Modelling Elderly Cardiac Patients Decision Making Using Cognitive Work Analysis: Identifying Requirements for Patient Decision Aids

Dhukaram, Anandhi Vivekanandan; Baber, Christopher

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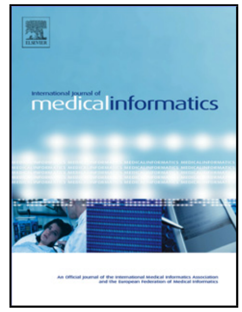

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Author: Anandhi Vivekanandan Dhukaram Chris Baber

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Research Highlights

- Patient's day-to-day decision making is a complex socio-technical system.
- Cognitive Work Analysis provides analysis of decision making from different perspectives.
- Decisions are not just rule based, it involves skills and knowledge based behaviour.
- Systems should support different approaches to patients' decision making.
- CWA is helpful in modelling decision making and for identifying requirements.

Modelling Elderly Cardiac Patients Decision Making Using Cognitive Work Analysis: Identifying Requirements for Patient Decision Aids

IJMI-D-13-00340 (RESUBMISSION)

Anandhi Vivekanandan Dhukaram and Chris Baber
School of Electronic, Electrical and Computer Engineering, University of Birmingham

Background: Patients make various healthcare decisions on a daily basis. Such day-to-day decision making can have significant consequences on their own health, treatment, care, and costs. While Decision Aids (DAs) provide effective support in enhancing patient's decision making, to date there have been few studies examining patient's decision making process or exploring how the understanding of such decision processes can aid in extracting requirements for the design of DAs.
Objective: This paper applies Cognitive Work Analysis (CWA) to analyse patient's decision making in order to inform requirements for supporting self-care decision making.
Method: This study uses focus groups to elicit information from elderly Cardiovascular Disease (CVD) patients concerning a range of decision situations they face on a daily basis. Specifically, the focus groups addressed issues related to the decision making of CVD in terms of medication compliance, pain, diet and exercise.
Results: The results of these focus groups are used to develop high level views using CWA. CWA framework decomposes the complex decision making problem to inform three approaches to DA design: one design based on high level requirements; one based on a normative model of decision-making for patients; and the third based on a range of heuristics that patients seem to use.
Conclusion: CWA helps in extracting and synthesizing decision making from different perspectives: decision processes, work organization, patient competencies and strategies used in decision making. As decision making can be influenced by human behaviour like skills, rules and knowledge, it is argued that patients require support to different types of decision making. This paper also provides insights for designers in using CWA framework for the design of effective DAs to support patients in self-management.
Keywords: Patient Decision Making; Decision Aids Design; DA Requirements; Cognitive Work Analysis; Self-management

1. Introduction

There is a pressing need for individualized healthcare systems as chronic diseases such as cardiovascular disease (CVD) and diabetics will be responsible for three-quarters of the world's deaths by 2020 [1, 2, 28]. Most hospital readmission rates are due to a definable set of problems that patients face: poor health, inadequate preparation on discharge, problems with caregivers, non-adherence to instructions regarding diet, medication or fluids, knowledge deficiencies etc., [3, 4, 5]. Taken together, the majority of these problems imply a socially important question: "how can patients be helped to make appropriate decisions on their health and care?"

To make appropriate healthcare decisions patients need to have: (i) a deep understanding of their illness and (ii) good access to support to cope with the illness and experience less

psychological distress [21]. Effective decision making can be supported by encouraging patients to recognize decision situations (i.e., occasions which present patients with the opportunity to choose between courses of action) and by providing aids to help them respond appropriately. Some of the more severe consequences of CVD can be minimized if patients know how to care for themselves [1, 2]. Although everyday decision making may seem to be an easy task, it can be complicated by many factors, including social isolation, lack of support for daily self-care activities, co-morbid conditions etc. [6]. The impact of these factors can be exacerbated by ambiguity in decision situations, e.g., "Is my tiredness related to exercise, stress, or heart disease?" [7]. Patients should be able to address such ambiguities through the use of Decision Aids (DAs). Patients can use DAs to help them make informed decisions rather than a "yes" or "no" response to their decision problems and it is argued that patients ought to become 'experts' in their own self-management.

DAs have been developed and applied in the last two decades. These have traditionally been in the form of textual and graphical materials, such as self-help leaflets, or (more recently) web applications, aimed at supporting specific treatment decisions. Some DAs have focused on developing decision support systems based on clearly defined rules and procedures. However, without an understanding of the nature of patient's decision making activity, there is a risk that DAs could be designed according to conventional models of medical decision making which may not be appropriate for patients. To effectively support patients in self-care decision making, we first need to understand:

- "How to model patients' healthcare decision making process?"
- "What are the requirements for supporting self-care?"

To address this challenge we need to gather everyday decision making scenarios from patients, as patients not only have the knowledge but they also engage in a range of tasks to identify, prevent and recover from medical problems [20]. However, we also need to recognise that patient decision making exists in the context of a wider healthcare system and that, as such, these decisions take place in a complex socio-technical system. Many innovations fail when they move from the design phase to the deployment phase if the breadth of socio-technical system is not explored in sufficient detail [16]. This paper considers patient decision making in its socio-technical context through the application of Cognitive Work Analysis (CWA) [13, 14], a structured framework widely used to gain insight into work domains. In general, applications of CWA have focused on experts in complex domains, such as command and control [12, 15] or process control [14]. In the medical domain, CWA has been applied to help in the design of decision support tools for nurse managers [22], in the design of systems to perform patient monitoring [23], or the design of clinical displays [24], intensive care units [25], and teletriage [26]. In this paper, our focus on patients as decision makers allows us to explore how well the CWA approach can accommodate the lay person.

This paper provides the methodology which has been used to collect instances of patient decision situations and the manner in which these have been analysed using CWA for a formal description of patient's decision making and specification of DA requirements that support different decision strategies. This paper also provides insights for decision aid designers in using CWA framework to identify the requirements needed for the design of effective self-management systems.

2. Methodology

Self-care decision making by patients can be conceptualized as a cognitive and behavioural process involving the choice of behaviours that maintain physiological stability including symptoms monitoring, treatment adherence, and response to symptoms [8 - 10]. Klein et al. [17] considered diabetic patients' self-management decision making as a set of macro-cognitive functions comprising of mental activities to achieve decision goals, including [17, 18]:

- Problem Detection: where the patient identifies anomalies and difficulties in available information.
- Sense making/ Situation Assessment: where patients identify causes and potential remedies. Patients' sense making is carried out through collecting, corroborating, and assembling information and assessing how the collected information maps to potential explanations.
- Options generation: where patients compare and evaluate options using mental simulations rather than analytical comparison.
- Planning: Glucose control by patients require decision making ranging from ordering from menu to plan or consider other options and managing multiple illnesses.

