

This is the author-manuscript version of this work - accessed from <http://eprints.qut.edu.au>

Kraal, Ben J. and Popovic, Vesna (2007) Looking for Expertise in Physical Interactions. In Proceedings OZCHI 2007 - Australasian Computer-Human Interaction Conference, Adelaide, Australia.

Copyright 2007 Association for Computing Machinery

Looking for Expertise in Physical Interactions

Ben Kraal
School of Design
Queensland University of Technology
Brisbane
+61 7 3138 4263
b.kraal@qut.edu.au

Vesna Popovic
School of Design
Queensland University of Technology
Brisbane
+61 7 3138 2669
v.popovic@qut.edu.au

ABSTRACT

In this paper, we describe the methods we have used to investigate expertise in interaction with physical interfaces. This paper covers the background of the interfaces (compression bandages), describes the methods used and presents findings on the use of tacit and explicit knowledge during interaction. Due to the increase in interest in interfaces that cross between the physical and digital, this method may be of interest to researchers who are involved in similar projects.

Categories and Subject Descriptors

H1.2 User/machine systems – Human factors

H5.2 User Interfaces

H5.m Miscellaneous

General Terms

Design, Experimentation, Human Factors, Theory

Keywords

Interaction, tacit knowledge, nursing, expertise, physical interface, activity

1. INTRODUCTION

In researching activities mediated through various interfaces we have become interested in how expertise is demonstrated during use of physical interfaces.

The interfaces that are the topic of this paper are compression bandages for venous leg ulcers. Our research focuses on the dynamic interaction between the users of compression bandages (nurse and patient) with current procedures used in the treatment of leg ulcers. Overall the research aims to gain a better understanding of the clinical application of pressure bandaging to develop improved bandaging techniques, inform clinical practice guidelines and design future bandages. In order to do this we needed to understand the context of the activity which we describe briefly here.

Chronic leg ulcers cause significant pain, cost, decreased quality of life and morbidity for a considerable segment of the older population [9]. Leg ulcers occur in approximately 1-2% of the population over 60 years of age in the US, UK, Europe and Australia [13, 1, 11, 14]. Considerable research has been undertaken to determine the best treatment practices that will aid in the management and the healing of these ulcers, and practical and effective strategies and techniques for healing venous leg ulcers have been trialed to demonstrate their beneficial effects [4, 15].

The specific techniques for the application of compression bandages are well established [7] though the physical skills and tacit knowledge involved in using the techniques are not. Experts in the field [3] agree that the most important aspect of applying compression bandaging is achieving the desired correct sub-bandage pressure. Achieving the correct pressure relies on the nurse having sufficient understanding of the materials being used and the science of compression bandaging in order to apply the materials correctly. That is, the expertise and experience of the nurse are critical to the correct application of compression bandaging.

In the remainder of this paper we first describe the methods we use to conduct this research and we then present some preliminary results that show the usefulness of our approach. We close with a brief discussion of the results and their applicability to the wider area of user-centered design.

2. RESEARCH METHODOLOGY

This study was conducted to understand the interactions occurring during the application of a compression bandage on patients with a leg ulcer, and to identify various levels of interaction. In order to achieve this, we have conducted a qualitative empirical study that will provide information about users' interactions (nurse-patient) and users-physical interface interactions (nurse-bandage, patient-bandage). This information will be used in order to clarify (i) the procedures that have an impact on bandage application (ii) nurses' decision making processes and the role of physical interface within the activity.

As this research is qualitative, we apply a triangulation approach to maintain its rigor. Research methods and techniques were:

- observations of the current procedures and interactions
- talk-aloud protocols (a nurse and patient are asked to talk aloud during the bandaging procedure)
- retrospective interview

The rationale behind these methods is that they provide rich data and have been demonstrated to be useful for studying interfaces [16] and various aspects of interaction [14]. In this paper we only discuss our technique for analysing observations which did not include nurses performing talk-aloud protocol.

