy technician who works principally by ensuring *parity* between external representations of information with minimal additional contextual analysis is termed to be performing a correspondence task.

It should be noted here that there is no absolute definitional boundary for correspondence. Any experienced employee can be expected to draw from their experience. In case of the pharmacy technician, we see that when she wonders whether a particular missing item of information is because it was recorded elsewhere in a hospice order (figure). The pharmacy technician is performing her task within an organizational knowledge context where she understand how the unskilled facilities operate and how the pharmacy documentation process works, rather than in a pristine context free environment.

Correspondence

Correspondence is first considered since it is the simpler of the two. It is more readily observed and requires fewer conjectural explanations. Correspondence tasks have predictable task structure and so are easier to automate. Additionally, correspondence tasks are typically noted when they have a repetitive aspect to them since isolated actions of correspondence will likely be subsumed in coherence. As stated earlier, the distinction is based on preponderance.

The highly repetitive nature of the yellows task incentivizes the pharmacy technician to restructure it in order to optimize its ergonomics as did the second RCM, to a lesser degree. The pharmacy technician did not perform the task, one patient at a time, unlike all the other subjects. Rather, she sliced the task into cognitively and ergonomically homogeneous subtasks and performed these subtasks in batches. From this we may posit the following:

Task decomposition and remodeling:

We find that the pharmacy technician breaks the task into some logical chunks and reorganizes them. It can be said that she is able to do this since her system is primarily based on paper. The unique aspect of paper-based systems is that they allow considerable flexibility to

their users to reengineer them. With the electronic system, while the potential opportunity for re-configuration is immense (absent the physical constraints of the representational medium), she would be reliant on the engineers and more importantly, the mass distribution constraints (having to maintain individual locally configured systems along no common axes side steps the benefits of single sourcing that makes software construction so manageable) that limit local modifications, at will.

Cost of constructing a cognitive space:

Assuming rational judgment on part of the subject, one can posit that the subject perceived the cost of constructing or configuring her cognitive and ergonomic space per patient is more expensive than preserving the information context of the patient across the states. This can be explained in two ways. The first is that the information under consideration itself is simple. The second is that the particular task strategy chosen by the pharmacy technician leverages a stateless architecture by efficient persistence serialization of her cognitive state into external representation between the remodeled stages.

Ergonomics are considered in conjunction with cognition in the above analysis. In the paradigms of distributed cognition and activity theory, physical activity is inseparable from cognition. If the speed at which we shuffle internal representations reflects the efficiency of the mind (internal cognitive space), the speed at which external representations are mobilized reflects the efficiency of the distributed cognitive space.

Below, this theme is explored in the context of information technology and software engineering since stateless architectures are a subject of much debate and consequence.

Componentization and loose-coupling in state-less architectures

In a software engineering sense, the pharmacy technician is modularizing her work into small work units (checking a single patient's yellow, calling a facility) that form instances of a small set of task classes (triage, follow-up). The pharmacy technician is framed as a self-configuring system that configures itself into specific states that are well optimized for each class of tasks and then streaming all the instances of the class in one batch, thereby taking

advantage of consequent assembly line ergonomics. Such flexible, modular architectures require loose coupling between work units.

A brief history of distributed computing architectural patterns may further help illustrate. Early enterprise distributed computing standards focused on providing a stateful metaphor for distributing work across multiple machines. Using classical object oriented abstractions that are applied for local execution in a single process space, distributed computing standards such as CORBA (Common Object Request Broker Architecture)(Common Object Request Broker Architecture (CORBA))(Common Object Request Broker Architecture (CORBA))(98) were able to provide a simplified model that appeared as if the entire application was running locally and seamlessly allowed programmers to use familiar stateful application models. However, this necessitated more complex state management across the nodes of the system making them harder to scale.

Later designs, such as Web Services, notably SOAP (Simple Object Access Protocol)(Simple Object Access Protocol (SOAP))(Simple Object Access Protocol (SOAP))(99) successfully demonstrated state-less models inspired by the World Wide Web. Each request typically contains the entire information input required by the server. This architectural pattern further culminated in ReST (Representational State Transfer) (Fielding 2000). In this paradigm, a dynamically served response can even be treated as a static resource named by the operation and its arguments. No client context is stored on the server, in between requests.

However, this comparison should not overly simplify the contrast between the two as the superiority of one over the other. When the process requires multiple operations, each based on a large number of largely unchanging information inputs, the stateful paradigm is more appropriate.

Returning to our immediate contrast between the pharmacists and pharmacy technician, the task of the pharmacy technician was successfully restructured into a state-less architecture, because the number of information points that need to be persisted by representation was small and no further tacit information needs to be preserved per patient between the subtasks. During the triage phase, the only information that needs to be preserved

is whether the patient should be further considered, and this information is nearly entirely encoded in the artifact configuration, where the patient information is partitioned to separate stacks. Any additional information is persisted as annotations. Thus, the subtasks are loosely coupled.

Coherence

The pharmacist review of the medication profile of the patient was based upon much more complex considerations, many of which cannot be formally and precisely be represented in artifacts even if the time constraints did not apply. The preponderance of tacit knowledge, and the need for decision-making under uncertainty (pharm: why) and potentially incomplete information (pharm: rummaging) make the task have less predictable structure and require it to be completed under one large contextual configuration of clinicians cognition. This state is expensive to construct and would be wasteful to discard before it is fully exploited.

This strategy is analogous to caching a disk-based file resource in memory in order to avoid the performance bottleneck of reading information from a mechanical component. Just as seek times represent a significant bottleneck in locating information from a conventional, mechanical hard drive, fragmented across its sectors... so too is expensive, the un-marshalling[9] of information, as the pharmacist searches across the patient's chart. Modern operating systems analyze system use patterns and preemptively perform this time expensive task in the background as much as possible. Enterprising programmers stream data in a bolus from a pre-optimized file image, rather than look for small individual files. We can similarly envision future systems that pre-emptively un-marshal the representations necessary for the cognitive units. In this way, machines take up the recognized aspects of representational configuration while the human cognitive units engage in those processes that still require tacit decision making from such representational configurations.

Computers perform representational transformations in order to support special operations on the data. Each representation serves special purposes. A raw text file with

[9] In programming, the process of converting a memory representation of an object to a string that may be persisted on the disk for later recovery and operation is termed marshalling. The converse process is termed as un-marshalling. These terms are also called serialization and de-serialization.

narrative text is optimal for cognitive consumption. However, this representation is ill-suited to machine searching, for a small text phrase, in a large collection of such files. A representational transformation into the search index constructs a representation that is well optimized for search but poorly optimized for the former task of linear reading.

These metaphors apply well to the pharmacist. Computational support can assist with the predictable bottlenecks of external information manipulation. From the observations, we find that the pharmacist is considering and aligning diagnostic, pharmaceutical and laboratory profile of the patient and making meaningful connections between them. She then compares the semantically coherent information network against her internal model of expectations. The internal model is difficult to explicate and previous efforts in this direction have not been very productive in real-world settings (DXPlain). However, it is much more feasible to eliminate the predictable interactions that the pharmacist has to invoke in order to construct the external model.

State preservation is a common theme that cuts across both correspondence and coherence tasks. In the pharmacy technician's correspondence task, the state preservation is encoded within the stacks and annotations.

The phenomenon of correspondence was observed in conjunction with low context states. To illustrate, the pharmacy technician knew little about the patient and could only directly compare medication lists. The home health nurses visiting the skilled nursing facility to provide specific services were not required to perform oversight functions and therefore could explain the correspondence nature of their medication management activities. The physician's nurse who does not extensively review the patient chart also performed the task as correspondence. The newer RCM performs the task as correspondence while the more experienced RCM with the benefit of extensive patient context and perhaps a better cultural understanding of the organization and its employees did not use correspondence as much.

Theory of Coherence and Correspondence

The theory is discussed below in three levels with decreasing levels of abstraction (high level to low level).

First Level Framework

The first level framework offers a simple dichotomous framework for classifying the activities within the subjects' task into two exclusive categories:

Correspondence

Correspondence activities involved the subjects checking for the presence of more or less directly analogous representations across artifacts. The representational space here may be said to be homogeneous i.e. the representations of interest are generally of the same type, but differ in some minor aspect. For instance, a subject may compare an order of a medication against a record of administration of the same medication. Both representational entities refer to the same medication but in different contexts. Another example would be of subjects comparing medication lists at the transitions of care, in other words, classical medication reconciliation task.

Coherence

Coherence activities on the other hand involved the subjects constructing a network of coherence within a heterogeneous information space. The links between the information elements were much more diverse with a wide variety of semantic relationships, not just analogous presence across representations. For instance, a subject may compare a medication entry against diagnosis and laboratory information around the same time period. Coherence activities may compare similar information as well. For instance, a subject may compare the changing doses of a medication and develop an explanation. This is different from

correspondence in that while similar information is being compared, more than mere presence is being checked and more complex new meaning is being constructed.

Meaning in Coherence

Meaning is an important component of coherence. Meaning has been variously described in literature of different disciplines ranging from philosophy, linguistics, semiotics, cognitive sciences and so on. For the purposes of this discussion, a representation is considered meaningful if it is considered in conjunction to its relationships with other concepts towards a particular goal (rather than merely incidental). For instance, simply reading Aspirin as a drug name without knowing anything about it may not be meaningful, but considering it either as an analgesic or an anti-pyretic or an anti-inflammatory or an anti-platelet drug would be considered meaningful, if any of those qualifiers is relevant to the goals/sub-goals of the task (Eg: Anti-platelet dose Aspirin - in case of an elderly patient without any evidence acute conditions). Note the emphasis is on relevance to goals, not merely incidental recall. This follows that it is possible for a domain expert to yet be able to perform a correspondence sub-task, despite processing a nuanced knowledge network that provides meaning. However, if the task may be explained entirely through the subjects' manipulation of the external representation, it is no longer considered a coherence task. But if the subject provides behavioral cues that suggest that the subject is complexly considering the information, such as creating a new re-ordered list, we can conclude that the subject is engaged in a coherence activity instead. Coherence activities can thus be differentiated requiring explanations that engage the subjects' rich networks of meaning, while correspondence tasks would instead require no such explanations.

Second Level Framework

From these general observations and high-level analysis offering entirely phenomenologically derived concepts (coherence and correspondence), the following definitions were further derived or re-aligned with existing theoretical primitives. The second level framework uses modified primitives from the theory of distributed cognition. It considers

the cognitive space to be distributed across actors and artifacts. However, unlike distributed cognition, which generally seeks to not specially distinguish between internal and external cognition, the second level framework retains the distinctions since it considers conceptual and artifact-based representational processing to be qualitatively different. Indeed, these cognitive-space boundary distinctions, in distribution of information processing will be pivotal in demarcating between correspondence and coherence activities at this level, as well as for sub-categorizing correspondence into further subtypes. Additionally, the framework is now framed in terms of logical continuity of these categories, rather than in terms of the dichotomy that distinguishes the level one framework.

Direct Correspondence

Direct correspondence activities can entirely be described in terms of external artifacts i.e. the activity is entirely located within the external cognitive space. This is not to say that no cognitive facilities of the subjects/actors are involved. The emphasis is on the lack of need for internal cognitive explanations, within the “activity descriptions”; in other words, the inevitable component of internal cognition is fairly basic and does not deserve special consideration. The subjects still processes each external representation in the internal cognitive space. However, no special transformations need to be proposed to be included within this process in order to fully explain.

