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Validation of a task demand measure for predicting mental workloads of physical therapists

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ABSTRACT

The purpose of this study is to validate an analytical method in assessing demanded mental workloads for physical therapists, and to discuss its possible ergonomics implications on the design of healthcare working systems in which physical therapists are considered as the users. A task analysis was first used to understand the operation steps of three identified physical therapies. Then, the McCracken–Aldrich technique was applied to assign ratings of mental workload demanded for performing each step of the therapies. Finally, the assigned ratings were validated by the analysis of correlation with the answers of the NASA-TLX questionnaire collected from seventeen physical therapists in the rehabilitation center of a university-affiliated hospital. Results showed that the proposed McCracken–Aldrich technique was suitable as an analysis tool for predicting metal workloads of physical therapists. Some possible implications about the information provision and user interface design for reducing therapists' mental workloads on current therapy operations were discussed.

Relevance to industry: Results of this paper are expected to contribute the research and development in healthcare industry on its system design and workflow analysis.

1. Introduction

With increasing aging population and low birth rate in most developed countries, healthcare industry has become an increasingly critical sector, and Taiwan is no exception. In light of this, a national health insurance program has been implemented in 1995. Now about 99% of Taiwan citizens have been covered by the program with more than 90% of hospitals and clinics under the contract (BNHI, 2013).

In this unique health insurance environment, a series of nationwide health information technology projects has been undertaken to achieve a better healthcare service. For example, the transformation from paper-based health insurance reports to digital records with the use of integrated-circuit smart cards has been completed in 2004, which aimed to better integrate with the information systems in hospitals and clinics (Liu et al., 2006). Moreover, the first version of the Taiwan electronic Medical record Template (TMT) has been developed in 2005, and has been continuously revised for compliance with the Health Level Seven Clinic Document Architecture (HL7-CDA) standard format (Rau et al., 2010).

These national projects had enforced individual hospitals and clinics to undertake their own initiatives to enhance the quality of care by introducing new machines, equipment, technologies, or methods and by utilizing these resources more effectively and efficiently. This research project has been part of the effort to seek out opportunities for improvement in the rehabilitation center of a university-affiliated hospital. The aim of this article is to adopt and validate a task demand measure for predicting the mental workloads of physical therapists in this rehabilitation center. It is anticipated that the task demand measure will be useful as an analysis tool in current and future designs for more effective and efficient healthcare working systems.

2. Related research

The implementation of healthcare information systems has been shown to improve the quality and utilization of medical care in general (Chaudhry et al., 2006). However, it also has led to negative consequences which might jeopardize the potential benefits. For example, physical therapists experienced loss of control, stress, discontent, and disheartenment as they faced the changes of their work environment due partly to the implementation of healthcare information systems (Blau et al., 2002). Physicians had

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to spend more time in writing orders by using a new physician order entry system compared to the time with the original paper-based method (Overhage et al., 2001).

One main reason for these undesired outcomes is that most of healthcare information systems are originally designed for finance or management purposes rather than for the support of practice at the point of care (Staggers and Troseth, 2011). It is therefore recommended that the discipline of human factors and ergonomics should be applied in system designing phases (Carayon and Friesdorf, 2006; Hedge et al., 2011; Lawler et al., 2011; Staggers and Troseth, 2011).

Healthcare is a complex sociotechnical system which involves the interactions among person, technology, organization, tasks, and environment (Carayon, 2006; Carayon and Friesdorf, 2006). From human factors and ergonomics perspective, the primary elements in the healthcare working systems are patients, staffs, and machines (Carayon and Friesdorf, 2006). Since staffs are often the users of healthcare information systems, it is important to take their needs into account in every phase of the development and implementation (Carayon and Friesdorf, 2006; Carayon and Karsh, 2000; Staggers and Troseth, 2011). Otherwise, a lack of staff support may be as a result and lead to unwillingness in adopting the changes or even abandon the implemented information systems (Kaye et al., 2010).

