Persuasive Argument Schemes for Clinical Conflict Resolution: an Empirical Study

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Abstract. Argumentation theory is particularly well suited to support clinical decision-making due to its ability to reason with uncertain knowledge and derive defeasible and understandable conclusions. Subsequently, models of argumentation are being increasingly deployed in clinical decision-making systems to facilitate reasoning. However, challenges remain, including the development of more human-like argumentation which has the potential to improve the effectiveness of systems. As a step towards addressing this challenge, we have examined real-life clinical discourse during which clinical conflict was resolved. The dialogues captured from these interviews have been analysed to determine the methods of information selection and argument generation used. Further, we describe several argument schemes and associated critical questions which have been based on this real-life clinical discourse.

Keywords: Argumentation Theory · Intensive Care Unit · Decision-Support Systems · Persuasive Dialogue · Argument Schemes.

1 Introduction

Non-monotonic reasoning enables the capture and representation of defeasible inferences (i.e. conclusions that can be challenged and retracted as a result of further information). Argumentation theory [15], provides computational models of defeasible reasoning and has been applied in artificial intelligence and multi-agent systems. It is a structured technique for reasoning with uncertain information by the construction and evaluation of arguments relevant to alternative, and in some cases, conflicting, conclusions.

Models of argumentation have been increasingly deployed in human decision-making systems to support high-quality reasoning. The ability to derive defeasible conclusions and reason with incomplete and uncertain information, together with the closeness and transparency of argumentation to human understanding, makes argumentation particularly attractive to support medical decision-making. Examples of argumentation applications include clinical treatment decisions, and cooperative agents in healthcare teams [2], [8]. Hunter and Williams proposed an argument-based approach to aggregating clinical evidence as a formal approach to synthesizing knowledge from clinical trials involving multiple

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outcome indicators [12]. Clinical systems implementing argumentation include the Carrel+ system used in human organ transplantation [14] and the CONSULT system which helps patients self-manage their treatment [13]. For a more complete review of argumentation in medicine see [18].

Making sense of conflicting clinical opinions and medical information is one application where argumentation-based tools have potential to reduce a clinician's cognitive load. Such systems may need to enter a persuasive dialogue with a clinician and systematically reason about the available evidence. Argument schemes provide abstract descriptions of acceptable, possibly defeasible, arguments [16]. Frequently applied argument schemes in the medical field have been identified e.g. Argument for Treatment Risk and Argument for Better Treatment [9]. However, a gap can exist between established argument schemes and many real-life instances of the formalized phenomena. In some applications, specialised argument schemes have been developed to capture clinical reasoning e.g. in the aggregation of evidence from clinical studies [10] and dementia diagnosis [11].

In this paper, we investigate whether reasoning patterns observed from dialogue from clinicians resolving conflicting opinions can be represented as argument schemes and associated critical questions. Ultimately, the schemes will be used to form the basis of a clinical decision support tool. In this preliminary work the authors have created argument schemes to directly reflect the extracted patterns; further work will compare these patterns to existing argument schemes. We have chosen to focus our work on senior Intensive Care Unit (ICU) clinicians. ICU patients are critically ill, and often require decisions to be made rapidly, based on uncertain information; challenging for both human clinicians and clinical decision support systems [6]. Further, ICU knowledge is not 'solid' and clinicians often hold different perspectives given their different training and case mix seen [3]. Interviews were held in which clinicians were asked to discuss and resolve differences of clinical opinion. The dialogues from this study consisted of several different stages in which persuasion is combined with information seeking and inquiry moves, during which evidence is brought forward, used, and assessed to resolve the conflict and establish an agreed explanation of the clinical situation. Two stages of analysis were performed using the interview protocols. In the first, through grounded theory analysis [7], several categories were formed which encapsulated the various stages of discussion. In the second, the protocols were used to inform the development of persuasive argument schemes and associated critical questions.

This paper is organized as follows; section 2 details the ICU clinician studies; section 3 details the subsequent protocol analysis; section 4 describes the creation of argument schemes; and in section 5 we discuss our future plans.

2 Interviews to Resolve Differences between ICU Clinicians

Background In a previous study [4], several Intensive Care Unit (ICU) clinicians were asked to identify physiological anomalies from a set of patient datasets.