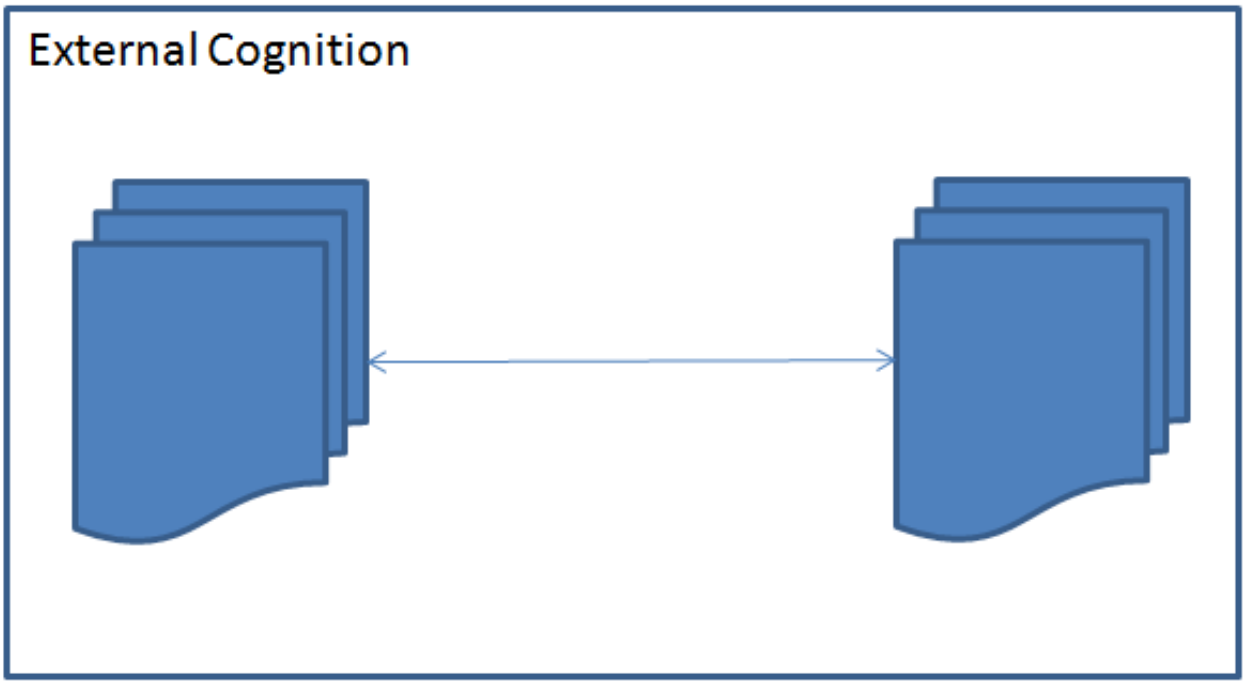


Figure 5.3: Model showing artifact to artifact representational comparison in direct correspondence tasks. Note that internal cognition is not significantly involved.

Note that this kind of modeling is constructivist (multiple candidate models offered to account for the observation data), rather than positivistic. Consequently, the models using this meta-model are not methodologically independent of the explanatory abilities of the investigator. However, this is true of qualitative modeling in general and even well structured modeling systems such as UML cannot yield common models in non-trivial settings across analysts. A future evaluation may need to examine the clarity, utility and operational ease of these categories when adopted by external investigators and compared against the primitives from existing and better-known theories (Distributed Cognition, Activity Theory etc).

Good examples of direct correspondence activities include the comparison activities of the pharmacist and home health nurses as they reconcile the copy of medication list with the local copy of the medication list at the facility. A nurse or a pharmacist examining an older medication list against a recent medication list can also be said to engage in direct correspondence.

Since direct correspondence activities entirely manifest in the external cognitive space, construction of optimal perceptual and ergonomic spaces becomes extremely important. The subjects must be able to see the items being compared at once. Requiring that they perform additional activities between the perception of each item would negatively impact the task.

If the physical properties of the artifacts permit user driven reconfiguration, the subjects will tend to perform that reconfiguration, unless the costs of such reconfiguration exceed the benefits. Latent in this claim is the claim that subjects will naturally be inclined to eventually develop representational optimal strategies (to the extent conceivable by a person with no special knowledge or training towards cognition, system design etc) to deal with their tasks, within the constraints imposed by the representational mediums, either by learning the strategies from their peers or even developing their independently[10].

Indirect Correspondence

Indirect correspondence activities slightly differ from direct correspondence activities in that they additionally engage a minor[11] component of internal cognition. This becomes necessary when the information being compared across the artifacts is the same, but the external representations that host of this information differ. To be able to execute this activity, the subject must be aware of the representational context of the artifacts.

Good examples of indirect correspondence activities can be observed when clinicians compare medication orders against MARs. The medication information is common across both these representations. The subject performing this task needs to understand the relationship between the two representational artifacts. Orders declare intent while the MARs declare a record. This would follow that orders must generally precede MAR entries.

[10] In most cases, the subjects did both i.e. they adopted from their colleagues and then adapted them to their specific needs.

[11] This is currently left to the judgment of the investigator. Admittedly, this is less desirable than providing clear criteria. However, the data examined so far is inadequate to offer criteria with such detail. Further experience with the framework may be able to shed insights sufficient to generate such criteria.

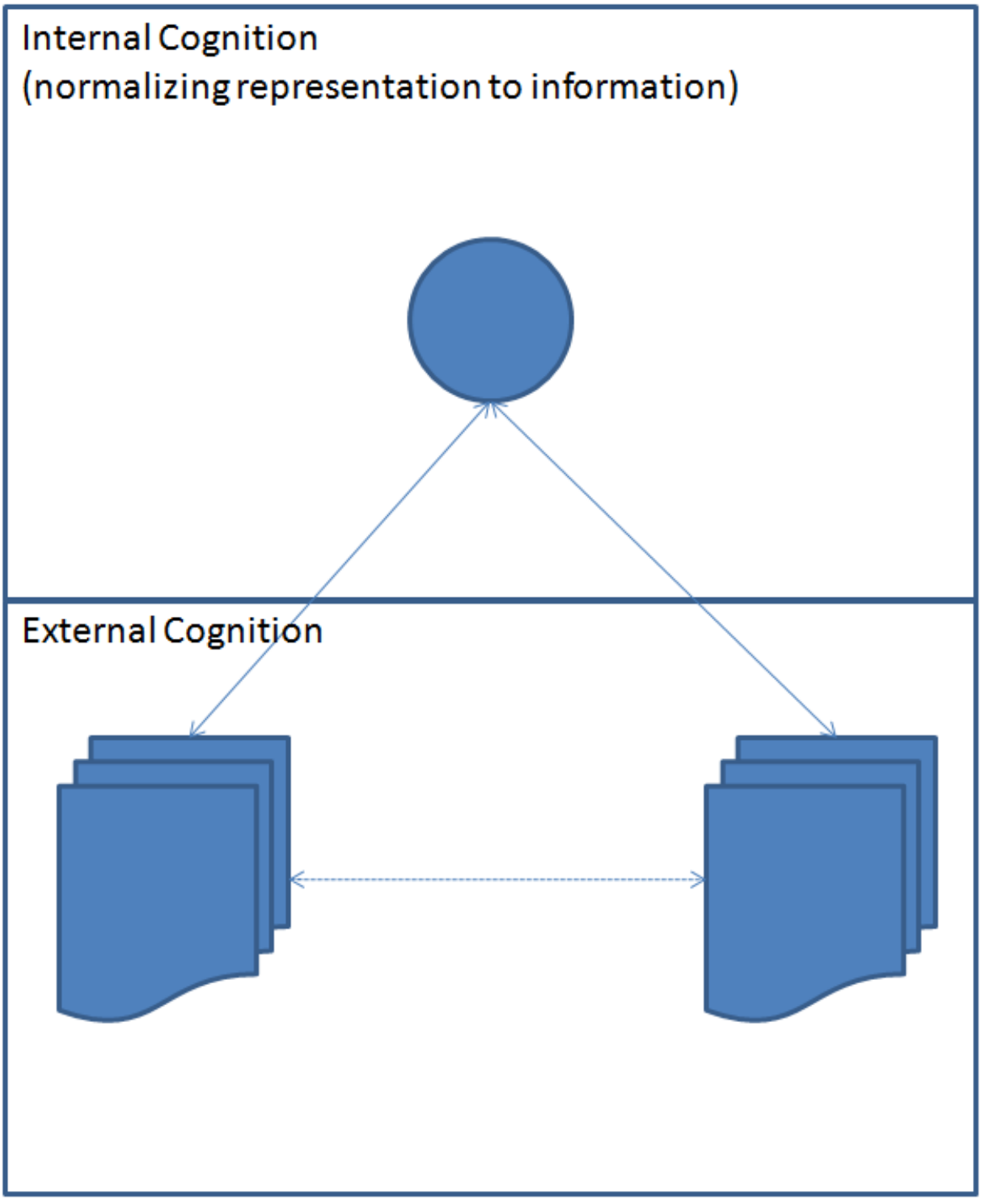


Figure 5.4: Model introducing a minimal component of internal cognition in order to execute the minor transformations necessary to normalize representations within a representational context.

Coherence

Coherence activities are a continuation of indirect correspondence, requiring significant cognitive explanations to describe the activity. They cannot be described with the representational explanations alone. On the descriptive axis, internal cognitive explanations must be provided to fill the gaps within the representational narrative.

Coherence activities also distinguish themselves on the methodological axis. Since correspondence activities occur primarily within the external cognitive space, they can simply be directly observed. Coherence activities, on the other hand, cannot be directly the evidenced. This requires a stronger interview component to be added to the observations, in order to address the more complex behavioral cues that the subject will likely exhibit. Additionally, an investigator lacking the domain expertise will be unable to produce a good account of the task through observations alone. The analysis will also require a greater degree of theoretical explanations.

A functional model of coherency

Coherence activities seem to be primarily concerned with the construction of a coherence network, which may be described as a graph data structure consisting of inter-connected information loci. The training of the clinician will supply the knowledge model, while h/er experience will provide the other models such as patient model, cultural and organizational models etc. The information extracted from the immediate representations of the patient chart is now interpreted within the context of this framework of coherence.

As information is incrementally elicited from the representations, the coherence theory proposes that it should be seen as being instantiated within the subjects' framework of coherence. The parts of the framework populated by this instanced data emerge within the subjects' cognitive focus. This information populated portions of the coherence framework in the current cognitive focus comprises the network of coherence. Supporting this coherence network is the coherence context which consists of the other portions of the network that are lit up by the information population/activation events, also including the relationships that fire

to make this possible. This passive, largely representation driven processes of coherency generation can be grouped under a new term, ***representational kinetics***. The term is derived from the well-recognized Pharmacology term: Pharmacokinetics, which is a study of how the drugs are absorbed, metabolized and excreted in our body.

Just as our body may adapt to prolonged exposure to external agents such as drugs, so too does the cognitive apparatus. The apparatus becomes more efficient at better perceiving representations as well as processing information.[12] Experienced clinicians read deeper into the chart, recognize more patterns and faster and are overall more efficient.