In addition to these cognitive functions, Klein et al. [19] show that it is important to appreciate how patients identify and respond to cues in decision situations and how they might anticipate future demands. Such identification and anticipation will draw on prior experiences of the patient or on the ability to identify a developing trend. Given these features, and the previous work of Riegel et al. [10], we employ these cognitive functions as a coding scheme for the CWA framework applied in this paper.

For this study, CWA is chosen as it focuses on what a system *could* look like rather than describing what it does look like [13]. Its main focus is on mapping the constraints within which decision and task activity can occur.

CWA consists of five phases [14, 29 - 31]. The order in which the phases are performed is largely up to the analyst and influenced by access to information but tends to work from the outside in, i.e., from organisational considerations to individual skill profiles. In this paper, the first phase is Work Domain Analysis (WDA) [27]. WDA is concerned with mapping the purposive and physical 'big picture' of the work domain, typically in the form of an Abstraction Hierarchy. The second phase, is Social Organization and Cooperation Analysis (SOCA), which concerns the division of functions between elements of the socio-technical system. The third phase is Control Task Analysis which establishes what needs to be done for the system to fulfil its purpose, exemplifying possible pathways between input states and output decisions. It is a mapping of information processing structures that the system as a whole needs to navigate. This stage of CWA is typically performed using Rasmussen's Decision Ladder [13]. The fourth phase, Strategies Analysis, concerns the routines that could be used to carry out the activities identified in Control Task Analysis. The fifth phase, Skills and Worker Competency Analysis, concerns the mapping between the required competencies of workers and the system constraints, and is typically performed using the SRK taxonomy (Skill-based, rule-based or knowledge-based [13, 14]).

2.1 Focus Groups and Questionnaire Survey

In order to capture decision situations from patients (which would then be described in terms of CWA), a series of focus groups were run. Focus group discussion [33 - 35, 38] is an effective way to gather information in which small groups of 5-12 participants gather to discuss a specified topic or an issue. For example, Ramanathana et al. [39] used focus group study to identify the preferences for mobile health applications for self-monitoring and self-management.

Participants (diagnosed with CVD) were recruited by contacting heart support groups in the UK Midlands. Initial contact with the support group coordinator was made in person, by email or by phone. We gave a presentation about our research and handed out information leaflets asking for participation. Participants who were interested in this study were asked to contact their group coordinator and give their names. Following this recruitment process, four focus groups where run, two in the West Midlands region of the UK and two in the county of Derbyshire, UK. The participants were recruited in May 2011 and consisted of 20 patients and 5 caregivers (17 Males and 8 Females). Participants were in the age group of 60 to 79 years. In terms of history of heart condition, all patients had suffered from the condition for more than 3 years. Each focus group lasted between 60-90 minutes, and the sessions were captured through audio recording and by a note-taker.

Projects involving human participants require approval from the University of Birmingham Ethics committee. This requires informed consent to be obtained from participants and for any data collected from them to be rendered anonymous. Participants are also informed that they could withdraw from the study whenever they wished or could request to have any data generated from their responses withdrawn from subsequent analysis.

Our focus groups started with discussions to understand and elicit decision making needs patient's face in day-to-day self-management. We discussed the need for decision making using examples from our previous study [7] like "knowing what you can't eat with things like Warfarin because there are certain things that will contradict". This discussion was followed by a questionnaire (provided in the supplementary document along with few patient responses) to collect decision making scenarios. The main aims of the questionnaire were to understand the following:

- Problem Identification: How do patients identify the need for decision making? Including the decision problem, health condition, and preferred choice.
- Past Experience: Did patient apply any of his/her previous experience knowledge?
- Decision Makers: who makes the decision and people involved in decision making?
- Information Needs: Does the patient have adequate information for arriving at a decision?

For the questionnaire, each patient was asked to recall a situation where they had to make a decision on their medication, pain, diet or exercise. Caregivers did not participate in the questionnaire study as they felt they were not the main decision makers.

3. Analysis

Twenty patients participated in the study and each produced a single scenario, resulting in 20 case scenarios for the analysis. It is worth noting that some patients found this quite difficult to do and hence the focus group discussions helped the patients to recall and elaborate specific decision problems. When they were given the questionnaires, patients were asked for the most unusual scenario to be included. This meant that, rather than having many scenarios on the topic of 'diet', for example, we sought to have a range of issues which patients face. We accept that this aim for breadth might give the impression that all of the scenarios are equally common (particularly when we were taking pains to produce some unusual scenarios). However, we would argue that the aim of this exercise was less the production of representative scenarios that apply to all patients and more to the production for illustrating scenarios that cover the range of decision situations that patients' face.

Table 1: *Recount of Patients' Decision Situations*

Case Scenario	**Decision Problem**	**Decision Options**
CS1	Felt unwell after medicine	Change medication or Visit GP
CS2	Felt unwell after medicine	Visit GP
CS3	Sickness	See doctor
CS4	Side effect – muscle ache	See GP/ Doctor/ Nurse
CS5	Increase diuretics	To increase diuretics
CS6	Severe cough	Change medication
CS7	Forgot Tablets	Take medicine next day
CS8	Felt unwell	Stop medicine immediately
CS9	Chest pain	Stop, don't go out when cold and windy
CS10	Chest pain	See GP for check-up
CS11	Muscular pain	See GP or Experiment – Wait and see
CS12	Surgery	
CS13	Heart Attack	See doctor or Call paramedics
CS14	Heart Attack	See doctor or Lower cholesterol down
CS15	Light headedness	Ignore or Call ambulance
CS16	Worsening Condition	Surgery
CS17	Muscular pain	Do not take medicine
CS18	Rehabilitation Programme	Take it or

		Leave it (do not attend rehabilitation)
CS19	Decided to change diet	Cut down fats and alcohol
CS20	Diet and overweight	Change diet

Table 1 shows an overview of the case scenarios (identified as CS followed by a number) of each patient's decision making along with the options that they supplied for decision making. Although each patient tried to recall a decision situation on their own for filling in the questionnaire, Table 1 shows that patients do experience common problems like "Feeling unwell" or "Chest Pain" or "Muscular pain". Moreover, the case scenarios imply that the options for patients' decision making depends on the severity of the problem. In 'severe' cases for example in CS13, CS10 and CS4, patients seek immediate help from GPs or Doctors without thinking much about their problem. We have put the word severe in quotes because the definition of severity for the patients is not always the same as the definition for the GP. In some instances like in the case of CS2-CS10, patients do not seem to consider any options. At one level, this echoes the assumptions that doctors seem to work on, i.e., the patient relies on the doctor to make decisions and should be expected to follow this guidance. However, some of the decisions can be seen to involve the patients making their own choices, weighing up options, or drawing on their previous experiences. Using this knowledge we now aim to identify patients' knowledge, information processing, and decision making process involved to extract the requirements for supporting patients' decision making. Therefore, in the next sections we will use CWA to model detailed analyses mapping goals of system functions, task responsibilities and actions.

