Applied Nursing Research 40 (2018) 99–105

Contents lists available at ScienceDirect

Applied Nursing Research

journal homepage: www.elsevier.com/locate/apnr

Original article

A preliminary psychometric evaluation of the eight-item cognitive load scale

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ARTICLE INFO

Keywords:
Cognitive load
Decision support
Working memory
Psychometric analysis
Healthcare technology

ABSTRACT

Aim: The aim of this article is to report the psychometric properties of the eight-item cognitive load scale.
Background: According to cognitive load theory, the formatting and delivery of healthcare education influences the degree to which patients and/or family members can engage their working memory systems for learning. However, despite its relevance, cognitive load has not yet been evaluated among surrogate decision makers exposed to electronic decision support for healthcare decisions. To date, no psychometric analyses of instruments evaluating cognitive load have been reported within healthcare settings.
Methods: A convenience sample of 62 surrogate decision makers for critically ill patients were exposed to one of two healthcare decision support interventions were recruited from four intensive care units at a tertiary medical center in Northeast Ohio. Participants were administered a battery of psychosocial instruments and the eight-item cognitive load scale (CLS).
Results: The CLS demonstrated a bidimensional factor structure with acceptable discriminant validity and internal consistency reliability (Cronbach's α = 0.75 and 0.89).
Conclusions: The CLS is a psychometrically sound instrument that may be used in the evaluation of decision support among surrogate decision makers of the critically ill. The authors recommend application of the cognitive load scale in the evaluation and development of healthcare education and interventions.

1. Introduction

As the aging population grows in the United States, the projected incidence of chronic critical illness is expected to double by the year 2020, largely affecting older adults and the families who care for them (Zilberberg, de Wit, Pirone, & Shorr, 2008). Characterized by multisystem organ dysfunction and cognitive impairment, the chronically critically ill (CCI) often require extended stays in an intensive care unit (ICU) and have higher mortality rates when compared to the general population of the critically ill. Because of the severity of illness and rates of cognitive impairment of CCI patients, their family members must often serve as surrogate decision makers (SDMs) and make complex treatment and/or end-of-life decisions on behalf of these patients. The participation of SDMs in the decision-making process for a CCI patient can present profound states of cognitive and emotional burden among SDMs who are often unprepared to serve in such a role (Pignatiello, Hickman, & Hetland, 2016). Specifically, there is a dearth of psychometrically sound instruments that capture the influential cognitive components of decision making among SDMs of ICU patients.

Working memory is an essential cognitive function for learning and making judgments that is underappreciated in the evaluation of behavioral research. Working memory involves the cognitive processes of processing, storing, and manipulating information. First described by Sweller (1988), the degree to which working memory is influenced during the learning process is contingent upon the *instructional design* used to convey the learned material. The influence of instructional design on working memory is now known as *cognitive load*. There are currently two recognized types of cognitive load: *intrinsic* and *extraneous*. *Intrinsic cognitive load* (ICL) represents the difficulty of the subject matter at hand and depends on the prior knowledge of the learner (Leppink, Gog, Paas, & Sweller, 2015). *Extraneous cognitive load* (ECL) represents the load imposed on working memory through instructional design methods that are not necessary for learning (e.g., presentation of redundant information). If an individual experiences an undesirable level of ICL or ECL during the learning process, a detriment to the learning process may occur. Within health care, such learning

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https://doi.org/10.1016/j.apnr.2018.01.006
Received 13 October 2017; Received in revised form 5 January 2018; Accepted 19 January 2018
0897-1897/

detriments may translate to undesirable health behaviors and/or impaired decision making.

Leppink and van den Heuvel (2015) proposed a psychometrically sound, self-report instrument that measures cognitive load. This eight-item instrument possesses two dimensions, with items one through four measuring intrinsic cognitive load, and items five through eight measuring extraneous cognitive load. To our knowledge, the Cognitive Load Scale (CLS) has not been directly applied to behavioral interventions within health care, and has not been used to evaluate the cognitive load imposed upon SDMs of CCI patients who are exposed to decision support. In its limited application, the CLS has been used within classroom settings to evaluate the effectiveness of educational materials and teaching styles. The evaluation of cognitive load imposed by decision support interventions is crucial in that it is hypothesized that individuals who experience undesirable states of cognitive load will demonstrate ineffective learning, potentially weakening the efficacy of the decision support intervention (Chandler & Sweller, 1991).

2. Purpose

Therefore, this psychometric study examines reliability and validity of the Cognitive Load Scale in a sample of surrogate decision makers who are exposed to one of two electronic decision support interventions.

