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Evaluating the effects of cognitive support on psychiatric clinical comprehension

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ABSTRACT

Objective: Clinicians' attention is a precious resource, which in the current healthcare practice is consumed by the cognitive demands arising from complex patient conditions, information overload, time pressure, and the need to aggregate and synthesize information from disparate sources. The ability to organize information in ways that facilitate the generation of effective diagnostic solutions is a distinguishing characteristic of expert physicians, suggesting that automated systems that organize clinical information in a similar manner may augment physicians' decision-making capabilities. In this paper, we describe the design and evaluation of a theoretically driven cognitive support system (CSS) that assists psychiatrists in their interpretation of clinical cases. The system highlights, and provides the means to navigate to, text that is organized in accordance with a set of diagnostically and therapeutically meaningful higher-level concepts.
Methods and materials: To evaluate the interface, 16 psychiatry residents interpreted two clinical case scenarios, with and without the CSS. Think-aloud protocols captured during their interpretation of the cases were transcribed and analyzed qualitatively. In addition, the frequency and relative position of content related to key higher-level concepts in a verbal summary of the case were evaluated. In addition the transcripts from both groups were compared to an expert derived reference standard using latent semantic analysis (LSA).
Results: Qualitative analysis showed that users of the system better attended to specific clinically important aspects of both cases when these were highlighted by the system, and revealed ways in which the system mediates hypotheses generation and evaluation. Analysis of the summary data showed differences in emphasis with and without the system. The LSA analysis suggested users of the system were more "expert-like" in their emphasis, and that cognitive support was more effective in the more complex case.
Conclusions: Cognitive support impacts upon clinical comprehension. This appears to be largely helpful, but may also lead to neglect of information (such as the psychosocial history) that the system does not highlight. The results have implications for the design of CSSs for clinical narratives including the role of information organization and textual embellishments for more efficient clinical case presentation and comprehension.

1. Introduction

In complex clinical environments, clinicians must cope with and manage multiple, voluminous, heterogeneous data sources to solve clinical problems [1,2]. Both comprehension and problem solving capabilities of physicians affect their efficiency, as comprehension is a prerequisite to problem solving [3]. Previous studies have suggested that the process of clinical comprehension differs between expert and novice clinicians with respect to selective filtering, pattern recognition and accuracy of inferences generated [4]. Specifically, experts use knowledge structures called "intermediate constructs" that represent clinically meaningful clusters

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of observations that lead toward specific diagnoses. The ability to generate intermediate constructs is a distinguishing characteristic of expert clinical comprehension [5]. In contrast, non-experts (e.g., residents) and other trainees may possess a less organized, albeit large, knowledge base.

It has been argued that the application of information technology to simulate aspects of expert comprehension in order to provide cognitive support may allow trainees to reason in an expert-like manner [6]. Therefore, a cognitive support system (CSS) that organizes the information in a manner that mediates efficient problem solving may improve the quality and efficiency of patient care. While we have chosen the narratively rich clinical specialty of psychiatry as our problem domain, the problem we describe is related to human information processing in general. As such, this work has implications for the organization of information in any knowledge-intensive domain.

In this paper, we describe the development and evaluation of a CSS based on intermediate constructs. The problem solving processes of users of this interface are characterized, and compared to those of users of another interface without cognitive support. The interface and its evaluation provide insights for the design of technology that can help clinicians organize information in a manner conducive to efficient decision-making.

2. Background

Experts have the ability to perceive the features of a problem that are most pertinent to its solution [7]. Seminal research from the chess domain showed that expert players are distinguished by their ability to recognize and reconstruct strategically meaningful configurations of chess pieces [8]. Similar studies conducted in various other fields of medicine such as radiology [9] and dermatology [10], demonstrated the expert's pattern recognition ability, especially in visually-oriented domains. Analogously, it has been found that expert physicians are proficient at recognizing diagnostically relevant patterns of symptoms in a clinical narrative [11], where information is presented verbally rather than visually.