4. Developing the CWA

The CWA described in this section is supported by The CWA Tool produced by Jenkins et al. (2008). This provides a step-by-step guide to the process and also the figures used in this paper. For this study, we took the 20 scenarios generated by the focus group and questionnaire activity (described above) and represented these using the five analyses of CWA. This paper will only present a set of this analysis, for reasons of space and clarity.

4.1 Work Domain Analysis (WDA)

Work Domain Analysis describes the ways in which the Functional Purpose of a system (on the first row of Figure 1) is achieved through the use of the performance of specific actions on specific physical objects in terms of specific values and priorities held by the system. Overall, for this paper the 'Functional Purpose' is to support 'Cardiac Patients' Decision Making'. We assume that this is achieved by the 'system' (which would include the patient and their carer(s), the General Practitioner and other Healthcare professionals, medication, information sources etc). This system-level view is an important aspect of CWA and allows the analysis to consider how different elements of the system might contribute to the overall purpose (rather than assuming, for instance, that there is only a single element). Having defined a Functional Purpose, the next step is to define the Value and Priority Measures of the system (the second row of Figure 1). These represent those aspects of performance that the system could use to indicate how well it is performing. From the review of the focus group and questionnaires, the values and priorities are as follows:

- Improved (patient) Self-awareness,
- Reduced risks,
- Shared decision-making (between GP, patient, carer and other health professional),
- Managed information.

The next step is to consider the Physical Objects (the fifth row of Figure 1) that the patients currently use to support their activity. Our scenarios collected from the questionnaire revealed that patient's decision making depends on many things including:

- people involved (either as repositories of information and advice or as actor), e.g., doctor, caregiver;
- physical objects such as leaflet; and
- specific pieces of information such as sleep, feelings, side-effects (of medication) or quantity (of food, drink or medication) or status (of eating, drinking or taking medication).

Having defined Physical Objects, we considered the scenarios to see how patients make use of these Objects. The Object-related Purposes are given below along with the case scenarios (Table 1) that helped us to define them:

- Report problem - As soon as patients encountered the problem they sought medical attention as in CS1, CS2, CS3, CS4, CS10, CS11, CS12, CS13, and CS14.
- Cues - Patients have tried to identify the cues for the problem like in CS2, CS4, CS9, and CS17.
- Problem Distinction - Try to isolate the problem like in CS9
- Side-effects - identify the side-effects based on the problem like in CS4, CS6, and CS9.
- Historic Information - in some cases, like in CS7 and CS3, patients have taken account of their previous experiences while making decision.
- Options – as seen in most of the case scenarios, patients have options in decision making, like for example: in CS15, the patients' options were either to ignore the symptoms or to call the ambulance.
- Anticipation - CS9 patient decided to stop walking when it is cold and windy as it might affect him later on.
- Patient Preferences - CS19 shows that the patient wants to cut down on fats, alcohol. Also in most of the case scenarios patient prefer to seek advice from the doctors.
- Formulate Plan - Patients seem to formulate treatment care plans like in CS5 on their own or with the help of doctor like in CS14 and CS16.
- Follow-up Procedure - For patients who sought doctors' help like in CS13, CS11, and CS10 received follow-up procedures including what symptoms to watch out for and when to seek medical attention.
- Scheduling - Some patients sough medical attention immediately like in the case of CS3, who felt sick in a conference, while for other decisions like CS12 they go for scheduling.
- Data Management - This deals with data management.

Finally, we define Purpose-related Functions which link the Object-related process to the Values and Priorities of the system and, hence to the Functional Purpose (in the third row of

Figure 1). In order to define Purpose-related Functions, we returned to the work of Klein et al. [19], discussed above, which identified a set of cognitive functions identified in patient decision-making.

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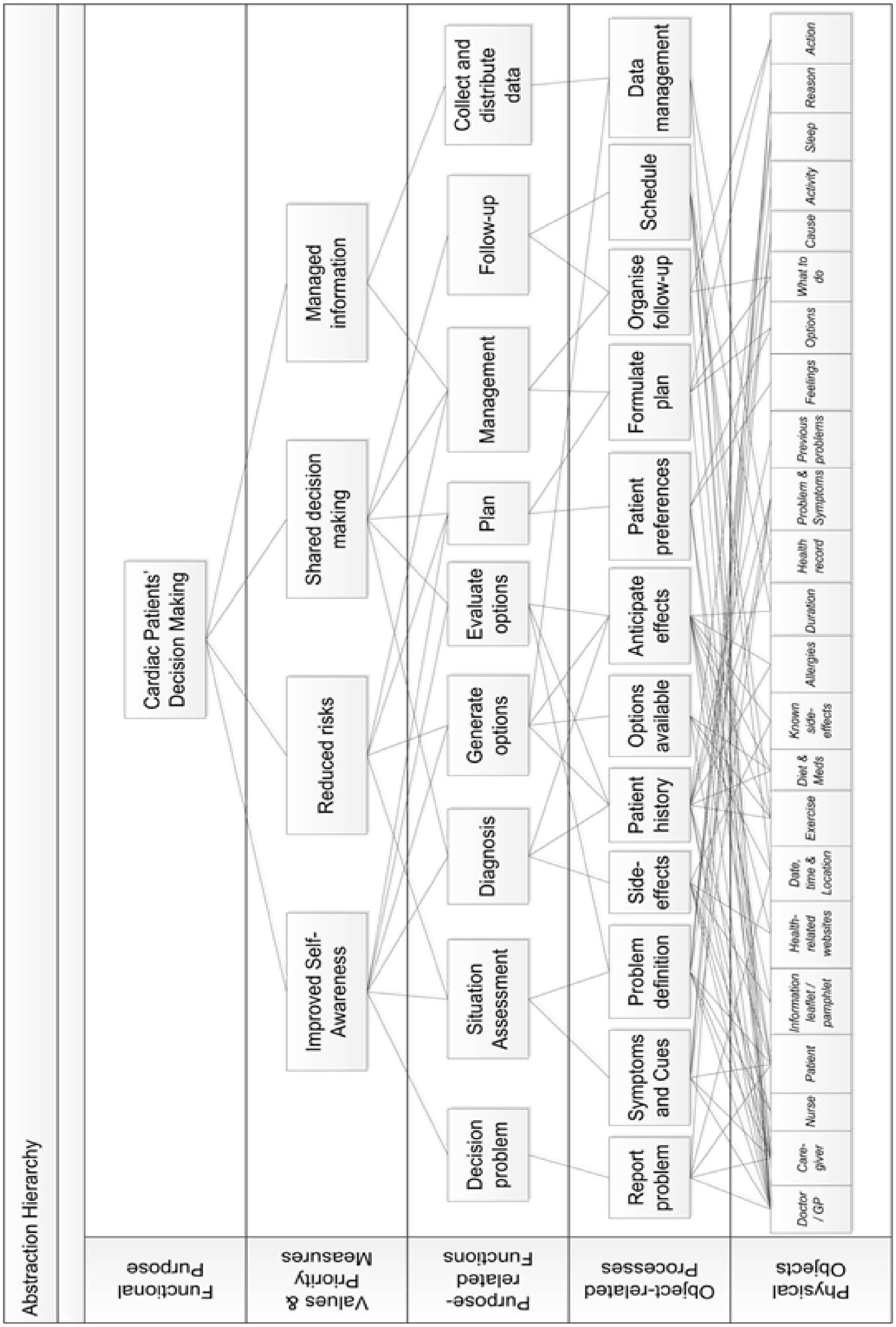