Clinicians were interviewed separately and shown patient datasets. A wide range of anomalies were identified by the clinicians, these included the following types of anomalies: patients not responding as expected to treatment, odd/unusual sets of physiological parameters or unusual rates of parameter change, unusual treatment, and unambiguously the wrong treatment given. We then investigated how clinicians developed explanations for one particular type of anomaly: anomalous patient responses to treatment. An example of such an anomaly and subsequent explanation is provided below:

Patient data contains: Adrenaline is administered to a patient and this is followed by a decrease in the patient's mean arterial pressure (MAP).
Clinician expects that: Adrenaline should increase MAP.
Consequently it is suggested that: A patient has responded anomalously to adrenaline.
One possible explanation for this is: The decrease in MAP may be caused by the patient's overall condition deteriorating at the same time.

Further analysis of the transcripts from this set of interviews found that different clinicians identified different anomalies from the same datasets. Although there may be many reasons for this (a paper on this topic is planned), in this work we are interested in how clinicians resolve these differences.

2.1 Resolution of Differences Study

In this section, we present a study in which we brought together two different pairs of clinicians from the previous interviews to discuss and resolve their differences in the identification of anomalies.

Stimuli: During the session, the clinicians were presented with examples of differences found during the earlier study and they were asked to attempt to resolve the differences. A difference was defined as an instance when one clinician has identified an anomaly and the other clinician in the group has not identified the same anomaly or has given a different reason for the anomaly. Below is an example:

Clinician 1 commented that the cardiac output increased when given noradrenaline (a vasoconstrictor) and that they wouldn't usually expect that (i.e. it was anomalous).

Clinician 2 commented that the noradrenaline was very high and the cardiac output was high but didn't make a comment on the connection between them.

The total number of instances in which the clinicians from both pairs differed during the previous study were examined beforehand by the interviewers (authors LM & DS) to determine the instances' suitability for the study. The potential instances of disagreement were also compared against the associated patient data and any instances with an obvious discrepancy between the comment and the data have been removed. For example, in one case a clinician references an increase in heart rate when the patient was administered noradrenaline as an anomaly; however, when the interviewers examined the patient data, the heart rate actually decreased, so such instances were removed.

For study 1, out of a combined total of 23 anomalies that Clinician 1 and 2 had identified, 1 instance was removed by the interviewers due to not enough data being available to discuss it in detail, 1 instance was removed due to the focus on an unreliable parameter[4], and 1 instance was removed because duplicate comments had occurred at different times in the session. 20 instances remained as suitable disagreements to discuss. A total of 9 instances were agreed upon between the two interviewers as representative of the range of types of anomalies and a suitable number for the length of the session.

For study 2, out of the combined total of 44 anomalies identified by Clinician 3 and Clinician 4, 12 instances were removed by the interviewers when the two clinicians immediately agreed with each other, 2 instances were removed as the data did not correspond to comments they made, 4 instances were removed as they solely referenced the same unreliable parameter as in study 1, 2 instances were removed because the corresponding clinician had not commented at all on the particular patient, and a further 6 instances were removed due to duplicate comments. 18 instances remained as suitable disagreements to discuss. The interview was time restricted. 11 instances were agreed upon between the two analysts as representative of the range of disagreement types found between the clinicians and a suitable number to discuss given the restrictions of session length.

Study Methodology: Each pair carried out the discussions independent of the other pair. Patient datasets associated with each difference were provided as a spreadsheet of recorded physiological parameters on a laptop, over which the clinician had full control. Before each discussion was carried out, the clinicians were told that the interviewers had found differences in the anomalies that they had detected for the patients and that the interviewers would like them to try and resolve these differences. The clinicians were told that the differences presented to them were from a comparison of their own transcripts. They were asked to see if they could resolve their differences using just the patient dataset and if this was not possible then they could request access to the patients' records. The patient records contained information routinely recorded on the ICU's Phillips ICIP system and included notes made by clinical staff on the patient during their stay, full drug information and some demographic information. The clinicians were asked to verbalize their thoughts as they tried to come to a resolution; the discussions between the participants was captured on a voice recorder and transcribed for analysis [17].

