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# Medication-related cognitive artifacts used by older adults with heart failure

Robin S. Mickelson[a,b], Matt Willis[c], Richard J. Holden[d,*]

[a]Vanderbilt School of Nursing, Vanderbilt University, Nashville, TN, USA
[b]The Center for Research and Innovation in Systems Safety (CRISS), Vanderbilt University Medical Center, Nashville, TN, USA
[c]School of Information Studies, Syracuse University, Syracuse, NY, USA
[d]Department of BioHealth Informatics, Indiana University School of Informatics and Computing, Walker Plaza-WK319, 719 Indiana Avenue, Indianapolis, IN 46202, USA

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**Abstract**
*Objective:* To use a human factors perspective to examine how older adult patients with heart failure use cognitive artifacts for medication management.
*Methods:* We performed a secondary analysis of data collected from 30 patients and 14 informal caregivers enrolled in a larger study of heart failure self-care. Data included photographs, observation notes, interviews, video recordings, medical record data, and surveys. These data were analyzed using iterative content analysis.
*Results:* Findings revealed that medication management was complex, inseparable from other patient activities, distributed across people, time, and place, and complicated by knowledge gaps. We identified 15 types of cognitive artifacts including medical devices, pillboxes, medication lists, and electronic personal health records used for: 1) measurement/evaluation; 2) tracking/communication; 3) organization/administration; and 4) information/sensemaking. These artifacts were characterized by fit and misfit with the patient's sociotechnical system and demonstrated both advantages and disadvantages. We found that patients often modified or "finished the design" of existing artifacts and relied on "assemblages" of artifacts, routines, and actors to accomplish their self-care goals.
*Conclusions:* Cognitive artifacts are useful but sometimes poorly designed or not used optimally. If appropriately designed for usability and acceptance, paper-based and computer-based information technologies can improve medication management for individuals living with chronic illness. These technologies can be designed for use by patients, caregivers, and clinicians; should support collaboration and communication between these individuals; can be

*Corresponding author. Tel.: +1 317 278 5323.
*E-mail address:* rjholden@iupui.edu (R.J. Holden).

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coupled with home-based and wearable sensor technology; and must fit their users' needs, limitations, abilities, tasks, routines, and contexts of use.


## Introduction

The scientific and practice-based discipline human factors engineering uses data, theory, design principles, and various methods to optimize interactions between people and other elements of a system to improve human performance and well-being [1,2]. Central to the human factors profession is a "systems" orientation, which states that human performance occurs within the context of a sociotechnical system [3]. Cognitive artifacts, tools and technologies that aid the mind in the performance of cognitive work, are an essential part of sociotechnical systems [4,5] as are people, tasks, the organization, and the internal and external environments [6]. These elements all interact, are interdependent, and act together [7]. Emphasis on interactions in context, as opposed to isolated system elements, distinguishes human factors from other disciplines and professions [8,9]. A human factors analysis of cognitive artifacts—our present aim—examines both the artifacts themselves and how they interact with different people, tasks, other artifacts, and organizational and environmental factors. To put it another way, a human factors analysis looks at how cognitive artifacts fit in their surrounding sociotechnical system [10,11] to inform system (re)design that optimizes performance and well-being [12,13].

### Human factors and patient work performance

Applying human factors methods and theories to health and healthcare dates back to the 1960s. It accelerated at the turn of the century due in part to the call by the Institute of Medicine for a human factors approach to achieving patient safety [13]. Healthcare professionals (i.e., clinicians) and their work have been the aim of the vast majority of applications of human factors in healthcare. Some have noted additional opportunity to apply human factors to understand and improve patient work [6,14]. Patient work is effortful, goal-driven, health-related activity performed by patients, families, and other nonprofessionals [15]. The need to study and improve patient work stems from several converging factors:

a. A realization that most care takes place in homes and communities, not in formal healthcare delivery settings [16];
b. The rising volume and expense of clinical care and interventions, combined with concerns about a clinical workforce that will not match future demands [17];
c. Perceptions of the financial value that patients and families can provide through self-care and preventive health behaviors [18];
d. Increased expectations for patients and families to engage in health-related tasks such as information seeking and self-care [19]; and
e. Newly available personal and clinical technologies that make it possible for people to manage health outside of formal clinical settings (e.g., home dialysis, mobile devices, tele-medicine, online medical knowledge bases) [20].

### Cognitive artifacts for patient work

We conceptualize cognitive artifacts as digital or non-digital artificial devices that maintain, display, or operate upon information through representations and that shape human cognitive performance [21]. Norman [5] describes cognitive artifacts bridging two gaps that jeopardize task performance. Artifacts bridging the gap of execution (action) provide alternative ways to act upon the real world (e.g., controls); representational artifacts bridging the gap of evaluation (interpreting effects) represent the real world (e.g., displays) [22]. Cognitive artifacts extend human performance by externalizing or offloading information processing to the environment [23]. They can also change the nature of the task itself [22]. Artifacts improve performance to the extent that they: a) address the important and leave out irrelevant information; b) fit the task, goals, and skills of their users; c) represent the properties or attributes of the represented entity; and d) use perceptual-spatial properties analogous to the real world [22].

Hutchins [24] argues cognitive artifacts cannot be separated from the human operator, task, or the environment and have no inherent separate value. The emergent coordination and functioning of those elements together determine performance [25]. Thus, cognitive artifacts are best studied in a relational context, rather than by the analysis of individual attributes alone [26].

### Study of cognitive artifacts used by older adults for heart failure related medication management

This study used a human factors lens to examine the cognitive artifacts of older adults with heart failure. Specifically, we identified cognitive artifacts in use, who used them, and how they facilitated or impeded successful medication management. In taking a human factors approach, we were attentive to how older adults' artifacts fit within the broader sociotechnical system.

Medication management for patients with heart failure is an important daily, lifelong process. However, reported heart failure medication adherence rates are 40–60% [27,28]. Medication non-adherence can be intentional non-use of medications or unintentional errors such as lapses in medication taking, adding doses, or mixing up pills. Therefore, cognitive artifacts and other strategies that support memory and performance, mitigate errors, or help people recover from errors, could address medication non-adherence [29].