Figure 1: Abstraction hierarchy for Decision Analysis

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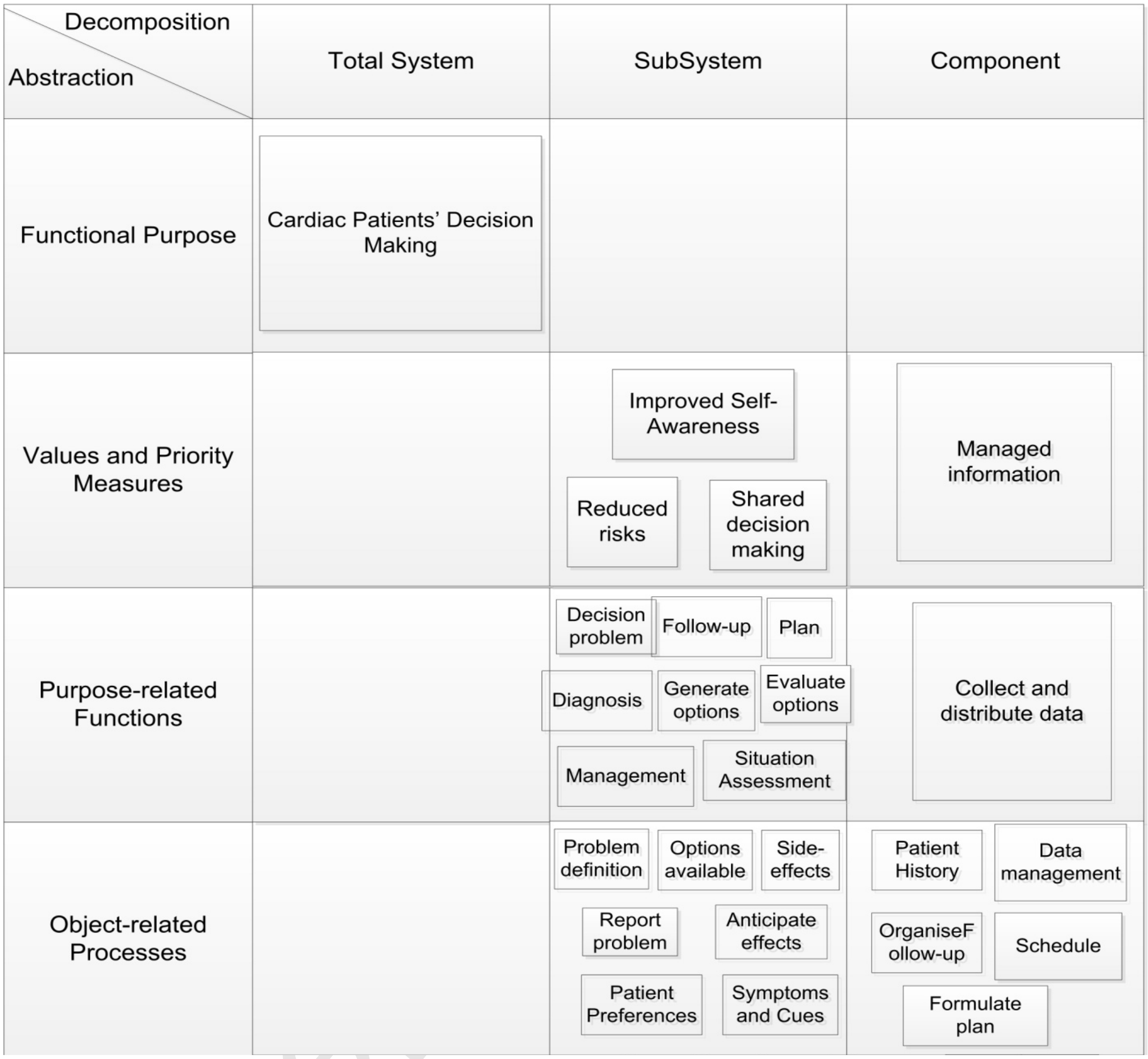

Figure 2: Abstraction Decomposition Space for Decision Analysis

Reviewing the scenarios outlined in the previous section, we were able to map these cognitive functions on to patient activity, and identified a further three functions (in italics below) which we felt were important in the context of this study. These represent the physical function-level information, or the components of decision domain and their capabilities.

- Decision Problem – carried out using problem identification, time and location.
- Situation Assessment – by using health cues, and problem distinction.
- Diagnosis – effective diagnosis includes anticipation, knowing side-effects, patient monitoring, and historic information.
- Options generation and Evaluation – is based on anticipation of the problem and accessing data from the data store.
- Planning – treatment planning is based on patient preferences and values.
- *Management/ Adaptation – course of action for the management.*

- *Follow-up – formulate follow-up procedures for self-care.*
- *Maintain database – for supporting shared decision making which involves scheduling, and managing healthcare information.*

WDA helps to identify values and priorities, purpose-related functions, object related processes, and physical objects needed to support decision process. Moreover, the functional purpose in WDA refers to the total system and the individual physical objects represent the components or subsystems as shown in Abstraction Decomposition Hierarchy (ADH) Figure 2. The 'total system' manages the Functional Purpose. The system is made up of subsystems which, in turn, are composed on components. The abstraction analysis considers whether functions are most likely to be performed at the subsystem or the component level. This leads to the distribution of the functions, values and priorities in Figure 2 (for ease of reading we have not include the physical components level of the ADH). Typically, CWA is applied to industrial systems in which the concept of subsystem and component is self-explanatory; in this paper, the division is less clear but we have assumed that a 'component' would involve an individual actor in the system whereas a subsystem would involve more than one actor. This abstraction helps designers to understand the patient's environment in terms of part-whole relationship through several conceptual levels that range from abstract to physical [22]. Each level in ADH provides a unique perspective of the same system to help the designer better understand the interaction between various resources and the information flow. WDA also helps the designer to understand what information is needed to accomplish the task goals and the implications for the design of DAs along with the underlying database and relationships [16].

4.2 Social Organisation and Cooperation Analysis (SOCA)

As noted in the WDA section, patient decision making often involves doctors, nurses and caregivers working with the patient. Our next challenge is to determine the role that each of these actors play in decision making. SOCA uses the ADH analyses, Figure 2, to map actors to functionalities in Figure 3. For example: 'decision problem' can be performed by patients on their own or with the help of caregivers / doctor / nurse, hence in Figure 3, white shading for "decision problem" refers to patient and "situation assessment" refers to all the actors involved in the decision process.

