Personality-Based Practical Reasoning*

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Abstract. In virtual training scenarios, agent technology can be used to build a virtual tutor that assists a student during training. In a dialogue using argumentation schemes, the virtual tutor provides reasons to the students to explain why a particular action is the most sensible. The tutor determines the best action using practical reasoning. The justification of this action is selected based on the personality type of the student. This paper studies how agent technology could be used to make a virtual tutor that assists the student during the training. In particular, we study how the tutor can generate persuasive arguments for what the student should do.

1 Introduction

The context of this paper is the training of firemen in virtual scenarios, such as the following:

> In a remote place a truck is involved in an accident, and catches on fire. On the truck there is a sign stating that there is gasoline inside. Gasoline is highly flammable and can cause an explosion when set on fire. Near the truck there are several injured people who are not able to move.

In this scenario there are several decisions that the student needs to make. For example, whether to first evacuate the injured people or first to extinguish the fire in the truck. If the student is training as commander, he might have to persuade his team members to take a particular course of action. In this case he has to learn to use the personality type of his team mates in order to give the right commands. E.g. one type of person might be concentrating on the overall situation and miss the sign on the truck. Another might start the standard procedure of using water to extinguish the fire, only thinking about a possible huge explosion, but ignoring the injured people. So, this is the first point where an argumentation dialogue should be supported.

The second situation in which a personality based dialogue can take place in the training scenario is when the student requires feedback while training in

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virtual scenarios. For example, when the student makes a mistake, he needs to understand what went wrong and why. A virtual tutor can assist a student in this process.

During training the virtual tutor will stop the simulation and engage in a dialogue with the student about the best action at that particular time. This paper focuses on how the personality type of the student can be used in selecting the best justification for a certain action in the case of such a feedback situation during the training. Personality theory explains how individuals of a certain type conduct their reasoning; from this we can ascertain what information they would be most receptive to initially. Presumptive reasoning using argumentation schemes is used to perform practical reasoning, i.e. to reason about what action is the most sensible thing to do.

This paper is structured as follows. After the background has been sketched in section 2, section 3 describes how practical reasoning is done using argumentation schemes, and describes an algorithm to select the best argument based on the personality type of the student. Section 4 shows how the theory can be applied to the scenario. Finally, section 5 provides some conclusions and directions for future work.

2 Background

2.1 Personality Type Theory

Within personality psychology there are many theories that study personality and individual differences. Type theories classify persons into personality types. A popular type theory, the Myers-Briggs Type Indicator (MBTI), is based on the typological theory of [1]. Although the scientific basis of both MBTI and Jung have been questioned, the theory describes aspects that we recognize in everyday life, and seem interesting for agent technology. Furthermore, [2] describes how to adapt communication to an individual using its personality type.

The Myers-Briggs Type Indicator (MBTI), as introduced in [3], is a personality questionnaire designed to identify certain psychological differences as described in [1] work. These psychological differences include attitude, perception function, the judgment function, and lifestyle. The personality type determines what effective communication is. [2] describes how to use MBTI to communicate effectively. There are two important elements in effective communication: what is communicated, and how it is communicated. This paper focuses on what is communicated. As we focus on the content of the message we will use only the Sensing/Intuition preference, and therefore omit three of the four dimensions, type dynamics, and type development. Our theory thus should be seen more as an example of how personality type should be incorporated in the argumentation framework rather than an all encompassing framework.

People who prefer Sensing first want and give information that is real, concrete, practical, factual, and specific, whereas people who prefer Intuition first want and give information that is insightful, opens possibilities, uses the imagination, presents an overview or synthesis, and shows patterns. Sensing people

ask what and how questions; they speak of what is or what has been and give precise factual descriptions. Intuition people ask what if and why questions; they speak of what might be, what the main issue is, and what jumped out using 'sort of' and general impression descriptions. All of us can and do use both Sensing and Intuition to gather information, but each of us has a natural preference for one over the other.

