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Failure in Context

Linking Observed Behavior to Cognition, Tasks and Adverse Events

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Introduction: Implementation of new technologies such as infusion devices poses unique challenges in the clinical setting [1]. Practitioners have difficulty programming infusion devices [2], but the causes of their difficulty is not well understood by either practitioners or their leadership. Users program devices to accomplish specific tasks, but imbedded in this process is a deeper level of cognition, in which goals, perceptions and beliefs translate into action. Video recording is a method that enables researchers to document and analyze observable behavior. Such recordings are potentially valuable sources of information, although this requires a way to link recorded behavior to cognitive theory, task categories and real clinical events. Computerized video presentation enables investigators to organize and categorize videotaped behaviors in a way that permits probing the ways people relate to and operate devices.

Methods: Forty clinicians were videotaped performing simple tasks on an infusion device. A reviewer selected examples of programming behaviors in 15- to 60-second long video segments. The researchers sorted video segments according to programming activities such as data entry, and cognitive activities such as decision-making. They sorted reports from an incident reporting database, looking for specific examples where observed behaviors may have played a role. This organization method formed the basis of a comparison tool to show the multiple links between data and concept.

Results: The researchers assembled traits into a table with hypertext links to video clips. These serve as examples of user programming activity. Pull-down text in the table explains the use context, the particular situation, and defines terms. By clicking on specific icons, users view related case reports. The multiple displayed relationships show how problems might manifest. The table and video segments will be available via the Internet and enable clinicians to understand the nature of programming complex electronic devices in the clinical setting.

Discussion: Research techniques that evaluate cognition and task performance provide insight into how failures arise [3]. Video recording captures clinician behavior in a form that can be made available for review and analysis. Human factors knowledge related to cognition sheds light on the larger issues related to clinicians' interactions with technology. Display tools that link concepts, recorded behaviors and actual events translate the clinician programming activity data into interpretive lessons. These insights about the clinical use of complex devices allow manufacturers, practitioners, and others who are interested in patient safety to develop guidelines for better design and training.

[1] Cook RI, Woods DD. Implications of Automation Surprises in Aviation for the Future of Total Intravenous Anesthesia (TIVA). J Clin Anesthesia (1996) 8, 29S-37S

[2] Nunnally M, Nemeth C, Brunetti V, Cook RI. Lost in Menuspace: User Interactions with Complex Medical Devices. Special issue on Studies in Healthcare Technical Work. IEEE Transactions on Systems, Man and Cybernetics-Part A. (2004) 34:736-742

[3] Hollnagel E, Woods DD. Cognitive Systems Engineering: New wine in new bottles. Int J Human-Computer Studies (1999) 51, 339-356

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What Is This?

Actual clinicians who were asked to perform simple infusion pump programming tasks became confused by programming menu complexity.

The lab team used human factors analysis methods including task analysis, interviews, observation and usability assessment to analyze clinician performance. We posted results to the lab web site, along with video clips showing actual programming performance.

Showing these clips through an interactive web site makes it possible to see the relationship between clinician programming activities and human factors issues. Understanding how pump menu design impedes programming performance allows us to understand how this makes adverse events not only possible, but likely.

Task Categorization

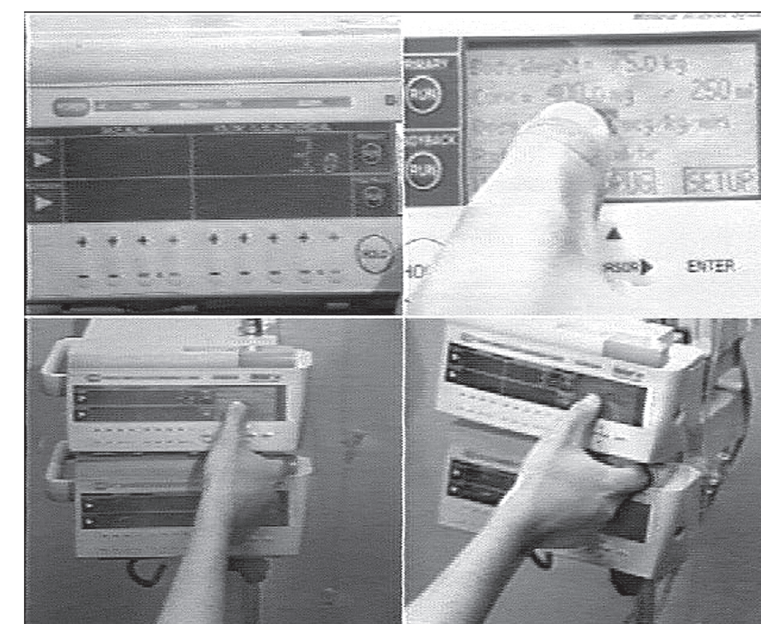
Video clips are organized according to discrete tasks

Cognitive Categorization

Video clips are analyzed according to cognitive activities

Video Link

Terms in the table open brief video examples of each programming behavior.



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Lost In Menuspace: *Video Examples*

Video *Click on the video title to see an example of difficulties clinicians have with understanding infusion devices.*	***Task****—the work being performed*					***Cognition****—the work behavior that relates to the task being performed*		
	Navigation finding correct programming route	***Data entry*** Actions necessary to commit variables programmed to the device to active working memory	***Numbers/input*** Programming numbers to the device, before they are committed to memory buffer	***Calculation*** Determination of pump rate to program to accomplish correct medication or fluid dose	***Fixation*** Repeated unproductive interaction with interface	***Perception*** Awareness and processing of sensory information.	***Memory*** The ability to retain mental impressions.	***Decision making*** Deliberation of possible alternatives and selection of one course of action .
Aborted key presses								■
Alarm surprise	■					■		
Awareness of states						■		
Cul de Sac	■					■		
Decimal error								■
Display error						■		
Dormant keystrokes	■					■		
Double-cuing				■				■
Drug library use								■
Enter/Menu confusion	■					■		
Expected cues missing	■					■		
False assertions about active defaults		■					■	
False validation		■				■		
Frustration with unknown forces							■	
Give-ups								■
Hold overuse					■			■
Inadvertent cursor movement	■					■		
Ineffective key presses	■							■
Looping	■							■
Piggyback switch						■		
Power downs	■					■		
Rapid-fire key presses					■			■
Refractory period key presses					■			■
Screen facilitated mode error			■			■		
Screen revisits	■							
Searching behavior								
Sequence repeats								
Side calculations								
Superhold								
Thumbwheel around								
Thumbwheeling								
Timeout selection								
Toggle backtrack								
Toggle overshoot								
Trying to thumbwheel								
Unaware if active default								
Unit trickery								

Definitions

Passing the cursor over any term causes a definition of the behavior to be displayed

What Does This Mean?

Cognition is a central feature of user-device interactions

Interactive tables establish links among the task, observed behavior, and cognitive activity in programming activity

Links make it possible to connect clinician programming and device features to anticipate potential adverse events.

Task and usability analysis use actual clinician performance to reveal problems that may be encountered in daily operations.

Device research, design and development must incorporate analysis of user-device interactions.

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