From figure 3, one can see that there is scope for the Purpose-related and Object-related Functions to be performed by either the patient or one of the other actors. In situations where there could be more than one actor performing a function, we assume that this could represent either a single individual performing the function or a combination of actors, perhaps in the form of a dialogue or collaboration. As with figure 2, we have omitted the physical objects level from this figure. In terms of designing DA, this could be used to determine when a patient might need to make contact with one of the other actors and to allow the design to consider how such contact could be supported.

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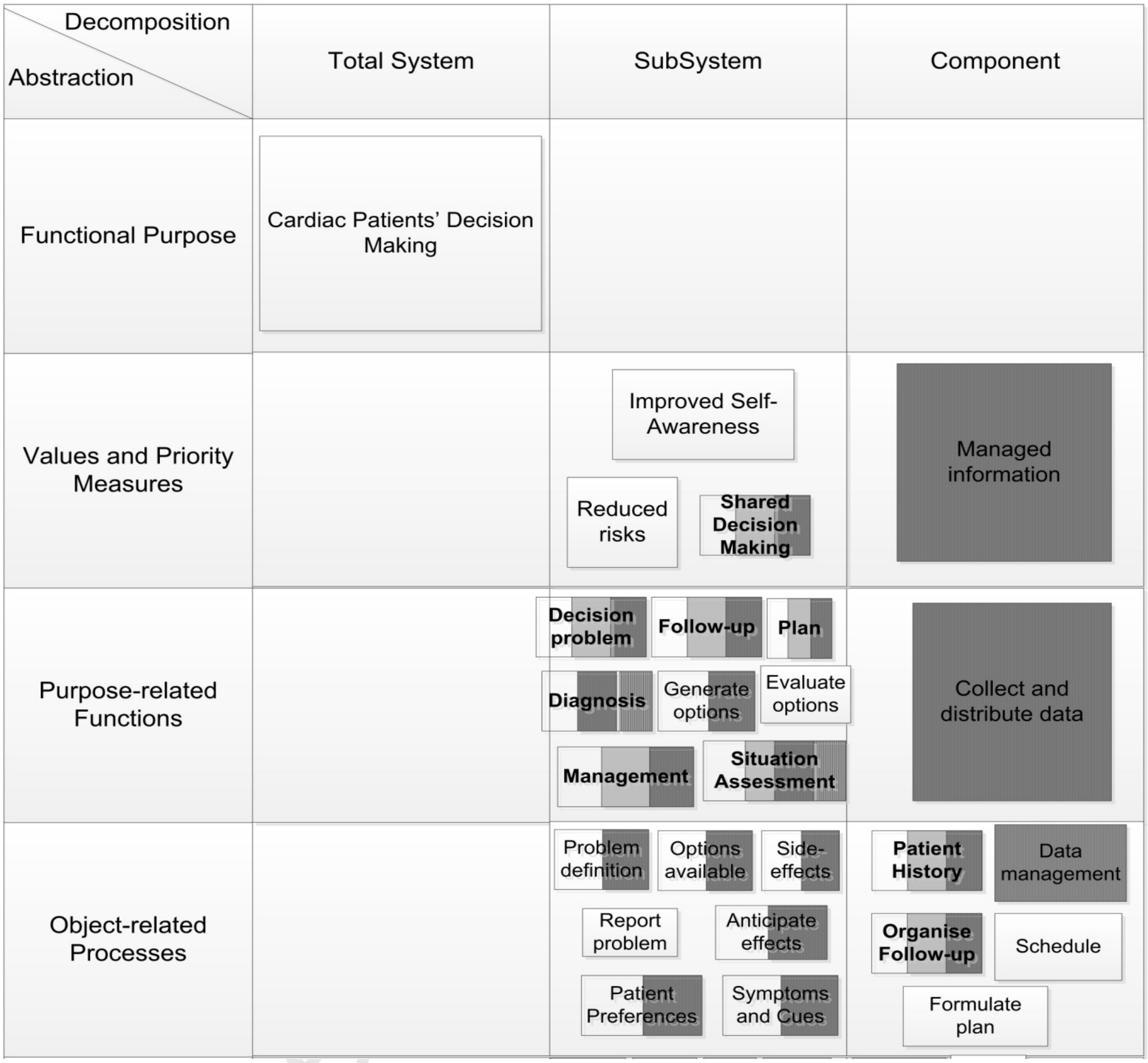

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Figure 3: Social Organisation and Cooperation Analysis

4.3 Control Task Analysis ('Decision Ladder')

From the functionalities and processes captured in the Abstraction Hierarchy, we can describe patients' decision making process using the 'decision ladder'. This allows us to focus on what decision goal has to be achieved independent of how the decision task is conducted or who the decision makers are.

To model the decision process, we grouped 20 patients' decision scenarios based on AH functional purposes such as medication, pain management and diet/ exercise for analysis. For this paper, we present four decision process scenarios CS7, CS12, CS15 and CS19 as shown in the supplementary document as an example for illustration (Figure 4). More decision processes using case scenarios are attached in the supplementary document.