2.2 Practical Reasoning

Using argumentation schemes to derive conclusions is a form of presumptive reasoning which is used commonly in everyday life [4]. Presumptive reasoning is non-monotonic since it is always subject to revision or correction when new information becomes available. Presumptive reasoning using argumentation schemes is used in [5] to do practical reasoning. Our goal is to make a virtual tutor that explains to a student fireman why a particular action is the best action to take in a certain situation. Using argumentation schemes is an appropriate way to do this since people use them naturally, and it allows the student to ask questions and to attack the conclusions.

In [4] Walton presents the argument from consequences that was already present in [6]:

> If action a is brought about,
> then good (bad) consequences will / might occur.
> Therefore, a should (not) be brought about.

However, in [4] (p. 77) Walton notes that the argument from consequences is highly problematic, in light of its treatments in logic textbooks of that time. In [7] Walton presents the following reasoning scheme for practical reasoning called the *sufficient condition scheme for practical reasoning*:

> G is a goal for a,
> doing A is sufficient for a to carry out G,
> therefore, a ought to do A.

The sufficient condition scheme for practical reasoning was later extended in [5] by separating the notion of a goal into: the state of affairs brought about the action, the goal (the desired features in that state of affairs), and the value (the reason why those features are desired). The extended argumentation scheme is as follows:

> $AS1$:
> In circumstances R,
> one should perform action A,
> to achieve new circumstances S,
> which realise goal G,
> which promotes value V

Preferences based upon individual values emerge through the practical reasoning process. [5] uses the term *values* to denote some actual descriptive social attitude/interest which an agent may or may not wish to uphold or subscribe to and they provide an actual subjective reason for wanting to bring about a particular state.

Disagreement about the conclusion is divided into two categories: those that dispute facts, and those that dispute value preferences. This paper takes $AS1$ as a starting point for its argumentation framework since it has a clear connection to BDI agents, which we plan to use for implementing the virtual tutor. It is clear that it does not contain references to personality type. So, the main goal of the paper is to fit elements of personality types in this scheme and the dialogue rules.

3 Basic Formalism

This section describes how to optimise the justification to perform an action for a specific personality type by anticipating on what justification is preferred by that personality type. The justification to do an action is an argumentation scheme with the conclusion that you should perform a particular action. Next, critical questions are described that test the validity of this argumentation scheme, and we give our interpretation of the natural interest that personality types have for specific critical questions. Finally, we describe what kind of answers personality types prefer to hear. We assume that the personality type of the student is known to the system (very simple, fast tests exist to find the MBTI type of a person).

3.1 Basic Notions

In this subsection some basic notions, which are mostly taken from [5], are described which will be used in later sections. We define separate sets containing the basic elements of the framework. A predicate logic is used in the standard way extended with several relations and one function.

- a finite, non-empty set, $State$, of states
- a finite, non-empty set, $Action$, of actions the student can perform
- a finite, non-empty set, $Prop$, of propositions in the predicate logic
- a finite, non-empty set, $Goal$, of goals where $Goal \subset Prop$
- a finite, non-empty set, $Value$, of values
- a relation $results(a, r, s)$ with $a \in Action$ and $r, s \in State$ to be read as: performing action a in state r results in state s
- a relation $realizes(s, g)$ with $s \in State$ and $g \in Goal$ to be read as: state s realizes goal g
- a relation $precludes(a, b)$ with $a, b \in Action$ to be read as: action a precludes action b
- a predicate $oughtToDo(a)$ with $a \in Action$ to be read as: it is sensible to perform action a in the current state

- a function $effect : Goal \times Value \rightarrow \{+, 0, -\}$ to be read as: the effect of the given goal on the given value is + when the value is promoted, 0 when there is no effect on the value, and − when the goal demotes the value
- $p \vdash_{arg} q$ to be read as that q can be derived using argumentation schemes from p

Besides these basic elements, in later sections new relations will be introduced when needed.

3.2 Practical Reasoning Scheme

We use a slight modification of the argumentation scheme for practical reasoning as used in [5]. We have modified it by making the premises and the conclusions explicit.