[4] Differences of opinion regarding the parameter, CVP, were largely discounted as it was suggested by the clinicians that CVP was an unreliable parameter. This is because the central venous pressure (CVP) reading is taken on an infusion line and can be easily affected by other transfusions given to the patient

3 Analysis of Transcripts

The transcripts of the protocols from both sets of interviews were analysed. The aim of the analysis was to analyse the structure and nature of the discourse to inform the development of argument schemes. Through grounded theory analysis, several categories were formed which encapsulate the various locutions during both discussions. Table 1 provides an overview of these categories. *Domain Knowledge Attack* and *Domain Data Attack* both described instances when a clinician's argument is undercut either using domain knowledge or the patient data as the source of the under-cutting argument. *Disagree* describes instances when a clinician disagrees with a statement, but does not offer a counter argument, or does not explain exactly what they disagree with. *Justify* describes examples in which an argument is reinforced with a more detailed argument to support it. *Understands Argument* describes instances when a clinician agrees with a sub-argument proposed by the other clinician. *Domain Data Support* and *Domain Data Refute* describe instances when the patient's data is used to support or refute an argument. *Restate Argument* is used to describe instances when the clinicians' original argument is restated during the course of the discussion. *Confirmation Request* encapsulates instances when the clinician asks a question to confirm their understanding of the situation. *Hypothesis* describes situations in which a clinician proposes a new theory to explain the clinical situation. This category differs from the attack categories as the clinician is not directly attacking a proposed argument. *Agreement* and *Discard* describe the outcome of the discussion.

Figure 1 shows a schematic representation of one of the discussions and illustrates our proposed coding scheme. The circles on the left of the figure denote the clinician number or interviewer. Following that is an abbreviation of the category applied to the transcription by the analyst. In this discussion, the original conflict was read out to both participants: Clinician 1 had identified that high doses of noradrenaline had been given to a patient and the patient appeared to have high cardiac output readings, whereas Clinician 2 had not commented on the patient's readings. The clinicians then proceeded to discuss the instances. Firstly, Clinician 2 suggested that a reason for the patient's cardiac output increasing was because they had become vasodilated and their heart rate had increased. However, when the patient's data is referred to, this is discounted by Clinician 1. Clinician 1 continues to discount this theory by also determining whether the patient had received fluids. Clinician 2 points out that the patient data does not show the patient receiving fluids. Clinician 2 then repeats their argument that the patient could have become vasodilated and instead suggests they look at the patient's systemic vascular resistance (SVRI). This argument is supported when they observe the patient data. To further support this argument, Clinician 2 asks whether the patient has been on vasopressin. Again, the patient data supports this argument. Clinician 1 concedes and agrees with Clinician 2 that the patient was vasodilated, causing the observed increase in cardiac output.

Table 1. Coding Scheme

Category	Code	Description
Domain Knowledge Attack	DKA	Clinician uses domain knowledge to undercut an argument
Domain Data Attack	DDA	Clinician uses knowledge from the patient data to suggest a counterargument
Disagree	D	Clinician states disagreement with an argument, but does not propose a counterargument
Justify	J	Clinician provides a justification as to why they made their statement
Understands Argument	UA	Clinician understands another clinician's point.
Domain Data Support	DDS	Clinician uses domain data to confirm a hypothesis
Domain Data Refute	DDR	Clinician uses domain data to refute a hypothesis
Restate Argument	R	Initial argument is restated
Confirmation Request	C	Clinician asks a question to confirm they have understood correctly
Hypothesis	H	Clinician states a hypothesis
Agreement	A	Both clinicians are in agreement with a particular point
Discard	DI	Clinician concedes that the other clinician was correct and their original point was incorrect