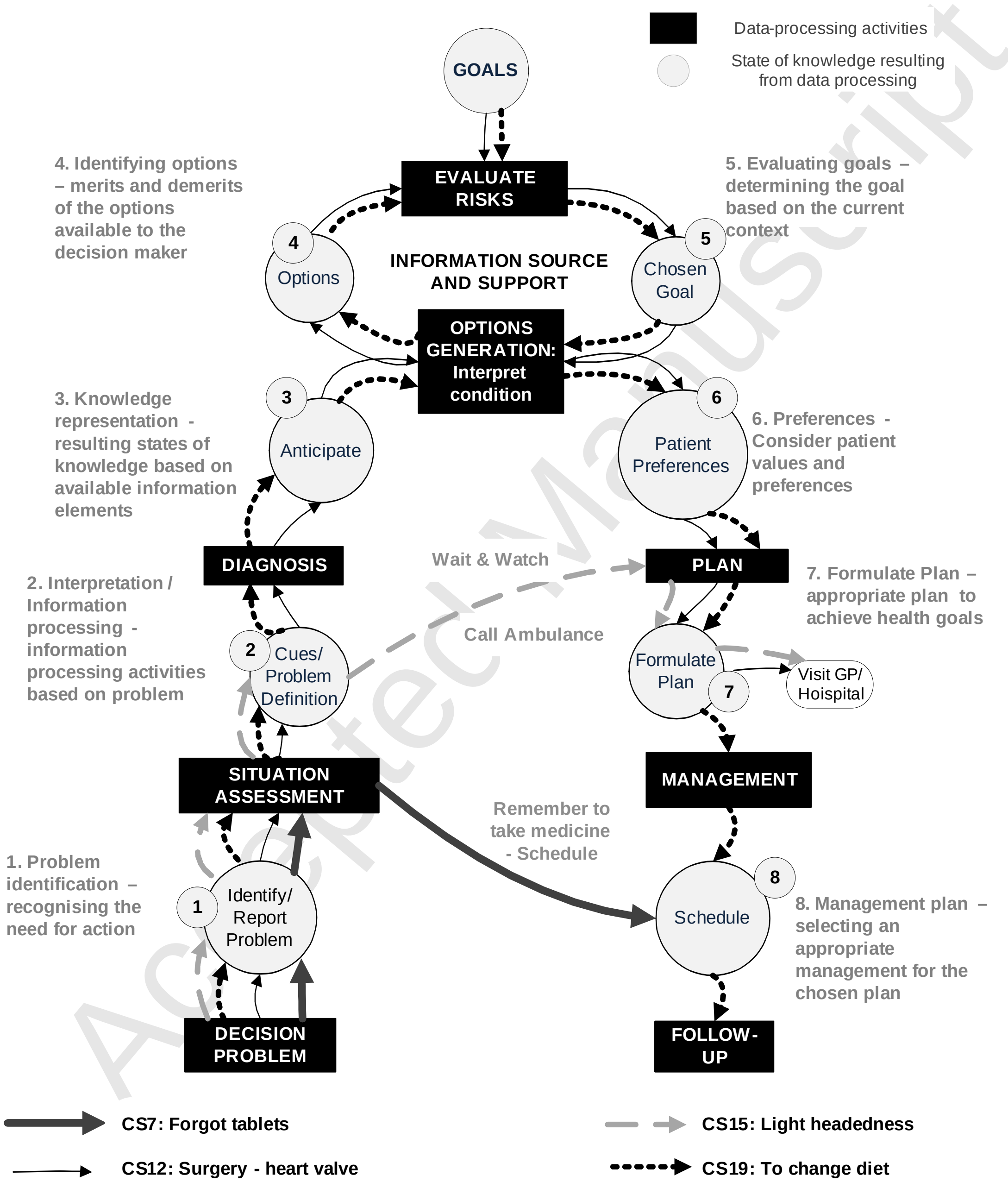

Figure 4: Patient Decision Making Process for Pain

The basic structure of Decision Ladder is defined by a series of states of knowledge and information processes arranged in a sequence that characterises rule, skill and knowledge-based behaviour. The decision ladder has 8 states of knowledge, shown as circles in Figure 4. These knowledge states arise from data processing actions, which correspond to the Purpose-

related Functions in figure 1, performed by the decision maker (shown by boxes in figure 4). As the Decision Ladder in this study is used to represent the processes involved in patient decision making, we have modified the names of activities from the traditional terminology used in the process industries to a more medically-oriented description. The dotted lines and the lines passing through the middle of the hierarchy labelled as "schedule", "call ambulance" and "wait and watch" (Figure 4) represent the 'shortcuts' that patients took in their decision making based on their knowledge and experience. This implies that patients' decisions are not always rule-based but can be influenced by skills, knowledge, experience and information / cues available to them.

Although patients' decision making can be described using decision ladders, it tends to be dependent on the nature of the problem and various factors including self-awareness, health condition, previous experience, and patient preferences. Due to these dependencies, each problem is considered to be distinct but the Decision Ladder analysis shows that due to the shortcuts the process seems to be similar. For example, the patient who has encountered decision problems like CS12 – Surgery for heart valve and CS19 – To change diet as gone through the whole decision process including gaining additional information for planning and management. Whereas in the of CS7 – Forgot tablets the patient seems to have used his past experience to decide as soon as the patient has identified the decision problem but in the case of CS15 – Light headedness the patient seem to have understood the health cues before arriving at a decision.

Decision Ladder analysis helps in the design of procedures to support patients in achieving their healthcare goals or to automate portions of these procedures [16]. The analysis also indicates which variables and relations of the work domain are relevant for a particular situation so the interfaces might be designed to present the right information at the right time for human-computer dialogues, as well as the flow of those dialogues [16].

4.4 Strategy Analysis

Using the decision ladder, we can describe patients' decision making processes starting from problem identification through to follow-up with various shortcuts. The next task is to contrast approaches to the decision problem in order to identify various courses of action or strategies that patients follow and to understand which strategies are possible for each of the decision problem. This is done using strategy analysis in CWA. Figure 5 provides example of some courses of action based on the decision ladder analysis along with the case scenarios to understand when patients need additional information for their decision problem and when patients would decide on their own. For example, when patient "Forgot tablets" like in CS7 the patient has immediately decided to remember to take medicine. In the case of "decided to change diet" like in CS19 the patient seem to have analysed the situation, has gone through the diagnosis and options evaluation stages before planning and management.

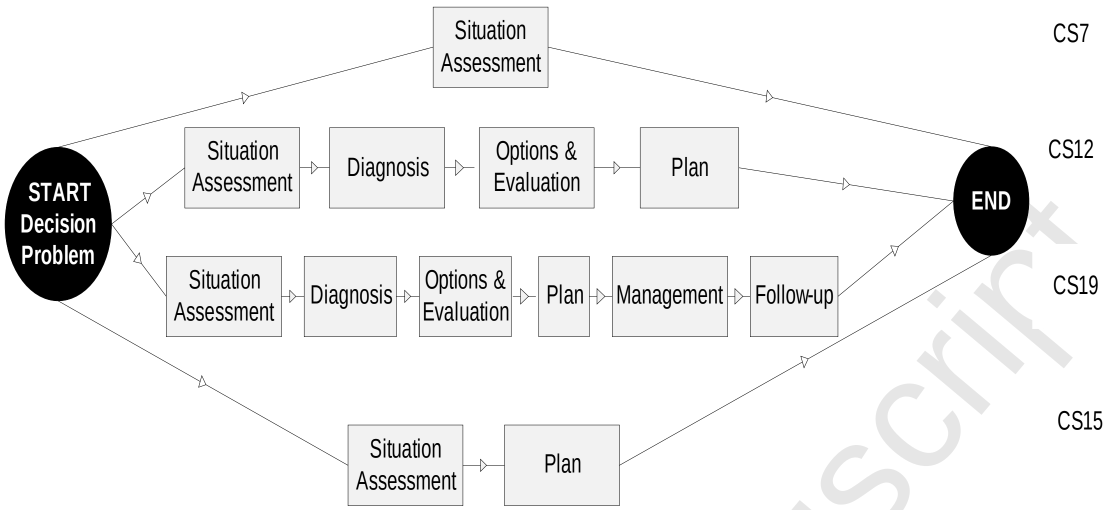

Figure 5: Example Strategies Analysis based on Decision Ladder Scenarios

The strategies analysis allows the designer to consider various courses of action to develop appropriate guidance and guidance for different strategies. At one level an essential aspect of self-management is the ability to ask the right questions. Through the decision ladder and strategy analysis, it is possible to develop a structured approach to asking questions to allow patient and DAs to reach a view.

4.5 Competencies analysis

The Control Task Analysis and Strategies Analysis show that decision making is highly dependent on patients' application of rules, skills and knowledge. Depending on the problem and patients' skill or knowledge the application of strategies or course of action differs. Therefore it is important to find out what competencies and system constraints are needed to support decision making.