> PR:
> premise 1: The current state is r,
> premise 2: performing action a in state r results in state s,
> premise 3: s realizes goal g,
> premise 4: g promotes value v,
> conclusion: therefore, you should perform a

The argumentation scheme PR provides a justification for the conclusion that you should perform action a. It states that the current state is r, and performing action a leads to a new state s which realizes your goal g. This goal promotes your value v, and therefore action a is good and you should perform it. It assumes that the student wants to promote value v, and that the student creates goals in order to promote value v. The formal notation of PR is

$$r \wedge results(a, r, s) \wedge realizes(s, g) \wedge (effect(g, v) = +) \Rightarrow oughtToDo(a)$$

For example, in our scenario a practical argument that justifies extinguishing the fire in the truck could be: in the current state where there is a fire in the truck and injured people being near, extinguishing the fire will result in no fire in the truck, which will realize the goal of having no explosion, which promotes the value of saving lives.

The argumentation scheme PR is not fool proof as it is a form of presumptive reasoning, hence a person can disagree with it, or can wonder whether the premises actually hold. To test the justification critical questions can be asked to which the proponent should respond. If the proponent cannot give satisfying answers, the conclusion that you should perform a is weakened.

The critical questions in table 1 are based on [5], and test the premises made in PR by asking whether the stated premises are true. Table 1 also provides the corresponding attacks which the receiver of the argumentation scheme can make when he has additional information.

Table 1. Critical questions and possible attacks associated PR

	Critical Question	**Possible Attack**
1.	is it true that the current state is r?	$\neg r$
2.	is it true that performing action a in r results in state s?	$\neg results(a, r, s)$
3.	is it true that state s realize goal g?	$\neg realize(s, g)$
4.	is it true that goal g promotes value v?	$\neg promote(g, v)$
5.	are there alternative actions that result in state that realizes goal g?	$a' \neq a \wedge results(a', r, s') \wedge realize(s', g) \wedge s' \neq s$
6.	are there alternative goals that promote value v?	$(effect(g', v) = +) \wedge g' \neq g$
7.	does a demote or promote other values?	$results(a, r, s) \wedge realize(s, g') \wedge \neg(effect(g', v') = 0) \wedge g \neq g' \wedge v \neq v'$
8.	does a preclude another action which promotes some value?	$a \neq a' \wedge results(a', r, s') \wedge realize(s', g') \wedge (effect(g', v') = +) \wedge precludes(a, a')$

The first four critical questions, CQ1-4, question the explicit premises in PR. CQ5-8 question implicit premises in PR which may not be obvious at first sight, but are relevant for the conclusion.

For example, attacks of CQ5-8 in our scenario could be an alternative action that results in the state that realizes the goal of no explosion, for example by removing the gasoline from the truck. An alternative goal to promote the value of saving lives would be to evacuate the people near the truck. The action of extinguishing the fire also promotes the value of minimising material damage.

3.3 Answers

To provide answers to the critical questions associated with PR, [5] is extended by using argumentation schemes with as conclusion the answer to the critical question. Walton describes in [4] 25 argumentation schemes, but here only a few are explained that are necessary for the scenario.

Argument from Expert Opinion. The argument from expert opinion states that when a true expert asserts $p \in Prop$ that is within his expertise, then it is reasonable to take p to be true. To represent this argumentation scheme, the following new notions are added to our predicate logic:

- a finite, non-empty set of experts called E
- a finite, non-empty set of domains of expertise called D
- a relation $expert(e, d)$ with $e \in E$ and $d \in D$ to be read as expert e is an expert in the domain d
- a relation $within(p, d)$ with $p \in Prop$ and $d \in D$ to be read as proposition p is within the domain of expertise d

– a relation $assert(e, p)$ with $e \in E$ and $p \in Prop$ to be read as expert e asserted that p is true

Now we can introduce the argument from expert taken from [4]:

AE:
premise: e is an expert in domain d,
premise: e asserts that p is known to be true,
premise: p is within d,
conclusion: therefore, p may (plausibly) be taken to be true.

formally: $expert(e, d) \wedge assert(e, p) \wedge within(p, d) \Rightarrow p$

Table 2 describes the critical questions and corresponding attacks of AE. The critical questions are taken from [4].