The coherence network has one emergent property… its coherency strength. If all the associated relationship conditions are satisfied by the framework resolutions themselves (context) or by data activations elsewhere in the network, the network is in a positive state of coherency. The coherence theory posits that a state of *"coherence tension"* emerges when the network is imbalanced by the lack of coherency. This state is perceived by the subject, who will then formulate the strategies to seek representations that might host the information necessary to correct these coherency imbalances and resolve the coherency tension. Towards this end, the subject engages in external cognitive activity that can be evidenced as representational behavior. The subject also engages in internal cognitive activity that proactively fires parts of the coherency network that are not fired passively and automatically in response to information population events. Such switches to the other side of the cognitive partition (in this case, from external cognition to internal cognition) are mediated by a hypothetical execution pointer of the cognitive apparatus modeled after such a component from the modern CPU architectures.

As the processing context of the subject switches to internal cognition, the external cognitive behaviors spin down to a minimum. This cessation or winding down of motor activity is observed by the investigator as *contemplation*. The interesting point to note here is that since actual internal cognitive activity cannot be directly be evidenced by the investigator, it is

[12] In case of drug metabolism however, the adaptation causes problems… since more drug is now needed to obtain the same physiological effects since the body gets better at clearing the drug, without any awareness of the intent of the drug. The adaptation for cognition is happily, entirely a positive one.

inferred from the lack of activity instead, which is proposed by the *"synchronous cognitive context switching model of cognition"*. It should be noted that the subject also becomes less perceptually active as he/she becomes less motor-active. A new term, ***coherency dynamics*** is coined to group contemplative resolution of coherency tension. Like representational dynamics, this term is derived from a well-recognized Pharmacology term: Pharmacodynamics, which is a study of how drugs interact with our body, effecting physiological states.

The activity of perception and motor activity do not entirely cease for the duration of contemplation, but continue at a low grade activity level. When contemplation state proactively evaluates the non-obvious (frequently evaluated relationships) context relations, it may identify information gaps. When this occurs, the representation seeking strategy is quickly formulated (likely, as an efficient script formed through subject experience with document navigation. Hence, individual process is readily available, and generally only requiring declarative demands) and the perceptual and motor components are rapidly engaged in bursts to meet the information demands.

For instance, the pharmacists' coherency framework states that information pertaining to significant medication (drugs treating life threatening conditions and those that have a narrow therapeutic window) must be coherent with problem information, in order to ensure that patients are not being over-medicated. Likewise, medication information must be appropriately balanced by matching laboratory information, which will suggest that important drugs are being carefully monitored.

This means that the pharmacist will attempt to locate the documentation of a problem that would justify the presence of a medication item in the chart. Likewise, the pharmacist may also attempt to ensure that the documented problems are being addressed by the appropriate medications. Additionally, the pharmacist attempts to make sure that the necessary laboratory monitoring is being performed, and will look for orders or reports that indicate this.

When the pharmacist finds a medication for which an appropriate problem or a lab review has not been located yet through the course of routine representational dynamics, an imbalance is flagged in the coherency network, creating coherency tension. With an active

evaluation of the coherency network, the pharmacist identifies potential situations including alternative coherency conditions, such as when the drug may be prescribed in other, less common disease conditions. He/she then identifies and mentally visualizes the types of representations that should be rapidly, perceptually identified to rule out or fit those potential models.

In this manner, the subjects incrementally builds the final state of coherency, often identifying minor structural anomalies (unbalanced coherency) in the process, and quickly moving each time to immediately address it. In some events, resolving a tension may automatically result in a new tension that needs to be addressed (when a part of the coherency network previously thought to be balanced is found to not be, as it needs to be invalidated after repurposing some critical information item previously misplaced – For instance, when the pharmacist finds that a certain drug was being prescribed for a different disease condition than initially expected, necessitating search for its requisite lab reports). In other cases, the final coherency state is unsatisfactory even after thoroughly considering all available information. In this case, the pharmacist will seek more expensive resources of coherency on the care plan: The RCM.

The tale of the two coherencies

There are two networks of coherency that the pharmacist is concerned with. The first is the personal network. Since the current record systems maintain lists of documents, rather than explicit coherency states, it needs to be slowly created on a per-task basis. The pharmacist does not have access to any subset of physician's coherency network. Admittedly, it consists of a different coherency framework due to differing training, emphasis and concerns on various information elements that comprise even the intersecting and common subset of the coherency networks between the physician/pharmacist/RCM. A significant effort is made by the pharmacist to ensure that her network is complete (or has the necessary coverage, given her goals), without any means to assess its completeness other than the coherency state itself. The actual validation of the coherency network is relatively trivial, both for her own network as well as for the care setting, with the exception of one detail. The pharmacist must inferentially

create hypothetical models of physician's intent to make the final validation, unlike the case with the rest of the components of the network for which more concrete sources may be found (knowledge and patient information models). Since the source cannot be readily checked (other than the response on the report which will be seen a month later), a confident assertion of coherence cannot always be made and *"vicarious coherence"* (discussed later), where the pharmacist attempts to predict how the physician would find the network meaningful, has to be substituted.

Questions

This perspective of coherence leads into an important question. Are disconnected document artifacts, the proper approach to organizing health information? Wouldn't a coherence network be a better structural alternative? What are the barriers for this adopting this approach? What are the benefits and costs? Since coherency is a more delicate state than a list since it is a determination from the stand-point of meaning, who should be charged with maintaining it? What concepts need to be explored and codified in order to make broadly useful coherence networks? I.e. what information elements must be included? What should be the appropriate level of granularity for meta-model of the network? The coherency network includes parts of the coherence framework that is subjective and tacit, not to mention conjectural. This is reasonable given the immediate descriptive goals. But to design as a solution, how should a more general purpose network be framed as while not robbing it of context. What technologies are best suited to create implementations that map well to both the structural aspects of network organization of information as well as the representational aspects of holistic cognition?

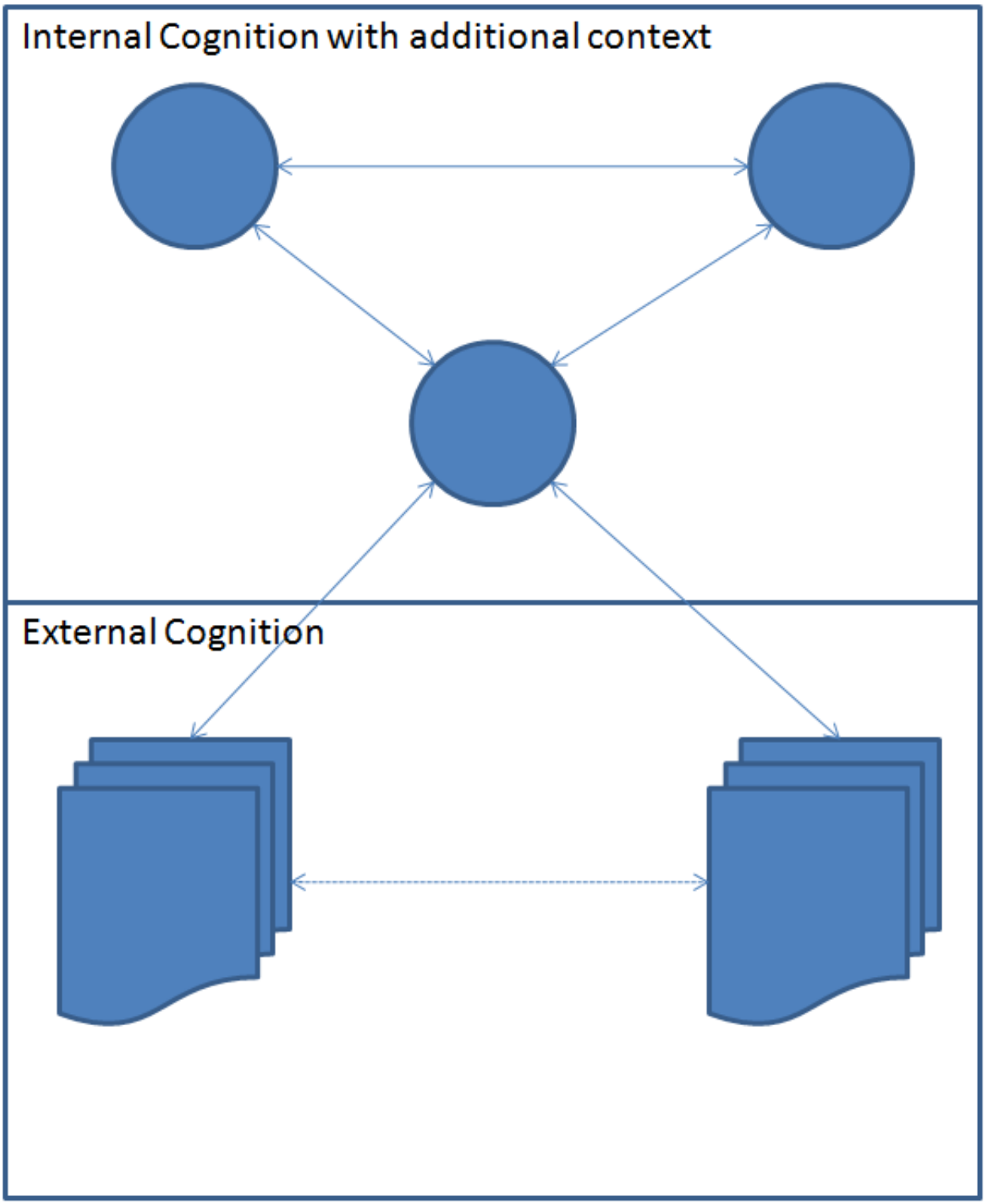


Figure 5.5: Model showing a more distributed cognitive workspace spread across both external and internal cognitive spaces. Information is consumed from artifacts and transformed in special internal cognitive context.

Composition in natural settings

After distinguishing between the different activity-types, it is essential to note that any given clinical task would likely contain varying compositions of correspondence and coherence activities. The task itself may be described as a correspondence or coherence task only by the relative preponderance of a particular type.

