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EVALUATING PRACTICAL REASONING

ABSTRACT. In this paper, the defeasible argumentation scheme for practical reasoning (Walton 1990) is revised. To replace the old scheme, two new schemes are presented, each with a matching set of critical questions. One is a purely instrumental scheme, while the other is a more complex scheme that takes values into account. It is argued that a given instance of practical reasoning can be evaluated, using schemes and sets of critical questions, in three ways: by attacking one or more premises of the argument, by attacking the inferential link between the premises and conclusion, or by mounting a counter-argument. It is argued that such an evaluation can be carried out in many cases using an argument diagram structure in which all components of the practical reasoning in the case are represented as premises, conclusions, and inferential links between them that can be labeled as argumentation schemes. This system works if every critical question can be classified as a assumption of or an exception to the original argument. However, it is also argued that this system does not work in all cases, namely those where epistemic closure is problematic because of intractable disputes about burden of proof.

Practical reasoning is so fundamental to artificial intelligence that is it impossible to see how current computational AI systems of multi-agent reasoning could get by without it (Reed and Norman 2003). It is also fundamental to the basic notion of rationality in logic and philosophy, as well as being commonly used in familiar every-day deliberations and arguments (Clarke 1985; Audi 1989). However, there remain serious differences of opinion about how it should be identified, analyzed and evaluated as a form of argument. One early proposal (Walton 1990) was to analyze it as a defeasible argumentation scheme, a form of argument that can hold provisionally on a balance of considerations under conditions of uncertainty, but that can be defeated by the asking of critical questions that pinpoint weaknesses. Such a scheme can be used to identify and analyze practical reasoning, but the problem of how to evaluate it as a defeasible form of argumentation remains open. One issue is whether it should be seen as merely an instrumental form of reasoning, or whether it should be based on moral or social values.

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Automated systems of practical reasoning for multi-agent deliberation between a human agent and a computer in electronic democracy (Gordon and Richter 2002; Atkinson et al. 2004a 2004b) take values into account.[1] In this paper, solutions to the problems of identification and evaluation are worked out, as means to solving the latter problem.

The study begins by explaining how practical reasoning is foundational to current research initiatives in computing, including the project of designing systems for electronic democracy based on it. Next, some examples are given to illustrate how to formulate three models of practical reasoning, including a basic model and two more complex models. Having shown how to identify and analyze practical reasoning as a defeasible form of rational argument, I then take up the problem of how to evaluate it as a strong or weak form of argument in a given case. The method set out builds on the technique of using critical questions as ways of attacking or defeating an argument fitting the scheme. The conclusion reached is that earlier versions of the scheme, and accompanying sets of critical questions, need to be revised. These are replaced by two new schemes with a new matching set of critical questions for each. One scheme, called the basic scheme, represents a simpler model of instrumental practical reasoning while the other, called the value-based scheme, represents a richer model that takes values into account. It is shown how both schemes can be represented on argument diagram structures to represent two types of practical reasoning. The paper concludes by setting out a method of solving the problem of evaluating such arguments by fitting the critical questions onto the diagram structure, but in a way that does justice to variations on burden of proof requirements appropriate for stages of a deliberation that may be open or closed.

1. MULTI-AGENT PRACTICAL REASONING AND ELECTRONIC DEMOCRACY

Practical reasoning of the kind used most commonly in everyday argumentation is neither inductive nor deductive, but represents a different type of logical inference sometimes classified as abductive, but most commonly as defeasible reasoning.[2] It is used by an agent to select a contemplated action as a hypothesis from a set of available alternative actions the agent sees as open in its given circumstances.

Once the hypothesis is selected as the best or most practical in the given situation, relative to the agent's goals, the agent draws the conclusion to go ahead with that action. Such an inference is defeasible, because an agent can learn that its circumstances have changed, and thus a different action might now become the best one available. We carry out such practical inferences in our daily lives all the time without being aware that they represent a kind of reasoning. Suppose I have a goal to close a door, and the action needed to do it is to push the door in such a way that it closes. Without thinking about it, I might just push the door in the required way. I don't really need to think about such an action very much, but still, the process can be classified as practical reasoning.