Observation and talk-aloud protocol were video and audio recorded simultaneously using digital video cameras. Observational and verbal data have been collected from 18 patients and their treating nurses. Only patients with venous leg ulcers were included in the study. This is qualitative research and

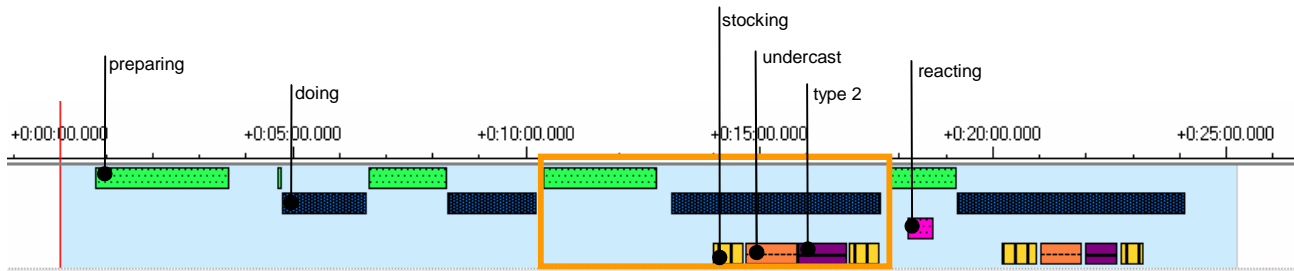


Figure 1: Time-series chart for an experienced nurse. Callouts identify meaning of codes. Box shows location of detail view (figure 2).

the number of participants is sufficient to provide the expected results.

The coding scheme (Table 1) structures our analysis of our observations. The coding scheme also allows us to compare and contrast different observations.

Table 1: Initial Coding Scheme

Group	Action
Expertise	Planning
	Doing
	Reacting
Bandaging Materials	Dressing
	Undercast
	Type 1
	Type 2
	Type 3A
	Type 3B
	Type 3C
	Type 3D
Stocking	Stocking (light compression)
	Stocking (strong compression)
Bandage Modification	Cut
	Taped
Bandaging Technique	Foot
	Ankle
	Spiral
	Figure Eight
	Putter
	Stocking
	Other

There are four sections in the coding scheme.

The first group, “Expertise”, deals with basic actions that are used in combination with actions from the other groups to derive times when a nurse has performed using tacit knowledge and times when she has performed using explicit knowledge.

The second group, “Bandaging Materials” is used to code which particular materials the nurse is using as she bandages a patient’s leg. Not every code is used in each bandaging interaction. For

example, a typical sequence of codes might be: dressing, undercast, type 2, Stocking (light compression). The different bandaging types are of increasing compression and their names are based on the British Standard described in the European Wound Management Associations position paper on Compression Therapy [6].

The third group “Bandage Modification” is used when a nurse cuts a bandage to shorten it or tapes a bandage down to fix its end.

The final group, “Bandaging Technique” contains the methods that may be used to apply compression stockings or hosiery. Depending on the bandage type and how it is used in conjunction with other bandages, different techniques are specified by the manufacturer of the bandages as achieving a particular level of overall compression. (The Bandaging Technique codes are not used in this paper.)

3. INTERPRETATION OF RESULTS

The coding scheme allows us to generate time-series charts using The Observer [16] software. Each time-series chart shows a particular nurse-patient interaction. Two charts, which are representative examples, are shown in figures 1 and 3. The interpretation of the time-series charts is discussed, below. Figures 2 and 4 are detail views of figures 1 and 3, respectively.

Figure 1 begins with a preparing code because the interaction began with the nurse washing the patient’s legs. Figure 3 begins with a “doing” code as the interaction began when the nurse removed the patient’s old bandages. Additionally, Figure 1 depicts a bandaging interaction where two legs were bandaged, while figure 3 depicts an interaction where only one leg is bandaged.