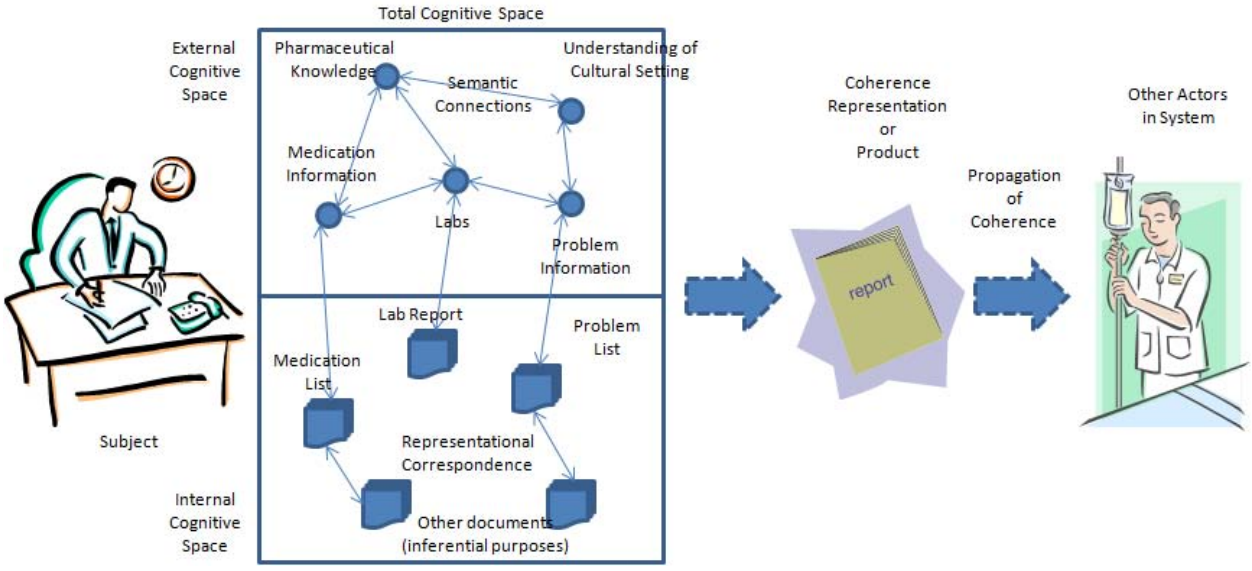


Figure 5.6: Model of a natural task comprising of various activity types showing different information types, representations and the different interactions between them. The figure also shows a physical representational product generated after ensuring correspondence and developing coherence. This may simply state the task has been completed (as with the Pharmacist) or may encode the coherence itself (as with the RCM). These products may be transmitted to other actors in the care system (within or across organizations).

For instance, a pharmacist begins her task with a direct correspondence activity where she compares her electronic copy of the medication list against the medication list in the chart. She performs an indirect correspondence activity when she quickly compares the MAR against the medication list (much less emphasis than when to the RCM performs the same activity).

However, it is the coherence activity that dominates her task as she ponders on the clinical picture that she develops of the patient until she's satisfied that it is *coherent* to her expectations.

Third Level Framework

The third level framework further expands to further features that describe the task and its principle components. The principle components are based upon the primitives of the activity theory. The core model of activity theory (Barab et al. 2004) is as follows. The core abstractions are activities that comprise tasks. An activity is model in which *subjects* perform actions on the *object* of their attention through *mediating artifacts*. An expanded model (Engeström 2000) additionally incorporates *rules*, *community* and *division of labor*. The simpler core model was mainly used. Community and division of labor are less important within the context of this study since the subjects in most cases worked in solitude. While the results of their task indeed affected the work of others and the entire care system may be seen as one cohesive unit, such interplay only manifested peripherally within the context of observations. Therefore no special effort will be made to fit this (meta-) model.

The reason a different framework was chosen for this lower level of abstraction is that distributed cognition serves well as a structural framework as it focuses on the distribution of the information across physical hosts (cognitive and external physical representational mediums) and the processing resources available to address it. It is less committed to codifying the process in which this distribution is mediated. Activity theory on the other hand offers such a codification while in turn being less committed to the distribution of process and resources.

It is also important to note the paradigmatic incommensurability (Kuhn 1996) of the terms within distributed cognition and activity theory. A paper on which a subject performs a calculation is a cognitive artifact serving as a representational medium. The same artifact becomes a tool or a mediating artifact within activity theory. However, it is essential to stress that the while the entity is the same and the terms appear to be analogous; the activity theory viewpoint stresses its dynamic participation as an enabler rather than as a place where the

actual information processing is situated. It is neither productive to consider these theories as competing theories nor is it productive to be compelled to consider them in exclusion of the other. Both the theories offer insightful and novel concepts to examine real world system. However, neither offers adequate clarity or completeness to merit exclusive application, especially in studies where the loyalties are to domain models rather than methods.

With that discussion of the modeling philosophy, an activity-theory based, but otherwise phenomenological model of the clinical task framework will be presented. This framework will first describe the features of the task before enumerating its main components and describing the hierarchy of features.

Defining tasks and activities

The terms task and activity have been used somewhat interchangeably so far. However, for the following discussion the terms will be used in the following ways. Tasks have broader domain goals (Eg: I want to make sure that I understand the patients' medications and ensure that they are appropriate for his current problems and needs) while activities will be framed as sub-tasks with much narrower representational or informational processing goals (Eg: Which of the medications here causes body-aches, as a side effect). When a clinician reconciles a patients' medication list or of a group of patients, it will be termed as a task. Tasks themselves will consist of activities. For instance, document navigation is an activity within a broader medication review task.

Task Features

The key emergent, task-level features that are proposed to distinguish between correspondence and coherence are task boundaries, the time taken for the task and the general nature of assurances they provide. Each of these will first be discussed before moving onto the features of its constituent components framed with an Activity Theory perspective.

Task boundaries

This feature addresses the issues concerning the specification of where the task might be considered to begin and end.

Correspondence tasks are well bounded in that nearly all the information needed to complete the task is present within the available representations (inputs) and that aside from providing parity checks, the tasks do not complexly consider information embedded in the representations. Also, their influence on other tasks is low.

Coherence tasks can and do exist independently like correspondence tasks (), but are more likely to be embedded within a much richer task setting. The coherence built during the task can remain with the author and influence other tasks, while in turn simultaneously adding to the coherence generated from other coherence tasks performed by the same person. This makes studying natural coherence tasks in isolation, impractical.

When multiple coherence tasks are performed by a subject based on the same coherence network, the network improvements made during one task pay off dividends in other coherence tasks and vice versa. Performing coherence tasks both benefits from an existing coherence network as well as contributing back to the very same coherence network (***Coherence begets Coherence****… as in* Learned individuals learn quicker). Therefore, it might be advisable in terms of productivity to concentrate coherence tasks amongst few individuals who would perform them frequently rather than assign them across many who would perform them infrequently.[13]

When a coherence network is available, the subject might perform what would otherwise be correspondence tasks as coherence tasks instead. This was the case with the RCM who when checking for parity, compared not against external representations, but against her internal patient model resulting in a more meaningful task (coherence task) which replaced the expected correspondence task. The RCMs also used their coherence to make correspondence

[13] No position is taken here on the prudence of limiting coherence to few clinicians rather than improving its distribution.

tasks of CNAs, less error-prone by adding case-specific representational safe guards to the forms. In other words, coherence is infectious.

This phenomenon also stresses the importance of activity as a component of cognition. In other words, by eliminating the pro-active process of the activity of coherence generation and simply provide a report on coherence, it is unlikely to be able to obtain equivalent results. The clinician who actively generates coherence is much more likely to possess stronger internal models than a clinician who only passively consumes the provided coherence model.

Time taken

Coherence seeking activities were in most cases, more complicated than correspondence seeking activities. This is understandable given the greater amount and a richer type of information that needs to be reconciled, along with higher uncertainty. As a result, coherence tasks typically took longer and were more complicated. When performed in batch, correspondence tasks were more readily seen as repetitive tasks and had a relatively fixed workflow. Coherence tasks did not become too repetitive even when performed in batch since new challenges came up from time to time. Ergonomic optimization featured less prominent advantages with coherence tasks. However, the mechanical feel of the task proportionally seemed to shift along with increasing correspondence component. The second who was newer to the setting predictably set her task up with prominent correspondence strategies.

Not all correspondence tasks were short however; some exceptional cases took significantly more time than normal cases as the regular and efficient workflow was inadequate to accommodate these. With coherence tasks, cases requiring careful consideration were common rather than exceptional and hence typically took more time to complete.

Although both task types required the clinicians to adapt in the face of uncertainty, the adaptive needs were greater with coherence tasks. With correspondence tasks, the workflow necessary to establish correspondence is often very clear. This was not the case with coherence tasks. The subjects needed to look up information based on their hunches, without a single clear idea of how the desired state of coherence would manifest for the current instance of

patient information since more than one channel needed to be checked. For instance, when a pharmacist finds a medication that can be used for more than one condition, none of which appears to be obviously documented in the chart, she may have to look for clues that point to one of the possible conditions.

Assurance type

Correspondence and coherence tasks both provide assurances that are independently valuable. However, the type of assurance varies significantly between the task types. A correspondence assurance is an assurance of parity while a coherence assurance is an assurance of meaning, both within the items under consideration and within a much broader context.

As noted earlier, these are tasks are often embedded within much broader task contexts. Providing an assurance is not always the sole intent or effect of coherence. The pharmacist in the study was principally concerned with the assurance of coherence. However, the Residential Care Managers both helped themselves as well as other clinicians with their coherence beyond providing assurance. This is possible because while different clinicians do indeed perceive separate slices of patient's data with varying concerns and considerations, an ontological common ground that interests several clinician classes and activities still exists.

Task components

The observed activities could productively be examined across several features. In many cases, the features bring out the difference between correspondence and coherence. In a few cases, the differences are absent or less clear. In such cases, the common expression of features is still explored if the exploration of the feature presents other items of interest or insight.

Since the features are many, they are organized once again by a categorical scheme. The categories were derived from the core model of Activity Theory.

Subject ---- Mediating Artifacts ---> Object

The scheme offered two main advantages.

- The concepts are relatively well recognized, as is their source.
- The features were distributed in a relatively even manner.

The major component categories are ***subject features*** which describe how the subject may be thought to be composed of in the context of the task, ***object features*** which address the entities that the subject focuses on, consisting of both abstract information as well as physical representations, and finally, the ***process features*** which describe the particular ways in which the subject deals with the object.

Subject Features

In order to further organize subject features, we need to expand the category. This time, the categories were chosen from the conceptual themes of distributed cognition. Subjects are holistic[14] cognitive agents that process information both internally and externally. This gives the considerations of internal and external context.

Observed Subject Behaviors

Focus

Both correspondence and coherence tasks were associated with high needs for focus. This was particularly apparent during batch tasks.

We can examine focus as both a behavioral phenomenon as well as an analytical construct. A common definition that can accommodate both these considerations is as follows: Focus is a filter of concerns within the problem space with the goal of increasing the amount of attention directed towards core concerns critical to the task such that task performance improves.

[14] DCog system prefer system level abstractions to be more appropriate contenders for notions of holism, not human agents.

Focus Behavior

The subjects explicitly stated that they did not wish to be disturbed during these tasks and their colleagues understood and accommodated this need. The first RCM joked that her colleagues knew that she would be cranky during her task. The second RCM endured heat discomfort of a small closed room, rather than compromise her solitude during the task. Similarly, the pharmacy technician was provided with her own room, something that other employees at the pharmacy that significantly outranked her did not have. In all cases, their colleagues kept the interruptions to a minimum.

Here the subject is using an explicit physical or spatial filter to keep non-critical distractions from her colleagues. This kind of filter also needs to be supported by a shared understanding by actors involved of the nature of the task, its cognitive demands, its importance, (know when to override privacy request) frequency and duration (so that non-critical affairs that require the subject can be deferred till later or alternative approaches sought).

Focus as an analytical construct

This is covered below in conjunction with context. It is a similarly filtered problem space, although the filter is not explicitly controlled. Just as context is the information activated coherence framework subset, focus is framed here as a subset of context that is currently receiving attention resources. Since attention is an execution pointer in cognition, we may expect focus boundaries to rapidly shift during any information task.