Patel and Groen identified three important characteristics that differentiate experts from non-experts [11]. The *first* characteristic is a pattern of reasoning. In routine problems, experts use a data-driven pattern of reasoning where observations pertinent to problem data lead to an accurate diagnostic hypothesis, often progressing through pre-diagnostic hypotheses (e.g., "a cardiac problem") before reaching a final diagnosis (e.g., "left ventricular failure secondary to a myocardial infarction"). In contrast, non-experts and experts in unfamiliar situations use a hypothesis-driven pattern of reasoning, where a hypothesis, or set of hypotheses, guides data collection and interpretation.

The *second* characteristic that differentiates experts from non-experts is the organization of their knowledge base. Experts have a highly organized knowledge base that allows them to partition a problem into manageable "chunks." In the context of diagnostic reasoning, these "chunks" consist of intermediate constructs—diagnostically meaningful clusters of signs and symptoms that are not in and of themselves diagnoses, but serve to partition the diagnostic problem space and lead the way toward a correct diagnosis [12]. The recognition of a cardiac problem before reaching a more specific diagnosis is an example of the application of an intermediate construct. As an example drawn from the domain of psychiatry, psychotic symptoms such as hallucinations and delusions would be considered components of an intermediate construct indicating a psychotic episode. The organization of clinical findings into intermediate constructs provides a support structure for the ultimate diagnosis. While trainees may have large knowledge bases, these tend to be less organized than an expert's knowledge base. This may lead to the generation of diagnostic hypotheses without adequate supporting evidence. The *third* characteristic is the approach to a clinical problem. Experts typically generate a small set of relevant diagnoses at a high level of abstraction and quickly narrow down to the most accurate one, while non-experts tend to generate a large number of irrelevant diagnostic hypotheses [11].

Sharda and colleagues investigated the effect of expertise on comprehension of psychiatric narratives [13]. They found differences in knowledge organization between experts and non-experts. Experts approached a diagnostic solution using relevant intermediate constructs, while non-experts failed to generate key constructs, a finding consistent with those obtained in other clinical domains [8,9]. This raises the question of how the explicit presentation of intermediate constructs may affect clinical reasoning. This question motivates the current work, in which we evaluate the effects of such an interface on clinical comprehension and diagnostic reasoning.

3. A CSS for psychiatry

In this section, we describe a prototype user interface that presents psychiatric narrative in a manner conducive to the recognition of key intermediate constructs. In contrast to traditional decision support systems that seek to emulate expert performance of a decision-making task, this system supports the decision-making process at a point that is proximal to the decision itself. The basis for this design is the thought process of experts, as revealed through cognitive methods for the study of comprehension [4].

This approach is motivated by the theory of distributed cognition [14], which views cognition as the product of a distributed system involving both human actors and the external media that support them in their cognitive tasks. Rather than being confined to the mind of a single clinician, clinical comprehension can be viewed as a distributed process involving, for example, a human reader and a textual display (see Fig. 1). Comprehension involves the construction of a mental representation of a clinical case that is influenced by structured knowledge stored in the mind of the clinician [5]. By organizing the information presented in accordance with a simulation of the structure of expert knowledge, a system can redistribute part of the cognitive work of expert comprehension from man to machine.

3.1. System description

We provide a brief account of the system design and development, but refer the interested reader to [6,15] for further details of the development and evaluation of the back end of the system, which provides the means to draw associations between short segments of clinical narrative and a set of four diagnostically and/or prognostically relevant intermediate constructs, "psychosis", "mood", "substance abuse" and "dangerousness." We refer to these constructs as "facets" in accordance with terminology developed in [16]. These facets were selected based on their clinical importance for patient assessment in emergency psychiatry. The selection of facets on this basis was informed by discussion with author BB, an expert in the domain of emergency psychiatry, as well as by our observation of an emergency psychiatry unit during the course of qualitative research conducted prior to the commencement of this project. For a detailed description of the unit concerned, we refer the interested reader to [6]. To link text in a discharge summary to each of these facets, we used a combination of latent semantic analysis (LSA) [17] and a training mechanism motivated by the conceptual spaces framework proposed by Gärdenfors [18]. LSA provides the means to derive high-dimensional