The time series charts demonstrate tacit knowledge representation by revealing how a nurse’s behavior changes when bandaging and preparing for bandaging.

Figure 1 shows the time-series chart for a nurse who used a great deal of tacit knowledge while figure 3 represents the practice of a nurse who relied in part on explicit knowledge.

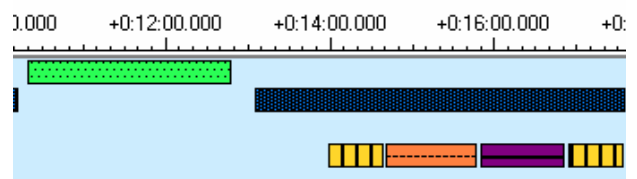


Figure 2, detail from figure 1

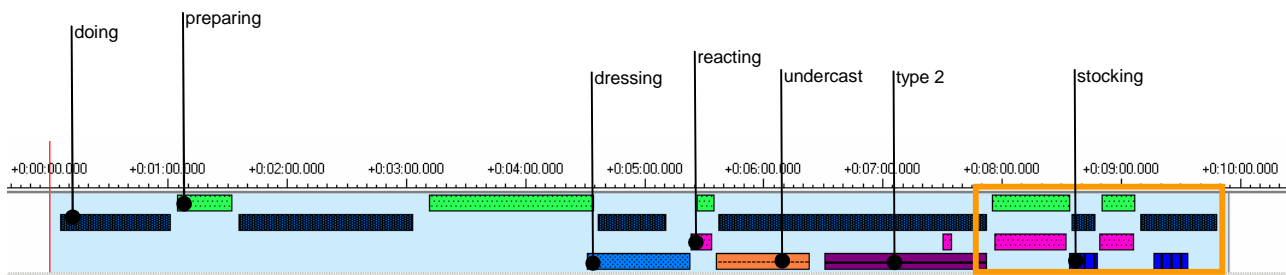


Figure 3: Time-series chart for an experienced nurse. Callouts identify meaning of codes. Box shows location of detail view (figure 4).

Interpreting the time-series charts to assess the apparent degree of tacit knowledge use is a matter of comparing when bandaging actions occurred with relation to planning, doing and reacting codes. For example, figure 2 shows a detail view of figure 1 from time 0:10:20 to 0:17:35 minutes. During this time the nurse prepared bandaging materials and then bandaged the patient's left leg. Prior to this (see figure 1) there were several iterations of planning and doing when the nurse was preparing materials for washing the patient's legs and then performing the washing actions.

Figure 1 shows how the nurse did all her preparation before bandaging and then performed all the bandaging without breaking away from bandaging actions to return to preparation of materials or for any other reason. In order to prepare all the materials necessary for bandaging, the nurse planned all of her actions before beginning the bandaging process. To do so requires the perception of the entire bandaging process – from beginning to end. This demonstrated a high level of expertise and experience in bandaging.

Figure 2 shows that from 0:10:20 to 0:12:25 minutes the nurse was preparing bandaging materials. This preparation involved locating materials from the various locations in which they are stored and preparing them for use. Bandages must be prepared for use by removing them from packaging. Stockings must be prepared for use by mounting the stocking on an applicator. The nurse assembled these materials on a trolley which was within her reach next to the patient.

Beginning at time 0:12:30 minutes and continuing to 0:17:35 minutes the nurse was "doing bandaging". From 0:12:30 to 0:14:00 minutes she was massaging moisturizing solution into the patient's leg. From 0:14:00 to 0:14:35 she applied a light compression stocking using an applicator that she had prepared earlier. She then retrieved the roll of undercast bandage from the trolley and bandaged the patient's leg until 0:15:40 minutes. The next bandage applied was a "type 2" compression bandage which occurred from 0:15:40 to 0:16:50 minutes. Finally, from 0:16:50 to 0:17:35 minutes the nurse mounted a second light compression stocking to the applicator and applied it to the patient's leg.