Flow

Flow is a psychological state, originally described by Csikszentmihalyi. Flow is a pleasurable, high-focus and high-productivity state that subjects engaged in activities that are neither so easy that they become boring nor are they so difficult so that they may become frustrating, perceive. Subjects in flow become deeply engaged in the task, and feel a desire to continue the activity until significant deterrents emerge. The subjects consider that the activity is a reward on to itself. Their perception of time is altered. The complete immersion in the activity increases productivity.

Flow (Nakamura & Csikszentmihalyi 2002) is generally seen as a positive state even though it may just as easily become a disruptive influence when manifesting as an activity addiction. But here, only positive flow is considered since the phenomenon was observed in conjunction with batch tasks. In all cases of batch tasks, the subjects were deeply immersed in their task. Some small cues hinted at minor improvements in cognitive performance, although these might have been mis-interpreted. When the subjects began their tasks, they made slightly more frequent use of cognitive artifacts to manage their state. However, once they became immersed in the task, they no longer needed them as much.

Certain pre-conditions were noted in literature to promote the likelihood of reaching the flow state. These include

1. Activity features
    a. Activity is familiar
    b. Activity is neither too easy nor too hard
    c. Subject feels in control of the activity
    d. Activity provides feedback of progress
    e. Activity is repetitive
2. Environment features
    a. A limited stimulus environment
3. Subject features
    a. Subject has an Autotelic[15] personality

Like the batch-tasks that it is reported as being associated with, flow has not yet been exploited in the design of healthcare systems and presents exciting opportunities. Even without new electronic systems, Flow can be exploited by providing interruption free settings for subjects engaged in batch tasks. Fortunately, the clinicians and other personnel observed in the study seemed to be tacitly aware of the requisites of flow. Notably, the pharmacy technician, admittedly quite low ranking in a pharmacy that employs much more trained pharmacists, was

[15] Autotelics are those who enjoy things in themselves (telos is Latin for end) rather than for a purpose beyond the thing. Eg: An artist who paints because he loves painting in itself rather than for monetary gain, peer recognition etc. From Merriam-Webster: “having a purpose in and not apart from itself”.

allotted perhaps the largest office room in the facility for doing the yellows. Other clinicians hinted at their flow state. The RCM talked about how she got cranky during the Recap task. Another RCM isolated herself in her small office. The pharmacy technician used the radio as *"white noise"*.

Neither correspondence, nor coherence tasks had a monopoly on focus or flow. The real association was with batch tasks, which were found in either task type.

Modeled description of subject

Context

Both correspondence and coherence tasks are information tasks. Coherence tasks were characteristically associated with a rich context. Context is any significant information that is located outside the obvious inputs of the task i.e. the information environment existing both within the subject as well as outside the subject in the physical task space, which is the physical space in which the subject operates during the task.

Context comes in many forms such as knowledge from professional training, experience from having worked for many years, understanding of the local setting etc. Context is a fuzzy term and it is therefore necessary to define it with adequate precision in order to make operationalization possible.

Brynskov et.al (Brynskov et al. 2003) explores the term context, notes its fuzzy nature and defines it in a general sense as a dialectical concept. In this form, context can only be defined in relation to the current focus of attention. It exists whenever focus exists and changes whenever focus changes.

Additionally, by Brynskov formulation, context is often unspoken. Unspoken context is simply tacit knowledge. Since context is not directly evidenced, it must be explicitly elicited. One method that a practitioner may use is to ask the subject how the task is performed and then ask oneself why s/he cannot do it themselves with the same results. This resource differential can practically be described as context.

With this background, a better defined notion of context, which would retain logical continuity with other concepts introduced earlier, is presented below, which incidentally retains the theoretical and dialectical aspects of the Brynskov formulation.

The internal information environment was earlier termed as coherence *framework* since it provides the *slots* for instantiating patient data. The term internal context here refers to the subset of coherence framework that has been activated by the data instantiation so far. Since activation happens through semantic relationships between data to framework or between framework loci (of knowledge), orphan islands of context do not exist and context is framed as a single, well-connected graph data structure.

Since context is a simple subset of the coherence framework, it is composed of the same constituents as its parent i.e. knowledge models, cultural models and organizational models.

Focusing context

We may further explore this focus model of context. Since subjects hold vast amounts of information, it is essential to locate the relationship between focus and the background information. Information systems rarely exist in isolation and instead are embedded within the rest of the world. Information focus exists as both a practical necessity in that no system can consider every piece of information in conjunction to the entirety of the rest of its information space. Instead systems always consider only small subsets of information at any given time.

Since we may not directly and objectively experience information context in cognitive environments (unlike in computational systems where a memory dump may be requested), it is considered here as an analytical construct logically defined as an information locus bounded by the data collected towards it in observed instances. This means that there may be a certain degree of variability across instances depending on the circumstances controlling the focus.

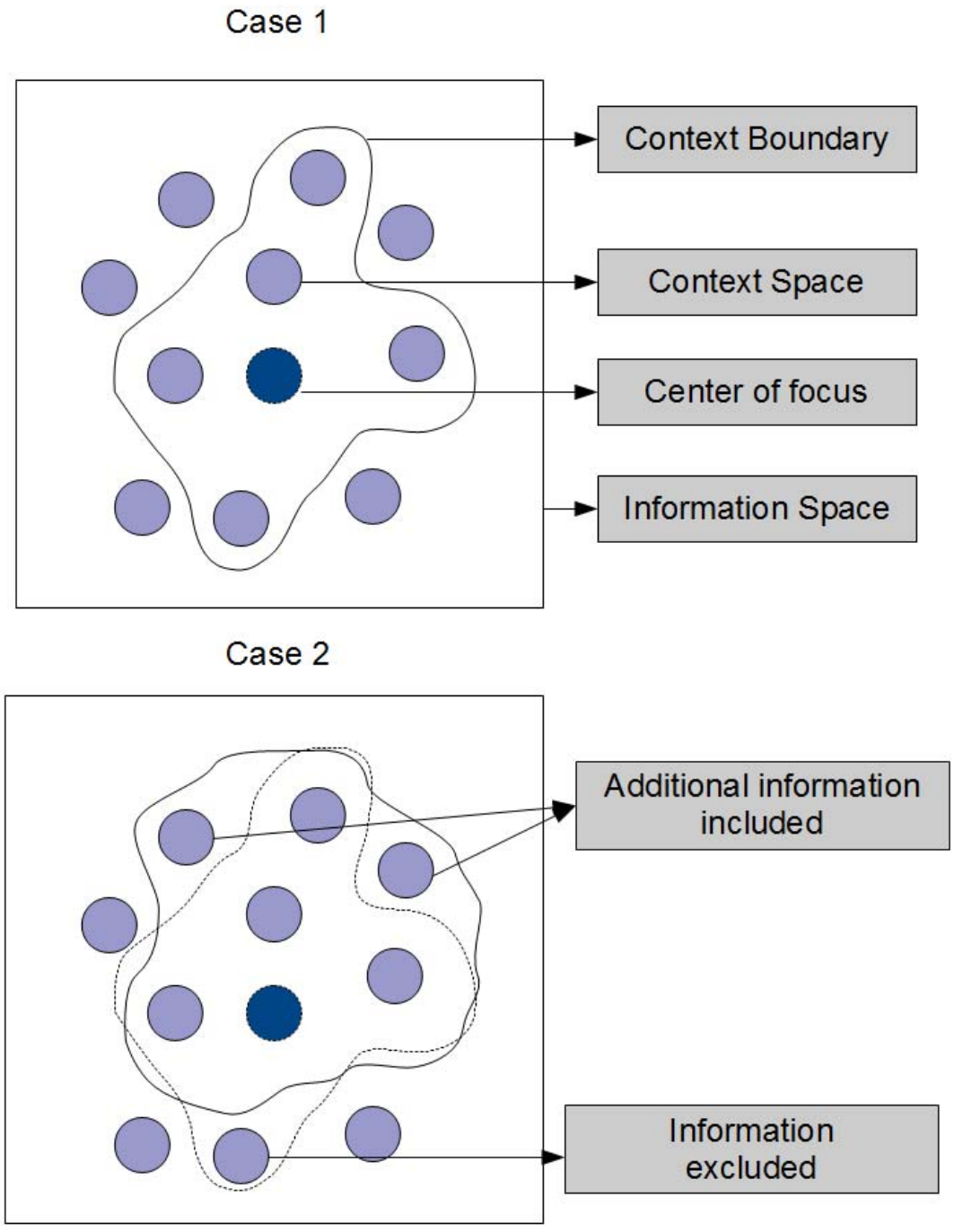


Figure 5.7: Illustrating context space instances with varying boundaries

The contextual subset of information is the information in the background that can be considered to be somehow related to focus, the determination of which can only be done on a case by case basis. The practitioner goes through several instances of a given task in order to understand all the different kinds of information that is considered in conjunction with a particular information focus. The frequent and essential information is identified from the infrequently useful in order to obtain a manageable subset.

It is perhaps more common to define context as something that is local and specific to a particular circumstance. However, in this formulation, non-local elements such as professional education, training and other common experience are not excluded. So it is more precise to call this expert context rather than general context. The principle used here is to consider additional information that is not embodied in external representations. This is believed to be essential in order to design a system that fully participates in the coherence building activity rather than only in the side lines as cognitive support for the development of the same within internal cognition.

Internal information context

A parallel comparison may be drawn to object oriented programming. Classes define the member data that will constitute the information context for the operations they define. The standard model of the class remains constant (at least in statically typed languages which are considered a more canonical implementation of object orientation) while the contents may change. Likewise, subject information models may be said to be mirrors of class models. They both present common and local environment for their information processing.

The subjects' internal information models may be described in two ways. There is a relatively formal and standardized knowledge model that the subject acquired through training and then there is a more tacit information model that the subject develops through experience. The formal establishes the core and general infrastructure while the later adapts it for flexible application in local settings.

Sources of context

Different clinicians will have different degrees of sophistication when dealing with the same content. For instance, a pharmacist would have access to a finer level of detail, with respect to medications than does the physician. On the other hand, the pharmacist would be less sophisticated in recognizing clinical patterns from the patient chart. So it is not only important to ensure that the right clinician performs the task, it is also important to note that different clinicians will inevitably perform the tasks differently. Both training as well as local knowledge and experience seem to determine the context and consequently, the task. The pharmacist was able to examine the medication information in a richer knowledge context, while the RCM was better able to interpret his medications in his immediate care context.

Information Models in Cognitive Context

Patient models / Role of case familiarity

Being familiar with the patient's case is very helpful for coherence tasks, but such familiarity is generally not essential for correspondence tasks as additional information considerations have no utility. However, the first RCM with intimate familiarity with the cases over several years performed a correspondence task different from those that did not. Rather than compare item by item, she compared the items against her own robust mental models of the patient. It was much easier for her to recognize newly introduced medications. In other words, her correspondence task was partially transformed into a coherence task. The current study did not address the implications of such a task model and cannot comment on the potential outcomes. But it is reasonable to expect the change to be positive and to note that the same task performed by equally qualified clinicians but with very different case familiarity will yield very different tasks, making performance comparisons moot.