Practical reasoning can be quite complex in some cases, and the literature has shown that there are borderline cases where it's hard to decide from the data in a given case whether the agent was using practical reasoning or not. Indeed, there are philosophical questions on whether animals, machines, and other entities can engage in practical reasoning at all, and if they do so, whether it is a kind of practical reasoning different from what humans do. Borderline cases of apparently intelligent behavior by animals, and by electrical, chemical and physical systems that interact with an environment, are controversial. Do they exhibit goal-directed practical reasoning of some kind or not? Other controversial cases are reflexive and habitual human actions, and actions of a person judged to be mentally ill. To make sense of practical reasoning it is necessary to begin with the notion of a rational agent as an entity that is capable of goal-directed action based on its capability to have limited knowledge of its circumstances. Such a notion is now widely accepted in distributed computing (Wooldridge 2000). Such an agent is assumed to be capable of carrying out actions based on how it is programmed with goals. Thus it has a certain limited kind of instrumental rationality. However, as such agents are now being widely used to carry out a variety of tasks that involve not only knowledge of circumstances, but also capability for communication with other agents (Wooldridge 2002), they can often rightly be called autonomous agents.

Practical reasoning is most visible in paradigm cases of intelligent deliberative goal-directed action by an agent exhibiting eleven properties. The following 11 characteristics of practical reasoning in intelligent, goal-oriented, deliberation (Walton 1990, pp. 142–143) provide an orientation to agent-based practical reasoning.

1. Goals. The first characteristic is the setting of goals, selected propositions that describe possible actions to be carried out by an agent. Once selected by the agent, the goal tends to remain relatively fixed or stable, and becomes part of the agent's base of commitments.
2. Actions. The set of actions produced flow from the agent to the environment or external situation of the agent.
3. Knowledge. The third characteristic is the intake of information from the world external to the agency taken into account in acting. Included in this intelligence may be observation of the consequences of the agent's actions in the external situation, and common sense knowledge about normal expectations and usual (expected) procedures.
4. Feedback. The intelligent agent monitors the consequences of its actions and has the ability to compute error correction if consequences are contrary to the goal.
5. Complexity of the Act-Sequence. An intelligent agent is capable of carrying out a sequence of different kinds of actions through a list of instructions.
6. Hierarchy of Act-Descriptions. The sixth characteristic is the ability to organize the sequence of actions into a hierarchy with levels of abstraction relating general goals to specific actions.
7. Conditional Projections. A seventh characteristic is the capability of an intelligent agent to ask questions, and to project possible future consequences of contemplated lines of action using foresight.
8. Plasticity (Alternative Lines of Action). This characteristic is the ability to use a search-and-scan procedure to look over different possible alternative lines of action in flexible decision-making that can adapt to new information.
9. Knowledge (Memory). An intelligent agent can keep track of its goals and the actions it has already carried out listing this set of propositions in a knowledge base. Higher-order agencies have the capability to choose between multiple goals, and to change goals. These capabilities may require retraction of some propositions from the knowledge base as well as the insertion of new propositions.
10. Persistence. This characteristic means that if one action fails to lead to a goal, the agent will try another. As some alternative actions are blocked, others will be tried.

11. Criticism. An intelligent agent has the ability to criticize or evaluate its own actions An important task of criticism is to uncover practical inconsistencies in a plan, i.e. action sequences where the plan runs counter to itself, or tends to defeat its own goals.

The problem remains of how each of these characteristics should precisely be defined, and how they should be implemented in computer models of practical reasoning designed to carry out or assist in various tasks. As characteristic 2, indicates, any model of practical reasoning presupposes a theory of action. There is no space for further comment on theories of action here, except to say that the model of practical reasoning put forward here analyzes an action as the bringing about of a state of affairs (proposition-like entity) by an agent (Horty and Belnap 1995). Characteristic 11 is particularly important, as it indicates that many cases of practical reasoning require multi-agent systems in which agents need to communicate information to each other and to collaborate in carrying out goals that require teamwork. In such cases, agents need to deliberate collectively on how to achieve a goal by asking and answering questions about ways and means.

The two concepts of practical reasoning and deliberation are so closely intertwined that one cannot be understood without the other. Practical reasoning is the inferential process of arriving at a conclusion to take action through which deliberation can be understood as goal-directed method of decision-making based on an agent's knowledge of the data of its particular situation. Thus deliberation cannot be understood without grasping practical reasoning. Woodridge (2002 p. 66) divides practical reasoning into two component activities: (1) the process of deciding what state of affairs to achieve, called deliberation, and (2) the process of deciding how to achieve these states of affairs, called means-end reasoning. The end result of means-end reasoning is a plan or recipe of some sort (Wooldridge 2002, p. 66). Thus practical reasoning is closely related to the technology of planning, a field well developed in AI.

