# Understanding the Dynamics and Temporal Aspects of Work for Human Centered Design

Kate Sellen(✉)

Ontario College of Art and Design University, Toronto, Canada
ksellen@faculty.ocadu.ca

**Abstract.** This paper explores an information theoretic approach to identifying strategies in work practices in dynamic contexts using blood issuing for the operating suite as a case study. Going back to conceptual models of strategies indicated in early human computer interaction work, together with contemporary representation of work practices in dynamic healthcare contexts, the concepts of temporality and pace are explored. This exploration highlights a number of strategies that may be generalizable and could be used to guide inquiry in the early stages of design. Attending to potential general work practice strategies that can arise in response to dynamics and temporal aspects of a particular setting and its conditions, by focusing observations and contextual inquiry for instance, has the potential to avoid idealized conceptions of work practices and inform system design.

**Keywords:** Human-centred design · Task analysis · Cognitive systems · Workarounds · Task representation · Temporality

## 1 Introduction

Human centred design techniques began to be applied to human computer interaction in medical settings nearly two decades ago, as these techniques were developed for use in other domains but also in response to the call for better understanding of issues related to Information technology specific to healthcare (HIT).

The adoption of HIT has not been universally successful. Often the proximal cause of HIT failure is identified as a lack of HIT adoption or resistance from clinicians and staff [1–3]. However, the prevalence of issues that have been identified with HIT relating to workflow, communication, ease of use, system design, and usefulness, suggest a gap between the HIT systems as designed and their fit with the work practices they are intended to support. Calls for different strategies for system design and implementation have been growing in response to these reports [4–6] – a challenge well suited to a human centric approach.

There are now many examples of a human centric approach combining cognitive science, human computer interaction, and human factors engineering techniques at multiple levels of analysis of HIT, including the individual, team, group, and institution [7–9]. However, how might we develop design strategies from these investigations that support human centric design in the early stages of system design – taking into account highly dynamic and temporal aspects of work practices in the healthcare context?

© Springer International Publishing Switzerland 2016
S. Yamamoto (Ed.): HIMI 2016, Part I, LNCS 9734, pp. 454–461, 2016.
DOI: 10.1007/978-3-319-40349-6_43

### 1.1 Representing Dimensions and Temporal Dynamics

There are approaches to system design that include dynamic and temporal aspects, for example, Cognitive Work Analysis (CWA) and its use for assessing work domains in settings that include surgical procedures, critical care, and emergency room diagnosis, among others [10, 11] and resiliency engineering is also relevant here.

CWA is one of a suite of tools that support Ecological Interface Design [12]. A growing theme among researchers experimenting with CWA for strategy analysis is the challenge of conceptualizing the mapping between a work practice strategy and the dynamics of the work practice and the representations that can be used in practice for system design [13, 14]. Resiliency is an approach which includes concepts that allow for recognition and representation of dynamics and temporality, including a stated aim to design in order to support flexibility to respond to changing demands in a work system [15, 16]. An human centric approach to design could be supported by some of the concepts central to resiliency [18–20], however understanding strategies to support resiliency and representations is also a challenge.

The common issue of how to conceptualise work practice strategies, task dimensions, and temporal dynamics for system design motivates the theoretical exploration of this paper through the lens of a case study on blood ordering. The starting point of which is not CWA or resiliency engineering but how researchers have explored temporality and pace in healthcare and human computer interaction and in particular concepts that may be useful to understanding work practices.

## 2 Case Study

This paper discusses some of the theoretical implications of the findings from a multi-site sociotechnical study of the introduction a new system of blood ordering into a variety of surgical suites covering different scales and types of surgery. This study provided an opportunity to investigate the context and characteristics of the work practices of the surgical suite. Analyses of critical incidents and interviews highlighted the issue of the dynamics of certain aspects of the work of blood ordering. This included volumetric dynamics and temporal dynamics – a change in pace or urgency of the blood need and pace of the task of blood ordering that was not accounted for in the design of the system under study [20].

## 3 Temporal Dynamics

### 3.1 Temporality

In more recent work, human computer interaction research has turned to questions of supporting complex and unfolding work practices over time [21]. In particular, the concept of temporality has been explored in studies of information and information transfer between members of healthcare teams, and work organization and mobility have informed new thinking [22, 23]. The conceptual diagram (Fig. 1) illustrates the potential interplay of pace and the concept of temporal dynamics.