In contrast with figures 1 and 2, figures 3 and 4 show a nurse who relied more heavily on explicit knowledge. It can be seen in figure 3 that a similar pattern of preparation and doing to that in figure 1 occurs when the nurse is washing the patient's leg at the beginning of the interaction(s) and the differences in tacit knowledge use occur during the bandaging process.

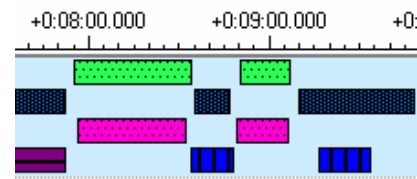


Figure 4, detail from figure 3

Figure 4 shows a detail view of figure 3 from 0:07:35 to 0:09:50 minutes. From 0:07:35 to 0:07:50 minutes the nurse is completing the type 2 bandaging process. From 0:07:55 to 0:08:35 minutes she is preparing the light compression stocking she will apply from 0:08:35 to 0:08:50 minutes. The time for preparing the stocking is coded as reacting as well as preparing because the nurse had to move from the bandaging area to a materials storage area to locate a roll of compression stocking and cut a piece to length before returning to apply the stocking at 0:08:35 minutes. At 0:08:50 minutes, having applied the stocking it is apparent that it is too short so the nurse again leaves the bandaging area and retrieves another length of stocking, this time of the correct length. She returns at 0:09:10 and at 0:09:15 minutes begins applying the stocking. The remainder of the time depicted, from 0:09:30 to 0:09:50 minutes is spent assisting the patient with her sock and helping her to stand.

4. DISCUSSION

It is known that experts rely more heavily on tacit knowledge than less experienced practitioners. The research we report shows that it is possible to observe people involved in a complex physical interaction and demonstrate their use of tacit or explicit knowledge. Therefore, it is possible to suggest that we may be able to ascertain nurses' relative expertise in bandaging by observing their practice [2]. From a nursing perspective that is a valuable contribution as it is normally only possible to assess a nurse's expertise in bandaging in a non-field setting through an assessment of the therapeutic compression level achieved on a non-injured person or a training dummy.

From a bandaging practice point of view our results, of which figures 1-4 are only a small sample, allow us to examine where in the bandaging process nurses use tacit and explicit knowledge. The techniques reported here make up a part of our wider process to understand how nurses perform bandaging. By understanding the types of knowledge used during the bandaging process we will be able to better understand the bandaging process from the point of view of the nurses who perform it. We will also be able to

suggest modifications to existing training methods if we identify locations where it is apparent that many nurses rely on explicit knowledge. Finally, having understood the bandaging process as it is currently we will be able to design new bandages that take into account what nurses know and how they currently bandage which is a user-centered approach to the design of this medical technology.

5. CONCLUSION

In this paper we have described how we have analysed some aspects of our research into a physical interface, that of compression bandaging for leg ulcers. This research is part of our wider user-centered research into compression bandages with a view to ultimately designing new therapeutic devices.

Our research also has contributions to make to the wider field of user-centered research. We feel that research about physical interaction will be of increasing relevance to technology design as digital technologies move off the desktop and into the wider world of work and play. Recent advances in technology have made the type of interfaces envisaged by Weiser [17] easier to build and deploy in research and non-research settings which has made them of interest to those outside of the pure research community [9]. At the same time research interest in how physical interfaces are used by people have increased [8]. Our research contributes to the growing corpus of user-centered studies into physical interfaces. The methods we use to analyse our data are sophisticated and explicitly rely on the inter-relatedness of users actions with interfaces over time.

Another contribution we have made to the wider field of research in physical interfaces is the coding scheme that we use to identify the use of tacit and explicit knowledge in conjunction with domain-specific codes. The knowledge-related codes (doing, preparing, and reacting) are based on established research regarding how experts approach problems and the strategies they use to solve problems [5]. Being able to show how and where users of complex interfaces rely on tacit or explicit knowledge can contribute to understanding issue of ease-of-use and expertise.