Competency analysis deals with the mapping between required competencies of patients and the system constraints, and is typically performed using Skill, Rule and Knowledge based human behaviours referred to as SRK taxonomy (Skill-based, rule-based or knowledge-based). The application of different SRK taxonomy are as follows:

- In skill-based behaviour patients perception of the situation is mapped directly to the actions with no conscious behaviour control involved.
- In rule-based behaviour the patient is guided through a pre-planned sequence of actions.
- In knowledge-based patient uses situation assessment, planning and reacting to contingencies.

Table 2: Sample SRK inventory for Patient Competencies Analysis

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	Information Processing Step	Resultant State of Knowledge	Skill-Based Behaviour	Rule-Based Behaviour	Knowledge-Based Behaviour
1	**Decision Problem**	Identify the need for making a decision	Decision problem would be cued internally and have an automatic response.	Recognition of automatic response	Recognise uncertainty and lack of knowledge
2	**Situation Assessment**	Access the situation	Apply pattern recognition and/ past experiences.	Comparison between normal and current state. Analyse situation using past experiences.	Problem identification considered against overall objective.
3	**Diagnosis**	Anticipate future states and the current situation.	Anticipate the future state based on health cues.	Monitor vital signs and gather health cues. Rule-out side-effects and other causes.	Investigate the situation using patient history, health cues and side-effects.
4	**Options Generation & Evaluation**	Anticipation of the problem by comparing and evaluating the situation using information from various sources including doctors, hospitals, journals and more.	Evaluate the situation based on available information.	Evaluate the options available by considering the risks and benefits.	Recognise uncertainty and lack of knowledge by seeking additional information for considering the overall objectives and implications.
5	**Planning**	Course of action or management plan.	Choose a course of action based on the information gained.	Choose an appropriate action based on the patient's values and preferences.	Solve the problem with doctors, caregivers and family.
6	**Management**	Patient adapts to the plan.	Patient decides on the management plan for adoption.	Discuss with doctors and/ caregivers about the management plan for adoption.	Eliminate uncertainty and adapt to the plan to achieve the objective.
7	**Follow-up**	Encourage patient to accept appropriate responsibility.	Follow the management plan.	Patients take responsibility for self-management to improve health and well-being.	Follow management planning to successfully meet the goals.

By understanding activity using SRK we can map this information to the decision ladder to understand patient's behaviour at a control task level [13]. Table 2 shows the SRK based competencies for each information processing activity in the decision ladder. Each row in the table describes a single information processing activity and the column represent conceptualisation of behaviours that patients may exhibit when they perform an information processing activity. Table 2 column "Resultant State of Knowledge" is highlighted in grey to show the state of knowledge that would be achieved from the SRK given in the other columns. For example, a patient who has been diagnosed with CVD for more than 10 years would be demonstrating more skill-based behaviours, but may occasionally switch to rule-based behaviours when an appropriate rule set is available to enhance health and well-being. For example in CS9 when the patient experiences chest pain the decision is to "Stop, don't go out when cold and windy" which is a skill-based decision. Therefore, each of the actors can work at three different SRK level depending on the support provided for the patient to complete the desired activity. Table 2 helps to examine how information is used, exchanged, or processed and the need to support different human behaviours [37].

5. Discussion

CWA provides analysis of activity through the application of different perspectives. We can see, for example, which functions are most likely to be performed in collaboration with other actors (from the SOCA) and which functions might be more problematic for patients (from the Competencies Analysis). In terms of supporting decisions, CWA provides two very useful views which can be used to inform the requirements for patient DAs: the decision ladder highlights the ways in which patients (in the scenarios considered in this paper) obtain and make use of information in their decision making processes, and the strategies analysis illustrates how these processes might vary between patients. The analysis shows that decision making is a dynamic process rather than simply a matter of adhering to rules. Therefore it is evident that patients need a DA which can support different approaches to decision making.

From the WDA analysis, the high level requirements for the system become obvious (Table 3). Following this, the Decision Ladder and Strategy Analysis indicate that there are two types of decision requirements: the 'normative' sequence of stages through which one passes in order to make a decision and the decision 'shortcuts'. The 'normative' sequence is, in a sense, the rule-based approach in which patients comply with the instructions provided to them by health practitioners. Alternatively, one can look at the 'shortcuts' in which patients omit some of the steps in the Decision Ladder and ask how these might be considered in the design of DAs. In requirements Table 3, these approaches lead to different designs. In each design, the emphasis is less on providing information or cueing particular decisions and more on helping the patient to either recall similar experiences or to offer a means of recording the decision being made (for later recall).

Table 3: Summary of Requirements Extraction from CWA

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	1. Requirements Based on AH Phases
Functional Purpose	Design objectives: DA should be capable of guiding patients in their decision making process.
Values & Priority Measures	DA should help patients to improve self-awareness, reduce risks, help in shared decision making and manage health information by recording everyday activities.
Purpose-related Functions	Provide clear paths—including initial steps—for the user goals. Based on the decision problem, DA should generate a schema and initial plan based on considering all the purpose-related functions through pattern matching, helping patients to recall from past experiences.
Object-related Processes	Patients need to make their own decision so the system should not force patients instead guide through the process. Provide clear information scent at choice points to guide users to their goals through diagnosis and options generation. Provide feedback and status information to show users their progress toward the goal. Allow users to back out of tasks that didn't take them toward their goal and record their progress.
Physical Objects	Store information about patient's medical history, medications, side-effects and other information based on AH.
	2. Requirements Based on Strategies Analysis
Decision Problem	Help patient to define the decision problem. For example, when the patient has a decision problem, the user should choose the decision problem as – 'Pain', or 'Feeling Unwell'.
Situation Assessment	DA should help patients to identify the exact problem. Ask questions, help patients to recall their activities to find out if any lifestyle or behavioural or medication could have caused the problems. Help patient to apply past experiences in understanding the current decision problem.
Diagnosis	Summarize patients' identification of the problem and its cause for correct interpretation by looking into side-effects and medical history.
Options and Evaluation	Help patients to evaluate the optionsfrom trusted information sources like American Heart Foundation, NHS (National Health Service, UK) and BHF leaflets.
Plan and management	Help in patients care plan and management.
Follow-up	Follow-up procedures are created based on the care plan and management.
Collect and Distribute Data	Easy to use application to collect and store everyday activities
	3. Requirements Based on Decision Ladder for Shortcuts
Schedule	Help patients to schedule their diet, medication, exercise and follow-up meetings
Visit GP/ Call Ambulance	If the patient wants to see GP or call ambulance, DA should help patients.
Wait and Watch	DA should be able to record patients' decision making process along with the decision so it can follow up.
Review Past Experience	DA should be able to record all patients' decision needs and decision making process so that the system can help patient recognize past experiences and apply this knowledge in identifying and solving problem.
Reminders	DA should provide reminders for treatment adherence.