3. Background and conceptual framework

Cognitive load, defined as a "multidimensional construct representing the load that performing a particular task imposes on the learner's cognitive system" (Paas, Tuovinen, Tabbers, Van Gerven, & Van Gerven, 2003, p. 64), was first described by Sweller (1988), who recognized that particular learning strategies consume a disproportionate amount of cognitive resources, hindering the learning process. Cognitive load theory attributes this process to humans' limited working memory capacity (Paas et al., 2003). Cognitive Load Theory recognizes potential sources of ICL and ECL. Since ICL represents the cognitive load imposed by the difficulty of the learned subject matter, ICL is dependent on the knowledge of the learner. Moreover, ICL reflects the *element interactivity* of the material being presented. Element interactivity also depends on the prior knowledge of the learner, but also reflects the ontological organization of the subject matter and the relationships of the interacting elements. Low element interactivity, resulting in low ICL, reflects simple elements to the learned material that can be learned in isolation. Conversely, element interactivity is increased when learned materials are presented in a way such that they can only be understood when in relation to other elements. Sources of ECL stem from the learner being exposed to information that is not necessary for learning. De Jong (2010) discusses several potential sources of ECL.

3.1. Measuring cognitive load

Initially, cognitive load was evaluated indirectly by observing problem-solving strategies, learning time, and error rates (Ayres, 2001; Ayres & Sweller, 1990; Sweller, Chandler, Tierney, & Cooper, 1990). Furthermore, subjective measurements of mental effort, mental workload, and learning efficiency were used as proxy measures of the cognitive load experience (Gerjets, Scheiter, & Catrambone, 2006; Hart & Staveland, 1988; Kester, Lehnen, Van Gerven, & Kirschner, 2006; Van Gog & Paas, 2008). However, due to questioning of validity and conceptual ambiguity, these measurement techniques fell out of favor to distinct measures of cognitive load. The first measures of cognitive load were commonly single-item instruments evaluating one or more types of cognitive load (Ayres, 2006; DeLeeuw & Mayer, 2008). Eventually, a 10-item, psychometrically sound instrument was developed by Leppink, Paas, Van der Vleuten, Van Gog, and Van Merriënboer (2013). This instrument was tested, refined, and re-introduced by Leppink and van den Heuvel (2015).

The refined Cognitive Load Scale (CLS) introduced by Leppink and van den Heuvel (2015) is eight items and possesses 2 four-item subscales measuring ICL and ECL, respectively. It is administered after the completion of a learning activity, as all the questions on the CLS relate to the perceived learning experience of the learner. Individuals rate the extent they agree with each question on a scale from 0 (not at all the case) to 10 (completely the case). A total score is not calculated; instead, subscale scores are calculated by summing the individual responses from each subscale item, with higher scores indicating a greater degree of cognitive load. Psychometric evaluation of the refined eight-item CLS has not been reported; thus, this will be the first known study to report the psychometric properties of the Leppink and van den Heuvel (2015) CLS. However, the initial version of the 10-item CLS demonstrates adequate goodness of fit indices ($\chi^2 = 36.89$, $p = 0.25$; RMSEA = 0.04) and internal consistency reliability (Cronbach's $\alpha > 0.80$) (Hadie & Yusoff, 2016; Leppink et al., 2013). Moreover, another cognitive load scale developed by Sewell, Boscardin, Young, ten Cate, and O'Sullivan (2016) demonstrated acceptable psychometric properties.

4. Methods

4.1. Design

This psychometric evaluation used data generated from a randomized, controlled trial of SDMs of decisionally impaired CCI patients who were receiving two types of decision support. One decision support intervention, Information Support (IS), produced a passive experience, consisting of videos related to communicating with healthcare providers. The alternative intervention, Interactive Virtual Decision Support for End of Life and Palliative Care (INVOLVE), produced an avatar-based, experiential-based learning experience which taught a communication strategy to the user and provided an opportunity for the user to practice the communication strategy in a simulated experience one might encounter within the ICU. Upon completion of informed consent, participants were allocated to a study group (control, IS, or INVOLVE) through a minimization allocation procedure (Scott, McPherson, Ramsay, & Campbell, 2002). To ensure balance among the three study conditions, participants were allocated to a study condition according to three factors: sex (male/female), relationship to patient (spouse, non-spouse), and race (White, non-White). Participants were administered a battery of psychosocial instruments, which included the Decision Fatigue Scale, the Emotion Regulation Questionnaire, the Family Decision Making Self-Efficacy Scale, the Preparation for Decision Making Scale, and the National Institutes of Health (NIH) Toolbox Flanker Inhibitory Control and Attention Test (Flanker).

4.2. Sample

A convenience sample of 62 SDMs were recruited from four different ICUs (cardiac, medical, neuroscience, and surgical) at an academic medical center in Northeast Ohio. All participants were: (1) aged 18 or older, (2) able to understand English, (3) recognized by the ICU team as the next of kin or legal representative for healthcare decision making for a decisionally impaired patient requiring at least three consecutive days of acute mechanical ventilation. Surrogate decision makers were excluded if: (1) the critically ill patient was not expected to be in the ICU for two days past study enrollment or (2) the surrogate decision maker could not hear audio using a standard set of headphones and/or unable to view the decision support material on a 10-inch computer screen.