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Guest Editorial

Modeling the mind: How do we design effective decision-support?

1. Introduction

The articles in this collection converge to address the overarching challenge of leveraging the Electronic Health Record (EHR) to improve cognitive support for clinicians. They push the boundaries of what we currently think of as decision support by expanding the usual focus on the individual decision-maker to include the wider technical and social system. Although others have emphasized multi-component implementation models, the need for a seamless path that integrates design with implementation still exists [1–5]. The result is a new integrated vision of how Information Technology (IT) that can further influence the cognitive aspects of health-care delivery.

The need for a new vision is increasingly apparent as reports of discontent with EHRs continue to emerge. General reports of dissatisfaction are ubiquitous [6–11]. Reports suggest that EHRs are contributing to physician burn-out [12], that documentation alone adds almost an hour onto the day, which comes out of free time [13], that electronic documentation is frustrating and inadequate [9], that clinicians suffer from loss of overview and display fragmentation, and that many displays are simply confusing [14,15]. Concern about risk to patient safety adds to the frustration [16–20]. Implementation of Computerized Provider Order Entry has been related to increased mortality [21] and more communication errors [22,23]. An approach that integrates design with workflow, implementation, and organizational change is essential for effective decision-support.

Standard approaches to providing decision support, such as alerts, education and performance feedback, are having mixed impact. Alert fatigue (high rates of alert overrides) is now a pressing and prevalent problem [24–26]. Doctors appear to override computerized alerts between 49% and 96% of the time [27,28], even when the alerts are clinically important [29]. The effect increases substantially with continued exposure over time suggesting that clinicians are habituating to the stimulus [30,31] and may not be influenced by reductions in the prevalence of alerts alone [32]. Recent calls to improve computerized decision support for diagnostic reasoning have also gained increased support [33]. Although implementation science has had success with multi-component interventions, work process modeling, and quality improvement change processes, these successes have not been integrated with design. In summary, there is widespread concern with current EHR designs. As the American Medical Association (AMA) recently noted: "Health IT is misaligned with the cognitive and workflow requirements of medicine." [34–36]

2. Theory-inspired design

Translating evidence from basic cognitive science to the applied problem of EHR design is one way to address the problem. Dual process theories have emerged from the basic psychological sciences experimental research and provide an overarching framework of evidence-based principles for understanding cognition in context [37,38]. This group of theories propose two memory or "thinking" systems/processes: (1) a network of well-learned associations that function by spreading activation across well-established networks that support rapid pattern-matching (System 1); and (2) a slow, rule-based, conscious system that functions through active reasoning (System 2) [39–45]. This framework explains how the same variables have different effects on behavior as a function of variation in social contexts, time pressure, emotion, and/or cognitive load. System 1 is usually automatically activated by environmental cues and that is why understanding of workflows is so important to implementation. When the situation is incongruent, urgent, interesting, and/or important, System 2 monitoring will engage to support deeper processing and conscious reasoning, suggesting the need for learning and effective change processes.

Both systems are generally always active. However, System 2 discrimination requires sufficient available cognitive resources. When we are busy, overloaded, or simply not interested, we prefer to function from a System 1 or intuition perspective. Many domains are so well learned that our cognition about them is nearly always automatically cued, such as social and emotional areas. This is also true of work areas, where most of us are experts. These principles have many implications for the design of decision-support. For example, they explain why we use stereotypes in caring for older patients (e.g. confuse delirium versus dementia) [46], assume that we communicate better than we do [47,48], don't respond to alerts once decisions have been made [40], base our decisions on the "gist" of the situation versus specific information [49–51], make diagnostic errors [38], or generally have "attentional myopia," and rely mostly only on salient cues [45,52]. Maintaining the necessary balance between System 1 and System 2 for effective performance requires tools that individuals can use to support executive and self-regulatory control of their behavior in the face of conflicting demands, values, and goals [53,54].

From this perspective, we recommend that designers should pursue an "Integrated Model" of design where three core functions are addressed simultaneously: (1) support for pattern-matching by integrating information into single views that capture the "gist" of a situation, thereby minimizing cognitive load associated with

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perception, (2) highlight (make salient) the motivational components in the environment that require attention, (e.g., relevance, complexity, urgency, incongruity), and (3) provide tools to support clinician's active control of their information space (adaptive control) [55]. In this way, cognitive function can be addressed across the full sociotechnical cycle from design and implementation. The VA IDEAS Center uses this approach and is illustrated in Fig. 1 below. This approach is similar to the work of Zhang and associates on functional decompensation [56], Hollnagel [57,58] and others [59]. In Fig. 1, we present a cycle starting with understanding the gaps and needs, creation of theory-based designs, integration with implementation processes and a continuous improvement cycle that builds experience that feeds back into understanding the gaps and needs.