Previous studies have noted that the levels of job demands for physical therapists were moderate to high and might lead to job strain, stress, and burnout (Broom and Williams, 1996; Campo et al., 2009; Deckard and Present, 1989; Lindsay et al., 2008; Park et al., 2003; Schuster et al., 1984). Excessive workloads have been identified as one of major stressors for physical therapists (Campo et al., 2009; Lindsay et al., 2008), and medication errors and staff burnout due to excessive mental workloads have been reported among nurses (Holden et al., 2011) and pharmacists (Holden et al., 2010). Therefore, the design and implementation of healthcare information systems for physical therapists should not increase but try to reduce their mental workloads. To achieve this goal, a workflow analysis has been recommended (Fenety and Kumar, 1992; Vreeman et al., 2006), and a measure for mental workloads of physical therapists is necessary.

Mental workload is defined as the demanded resources of human information processing for performing a task (Tsang and Vidulich, 2006). It may be influenced by task difficulty, human skill level, and technology support (Megaw, 2005). The nature of mental workload has been explained in theories of single channel and multiple attention resources. The single channel theory merely suggests the positive relationship between task demands and mental workloads (Welford, 1967). The multiple attention resources model further divides resources into four dichotomous dimensions: modality (visual and auditory), code (spatial and verbal), stage (perceptual-cognitive and responding), and visual processing (focal and ambient). It is suggested that if a task shares demands for different levels on the four resource dimensions, the concurrent performance of multitasking will be better than the one with demands for common levels (Wickens, 2002).

The assessment of mental workload can be categorized as empirical and analytical methods. Common empirical measures are task performances, physiological parameters, and subjective ratings (Tsang and Vidulich, 2006), whereas analytical methods often involve task analysis, mathematical models, or computer simulation (Linton et al., 1989).

Since the assessment of mental workloads by applying empirical measures is usually conducted in the late stage of system development, and it takes time to collect data from participants, an analytical method is a superior approach which can be carried out in the early stage of the design and is time-efficient. Hence, an analytical method, the McCracken–Aldrich technique (McCracken and Aldrich, 1984), was chosen as a possible analysis tool for assessing task demands of physical therapies.

McCracken and Aldrich (1984) established rating scales for mental workloads based on the data collected from helicopter pilots. The McCracken–Aldrich technique defines mental workloads in terms of the four independent dimensions of visual, auditory, cognitive, and psychomotor. Relative ratings, as shown in Table 1, ranging from 0 (lowest) to 7 (highest) were assigned to different levels of demand in each dimension. The total score of mental workload for a task is the sum of the rates assigned to the four dimensions, so the total score ranges from 0 to 28.

The McCracken–Aldrich technique has been the foundation in other analytical methods, such as the Micro System Analysis of Integrated Networks of Tasks (Micro-SAINT) model (Keller, 2002),

Table 1
Rating scales of the McCracken–Aldrich technique (Aldrich et al., 1989).

Dimension	Rate	Description
Visual	0.0	No visual activity
	1.0	Visually register/detect (detect occurrence of image)
	3.7	Visually discriminate (detect visual differences)
	4.0	Visually inspect/check (discrete inspection/static condition)
	5.0	Visually locate/align (selective orientation)
	5.4	Visually track/follow (maintain orientation)
	5.9	Visually read (symbol)
	7.0	Visually scan/search/monitor (continuous/serial inspection, multiple conditions
Auditory	0.0	No auditory activity
	1.0	Detect/register sound (detect occurrence of sound)
	2.0	Orient to sound (general orientation/attention)
	4.2	Orient to sound (selective orientation/attention)
	4.3	Verify auditory feedback (detect occurrence of anticipated sound)
	4.9	Interpret semantic content (speech)
	6.6	Discriminate sound characteristics (detect auditory differences)
	7.0	Interpret sound patterns (pulse rates, etc.)
Cognitive	0.0	No cognitive activity
	1.0	Automatic (simple association)
	1.2	Alternative selection
	3.7	Sign/signal recognition
	4.6	Evaluation/Judgment (consider single aspect)
	5.3	Encoding/Decoding, recall
	6.8	Evaluation/Judgment (consider several aspects)
	7.0	Estimation, calculation, conversion
Psychomotor	0.0	No psychomotor activity
	1.0	Speech
	2.2	Discrete actuation (button, toggle, trigger)
	2.6	Continuous adjustment (flight control, sensor control)
	4.6	Manipulation
	5.8	Discrete adjustment (rotary, vertical thumbwheel, lever position)
	6.5	Symbolic production (writing)
	7.0	Serial discrete manipulation (keyboard entries)