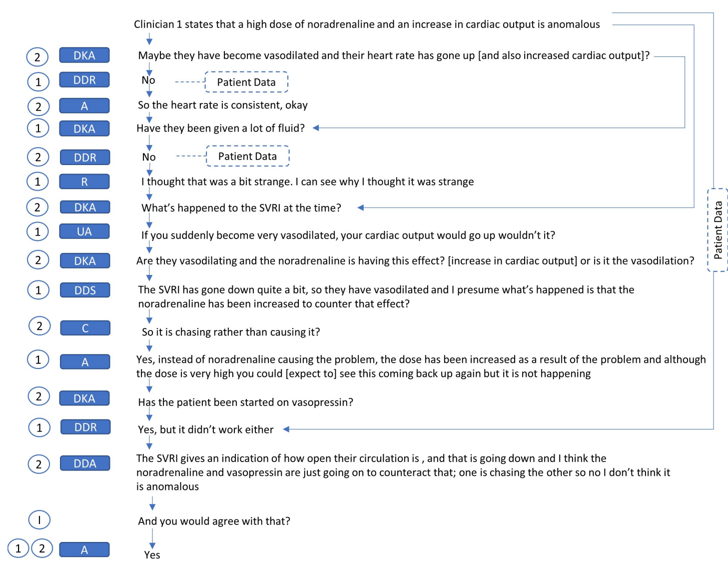

Fig. 1. Schematic Diagram. Key: 1 = Clinician 1, 2 = Clinician 2, I = Interviewer, dotted lines represents instances when the patient data examined

4 Argument Schemes and Critical Questions

The analysis of the clinicians' transcripts has provided us with insights into how clinicians *themselves* formulate and conduct discussions to resolve differences. In this section we use these insights to develop a number of persuasive argument schemes. Argument schemes are abstract descriptions of acceptable, possibly defeasible, arguments [16]. Associated with each argument scheme is a set of critical questions which can be used to evaluate the specific argument that fits the scheme. If the critical questions cannot be answered adequately, then the argument will fail to hold. For example, if argument A1 is an instantiation of an argument scheme and CQ1 is a critical question associated with it. The instantiation of CQ1, in the form of A2, can be used to attack A1.

From Table 1, the examples in which clinicians' locutions were coded as DKA, DDR, DDA, H and J were converted into defeasible argument schemes. Examples of argument schemes and critical questions are in Tables 2 and 3[5]. The argument schemes and critical questions make explicit the clinicians' reasoning. We have also shown how the argument schemes are applied by the clinicians.

Table 2. Example Argument Schemes. Key: DK(Domain Knowledge e.g. ICU knowledge), En(Entity e.g. drug), E(Expectation e.g. expected drug effect), S(Scenario e.g. drug administered), O(Observation e.g. clinical data), En2(2nd entity), En3(3rd entity)

Argument Scheme	**Description**	**Critical Questions**
Anom (DK,En,E,S,O)	DK contains En with an associated E in a given S AND O contains En, ¬ E, and S	Anom_CQ1, Anom_CQ2
DKA_1 (En, En2, En3)	En3 causes En2, therefore En does not cause En2	DKA_1_CQ1, DKA_1_CQ2
DKA_2 (En2, E)	En2 causes ¬ E, therefore ¬ E explained by En2	DKA_2_CQ1, DKA_2_CQ2
DKA_3 (En2, En, En3)	En2 causes ¬ E. En2 causes En3. Therefore ¬ E explained by En2	DKA3_CQ1, DKA3_CQ2
DKA_4 (En2, En, En3)	En2 causes ¬ E. En3 causes En2. Therefore ¬ E explained by En3.	DKA_4_CQ1
DDR_2 (O, En)	O contains ¬ En, therefore En did not occur in O.	

To illustrate the argument schemes, we return to the example dialogue shown in Figure 1. Due to space limitations we have only discussed part of the dialogue; the rest is visualised in Figure 2. Originally Clinician 1 stated that noradrenaline had been given to a patient and an increase in cardiac output was observed. This anomaly can be represented as an instantiation of the Anom argument scheme (Table 2) and considered as Argument 1 (A1) submitted by Clinician 1.

A1: *Clinician 1 believes that noradrenaline is expected not to increase cardiac*

[5] For a full listing of argument schemes see http://www.ideasresearch.org/CMNA.html

Table 3. Example Critical Questions. For key see Table 2

Critical Question	Description
Anom_CQ1	Is ¬ E caused by another En?
Anom_CQ2	Does O contain another En?
DKA_1_CQ1	Does O contain another En2 in S?
DKA_1_CQ2	DK contains En with E. Did O contain, En and E?
DKA_2_CQ1	Does O contain En in S?
DKA_2_CQ2	Does another En3 cause En2?
DKA_3_CQ1	Does O contain En in S?
DKA_3_CQ2	Is En2 caused by another En?
DKA_4_CQ1	Does O contain En in S?

output following administration to a patient. Patient data contains noradrenaline and an increase in cardiac output following administration to the patient.