The articles in this collection illustrate many aspects of the Integrated Model for DSS design by highlighting either future areas of focus, reporting on experimental evaluation of interventions, or presenting reviews of existing literature. Although not every article refers to the Dual Process perspective, each is relevant to the notion of an integrated model together they support the full sociotechnical cycle as shown in Fig. 1 and demonstrate the key dependencies between design and implementation.

3. Review of articles in collection

3.1. Kramer and dews

Checking the lists: A systematic review of electronic checklists in health care [60].

The use of checklists is a straightforward attempt to activate System 2 deliberative processes by mandating attention to a task. Kramer and Drews present their systematic review of the empirical literature on the impact of checklists and report mixed results. Out of the fifteen studies that met inclusion criteria, thirteen used a pre/post design, and only two used a randomized clinical trial. Of the thirteen pre/post designs, eight showed benefits across all measures, whereas five had mixed results. Of the two randomized control studies, one showed mixed results and the other study was negative when compared to face-to-face intervention. An examination of the areas of failure found that the increased cognitive demand for using a checklist combined with the lack of needed information to quickly do the task might have been a factor in finding significance.

3.2. Roosan et al.

Identifying complexity in infectious diseases inpatient settings: An observation study [61].

In this paper, Roosan et al. [61] address the issue of cognitive support for System 2 by attempting to quantitatively operationalize the complexity of clinical decision-making and diagnostic reasoning by infectious disease experts. The team observed three different ID teams across 30 patients and using a previously identified complexity factor and coded the interactions using a previously created taxonomy. After conducting data reduction of ratings (factor analysis) the authors find three high level dimensions: (1) information attributes related to goals and expertise, (2) patient urgency and acuity (e.g., age, acuity and urgency), and (3) psychosocial factors (e.g., noncompliance or poverty). The top four items contributing to ratings of complexity were, in order: (1) unnecessary information, (2) lack of expertise, (3) team coordination, and (4) changing information, followed by multiple decision steps, and patient acuity. In other words, the sheer amount of information and the lack of match of expertise and team capacity to organize this information created the complexity. These results strongly support the use of an integrated model for design. Displays of complex content must be carefully organized in order to maximize pattern-matching, especially in terms of patient acuity. Providing measures that can accurately provide risk management information will capture System 2 attentional resources more efficiently. Finally, tools to support complex decision-making are essential (e.g., Infobuttons, antibiotic advisors). Roosan et al. nicely review each complexity factor in terms of recommendations for design.

3.3. Jones et al.

Think twice: A cognitive perspective of an antibiotic timeout intervention to improve antibiotic use [62].

Jones et al.'s paper [62] clearly illustrates the tension between supporting both System 1 and System 2 processing with the minimum of cognitive load. Much of the source of this tension stems from multiple active goals and frequent goal conflicts. The overall purpose of this work is to decrease antibiotic resistance by encouraging early narrowing of antibiotic coverage during an infectious disease episode. Residents must be aware of the needs of the patient, the demands of their attending, the rules of their institution, and the impact of their ordering on antibiotic resistance. The qualitative analysis of critical incidence interviews illustrated the automaticity of emotions that arise from a patient's acute clinical situation (fear of regret) and the social pressures of the medical team (especially the wishes of the Attending physician). Social and emotional issues are automatically activated, whereas providing decision support that will motivate busy residents to pay attention to the antibiotic regime at day 3 requires significant work process manipulation. The article details the intervention, which was intended to address both System 1 and System 2 simultaneously. The new reminder system was experienced as providing increased choice, control, and a nudge to "make them think." All of these themes speak to the interplay and dynamics between S1 and S2 processing.

3.4. Weir et al.

Making cognitive decision support work: Facilitating adoption, knowledge and behavior change through QI [63].

In another illustration of the inter-dependencies of S1 and S2 processing, Weir et al.'s paper illustrates the necessity of taking into account the complexities of creating habitual behavior (moving from System 2 to System 1). Nearly all computerized decision support requires making a change in the relationship between environmental cues and behavior – in other words, individuals need to learn a new way of working and the work needs to become automatic. In this paper, local Quality Improvement (QI) methods were used to implement decision support for the care of older adults. QI focuses on implementation over time, measurement, and feedback while offering extensive user involvement. Using these techniques, providers gained self-efficacy (an indication of learning) in the care of older adults, but only in the clinical domain related to their QI project. In other words, increases in self-efficacy mediated the behavioral change. Those areas that were not targeted by the IT intervention (but were also part of the overall education program) did not result in increases in self-efficacy and, in turn, did not result in changed behavior. Self-efficacy is a marker for expertise and indicates the development of automatic processes. This work nicely links to other implementation research that focus on QI.

3.5. Gundlapalli et al.

Detecting the presence of an indwelling urinary catheter and urinary symptoms in hospitalized patients using natural language processing [64].