Knowledge models / Role of professional training

Coherence tasks were only observed to be performed by well trained professionals. Correspondence tasks were observed to be performed both by extensively trained and less-extensively trained clinicians. When well trained clinicians performed correspondence tasks, they were not significantly engaging their training, although training does play a role. Although

correspondence tasks require or benefit from less training, it appears that correspondence tasks were performed by subjects with at least some training. The minimally trained the med-aides were only tasked with executing orders and were not comfortable with interpreting clinical data at any further level of sophistication.

It then follows that if a task well described and is recognized to be a correspondence task, such as the current canonical task of medication reconciliation, assigning a well-trained clinician would be a waste of resources since proportional improvements cannot be expected. Likewise, coherence tasks simply cannot be performed by clinicians lacking the coherence frameworks necessary to instantiate the patient data in. The later perhaps is

Object Features

Information

Information type

The category of coherence was only meaningful within the context of tasks that consider heterogeneous information. Complex considerations of information are difficult to imagine when only one type of information is being considered. However, when a clinician considers different types of information, it becomes important to think in terms of the various ways in which they might be related. It is possible that future studies might discover instances where complex information considerations within homogeneous collections occur. But for now, this appears to be a good rule of thumb. However, practitioners must be open enough to be ready to discard the rule, rather than force a fit, should the circumstances warrant.

Temporal Perspective

All the correspondence tasks observed were directed at establishing correspondence between past or present data i.e. data until that point. Coherence tasks addressed the data in this sense, but also additionally propagated coherence (RCM to CNAs, home health nurse to med-aides, home health nurse to patients) into the future. The chief determinant here is that

while correspondence is primarily a periodic safety check, coherence is a much more integrated preservation of the *"continuity of meaning"* that informs care at many.

Give this broad and general temporal framework, two special types of coherence may be formulated from the observations.

- **Anticipatory coherence:** Anticipating needs for sense-making for others and constructing coherence for them. Eg: RCM for CNAs and Home Health Nurses for med-aides.
- **Vicarious coherence:** Attempting to make sense from another's behavior or point of view. Eg: Pharmacist who comes in as an outsider not having detailed context beyond the information recorded in the chart and attempting to explain why the local clinicians might have done something.

Understanding how the properties of these unique cognitive phenomena differ from the more typical could lead to more insights towards better design of future tools. From the surface, anticipatory coherence is exciting. It calls our attention to the rich ways in which clinical experience is leveraged and reminds us the importance of creating nuanced models rather than simple data models. It also signals an opportunity for automatically generating coherence facilitating representations for known and understood target user classes (types). Some of the wisdom and experience at play is to address local factors, but studying them might still inspire further general design ideas.

Vicarious coherence on the hand seems to be something we need to strive to reduce the need for. It results from missing information in the record; information that is necessary for the given subject to construct coherence since it was unavailable in chart. It is time consuming and cognitively demanding to construct. We need to look at *practical* ways of ensuring that adequate information is available i.e. without further burdening clinicians with more data entry tasks. Small, but routine investment in recording this information could payback in saved time by avoiding vicarious coherence building exercise. Given the history of clinical informatics in not producing time-saving technologies consistently and the

potential for mal-alignment of effort and incentives, this might be prudent to assume this not to be an easy task.

Representation

Products

Correspondence tasks are almost exclusively concerned with creating external products such as an explicit report stating that the check has been completed or simply leaving behind informal annotations and other cues to indicate similar status. While the same can be said of coherence tasks as well, the chief product/outcome of these tasks is the understanding produced within the internal cognition of the clinician performing this activity. This understanding was propagated beyond the formal record in some cases, but in other cases, was left un-persisted and un-propagated; a seeming waste in case of the later.

State management

A significant component of external representational behavior with correspondence tasks was associated with the use of representations to maintain the state of the task. The subjects were much more likely to mark individual items of the medication lists when they were checking for correspondence than they were for coherence.

The pharmacy technician employed information focusing annotations to preserve state across restructured tasks, which is something unique to correspondence tasks.

Correspondence batch tasks in general were associated with workspace level representation management. The second RCM whose task had a greater correspondence component and the pharmacy technician maintain the documents in stacks to permit a consistent workflow.

The first RCM, whose task had a greater coherence component and the pharmacist needed to check if two medication lists matched. The RCM checked against two paper based lists, just like the home health nurse visiting the skilled facility did. The pharmacist compared a paper medication list to the medication list on her screen, just like the pharmacy technician did.

However, the use of item by item annotations (check marks) were employed significantly more frequently with coherence tasks.

Document navigation

Chart navigation was uniquely associated with coherence but not with correspondence. This was because coherence activities often required pursuit of information defined by criteria rather than a specific document. For instance, the pharmacist would need to locate a diagnosis to find a particular medication in the medication list coherent. However, she would not know exactly which document would contain the information, but only the general class of documents within a particular time frame. If a search did not yield a diagnosis, she may expand the search to other document types (for instance, she may now also look at lab reports if she feels that the medication might also have been in response to a particular result). Correspondence tasks on the other hand seemed to be relatively straightforward with respect to locating the documents necessary.

Annotations

Use of annotations for own use (cognition)

Since coherence is framed as a more complex meaning building activity and since correspondence is a simple check of item parity, it would be more natural to expect coherence tasks to take a greater advantage of representational mediums for cognitive support. However, it was the correspondence tasks that made a more substantive use of external artifacts. The following explanations are offered.

Since the items are only perceptually compared no cognitive model of the patient's medications forms in the internal cognition. As a result, it is easier to forget which medication has been checked and which has not been unless meticulous tracked in external cognition.

Another reason is that while it is clear of how to represent the simple linear progress of parity checks, it is not clear how the complex models of coherence should be represented. Herein lays a paradox of representation (or modeling in general when a meta-model is not present). External representations are most valuable when the internal model of coherence is

least formed and it is hardest to know how to structure representation when the internal structure is not well understood.

First, it must be noted that no *losing-track* concerns were noted in coherence building. There was no indication that any coherence building clinician forgot the meaning she just generated. Representational strategies should instead be examined for whether they can optimize the thinking process into well-considered paths and provide new ways of looking at information.

This is unlikely to be a strategy that clinicians can independently develop through their individual ingenuity (unlike the pharmacy technician's task-restructuring). The natural coherence building strategies need to be carefully studied by clinical cognition experts and core primitives (which form the meta-model of the representational model) identified before candidate strategies and representations proposed. With the core concepts uncovered and notational primitives offered, clinicians can then individually adapt them in forms that best suit them.

This may be compared with the development of UML. After much practice variation, UML's originators (The three amigos) provided the core ideas which were subsequently refined and presented to the community. UML today is utilized in both formal (for communication and machine action) and more importantly, informal (for cognitive support) notational conformance.

External representations are however not a silver bullet. The worst approach however would be to impose a formalism when none is warranted. Not every thought process benefits from them. It may just be that this kind of clarity generation with limited time resources and ill-suited for representational costs. As we see from the pharmacist's think-aloud, she considers several alternatives in less than a minute. Representation could only hinder this flow.

Use of annotations for others (cognition + communication)

Annotation use in correspondence tasks was strictly for the author's purposes. While a small amount of this was present in the coherence tasks, the more interesting finding was that

annotations and other superimposed layers of representation were used for the purposes of clinicians, other than the author.

Factors facilitating annotation

Another axis of discrimination that needs to be stated in conjunction to external state management, but one that is otherwise independent of correspondence or coherence is that subjects are more likely to annotate representational mediums that they have *ownership* of, or in the case of a more collaborative medium, are in a *position of authority*. The yellows were recognized as a primary working space of the pharmacy technician. Consequently, the pharmacy technician was uninhibited in freely marking it up. The RCM is the primary oversight authority on a MAR and this was where she located most of her representational activity. The home health nurse visiting the facility marked up her *own copy* of the medication list. The rationale for this is easy to imagine. In collaborative workspaces, the participants need to be mindful of the impact of their own representations, whether they use is intentional (RCM representations for CNAs) or personal (state management for cognitive support).

Unlike the paper medium, electronic representational spaces can potentially offer much more flexibility in allowing the subjects create their private representational spaces. This could allow the clinicians to create personal representational spaces that can better serve them for cognition support without having to worry about the implications of a collaborator workspace. With the current limitations of the paper medium, and the lack of support from the electronic mediums, the subjects do create they own private cognitive workspaces. The illustrative example of the book of napkins demonstrates this very well. However, while these kinds of mediums serve the purpose of transient cognitive support by virtue of the encoded message of non-permanence in the medium, there does not seem to be any way in which a more persistent personal cognitive workspace may be created in close association with a particular patient's record or even a particular document with an record. The subjects may currently take notes independently, but this will only work for patients of immediate concern. It would be much harder to maintain such notes across patient visits. To facilitate this, electronic workspaces must allow for the creation of private representational spaces, where the clinicians may

annotate documents or add notes, just for their eyes only. The clinicians must be given complete freedom, privacy and security on how these spaces are managed. Polluting these spaces with the general IT tendencies of review and record keeping will negate the intended effect.

Propagation value

Coherence is promising in its reuse potential. If coherence is seen as the connectedness of information, it need not be redone over and over again. Correspondence has more specific utility and will not likely benefit from further propagation beyond the report.

Both correspondence and coherence are incrementally performed. However, while correspondence tasks can be picked up by alternate clinicians, the incremental-ism of coherence tasks does not transfer over when a different clinician encounters the task, given the current persistence limitations.

Process Features

Primary mode

Correspondence tasks seem to be primarily perceptual tasks while coherence tasks seem to be primarily cognitive tasks. Many models of cognition, for good reasons, consider perception to be a component of cognition. This is especially true of distributed cognition, which places the emphasis on external representations which must always be perceived. However, delineating between these two is productive for operational purposes.

Batch tasks

A batch task is any task that is performed in sequence without any other tasks intervening. Batching was observed within both coherence and correspondence tasks. Batch tasks were associated with the need for high focus in both categories, but were associated with task-restructuring only in the case of correspondence tasks.

The subjects seem to enter a state of flow where they became completely immersed within their tasks.

Flow was first described by Csikszentmihalyi (Csikszentmihalyi & Csikszentmihalyi 1975) as a subjective state with the following characteristics (Nakamura & Csikszentmihalyi 2002)

- Intense concentration
- Merging of action and awareness
- A sense of self-control.
- Loss of self-awareness
- Distortion of temporal experience
- A demonstration of an auto-telic behavior (the activity is an end unto itself)

Flow is generally seen as a beneficial state within work settings and arises within the delicate balance between capacity and challenge. While the subject is resilient to distractions by virtue of flow itself, s/he is still vulnerable to them.

Flow is observed only after developing some degree of familiarity with the task such that the subject feels confident that s/he can react to all potential circumstances.

Flow within clinical batch tasks needs to be investigated further. In particular, clinical environments have often been described as interrupt-laden (Laxmisan et al. 2006) and sometimes even curiously, interrupt-driven (Chisholm et al. 2000). Clinicians have also been described to think through acts of discourse(Atkinson 1995). Batch tasks stand in stark contrast to them since they often happen in uninterrupted solitude. It may be essential to distinguish between the two cognitive environments such that they may specially be accommodated with tools that fit them.

Task restructuring

Task restructuring was the unique feature of correspondence batch tasks. The theory was offered here that subjects resort to restructuring when

- Information under focus is relatively stateless
- Subject perceives that the cost of restructuring the internal cognitive space is more expensive than restructuring the external cognitive space.

