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# Detecting Learning and Reasoning Patterns in a CDSS for Dementia Investigation

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**Abstract.** Reasoning conducted in clinical practice is manifested through different and often combined reasoning and learning strategies, adjusted to the characteristics of the available information, the medical professional's experience and skills, and the available tools, such as clinical practice guidelines. This research outlines a design model for supporting the commonly used strategies. This design model was implemented into a clinical decision-support system (CDSS), in addition to a method for detecting reasoning strategies applied when using the CDSS. This method was applied in a case study, with preliminary results presented in this paper and will be further implemented in future studies.

**Keywords.** Continuing Medical Education, Computer-Assisted Decision-Making, Clinical Decision-Support Systems, Dementia

## Introduction

Clinical decision-support systems (CDSS) are typically aimed at supporting the medical and health practitioners in their reasoning and decision-making processes. This is commonly done through alerts integrated in medical health records, which are activated when potentially hazardous situations occur, and as guidance to take action to resolve the situation[1]. Other CDSSs aim at educating the practitioner at the point of care, and put more focus on supporting a clinical process[2]. The Dementia Diagnosis and Management Support System (DMSS-W) is a CDSS, which is designed for the latter purpose[3-4]. By integrating support for different reasoning strategies and for handling ambiguous and incomplete information, the CDS is aimed to also educate the practitioner, as a means to increase adherence to clinical practice guidelines[5]. Reasoning conducted in clinical practice is manifested through different and often combined reasoning strategies, adjusted to the characteristics of the available information, the medical professional's experience and skills, and the available tools, i.e., the current situation[6]. Since the reasoning strategies differ depending on acquired knowledge, skills and experience[6], as a consequence, a CDSS should support different types. However, for evaluating what strategies a user uses, and whether these strategies change over time, which may be an indication of knowledge and skill development, new methodologies for evaluation are needed. This work builds upon earlier findings, where the non-compliance between DMSS and the medical professionals was found to be mainly due to lack of knowledge in individuals about critical features such as

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memory deficits when diagnosing dementia diseases[4]. As a consequence, additional functionality has been implemented into the web-version DMSS-W, which aims at capturing the reasons for non-compliance, which are due to insufficient knowledge, and allowing the medical professional to become aware of the reasons.

This paper outlines a model for evaluating knowledge and skill development in users of a CDSS, and presents a pilot study of DMSS-W in which the model was applied as an initial step. Our immediate future work is to conduct a study with a larger number of users of different skills and experience for classifying reasoning strategies and behaviour. The aim is to develop an automated adaptation module based on the model for tailoring the support to a particular user's needs and situation.

## 1. Methods

The design of the CDSS was based on models of reasoning and decision making among novices and skilled medical professionals[e.g,6] and is described in[3]. An ontology-based model for storing and evaluating click-events associated to different clinical activities supported by the CDSS was developed based on the observations of 50 physicians using DMSS[4], and implemented. The ontology contains activities related to a continuing medical education, learning how to use the CDSS, data capture, reasoning about diagnosis and interventions.

Four medical professionals, who had not used DMSS-W volunteered to participate in a pilot study, to be followed by additional 40 professionals in a future study. Two participants valued themselves as novices in the dementia domain and two as experts. They used the CDSS during a period when the click-events were logged. The data was analysed qualitatively and manually, for finding patterns of reasoning following the ontology of activity. This paper presents the preliminary results from two of these participants who generated most events.

## 2. Results

DMSS-W contains support for learning i) how to use the application, ii) about each relevant symptom, syndrome and disease, iii) how each relates to assessing a cognitive disorder, iv) about the ambiguities and uncertainty related to diagnosis, and v) a procedure for assessment[3].

The activities ii) – iv) are divided into two major activities organized by the two tabs *Data Capture*, and *Diagnosis and Intervention*. The design and information model function as a *checklist*, and supports a systematic process of *forward-chaining* reasoning, where a professional first assess the situation for the patient regarding various aspects, which are used for building up evidence for the presence of syndromes, before moving into reasoning about the potential causes and conclusions about diagnosis[6]. The application also has a *guide* functionality, which is activated by a button called "*What to do next?*". This guide functionality supports the forward-chaining reasoning process by providing the user a subset of the features to investigate in the current situation taking the information collected so far into account and a set of guidelines. Explanations and intermediate conclusions are provided when possible, such as whether there is a cognitive deficiency and what type.

A different reasoning strategy is to begin with a hypothetical diagnosis and investigate features, which support or contradict this hypothesis, i.e., *backward-chaining* reasoning. A user of DMSS-W can any time access this reasoning functionality, which generates support for different diagnoses, and which provides an overview of the available potential hypotheses and their support. In case a medical professional suspects a certain disease, this functionality can provide information about the corresponding diagnosis, and information that are potentially missing that is necessary for diagnosis.