Table 2. Critical questions and corresponding possible attacks associated with AE

	Critical Question	**Possible Attack**
1.	Is e a genuine expert in d?	$\neg expert(e, d)$
2.	Did e really assert p?	$\neg assert(e, p)$
3.	Is p relevant to firefighting?	$\neg within(p, d)$
4.	Is p consistent with what other experts in d say?	$expert(f, d) \wedge f \neq e \wedge assert(f, q) \wedge (p \wedge q \vdash \bot)$
5.	Is p consistent with known evidence in d?	$p \wedge q \wedge within(q, d) \vdash \bot$

Our application deals mostly with a single domain, namely firefighting, but in more complex situations there will be other domains like for example health care, police force, and traffic regulation.

Argument from Observation. The argument from observation is a simplified version of the argument from sign and the argument from evidence to hypothesis, both from [4]. The argument from observation is that because I have observed that p is the case, p is the case. For this a new predicate is introduced which is added to the logic:

– a predicate $observation(p)$ with $p \in Prop$ to be read as I have observed that p is the case

With this predicate, we can now introduce the argument from observation:

AO:
premise: p is observed in this situation,
conclusion: therefore, generally p is true

formally: $observation(p) \Rightarrow p$

The associated critical questions and attacks are described in table 3.

Table 3. Critical questions and possible attacks associated with AO

	Critical Question	**Possible Attack**
1.	How certain was the observation?	$\neg observation(p)$
2.	Is the observation consistent with other observations?	$observation(p) \wedge observation(q) \wedge (p \wedge q \vdash \bot)$

Argument from Cause to Effect. The argument from cause to effect, taken from [4], argues that if an event takes place, then that will cause an effect. For example, fire and gasoline brought together will cause an explosion. For this we need a new relation which is added to the predicate logic:

- a relation $cause(s, t)$ with $s, t \in State$ to be read as state s causes state t to occur

The argument from cause to effect is as follows:

ACE:
premise: generally, if p occurs, then q will (or might) occur,
premise: in this case, p occurs,
conclusion: therefore, in this case, p will (or might) occur.

formally: $cause(p, q) \wedge p \Rightarrow q$

The associated critical questions and attacks are described in table 4.

Table 4. Critical questions and possible attacks associated with ACE

	Critical Question	**Possible Attack**
1.	How strong is the causal generalization (if it is true at all)?	$\neg cause(p, q)$
2.	Is the evidence cited strong enough to warrant the generalization as stated?	$p \wedge cause(p, q) \wedge \neg q$
3.	Are there other factor that interfere with or counteract the production of the effect in this case?	$p_2 \wedge (\neg cause(p \wedge p_2, q) \vee cause(p_2, \neg q))$

The above argument schemes and critical questions do not contain personality elements yet. These will be added in the next subsection.

3.4 Personality Types and Practical Reasoning

Table 5 is taken from [2] and and quotes several characteristics of people who prefer Sensing and people who prefer Intuition to provide some insights to the reader of what the Sensing and Intuition functions are. [2] is not written with argumentation schemes nor software agents in mind, so the techniques described in this paper are our interpretation of [2].

Table 5. Characteristics of the Sensing and Intuition functions

People who prefer Sensing	**People who prefer Intuition**
trust experience	trust hunches and inspirations
respect what is proven	use imagination to create something
first want and give information that is real, concrete, practical, factual, and specific	first want and give information that is insightful, opens possibilities, uses the imagination, presents an overview or synthesis, and shows patterns
give precise descriptions	use 'sort of' and general impression descriptions
give factual statements	give analogies and metaphors

[2] explains that the Sensing function considers facts and focuses on what is: what is the problem, what is the purpose or goal, what is the time frame, what is the status of resources, etc. The Intuition function generates possibilities and focuses on what could be: what are the ideas, what are the possibilities, what is the vision, dreams and the ideals.

Table 6 is taken from [2] and provides suggestions how to gear teaching towards people preferring Sensing or Intuition. This table is relevant for our virtual tutor since our tutor teaches the student what to do in a certain situation.