Further studies should attempt to explore whether we economies of scale are being realized with these kinds of tasks. Measuring the time taken for the task, with and without restructuring and also measuring the time taken for the early subtasks vs. the time taken for later subtasks can give important insights into the value of such tasks.

Feedback to Performance

Coherence begets coherence. A clinician who performs a coherence task was seen to retain the products of that coherence much more substantively than a clinician who simply reviews a report of that coherence. This means that the activity of coherence generates more coherence than is conventionally persisted in a report and also that the activity itself aides with increasing the retention of coherence. The recap task helped the RCM to do her other tasks better and it helped the home health nurses to better understand their patients. The pharmacist however, does not get an opportunity to further leverage the advantage. The correspondence tasks did not seem to have such effects.

Self accentuation raises important questions. Should we attempt to build tools that better enable the clinicians to build their own coherence or should we build tools that better persist the richness of coherence.

Cognitive distribution

A larger portion of the Correspondence tasks made use of external representations and cognitive artifacts. While coherence tasks also took advantage of similar tools and strategies, their use appears diluted by the substantial contemplative component present. Since individual coherence tasks are more complex, more information processing activities can be observed with them than correspondence tasks. However, as a proportion, much more time is spent in thinking than in manipulating cognitive artifacts. For this reason, correspondence tasks are considered as externally processed tasks while coherence tasks are considered as internally processed tasks.

Chapter Six: Implications And Contributions

Domain Contribution: Medication Reconciliation

Medication reconciliation is currently conceived as a correspondence task. It is also mandated and described as a distinct and isolated activity at the transitions of care. The current study quickly found this model from the literature inadequate. It subsequently discovered a much richer set of concerns (constructing meaning is more important than simple comparisons), considerations (how tasks are entwined with one another), diversity (different goals, people, settings, approaches), strategies (how clinicians currently use tools in these tasks and how they can be accommodated and enhanced) by identifying a number of medication safety practices as they exist today.

The study then explores how these unique tasks, though distinct from one another participate in the preservation of the continuity of medication safety, from orders to the later reviews of the record of administration of these medications. The study then attempts to understand these tasks in detail, especially from a cognitive perspective.

It notes that many of these medication management activities are often embedded within other activities and influenced by additional concerns. Without a comprehensive and nuanced understanding of the spectrum of medication management practices, their drivers, goals, and properties, the current simple models of medication reconciliation appear naïve. By conceiving and promoting the medication safety task that is divorced from the rich and unique settings in which medication data is interpreted and managed, we are much more likely to add yet another regulatory document that needs to be taken care of, rather than contributing to actual patient safety.

On the other hand, medication safety would be a natural consequence, if the clinicians operating in the setting, possess or have rapid access to a coherent understanding of the patient's care. The concept of coherence was derived by identifying the key components of the medication management activities and was subsequently defined in more general and axiomatic terms, drawing from earlier scholarly traditions and approaches, ultimately culminating in the theory of Coherence and Correspondence.

The state of coherence is a complex cognitive state that reconciles not merely medication lists, but rather all the major information components of the patient's chart, including an understanding of how the medications map to the patients problems, possessing an intuitive understanding of the history of evolution of the patient's physiological state and through this lens of health, interpret the medication lists and laboratory investigations that react to this core concern.

By conceiving of a process without a solid understanding of the medication management setting, theoretical or not, we expose ourselves to the *nomothetic fallacy*. We prematurely assign a name to a proposed solution that targets an only incompletely understood problem. We then can mislead ourselves by assuming that our understanding of the core problem is as simple and straight-forward as the simple solution. Such a confidence may lead to misplaced efforts on making sure that the clinicians confirm to unhelpful practices rather than examining the foundations and complexities of the problem first.

No doctor ever writes a prescription without first examining the patient. Before the doctor can prescribe the medication intervention, he must first describe the examination findings and label the problem drawing from his extensive theoretical and expansion understanding of the human body. Similarly, we must first produce a comprehensive description of how medication information is richly managed in healthcare, and then we must attempt to distill this understanding into coherent theoretical formulation. If we hope to develop healthcare solutions in a systematic manner, we must first develop strong foundations that provide the tools and lay the ground work for such a pursuit. Any solution that is eagerly pushed onto healthcare will incur significant costs to the system. Therefore, we owe it to ourselves to commit ourselves to the discipline of grounding our solutions in both strong theoretical understanding of the problem, as well as on a disciplined theoretical understanding of intervention strategies. Without such grounded approaches, these solutions will not be able to recognize and adapt to unanticipated consequences that will inevitably arise from the practice changes introduced by the interventions.

This study attempts to provide that rich description of the settings where the problems and solutions occur. Medication safety is not a new concept. As concerned practitioners, clinicians had always applied their own strategies to reach the safety goals. By studying these natural activities, insight was gained towards how clinicians think about medication management. These insights will better inform system designs that can better map to their resources, constraints and needs.

Theoretical Contribution

The above analysis offers a novel theoretical framework. A good theory must either offer explanations, or provide predictions or both. We shall examine how this framework addresses these aspects. In its current state, this theoretical framework is promising in the following respects. First, it provides a model for systematically explaining the cognitive phenomena that were observed during the study. Second, it offers a multi-level categorical framework that can reduce the perceived complexity of the clinical activity settings. Third, it can assist future examinations of the setting. Fourth, it is able to offer predictions by logically extrapolating from the axioms of its model. Finally, it can potentially assist in the development of a design philosophy. Now we shall examine each of these claims.

As an explanatory theory: the explanatory aspect of theories was generally emphasized prior to the Newtonian revolution, under the influences of Cartesian philosophical principles. With the Newtonian revolution, the focus shifted towards predictive theories. However, explanatory theories continue to thrive in qualitative research settings. The current theory has been designed with a conscious goal of facilitating attempts to explain "why" the given phenomena manifest. For instance, the theory may be used to explain why two clinicians with relatively similar professional training, would examine medications in very different ways (differences in the patient models, despite the knowledge models being comparable).

The purpose of desiring the coherence theory to be explanatory is to make it in turn more coherent. When a non-intuitive observation is noted, a new explanation is formed which must be added to the existing theory. This will increase the richness of the theory. The increasing detail will also force non-coherent conjectures apparent.

As a categorical framework: the current theoretical framework offers a novel and substantive organizational scheme that was hitherto absent. This enables us to view previously fuzzy clinical activities as real instances of elegant categories. The framework offers multiple levels of abstraction, both as a means to communicate the various aspects of the scheme (dichotomous versus continuous perspectives) and also to offer utility for varying future needs of analysis. The adopters may simply use the broad categorization of coherence and correspondence for simple descriptive purposes or adopt a more low-level framework for economic and novel tool development purposes.

As a descriptive theory: this particular aspect of the theory is simply a consequence of the prior told listed features namely, its explanatory goals and its approach through its categorical structure. In conjunction with empirically testable claims, this allows it to be used to develop incrementally sophisticated descriptions of the settings. Better descriptions are fundamental to better, theoretically grounded prescriptions of interventions. This argument is directed towards future academic application of theory. Additionally, the study explores and presents a number of concepts and phenomena such as information focusing, types of coherence, annotation behavior etc. Since we humans are generally better perceptive to phenomena that we have previously conceptualized, providing a previously synthesized concept base will improve data-gathering productivity. This argument is directed at an everyday analysts' application scenario for the theory.

As a predictive theory: the attempt to provide general explanations using broadly applicable primitives, rather than exclusively address observed data. This allows it to make predictions in two settings:

<u>Predicting findings in un-observed scenarios:</u>

Using (relatively) well-defined theory, we can do thought-experiments. Unlike the case with philosophy, we use these to generate better questions, not resolve them, such that we may observe more keenly.

It is quite likely that such attempts will yield results different from those expected since the theory currently does not yet support quantification. This means that while we may accept that there are two opposing forces, we cannot always predict which one will dominate. However, we would be able to explain the result in terms of the resolution between these forces.

As an illustration for prediction, we may postulate that since fourth year residents have noticeably superior knowledge models than first year residents and hence would be more likely to exhibit stronger coherence components. Likewise, since residents would have better patient information model for a patient who was admitted earlier than for a new admit, we would expect different tasks composed of different activities. In this case, we would expect to see information processing to be distributed within external cognition, with the new admit. Later, as the patient model better develops in the residents' internal cognition and becomes more efficient in information instantiation, we would expect to see a reduction in representational activity.[16]

Questioning findings in observed scenarios.

A rich theory will provide enough logical material to make counterintuitive explanations possible. The theory can be used to assert that a pharmacist would necessarily consume the information in a medication list, in a very different way from a residential care manager, even if they appear to exhibit similar apparent representational behavior. If the knowledge models and goals are different between the subjects, the information being consumed will be instanced differently in the respective coherence frameworks. We can test this hypothesis by asking the clinician to recall the information. If the information can be shown to have undergone different transformations, we can not only establish a difference, but may also infer additional details about the internal frameworks.

[16] Let's say that the use of external representations also increases even with the investigator being convinced that the information is being instantiated more efficiently (faster information consumption), we need to check if the coherence framework is much more elaborate so that we may expect a parallel rise in external representational support.

As an extensible theory: the theory development exercise attempted to create lucid and axiomatic theoretical constructs. While this goal will continue to be a journey rather than a destination, special attention was paid to not only describe key terms in terms of what they were, but also in terms of what they were not. Additionally, axiomatic prerequisites were identified whenever feasible. It is hoped that such a formulation, the theory is easier to be logically extended by the research community in a relatively objective, failing which, at least make possible structured methods with formal (as opposed to fuzzy) axiomatic extensions.

Another feature that aids extension is the use of broadly applicable primitives. In a phenomenological context, the primitives were well-grounded upon discovery. However, these were not used directly in the construction of the theory but rather were rationally processed into more generally-applicable constructs, often framed as or aligned with better recognized constructs. This transformation with its nativity costs for the utilitarian goals may be cast as an analogy using modern processed foods (E.g. sugar), that may be seen as a little less healthy than their raw sources, but make day to day cooking a lot more manageable.

With this design, while the current theoretical framework exclusively targeted medication management activities, the conceptual primitives used to create this framework are general enough that they may continue to be useful when applied to most clinical activities, not just medications. However, this claim is yet to be empirically verified. On a more ambitious note, it is also possible that this theoretical framework is applicable beyond clinical settings, especially those settings, which are similarly information and activity rich.

As a prescriptive theory: the discussion of the theory included implications for varying presence or prominence of the different factors and behaviors influencing medication management activities. Such formulations can easily be transformed into design principles. For instance, the correspondence activity is primarily described as a perceptual activity without rich considerations of meaning. It then follows that we can improve the productivity of correspondence tasks by optimizing perceptual effort. For instance, allowing two medication lists that need to be compared to be displayed next to each other would improve performance.

In another example, we saw that the pharmacy technician has set up a workflow with a significant emphasis on representations that manage state. When repurposing her activity using professionally developed electronic tools, the designers must carefully address the representational needs for state management or perhaps even attempt to make it unnecessary. But what should not be allowed to happen is the ignoring of the concern.