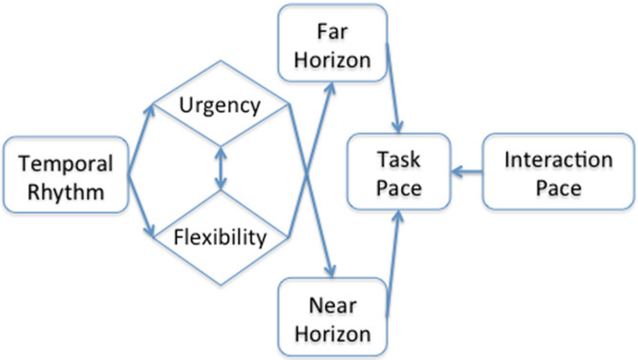


**Fig. 1.** Conceptual diagram of temporal aspects of medical work with the addition pace concept (adapted from Reddy et al. [23, 24].)

Where temporal trajectories describe the change over time of a situation or its unfolding over time, temporal rhythms describe recurring patterns, for instance the recurring pattern of checking a patient's pulse or ordering blood, and temporal horizons describe a foreseeable segment of activity and its timespan.

Flexibility and urgency determine the temporal horizon chosen (see Fig. 1). If there is greater flexibility and little urgency for a task a distant time horizon could be chosen by an individual. For instance filing a patient report could be postponed to the end of a shift. Equally, a near time horizon could be chosen if filing the report could make way for other tasks that are less flexible. Seen through this lens, the task of the HCI researcher/designer is to enable the work practices of managing and constructing time horizons, temporal rhythms, and temporal trajectories.

### 3.2 Information Theoretic Approach

Pace usually refers to the rate of speed at which an activity proceeds, whether it be walking through a museum or completing a surgery. The pace of an activity might be determined by a number of factors including the goal or motivation for the activity, spatial characteristics of the activity, and the circumstances of the individuals or team involved (are they busy or not). Many researchers in HCI have explored and exploited the notion of pace to move the design of interactive systems forward but mainly in the context of its more obvious meaning e.g. the pace of walking through a tourist experience, the pace of a game, or the pace of a museum experience [25–27].

Alan Dix introduced the concept of pace to interaction research in 1998 [28]. Using an experimental conferencing system to conduct much of the research, the analysis focused on the pace of communication between individuals working on a team and the pace of the tasks they were trying to achieve. Analysis of the conversations between individuals highlighted the issues that can arise when pace of communication and pace of task do not match. Drawing on concepts from information theory, the analysis described pace using the concepts of communication channels, bandwidth, reception,

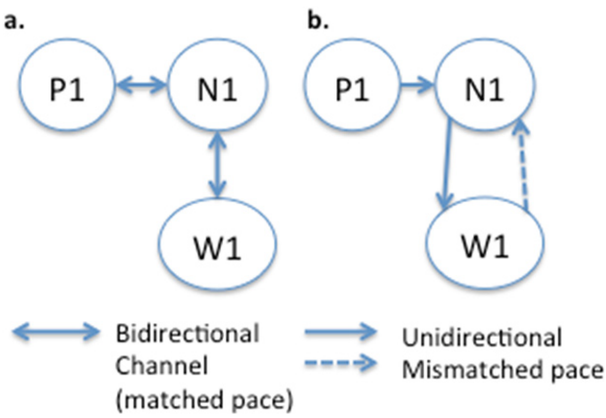


**Fig. 2.** Information theoretic conceptual diagram of open loop interaction (a) and closed loop interaction (b), to illustrate pace (adapted from Dix [28]).

control loops, and process control. Drawing on primarily on the work of Dix [28] the following example explores the concept of pace using the case of blood ordering (Fig. 2).

If a physician in an OR requests a blood order during surgery, a nurse usually receives the order verbally (P1 to N1), the verbal communication channel allows bidirectional communication between the nurse and the physician and so clarifications can be made. The nurse must complete the blood order by interacting with the work artifacts available to him/her (W1), feedback on the task to the physician can happen most efficiently if the pace of interaction with the work artifact matches the pace of the physician's task of getting the blood transfused in time (Fig. 2a closed loop control system). Often the interaction channel with the work artifact (W1) will not have the same pace as the communication between the physician (P1) and the nurse (N1). In this case an open loop control system is experienced (Fig. 2b open loop control system). The successful execution of the task under open loop control system conditions can only be accomplished if the task is predictable i.e. the physician must have confidence that ordering blood takes approximately 8 min and that this can be relied upon. Some characteristics will be revealed as inflexible to the influence of the work artefacts i.e. the circumstances of the patient that lead to a need for transfusion, the temperature at which red blood cells must be stored, and quantity of red blood cells needed. If there is a lack of predictability or the work artifacts do not have the same pace as the task, then a mismatch may be inevitable at some point in the interaction and a break down may occur. When there is a mismatch, some form of adaptation is likely.

### 3.3 Emergence of Workarounds

For the purpose of this paper it is the predictions about coping strategies, which emerge as a result of a mismatch in pace between task and interaction represented in Fig. 1, which will be applied to an exploration of blood ordering. In an ideal situation the task pace matches the interaction pace. Dix [28] identifies several different possible strategies noting that if a channel of interaction is too slow to meet the needs of the task then people will adapt by reducing the total interaction with the inadequate channel. This could be by *delegation, laziness/eagerness, or multiplexing*.