Table 6. Suggestions for teaching to people preferring Sensing and Intuition

People who prefer Sensing	**People who prefer Intuition**
Present facts and realistic details, paying attention to parts of the whole and steps of the process	Present options and possibilities
Provide thorough, concrete data	Provide analogies, symbols, and theoretical models
Allow the listener to build a body of evidence step-by-step from the details to the theory and to interact with the information about practical, hans-on information	Allow the listener to attach details, facts, and steps onto the conceptual idea and to interact with the information through imagination and insights

The Sensing function. A SENSER trusts his senses, experience, and respects what is proven. A thorough body of evidence is built by first focusing on real, concrete, practical, factual, and specific information. For example, observations are trusted since they come from the senses, and are real and concrete. With a thorough body of evidence, a detailed understanding is obtained of the problem, the goal, and the relation to the values. With a proper understanding of the goal, a SENSER reasons about what actions will realize the goal. Since the goal is clear, reasoning about the action can be practical, specific, and detailed. To a INTUIT, a SENSER might appear to be literal, narrow-minded, or stuck in a rut.

The practical reasoning process of a SENSER first focuses on obtaining a solid understanding on what is the case and the problem. When presented the practical reasoning scheme PR, a SENSER naturally starts with obtaining a solid understanding by using CQ1 to ask for justification for what the current state r is. When given an answer with the conclusion that r is the case, a recursive process of asking critical questions is started until either observations or expert knowledge is given, or when his knowledge can sufficiently answer the critical questions. With a proper understanding of r, CQ2 can be answered more concretely since the resulting state s from action a depends on r. With a detailed description of s, CQ3 can be answered by justifying that s realizes goal g. Similarly, CQ4 can be answered by justifying that g promotes value v.

When presented a practical reasoning scheme that provides proper justification to perform action a, a SENSER is pretty satisfied because of his practical nature. However, he might reason further, using CQ5, about whether there are alternative actions that realize goal g that are better than the proposed action a. He might also use CQ6 to reason about realizing other goals that promote v, use CQ7 to reason about the effect a has on other values, and use CQ8 to reason about whether a precludes another action that promotes other values.

The Intuition function. An INTUIT trusts hunches and inspirations, and looks for immediate and long-range implications by using intuition and imagination. Intuitive reasoning is reasoning without being aware of all conscious reasoning steps. Naturally, an INTUIT first wants information that is insightful, opens possibilities, uses the imagination, presents an overview, and shows patterns. Insightful information gives an overview of how to reach a conclusion, but does not give all reasoning steps that are required to reach that conclusion. Since the understanding is based upon hunches and intuition rather than facts and rules, an INTUIT may be wrong about the conclusions he takes. To a SENSER he might appear ungrounded and impractical.

When presented the reasoning scheme PR, the practical reasoning process of an INTUIT starts with CQ1 to get an overview or big picture of the current state r in which he does not make all reasoning steps that are required to derive r. Using hunches about that, for example, some observations indeed lead to a particular situation, the big picture of r is constructed. After getting an overview of r, an INTUIT uses hunches to get an overview of which state s results from

action a, and how s realizes goal g and how g promotes v. Now that a global picture is obtained of r and what and why to do a, an INTUIT naturally starts reasoning about possibilities using critical questions CQ5-8. CQ5 asks for other possible actions that realize g. CQ6 asks for other possible goals that promote values, opening again possibilities. CQ7 asks for the effect of a on other values which for example could be long-term effects. CQ7 thus asks for the implication of the facts. CQ8 asks whether a precludes other actions, thereby asking for the implication of and relation between facts.

3.5 Algorithm

This subsection provides two algorithms that generate justifications why a particular action should be done. One algorithm constructs the justification for people who prefer Sensing, the other constructs the justification for people who prefer Intuition. In this subsection, all references to critical questions refer to critical questions of PR. Critical questions of other argumentation schemes are not anticipated on, but can be handled when the student asks for them.

Inside the algorithms some new notation is used. The function $tell(X)$ should be read as tell the student that X. Furthermore, the relations are used here as sets but should be read as all the instantiations of that relation. For example, the set $cause$ is all $cause(p, q)$ that are true with $p, q \in Prop$.