In our example, Clinician 2 suggested that the increase in cardiac output may be because the patient was vasodilated and that their heart rate could have increased. This attack on A1 is reflected by Anom_CQ1 i.e. Is an increase in cardiac output caused by vasodilation? To form an argument based on this critical question, the DKA_3 argument scheme is applied:

A2: *Vasodilation causes increase in cardiac output and heart rate, therefore observed increase in cardiac output caused by vasodilation*

Clinician 1 then attacks A2, using the critical question DKA_3_CQ1, i.e. suggesting that the required symptom (increased heart rate) of vasodilation is not observed in the data. This is done through an instantiation of the argument scheme DDR_2:

A3: *Patient data contains no increase in heart rate, therefore increase in heart rate did not occur*

5 Discussion and Future Work

Computational models of argumentation which reflect observed clinical reasoning and subsequently are deployed in clinical decision support systems have the potential to improve the effectiveness of such systems and yet are largely unexplored within medical contexts. Earlier work by the authors created argument schemes based on actual mechanisms applied by clinicians to generate explanations [1]. In this work we have turned our focus to *persuasive dialogue between clinicians*. Formalizing clinicians' resolution of differences as argument schemes enables a greater understanding of the strategies applied by the clinicians. Contributions of this work include: 1) categories describing locutions relevant to the resolution of clinical conflict, 2) demonstration of the applicability of argument

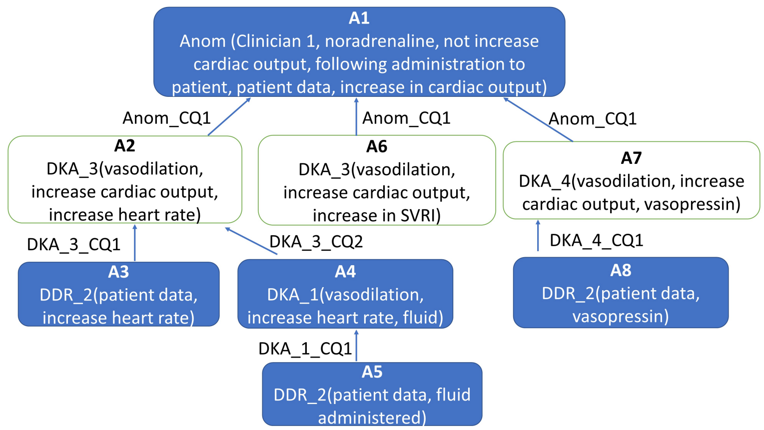

Fig. 2. Dialogue moves expressed in terms of argument schemes & critical questions.

schemes for representing the exchange of arguments made during clinical conflict resolution, and 3) a preliminary set of argument schemes and critical questions which could be implemented as part of a clinical decision support system.

Planned future work includes further exploration of clinical dialogue. Studies, such as the one presented in this work, are exploratory in nature, involve detailed and time-consuming protocol analysis, and virtually always run with a small number of subjects. In effect, they seek to identify interesting hypotheses which can then be subject to quantitative analysis. This work explored a total of 20 instances of disagreement covering a representative sample within an ICU context, but it would be interesting to compare and contrast styles of persuasive dialogue in other medical specialties and investigate the generalization of the current argument schemes. Additionally, the effect of a debating clinician's status, relative to the other clinician, could be considered; in this study, clinicians were of an equal professional status, however, it is hypothesised that if a junior clinician was debating with a more senior clinician, then different dialogue patterns may be observed. Such studies are planned.

The argument schemes observed, capture clinical reasoning during a specific clinical context and as yet have not been considered from a generic reasoning perspective. It is acknowledged that substantial work in the field has identified argument schemes which represent generic reasoning strategies [16]. Further analysis is planned to establish whether the clinical reasoning observed in this clinical context reflects such existing, generic, argument schemes, e.g. Argument from Best Explanation and Argument from Sign, or whether the observed clinical reasoning requires novel argument schemes to best represent it.

Longer term we plan to evaluate the developed argument schemes for their persuasive power and potential for use in a clinical, argumentation-driven, decision support tool. Further, there is potential for the critical questions that have been used in this work to develop junior clinicians' critical and argumentative skills as part of this tool.

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