The users' activity, represented by click events, was logged following the activity ontology. Whenever a user activated a menu item, represented in the information model as an *assessment protocol* (i.e., protocol for conducting a certain activity) an *event* is occurring, which has a time point. Consequently, sub-menu items represent sub-actions. A click on a value associated to a phenomenon, or symptom, generates an information node, which is represented as *evidence* associated to the ongoing event. A click on a button leading to aid functionality is logged as an *observation* associated to the event. The aid can be either about how to use the system, or explanations and definitions of concepts relating to symptoms and diseases.

We assume the following based on studies of physicians using earlier versions of DMSS[3-4]:

1) A click event on an item that activates an assessment protocol represents a *focus shift* towards the concept associated to the assessment protocol, which represents a task to be done.
2) A click event on an aid button represents either
   a. the intention to learn about the system, or
   b. the intention to learn about the particular feature, which then is assumed to be in focus.
3) Each click event that generates evidence represents a *conclusion* (decision) drawn by the user.
4) A click event related to the *guide* functionality represents either lack of knowledge about what to do next, or an intention to speed the process up, as a fast assessment track.
5) A shift from the diagnosis and intervention protocol to the data-capture protocol with subsequent logging of new evidence represents increased awareness of, or new insights about missing information.

The analysis of the data collected in the case study was done manually by following this algorithm. The results show some differences between the two participants who generated most events, PA (novice) and PB (expert). PA followed systematically the assessment procedure provided by the design of the user interface, which supports a diagnostic reasoning process. This was done after completing the brief introduction on how to use the system. PB did not go through the introduction until the beginning of Day 2. Instead, PB applied the system in patient cases directly and did also use the systematic procedure, collecting information before analysing the information. However, PB combined also this method with the hypothesis-based, by moving back and forth between the data-capture task and diagnosis and intervention task, generating new information between analyses. This behaviour follows the *diagnostic reasoning* process[6], which involves four types of inferences; abstraction and abduction (drives hypothesis generation), deduction and induction (drives hypothesis testing).

The definitions and explanations of the added features were consulted by PB when moving back to Data Capture. PB consulted definitions and explanations less than half as often, compared to PA, who systematically consulted these for almost all features to assess for the first three patient cases. As a consequence, the aid was used several times for several features, different days and in different patient cases, which indicates that a learning process is going on.

It was observed, in particular for PB, that the set of features that were focussed by consulting the explanations and definitions differed between patient cases. It appears that the physicians were only interested in the information, which was relevant for the particular patient in focus. Moreover, it was observed that the major difference between the two physicians were that the expert physician did not consult as often explanations regarding other potential causes of the cognitive decline, neurology symptoms or typical cognitive symptoms, except for memory functions, which were consulted frequently by both physicians.

It was also observed that the guide functionality was only used by PB, and only a few times. Since the physician had collected the necessary information before activating the guide, and did not collect new information directly after, it was probably used for merely testing the functionality, or verifying that nothing was missed out.

## 3. Discussion

The preliminary results indicate that the algorithm for analysing the log data seems to be useful for the purpose of detecting behaviour, which relates to learning and reasoning. Whether learning is actually taking place remains to be investigated by studying behaviour over a longer period of time. The algorithm is being implemented to automatically identify these reasoning patterns, and to analyse the change of behaviour over time. DMSS-W will be evaluated with a larger group of medical professionals in future studies, in order to investigate in what way the support for knowledge and skills development can be further improved, in addition to adherence to clinical medical guidelines[5].

## References


[1] Shojania KG, Jennings A, Mayhew A, Ramsay C, Eccles M, Grimshaw J. Effect of point-of-care computer reminders on physician behaviour: a systematic review. CMAJ 2010;182(5):E216-25.

[2] Kaplan B. Evaluating informatics applications – clinical decision support systems literature review. Int J Med Inf 2001;64:15-37.

[3] Lindgren H. Towards personalized decision support in the dementia domain based on clinical practice guidelines. UMUAI 2011;21(4):377-406.

[4] Lindgren H. Limitations in physicians' knowledge when assessing dementia diseases – an evaluation study of a decision-support system, Stud Health Technol Inform 2011;169:120-4.

[5] Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud P, Rubin HR. Why don't physicians follow clinical practice guidelines? A framework for improvement, JAMA 1999;282(15)1458-67.

[6] Arocha JF, Wang D, Patel VL. Identifying reasoning strategies in medical decision making: A methodological guide, J Biomed Inform 2005;38(2):154-71.