Algorithm 1 gives the justification that is adapted to a student who prefers Sensing. A person who is sensing is mostly interested in CQ1-4 of PR, therefore the algorithm does not anticipate answering CQ5-8 of PR. The notation used inside the algorithms is not precise enough at this stage, but is aimed to bring across the idea. The function $derivation(P, r)$ with $P \subseteq Prop$ and $r \in Prop$ returns all the steps required to derive r from P. A person who prefers Sensing can use this derivation to completely understand why r is the case. The function $derivation(a, r, P, s)$ with $a \in Action$, $r, s \in State$, and $P \subseteq Prop$ gives all the reasoning steps required to derive that when performing action a in state r results in state s. This derivation is now given loosely, where later is may need some action logic.

Input: $r \wedge results(a, r, s) \wedge realizes(s, g) \wedge (effect(g, v) = +) \Rightarrow oughtToDo(a)$
// CQ1
given minimal sets $O \subseteq observation$, $E \subseteq expert \cup within \cup assert$, and $C \subseteq cause$ are minimal sets such that $O, E, C \vdash_{arg} r$;
tell($derivation(\{O, E, C\}, r)$);
// CQ2
given minimal sets $rs \subseteq results$, and $c \subseteq cause$ such that $a, r, rs, c \vdash_{arg} s$;
tell($derivation(a, r, \{rs, c\}, s)$);
tell($realize(s, g)$); // CQ3
tell($effect(g, v) = +$) ; // CQ4
// PR: the student should perform a
tell($r \wedge results(a, r, s) \wedge realizes(s, g) \wedge (effect(g, v) = +) \Rightarrow oughtToDo(a)$)

Algorithm 1: how to give an argument for a person who prefers Sensing

Algorithm 2 gives the justification that is adapted to a student that prefers Intuition. A person who prefers Intuition is mostly interested in CQ5-8 of PR, but also needs to know the basic answers to CQ1-4. To answer CQ1, the full derivation of why r is the current state is not given, but only the extract, namely the observations and the conclusion. The student will use hunches and intuition to check whether r is indeed the case. Similarly for CQ2, not the full derivation of why performing action a in state r results in state s, but only an extract. CQ3 and CQ4 will be seen by a person who prefers Intuition, so they are not anticipated on. CQ5-8 are answered completely but again without proper derivations.

Input: $r \wedge results(a, r, s) \wedge realizes(s, g) \wedge (effect(g, v) = +) \Rightarrow oughtToDo(a)$
// CQ1
given minimal sets $O \subseteq observation$, $E \subseteq expert \cup within \cup assert$, and $C \subseteq cause$ are minimal sets such that $O, E, C \vdash_{arg} r$;
tell($O \vdash_{arg} r$);
// CQ2 and CQ3
given minimal sets $r \subseteq results$, and $c \subseteq cause$ such that $a, r, r, c \vdash_{arg} s$;
tell($a, r \vdash_{arg} s \wedge realize(s, g)$);
// CQ5
foreach $a' \in Action$ *with* $a' \neq a \wedge results(a', s') \wedge realizes(s', g)$ **do**
| tell($results(a', s') \wedge realizes(s', g)$);
end
// CQ6
foreach $g' \in Goal \wedge g' \neq g \wedge (effect(g', v) = +)$ **do**
| tell($effect(g', v) = +$);
end
// CQ7
foreach $g' \in Goal$ *with* $g' \neq g \wedge realizes(s, g') \wedge \neg(effect(g', v) = 0)$ **do**
| tell($realizes(s, g') \wedge effect(g', v)$);
end
// CQ8
foreach $a' \in Action$ *with* $a' \neq a \wedge (precludes(a, a') \vee precludes(a', a))$ **do**
| tell($precludes(a, a')$);
end