Using the coding scheme we describe, it can be shown that people who interact with an interface using mainly tacit knowledge have internalized the ways of working with the interface, that is they are demonstrating expertise. People who rely on explicit knowledge are figuring out the interface as they use it; their use is less expert. The expertise codes in the coding scheme, along with codes that describe a user's actions as they interact with a product can be used to illustrate that expertise is embedded in activity and interaction.

The power of our research approach is that our findings about the representation of tacit knowledge use are accessible. The time-series illustrated how and when specific actions were performed and allowed us to identify a nurse's knowledge utilisation.

By developing the analysis methods reported in this paper we make it easier for research in physical interaction to be performed.

6. ACKNOWLEDGMENTS

We thank our colleague Dr Fiona Coyer for her valuable help in this research. We also thank the nurses of Spiritus Care Services and their patients for participating in this research. This project is

supported by QUT Strategic Collaborative Program Grant Scheme 2004-2007.

7. REFERENCES

- [1] Baker, S. R. and M. C. Stacey. "Epidemiology of chronic leg ulcers in Australia." *Australian and New Zealand Journal of Surgery* 64, 4 (1994), 258-261.
- [2] Benner, P. *From novice to expert : excellence and power in clinical nursing practice*. Adison-Wesley. 1984
- [3] Clark, M. "Compression bandages: principles and definitions. Position Document", *Understanding Compression Therapy*. S. Calne. London, European Wound Management Association. 2003.
- [4] Cullum, N., E. A. Nelson, et al. "Compression for venous leg ulcers (Cochrane Review)". *The Cochrane Database of Systematic Reviews Issue 2, 2005*, John Wiley & Sons, Ltd., 2001
- [5] Ericsson, K.A. and Smith, J. (Eds). *Toward a General Theory of Expertise*, Cambridge University Press, Cambridge, 1991
- [6] EWMA (2003). *Understanding Compression Therapy*, Medical Education Partnership, London.
- [7] Finnie, A. (2002). "Bandages and bandaging techniques for compression therapy." *British Journal of Community Nursing* 7, 3 (2003), 134-142.
- [8] Ghazali, M., Ramduny, D., Hornecker, E., and Dix, A. *First international workshop on Physicality*. [retrieved 10 August 2007 from <http://www.physicality.org/physicality2006/Physicality2006Complete.pdf>] Lancaster University, 2006.
- [9] Greenfield, A. *Everyware : the dawning age of ubiquitous computing*. New Riders, Berkeley, California, 2006.
- [10] Hewett, T. T. and Scott, S., The Use of Thinking-Out-Loud and Protocol Analysis in Developing of a Process Model of Interactive Database Searching. In *Proceedings of INTERACT '87*, (The Netherlands, Amsterdam 1987), 51-56.
- [11] Johnson, M. The prevalence of leg ulcers in older people: Implications for community nursing. *Public Health Nursing* 12, 4 (1995), 269-275.
- [12] Jørgensen, A. H., Thinking-aloud in User Interface Design: A Method Promoting Cognitive Ergonomics, *Ergonomics*, 33, 4 (1990), 501-507
- [13] Lees, T. A. and D. Lambert (1992). Prevalence of lower limb ulceration in an urban health district. *British Journal of Surgery* 79, 10 (1992), 1032-1034.
- [14] Margolis, D. J., W. Bilker, et al. (2002). Venous leg ulcer: incidence and prevalence in the elderly. *Journal of the American Academy of Dermatology* 46 (2002), 381-386.
- [15] Nelson, E., N. Cullum, et al. (2004). "Venous leg ulcers." *Clin Evid* 12 (2004), 2774-2792.
- [16] Noldus. *The Observer*. Noldus Information Technology. [online: <http://www.noldus.com>] 2006.
- [17] Weiser, M. The computer for the 21st century. *Sci. Am.* 265, 3 (Sept. 1991), 94-104