As Dix predicted "cooperation can only succeed if the pace of interaction is sufficient for the task" [cf. 28]. Indeed, the work practices that emerge out of a period of adaptation are a series of workarounds to accommodate the challenging issue of task pace not matching interaction pace. Faced with this mismatch OR teams adapted using the strategies predicted by Dix, namely by:

- Delegating
- Eagerness
- Multiplexing

Dix even notes in conclusion on the subject of time-critical tasks that "such tasks are often of a safety critical nature and it is obviously important to know whether peoples coping strategies will be sufficient for emergency situations". Details of these examples can be found in previous work [20]. For the reader two additional examples are described here to support the discussion.

(1) Strategy 1: One adaptation involved skipping safety steps in the labeling and checking of blood units to achieve shorter temporal horizons. This *eagerness* suggests that staff in the OR have developed a strategy of interacting with the new fridge that allows them flexibility. The 'no scan' is used most often in a situation where the dimensions of their task are at an extreme (high number blood units needed, shortest time available, extreme trauma case).

Note that Dix's concept of Laziness [cf. 28] did not apply in the case of blood ordering since the pace of the task of retrieving blood was never slower than pace of interaction available.

(2) Strategy 2: Gradual realization that a better match could be made between the pace of task and the pace of the interaction channel through *delegation* to support staff, who work primarily outside of the OR rooms, was reflected in the software logs. These revealed that support roles encountered fewer interaction errors with the ERBI system than other roles ($X^2$ (9, N = 3210) = 51.2, p = <.001). So their interactions had a more predictable time horizon.

# 4 Discussion

## 4.1 Dynamics and Temporality

This exploration focused on the work practices of operating room staff as they develop strategies for incorporating interaction with a new technology into their work practice. From this we will discuss the implications of an understanding of pace in particular, for designing interactive systems.

An analysis that gives prominence to *pace* shifts the conversation from one about information and knowledge provision to one about the dynamics of work practices and tasks. This is particularly useful for HCI endeavors that seek not to support a task with information and knowledge to enhance knowledge based decision making but to replace a task with an interactive system to support primarily actions. As Dix [cf. 9] points out "…work has some associated pace and we should expect that this pace and the pace of interaction are well matched."

Using the notion of pace to articulate dimensions of work practice adaptation that have implications for design, an information theoretic approach [28] can be extended to include contemporary concepts of temporality and temporal horizons [22, 23].

The temporal horizon for the OR nurse retrieving a unit of red blood cells for a patient, would be different from a porter's temporal horizon for the same activity. Using the concept of the temporal horizon may help in understanding the dynamic nature of the task itself, and the circumstances of the individual healthcare worker. The idea of pace is key here. The pace of activity necessarily quickens when a close temporal horizon is called for, whereas, a distant temporal horizon may accommodate a slower pace or result in postponement of activity.

Dimensions and strategies of work practice that emerge from this exploration to consider that could be used to inform design based on this exploration of dynamics and temporality include: *delegation, laziness/eagerness, or multiplexing* in response to high to low volumes in tasks, compressed to extended time frames, routine to exceptional cases, novice to expert staff mix, or staff mix in general, and the artefacts available. Early phases of understanding the context and requirements gathering for design could be informed by a strategy that includes deliberate attention to these dimensions and strategies.

## 5 Conclusion

This exploration of the dynamics of pace and temporality in medical work was supported by examining both concepts of temporality and concepts of pace. The case study of blood ordering and the emergence of workarounds, in response to a new artefact that required adaptations in work practices, revealed examples of work practice dynamics that indicate a number of dimensions that are relevant in representing dynamics of healthcare settings in order to guide design. These dimensions offer a possible framework to guide contextual inquiry at the beginning of system design to better serve a human centric approach.

## References

1. Wager, K.A., Lee, F.W., White, A.W.: Life after a disastrous electronic medical record implementation: one clinic's experience. Ann. Cases Inf. Technol. Appl. Manag. Organ. **3**, 153–168 (2001)
2. Freudenheim, M.: Many hospitals resist computerized patient care. The New York Times, C6 (2004)