Algorithm 2: how to give an argument for a person who prefers Intuition

4 Application

In our scenario the virtual tutor stops the simulation and gives the student arguments that the student should extinguish the fire. However, the tutor must first reason about what to do. Next, the mental state of the tutor is described using atoms as described in table 7.
The sets are instantiated as follows

$$\begin{aligned} Action &= \{extFire, evacuate, pump\} \\ Goal &= \{g_1 \equiv \neg explosion \wedge \neg death, g_2 \equiv \neg people \wedge \neg death\} \\ Value &= \{saveLives, minDamage\} \\ E &= \{e\} \\ D &= \{firefighting\} \end{aligned}$$

This means that the tutor believes that there are three actions that the student can perform: extinguish the fire in the truck, evacuate the injured people, and

Table 7. The meaning of the literals used in our scenario

Atom	**Meaning**
$fire$	there is a fire in the truck
$people$	there are injured people near the truck
$gasoline$	there is gasoline in the truck
$explosion$	the truck explodes
$death$	the injured people near the truck will die
$saveLives$	the value that as many as possible lives should be saved
$minDamage$	the value that the amount of material damage should minimized
$extFire$	the action where the fireman extinguishes the fire in the truck
$evacuate$	the action where the fireman evacuates the injured people near the truck
$pump$	the action where the fireman pumps the gasoline out of the truck

pump the gasoline out of the truck. Furthermore, the tutor has two goals: g_1 and g_2 where g_1 is the goal of realizing no explosion in the truck and preventing the injured people to die, and g_2 is the goal of realizing that the injured people are not near the truck and do not die. The tutor considers two values: saving lives, and minimizing damage. There is only one expert, namely e, and there is only one domain of expertise, namely firefighting.

The relations and predicates are instantiated as follows. For simplicity, all the statements that can be made are within the firefighting domain of expertise.

$$
\begin{aligned}
&\{observation(fire), observation(gasoline), observation(people),\\
&assert(e, fire \wedge gasoline \rightarrow explosion),\\
&\forall p \in Prop[within(p, firefighting)],\\
&results(extFire, fire, \neg fire), results(evacuate, people, \neg people),\\
&results(pump, gasoline, \neg gasoline),\\
&precludes(extFire, evacuate), precludes(extFire, pump),\\
&precludes(evacuate, pump),\\
&realizes(\neg explosion, g_1), realizes(\neg gasoline, g_1), realizes(\neg people, g_2),\\
&cause(explosion \wedge people, death)\}
\end{aligned}
$$

Finally, the effects of the goals on the values are as follows:

$$
\begin{aligned}
effect(g_1, saveLives) &= +\\
effect(g_1, minDamage) &= +\\
effect(g_2, saveLives) &= +\\
effect(g_2, minDamage) &= -
\end{aligned}
$$

4.1 Practical Reasoning

First, the argument from observation, AO, is used to evaluate the observations.

$$observation(fire) \Rightarrow fire \tag{1}$$
$$observation(gasoline) \Rightarrow gasoline \tag{2}$$
$$observation(people) \Rightarrow people \tag{3}$$

Next, the argument from expert opinion, AE, is used to conclude that *explosion* will occur. Since we use a simplification, namely every $p \in Prop$ is within the domain of expertise, the within clause is always true and therefore not used.

$$expert(e, firefighting) \wedge assert(e, fire \wedge gasoline \rightarrow explosion) \Rightarrow fire \wedge gasoline \rightarrow explosion \tag{4}$$

The argument from cause to effect, ACE, is used to conclude that *death* will occur:

$$cause(explosion \wedge people, death) \wedge explosion \wedge people \Rightarrow death \tag{5}$$

From $results(extFire, fire, \neg fire)$ can be concluded that $\neg fire$ and therefore $\neg explosion$. Since $realize(\neg explosion, g_1)$ we can conclude that g_1 is realized and because of $effect(g_1, saveLives) = +$ we can construct the practical reasoning scheme PR which is instantiated as follows:

$$\begin{aligned} r &= death, \\ a &= extFire, \\ s &= \neg explosion, \\ g &= g_1 \\ v &= saveLives \end{aligned}$$

4.2 Argument for the Student

In this subsection the algorithms as presented in subsection 3.5 are applied to construct justification for that the student should extinguish the fire.