However, such perceptual co-location of representations would not be adequate for a coherence task, where meaningful relationships between heterogeneous data elements would need to be accommodated. Supporting coherence tasks is more complicated given that much of the activities are distributed within the internal cognitive space that is less straightforward to monitor and intervene with. We may have to concede that we may always be limited to providing only partial solutions.

On the other hand, it is possibly naïve to consider that such support must occur in a form that is faithful to the current organization of coherence tasks. Introduction of new technology necessarily reframes the task, in some cases, radically so. It might be possible to relocate the current information processing that occurs within the internal cognitive space to the external cognitive space, where we are much better positioned to investigate and support. The classical theory of distributed cognition would then suddenly be much better aligned in dealing with these activities. To remind, the theory of distributed cognition, as discussed in current literature, was initially considered, but was eventually rejected, since significant components of many activities was found to be easier explained as situated within internal cognitive space while acknowledging the unique properties of such information processing, rather than in a distributed cognitive space that eschews boundaries such as internal and external cognition.

A few examples can illustrate such steady evolution with a clear sense of direction. In software engineering, a common theme is the continuous evolution of imperative instructions specification methods towards declarative instruction specification methods (Procedural database access queries to SQL, imperative languages to functional and logic programming languages, XML DOM API to XPath expressions etc). Such active translocation of information

processing, by design, onto external cognitive artifacts could be framed as a progressive maneuver, much in the same way that written text and mathematical notation afford substantial scalability advantages to human thought that is otherwise largely internally located.

Such translocations could represent a radical shift in which distributed cognitive systems are actively *designed* rather than being only passively *observed* and contemplated upon. The question in these matters has always been about *how* such transformations must systematically be approached. Developing clear, comprehensive and axiomatic theories would be instrumental in creating systematic procedures for such transformations. In the journey towards such an ideal and adequate theory, the current theory of correspondence and coherence may be framed as a theoretical precursor, representing a step in the evolutionary continuum, from prior theories of distributed cognition and activity theory.

Other contributions

The theory of correspondence and coherence is presented as the principle novel theoretical contribution from the study. The study also identifies previously unreported phenomena of batch tasks and the associated task restructuring activities. Batch tasks were explained by the Coherence and Correspondence theory. However, they may need to be specially studied as they may be a low-hanging fruit that can enhance ergonomics.

There are significant implications when we identify tasks that would naturally be framed as batch tasks in work environments, where the participants retain substantial control of the representational mediums (paper). The design of electronic workspaces must either provide enough flexibility such that the user retains the ability to restructure the task or at least be able to identify batch tasks and then pre-structuring them appropriately. However, this still leaves behind a more fundamental question unaddressed. A more general problem of the consequences of removing or reducing the clinician inability to rapidly adapt information tools and mediums to changing needs is poorly understood. The newer electronic systems require elaborate, time-consuming and expensive procedures are now required to make even the most

modest changes to systems. This problem seems to be unacknowledged and consequently is unexplored and un-quantified in its implications and needs to be explored in future studies.

Next, it supports prior literature on the use of external representations (Norman, Zhang) and its clinical prevalence (Gorman, Hazlehurst) and super-imposed layers of information (Gorman, Hazlehurst). It also identifies instances of Flow(Nakamura & Csikszentmihalyi 2002), a model of mental state from psychology and calls further studies by identifying it as a knowledge gap that may have implications in clinician productivity and work-satisfaction if exploited.

Further work

This study concludes that we should focus our attention on strengthening the coherency of care among the various clinicians that participate in the care of the patient through the design of external representation forms. Addressing medication list discordance in isolation is perhaps only a patchwork solution that does not address the root causes of medication list errors. The current study describes the various medication management tasks and activities that quietly develop such coherence. It attempts to understand the processes involved in the coherency generation strategies. Since all our current clinical decisions are undertaken by rich cognitive considerations of clinical data, rather than by any mechanistic and algorithmic approach, the study uses modern and holistic cognitive perspectives in examining these practices. It then develops a theoretical description of medication management activities grounded in well established theories of cognition.

The resulting theory can be expected to be inevitably incomplete. However, it is framed with adequate axiomatic clarity such that it may be extended by other investigators. Likewise, its explanations of observed phenomena and its claims in untested settings can be subjected to empirical verification and subsequent refinement. These features are necessary because it is unlikely that any first attempt at a comprehensive description of the medication management setting immediately succeed in completeness. Therefore extensibility will serve it better than completeness.

Based upon these descriptive models of coherency, the study calls for the development of radically re-imagined prototype clinical information management systems built around a graph based, coherence of care as the fundamental architectural pattern. They need to acknowledge and support the various cognitive behaviors that the subjects demonstrated during their activities. In order to support such interactions, the user interfaces must transcend the traditional constraints of form based design and replace it with richly visual interfaces that offer flexible representational capabilities. The users must be able to actively work with these tangible user interfaces, rather than merely request information for display. The prototypes must enable the clinicians to construct visual coherence networks rather only through tacit, mental development in the recesses of internal cognition. But before this becomes possible, future projects need to develop a much more detailed theoretical model for coherency networks. The current study is only able to offer core concepts and a basic meta-model for these networks. The next step is to author runtime models of coherency frameworks with patient data, with the help of clinicians. The, runtime models of these structural models need to be manually instantiated and simulated parallel to the human decision-making in real life tasks. These exercises should enable us to expose additional concepts and data elements necessary to adequately represent coherency networks visually and to identify the various interactions that the users ought to be able to invoke upon them. This work would culminate towards the goal of translocation of replicas of coherency networks from their native internal cognitive spaces to external cognitive spaces, where they may be more easily studied, improved and adapted.

Recommendations

Current clinical information systems do not seem to explicitly distinguish between stateless and stateful tasks. While the current systems may not be sophisticated enough to support the stateful coherence tasks that engage tacit knowledge, it does not automatically mean that what we have now well supports stateless correspondence tasks.

Modular user interfaces

Correspondence tasks must be structured either in a way that allows subjects to reconfigure them or pre-configure them in such a way that the tasks are well optimized to

cognitive and ergonomic considerations. At least in the context of the “yellows task”, the interface would have to provide direct manipulation interfaces to partition patients and allow for private annotation. The qualifier that the annotation needs to be private will be further discussed later as an instance of the class of representations used for cognition alone.

Since the perceptual context forms a significant component of the task, making the perceptual space more efficient would enhance the outcomes. Currently, the pharmacy technician operates within a mixed environment that combines electronic and paper-based records systems. She constantly moves between the paper-based *yellow* representing the medication list at the facility, and between her local medication-list on her monitor. The task would be more economic if the two lists were displayed adjacent to each other. This adjacency display may be achieved in the three possible settings: all-paper, all-electronic and mixed paper-electronic settings. In an all-paper setting, the problem is largely about ensuring that the representational form of the one does not require excessive transformations and can be perceptually compared to the other. In an all-electronic setting, the two lists need to be displayed next to each other. In the mixed paper-electronic setting, electronic information may be overlaid on paper based information (Microsoft surface).

Semantic Medical Record

In its simplest form, coherence is an information network. The relationships between information are important. The current clinical systems however, take a more document centric approach to both storing as well as displaying information. This may be regarded as an inherited trait from the legacy of paper-based systems that they were intended to replace as well as the architectural models of the persistence (Eg: relational databases) technologies that they overlay.

The pharmacist's task would be trivially simple the patient charts were represented as a network. She will no longer be forced to guess why a particular medication was given when more than one use is present. The basic character of her task is to connect the diagnostic profile, medication profile and the laboratory profile of the patient. It is reasonable to say that any clinician looking at the chart of a new patient must make these connections. Sadly, once

this meaning or coherence is generated, the current facilities do not offer any means to assist it. As a result, this expensive cognitive effort is lost beyond the personal utility of its creator. We must look into ways of preserving it and facilitating its reuse.

If meaningful interpretation of the medical record is to be possible, it is not only important to record the information, but also to offer the relationships between information. This means that when a new prescription is entered into the system, it must be a semantic relationship to an information node describing the diagnosis. When a lab test is performed, it must either be linked to a diagnosis if it was meant to understand the progress of the disease or to a medication order if it was meant to monitor the physiological effects of the drug on the patient. This meaningful data representation was not possible that the paper-based systems. However, the flexibility of electronic data representation should mean that semantic architectures should not be considered.

A naïve implementation of this model may however burden the clinicians. The clinicians are already burdened with an excess of documentation tasks. And additional demand to specify the relationships between information nodes will only further add to this load. As Grudin's law states, the contributors must find value in the task, either in itself or by compensation. The designers of the network construction interface must strive to make it as economically efficient as possible by providing a responsive and richly visual interface. Further, the user of the interface must find value in the very act of creating this network of coherence. The RCM had stated that participation in these seemingly mundane tasks of doing a review of the patient's medications for reimbursement purposes enhanced her understanding of the patient. This illustrates an activity as a cognitive process.

The synthesis of coherence must be a collaborative effort. Different clinicians should be able to contribute to this network, and in between them, would be able to create a persistent and evolving model of coherence that they can all draw from. Any collaboration attempt will likely involve some issues of data ownership, responsibility and power precedence. These need to be explored.

A semantically coherent model would also open up new opportunities of machine support and analysis. However, this should be regarded as a secondary goal. Coherence should foremost be directed at human cognition, and any machine opportunities should only be regarded as an incidental opportunity.

Visual medical record

The semantic medical record described above is about creating more meaningful information architectures. Since humans consume information through representations rather than abstractly, a principled design of meaningful representations should overlay the semantic model, in order to promote coherence states. Different clinicians have different information needs. The current study identifies different task spaces and notes the different contexts of consideration. The user interface should present the appropriate representational models based on the task. For instance, a user interface designed for the pharmacist would simultaneously display the diagnostic information, the medication lists and lab reports. Since the pharmacist importantly considers all this data, a visual representation that takes this into account should be used. Timelines appeared to be the perfect fit for this task. Similarly, a user interface constructed for the RCM would display the orders in conjunction with the administration record, showing the connections between the two.

Limitations and future work:

Given the exploratory nature of the study that focuses on diversity rather than confirmation, the generalizability of findings remains to be established. Further efforts should be directed at examining whether the insights and themes are found in other care settings - geriatric or otherwise.

The framework of correspondence and coherence was a grounded synthesis from the experiences in the field. What remains to be seen is whether this framework can continue to retain its own coherence. When applied to additional settings.

A study of this nature cannot generate a list of insights that may be considered exhaustive. Further attempts to understand, these care settings should either expand upon the themes presented here by adding further detail or generate further novel insights.

The data was intentionally gathered under the influence of theory. While this is productive, it would be interesting to see how other observers with different theoretical backgrounds, would locate the findings in their own observations.

The framework of correspondence and coherence is but one synthesis. There is always room for additional conceptual models that give form to the same data and should be explored. The traditional models may feature differing strengths in being able to explain, predict or propose.

Summary

This study examined the medication management practices in a geriatric setting across a variety of professional types and care settings. The findings were cognitively analyzed. The practices observed during these activities were phenomenologically explained after comparing and contrasting between them. Novel themes emerged from this analysis that might provide new opportunities for creating better systems. The thematic findings were synthesized into a novel model that adds detail to the theory of distributed cognition. Recommendations were generated for system designers using this model. Finally, future work is proposed for both validating and extending the current effort.

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