6. Study Limitations

This study is valuable as it helps to analyse every day decision making using CWA to extract requirements for supporting different strategies and human behaviour. However, there are still some limitations to this study:

- Questionnaire study: it would have been ideal to observe patients in their day-to-day life making various self-care decisions and in understanding the 'activities' it was not feasible to carry out observations due to patients' age and intrusiveness involved. Although questionnaire study would not provide a true reflection of the process collected from patients based on their recount of situation, we found that this process has helped to extract and synthesis decision making using CWA.

- Sample size: Moreover, results of this study should be interpreted with care with regards to small sample size as the analysis involved an interactive human-centered approach for refining concepts. The focus in this paper is to really give a good sense of 'typical' patient experience rather than an exhaustive catalogue of all experiences.

- CWA translation: The translation from the scenarios obtained from the interviews to the CWA representations, while following approach that is commonly used in CWA, has some scope for analyst opinion. By explaining the rationale for our analysis and demonstrating how the assumptions made in one stage of the CWA are pulled through into the next stage (ensuring consistency of analysis), we believe that the resulting descriptions can be easily audited and tested.

7. Conclusion

This paper has helped us extract and synthesise decision making using CWA to decompose the complex self-management problem through the multi-stage analytical framework for: identifying the functional requirements at several levels of abstraction and decomposition, identify the decision processes and work organization and strategies. In this paper, we make no assumptions as to the precise nature of these DAs: in some cases, it might be possible for them to be entirely paper-based while in others they might need to be automated. It is proposed that the majority of contemporary patient DAs focus on specific problems in very high-risk areas or focus on giving the "right" answer to the patients. Moreover, some researchers focus on developing expert and decision support systems that code, filter, and interpret sensed data using algorithms based on heuristics and traditional biomedical models to detect and diagnose patient events; however, they are currently constrained by the limited capabilities of the programmed software and sensor technology [11]. Thus, commercial patient DAs might not support patients in their decision making processes but rather concentrate on the provision of information. Of course, the provision of information is essential to the desire to create informed patients. However, access to more information is not the same as having support for making decisions. In some instances, patients might need support and guidance more than information. From the discussion in this paper, one can conclude that such designs are based on the notion of decision making following the complete CWA. It is proposed that the frameworks outlined in Table 3 could be used to survey these (and this is the subject of ongoing work in our laboratory).

Elwyn [35] suggests that DAs have incorporated different decision making theories into their development, based on implicit assumptions of their designers, and only a few have translated theory into intervention design. Stacey [36] concludes that DAs increase people's involvement in reviewing treatment options, improve patients' knowledge of treatments, lower decisional conflict between patient and consultant, and lead to realistic perceptions of outcomes. But to date only few studies have examined how patients actually make decisions. So we really need designs which better reflect "how patients make decisions" rather than "how should patients make decisions". Consequently, systems lack an understanding of the human behaviour or the psychology. This gap can be realised by understanding the following:

- first, the decision need and the decision making process of the patients;
- second, by employing a framework for modelling actual decision making process which can reflect such an approach.

This exploratory study shows how CWA can be used to fill this gap and capture patients' decision making process. Moreover common approaches to requirements extraction and design of DAs' lack details and model provided by CWA including: this model supports even non experts with a comprehensive and systematic representation of the system and for catching potential problems, understand how systems interact with other agents and the information flows, identify the means-end relations to examine the path between individual element and system goals. Thus this paper shows how designers of DAs can gain several benefits from using CWA.

This approach will contribute to the design of DAs for CVD patients which will support patients' ability to make decisions (as opposed to simply encouraging them to comply to rules). This approach is based on two basic assumptions. First, patients are in a position to make decisions which have an impact on their treatment. These decisions represent adaptations to their behaviour based on contextual demands. Second, patients are 'expert' in dealing with a particular CVD case: one based on their experience of living with the disease (often supplemented with the experiences of people with similar diseases), and the other based on medical knowledge and accumulated experience of treating many patients with related conditions. The notion that patients possess 'expertise' has a bearing on how one might describe their decision making. It is worth noting that this comparison does not take the 'quality' of either the decision or its outcomes into account. Rather, it is assumed that patients apply heuristics in their decision making to allow them to make context sensitive decisions in time limited situations.

A good DA is not a substitute for patient-doctor consultation, but should help patients to better understand their health condition and support them in their decision making process, which in turn would improve their self-care. Our descriptive model supports O'Connors' [31] view on good decision making, by helping patients make an effective, informed decision that is consistent with the decision makers' values and behaviourally implemented. This model not only improves the self-awareness of the patient but also enhances patients' decision making process rather than on good decision.

It is important that DA designers understand the importance of recognizing the factors that influence decision making and the decision-making process. This will, in turn, help to identify decision process within a population so that appropriate interventions can be selected to address the decisional determinants of a particular population.

Summary points

What is already known about the topic?

- There is a pressing need to develop self-management systems for cardiac patients to reduce the disease burden.
- Self-management can be supported by encouraging patients to recognize decision situations and by providing aids to help them respond appropriately.
- Patient decision making exists in the context of a wider healthcare system and that, as such, these decisions take place in a complex socio-technical system.
- Majority of contemporary patient DAs focus on specific problems in very high-risk areas or focus on giving the “right” answer to the patients because designers have incorporated different decision making theories into their development, based on implicit assumptions.

What this study added to our knowledge?

- This paper provides insights into extracting and synthesizing decision making using CWA to decompose the complex decision making problem through the multi-stage analytical framework.
- As decision making can be influenced by skills, knowledge, experience and information/ cues available to patients, it is argued that patients require different forms of DA to support different types of decision making.
- Application of CWA helps to identify which functions are most likely to be performed in collaboration with other actors (caregivers, doctors or nurses) and which functions might be more problematic for patients. This paper provides insights for DA designers to identify decision process within a population so that appropriate support systems can be developed.

Authors’ contributions

Anandhi V Dhukaram involved in the design, data collection and analysis of the Cognitive Work Analysis research for her dissertation under the guidance of Professor Chris Baber (Chair of Pervasive and Ubiquitous Computing) who assisted in writing this paper.

Competing interests

The authors declare that they have no conflicts of interest.

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Modelling Elderly Cardiac Patients Decision Making Using Cognitive Work Analysis: Identifying Requirements for Patient Decision Aids

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AUTHOR DECLARATION – CONFLICT OF INTEREST

We wish to confirm that there are no known conflicts of interest associated with this publication.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept emails (AVD016@bham.ac.uk or Anandhi.vivek@gmail.com)

Sincerely,

Anandhi Vivekanandan Dhukaram 20/09/13

Chris Baber 20/09/13

Modelling Elderly Cardiac Patients Decision Making Using Cognitive Work Analysis: Requirements Extraction for Patient Decision Aids

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author is the sole contact for the Editorial process. She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Signed by all authors as follows:

Anandhi Vivekanandan Dhukaram 20/09/13

Chris Baber 20/09/13