Students who prefer Sensing. In algorithm 1 the tutor starts by giving the derivation of how the current state r can be derived from observations, expert knowledge, and causal knowledge. As such the tutors tells the student the complete derivation of r from the previous subsection.

Next, the tutor tells the student the complete derivation of why performing action a in state r results in state s. This derivation will be something like:

$$results(extFire, fire, \neg fire) \vdash_{arg} \neg fire \vdash_{arg} \neg explosion$$

Next, the tutor tells that $realizes(\neg explosion, g_1)$ where g_1 is $\neg explosion \wedge \neg death$ which means that the state that results from performing $extFire$ realizes goal g_1. Next, the student is told that $effect(g_1, saveLives) = +$ which means that goal g_1 promotes the value to save lives. Finally, the student is told the whole practical reasoning scheme with the conclusion that $extFire$ should be performed: $r \wedge results(a, r, s) \wedge realizes(s, g) \wedge (effect(g, v) = +) \Rightarrow oughtToDo(a)$.

When transformed into text, this argument given by the tutor could look as follows:

> I observe that there is a fire in the truck and the truck contains gasoline. Experts say that gasoline is highly flammable, so when the fire reaches the gasoline, there will be a big explosion. I observe that there are several persons near the truck who are injured and cannot get away. If there is a big explosion in the truck, those people will die. Because of my value to save lives, I have the goal to save those people near the truck. The action 'extinguish the fire' will prevent the fire from reaching the gasoline, which prevents an explosion, and thus saves those people from dying because of the explosion. Therefore, you should extinguish the fire.

Students who prefer Intuition. In algorithm 2 the tutor starts by giving an overview of the current state r:

$$observation(fire) \wedge observation(gasoline) \wedge observation(people) \vdash_{arg} r$$

Next, an overview is given of that performing action $extFire$ in r results in state s by telling that:

$$extFire \wedge r \vdash_{arg} s \wedge realize(s, g)$$

Next, CQ5 will be anticipated on by giving the alternative actions that realize goal g. The tutor tells the student the following:

$$results(pump, \neg gasoline) \wedge realizes(\neg gasoline, g_1)$$
$$results(evacuate, \neg people) \wedge realizes(\neg people, g_2)$$

CQ6 asks for all other goals that promote value $saveLives$. In this case, the tutor will tell $effect(g_2, v) = +$. Next, the tutor answers CQ7 by telling whether $extFire$ promote or demotes other values. In this case, the tutor tells the student that $effect(extFire, minDamage) = +$. Next, CQ8 is answered by telling the student that $precludes(extFire, pump)$ and $precludes(extFire, evacuate)$. From this, the student will conclude that $extFire$ should be done.

When transformed into text, this argument given by the tutor could look as follows:

Because there is a fire in the truck and there is gasoline in the truck, the truck will explode killing the pople that are near. By extinguishing the fire in the truck, the explosion will not occur, and thus the people will survive. Pumping the gasoline out of the truck might also prevent an explosion, and evacuating the injured people may result in that those people are not near the truck when it explodes. Extinguishing the fire minimizes material damage. However, extinguishing the fire precludes pumping away the gasoline and evacuating the people.

5 Conclusions

In this paper we have demonstrated how arguments can be adapted to personality types. We have concentrated on only one aspects of personalities: the sensing/intuition dimension. Because this dimension mainly influences the content of the arguments it alters the argumentation basically at the level of argument formation. The argument schemes that are used are almost identical to the classical ones used in the literature, but the way critical questions are chosen and answers are given is different for different personality types.

It is obvious that much work remains to be done in order to fully integrate personality types in the argumentation framework. However, we already have shown that it can make a crucial difference in the way argumentation functions. Especially in time critical situations where not all critical questions can be asked at leisure, it is important to start with the ones that most connect to the personality type and give the answers that provide most needed information.

We plan to extend the present work in several ways. First we will make the formalisation more precise such that we can reason more formally about things like "cause", "effect", etc.
We also will incorporate the other personality dimensions in the framework and check the consequences. Finally we aim at performing some real-time experiments in virtual training in order to see the effects of our approach.

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