3. Connolly, C.: Cedars-Sinai doctors cling to pen and paper. The Washington Post, 21 (2005)
4. Karsh, B.T.: Beyond usability: designing effective technology implementation systems to promote patient safety. Qual. Saf. Health Care **13**(5), 388–394 (2004)
5. Karsh, B.T., Brown, R.: Macroergonomics and patient safety: the impact of levels on theory, measurement, analysis and intervention in patient safety research. Appl. Ergon. **41**(5), 674–681 (2010)
6. Pagliari, C.: Design and evaluation in eHealth: challenges and implications for an interdisciplinary field. J. Med. Internet Res. **9**(2), e15 (2007)
7. Laxmisan, A., Hakimzada, F., Sayan, O.R., Green, R.A., Zhang, J., Patel, V.L.: The multitasking clinician: decision-making and cognitive demand during and after team handoffs in emergency care. Int. J. Med. Inform. **76**(11), 801–811 (2007)
8. Patel, V.L., Zhang, J., Yoskowitz, N.A., Green, R., Sayan, O.R.: Translational cognition for decision support in critical care environments: a review. J. Biomed. Inform. **41**(3), 413–431 (2008)
9. Horsky, J., Kaufman, D.R., Oppenheim, M.I., Patel, V.L.: A framework for analyzing the cognitive complexity of computer-assisted clinical ordering. J. Biomed. Inform. **36**(1), 4–22 (2003)
10. Nemeth, C.P., Kowalsky, J., Brandwijk, M., Kahana, M., Klock, P.A., Cook, R.I.: Before I forget: how clinicians cope with uncertainty through ICU sign-outs. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 50, no. 10, pp. 939–943. SAGE Publications, Chicago, October 2006
11. Nemeth, C., Wears, R.L., Patel, S., Rosen, G., Cook, R.: Resilience is not control: healthcare, crisis management, and ICT. Cogn. Technol. Work **13**(3), 189–202 (2011)
12. Vicente, K.J., Rasmussen, J.: Ecological interface design: theoretical foundations. IEEE Trans. Syst. Man Cybern. **22**(4), 589–606 (1992)
13. Cornelissen, M., McClure, R., Salmon, P.M., Stanton, N.A.: Validating the strategies analysis diagram: assessing the reliability and validity of a formative method. Appl. Ergon. **45**(6), 1484–1494 (2014)
14. Ashoori, M., Burns, C.M., d'Entremont, B., Momtahan, K.: Using team cognitive work analysis to reveal healthcare team interactions in a birthing unit. Ergonomics **57**(7), 973–986 (2014)
15. Dekker, S.W.: Doctors are more dangerous than gun owners: a rejoinder to error counting. Hum. Fact. J. Hum. Fact. Ergon. Soc. **49**(2), 177–184 (2007)
16. Woods, D.D.: Behind Human Error. Ashgate Publishing Ltd., Farnham (2010)
17. Lin, L., Vicente, K.J., Doyle, D.J.: Patient safety, potential adverse drug events, and medical device design: a human factors engineering approach. J. Biomed. Inform. **34**(4), 274–284 (2001)
18. Carthey, J., De Leval, M.R., Reason, J.T.: Institutional resilience in healthcare systems. Qual. Health Care **10**(1), 29–32 (2001)
19. Beuscart-Zéphir, M.C., Pelayo, S., Bernonville, S.: Example of a human factors engineering approach to a medication administration work system: potential impact on patient safety. Int. J. Med. Inform. **79**(4), e43–e57 (2010)
20. Sellen, K., Chignel, M.: Pace and temporality in safety critical medical work: concepts for understanding adaptation behaviors. In: Workshop Proceedings, HCI Research in Healthcare: Using Theory from Evidence to Practice. Workshop. International Conference on Human Factors in Computing Systems (2014)
21. O'hara, K., Kjeldskov, J., Paay, J.: Blended interaction spaces for distributed team collaboration. ACM Trans. Comput.-Hum. Interact. **18**(1), 1–28 (2011). doi:10.1145/1959022.1959025

22. Reddy, M., Dourish, P.: A finger on the pulse: temporal rhythms and information seeking in medical work. In: Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work, New Orleans, Louisiana, USA (2002)
23. Reddy, M.C., Dourish, P., Pratt, W.: Temporality in medical work: time also matters. Comput. Supported Coop. Work **15**(1), 29–53 (2006). doi:10.1007/s10606-005-9010-z
24. Reddy, M.C., Shabot, M.M., Bradner, E.: Evaluating collaborative features of critical care systems: a methodological study of information technology in surgical intensive care units. J. Biomed. Inform. **41**(3), 479–487 (2008). doi:10.1016/j.jbi.2008.01.004
25. Cheverst, K., Davies, N., Mitchell, K., Friday, A., Efstratiou, C.: Developing a context-aware electronic tourist guide: some issues and experiences. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, The Hague, The Netherlands (2000)
26. Galani, A., Chalmers, M.: Production of pace as collaborative activity. In: CHI 2004 Extended Abstracts on Human Factors in Computing Systems, Vienna, Austria (2004)
27. Mark, G., Voida, S., Cardello, A.: "A pace not dictated by electrons": an empirical study of work without email. In: Proceedings of the 2012 ACM Annual Conference on Human Factors in Computing Systems, Austin, Texas, USA (2012)
28. Dix, A.: Pace and interaction. In: Proceedings of the Conference on People and Computers VII, York, United Kingdom (1993)