At the same time, practical reasoning, to be understood, must be embedded in a context of deliberation. Deliberation is often taken to be a solitary process in which a single agent arrives at an intelligent conclusion on how to act by forming a goal and collecting data. But even a single-agent deliberation can be seen as a process in which a single agent "thinks aloud" by asking questions and then answering them himself. By answering such questions in a dialogue with himself, an agent can clarify his goals in light of his present situation and its potential future consequences. However, group deliberations are also common. For example, it is possible to take the advice of an expert in a political deliberation, or to have family deliberation.

Practical reasoning is a fundamental argumentation structure for multi-agent systems, especially in systems of electronic democracy, where the purpose of the system is to look at ways and means of carrying out political goals based on intelligent deliberation in a democratic system. The capability of the system to pose critical questions for a proposed plan of action is vital for this application, as such deliberations are only useful if weak points in a proposal can be questioned. The capability of the user, or the system itself, to pose and reply to counter-arguments is important as well. However, a system to represent practical reasoning fully, and especially one that would take into account all the critical questions and opposed modes of argumentation that could be brought to bear, would be highly complex. Even so, it is necessary to build accessible systems that will resemble natural language argumentation and be easy to use.

Gordon and Karacapilidis (1997) undertook the research project of designing and implementing a mediation system to be used on the Internet to enable interested citizens and representatives of public interest groups to take part in electronic discussions with government officials planning public projects, like zoning ordinances for example. The persons taking part in the discussion could include experts, like city planners, as well as politicians and ordinary citizens who wanted to make their opinions known, or interact in discussion with those implementing the system. In their study they reviewed formal models of argumentation that can be adapted to AI to represent knowledge and arguments in a way that could be used to assist the project. The problem they encountered it is that arguments and other speech acts expressed by the parties in the dialogue had to be represented in a simple enough way that laypersons could use it. They found that the system they developed to solve this problem, called the Zeno argumentation framework, was too difficult for laypersons to use effectively. There is danger of a "digital divide" (Gordon and Richter 2002, p. 248), in which not all stakeholders have effective access to the process of e-democracy.

There seems to be little doubt that the possibility of developing widely useful systems of e-democracy requires a blend of argumentation theory, including argumentation schemes and typologies of dialogue, with formal models of reasoning of the kind that have been developed in AI. Constructing such systems doesn't seem to be the problem. The problem is one of making different systems that can be adapted to the needs of different implementations. In particular, for electronic democracy projects, the problem is how to design an argumentation-based AI system that is simple enough for laypersons to use in questioning a policy or task and arguing about it. There is little doubt that the model of practical reasoning that should be used needs to be simple enough for laypersons to easily use it without becoming frustrated by communication difficulties. These observations suggest that we need to begin with simple models even though we know that more fully adequate models will have various levels of complexity.

Atkinson et al. (2004a) have devised a structure called the Parmenides System that can be used by a democratic government to solicit public input, viewpoints and arguments on a particular policy being contemplated. Once a specific policy is formulated, critics are allowed to pose a range of critical questions. The policy is formulated in the practical reasoning format, with a goal being stated, and proposed means to achieve the goal. The system solicits criticisms of the policy by allowing justifications of the policy to be presented, and a succession of screens then allows the critics to present objections to actions and goals that are part of the policy. The critical questions raise doubts about connections between goals and values, as well as connections between presumed consequences of the actions. They also allow for consideration of alternative actions to the one proposed, and the respondent can challenge the description of the fact situation.

There remain underlying logical and philosophical questions about how practical reasoning should be modeled and how its components should be defined. Practical reasoning leads to a conclusion representing an action that is the most practical or prudent thing for an agent to do, in a particular set of circumstances, as far as they are known or surmised by the agent. However, there are many disputes on how to define what an action is (theory of action), on how to define what a goal is (teleology), and how to define the practical 'ought' stated in the conclusion. It is quite possible that different computational implementations of practical reasoning might need to model these components in different ways. Thus we begin with the most basic form, and then examine different ways it can be modeled in more complex ways for different purposes of application.

2. THE MOST BASIC FORM OF PRACTICAL REASONING

There are three basic components of a practical inference in the simplest kind of case. One premise describes an agent's goal. A second premise describes an action that the agent could carry out and that would be a means to accomplish the goal. The third component is the conclusion of the inference telling us that this action should be carried out. The simplest and most basic kind of practical inference that is readily familiar to all of us can be represented in the following scheme. The first-person pronoun 'I' represents an agent. More correctly, it could be called a rational agent of the kind described by Woodridge (2000), an entity that has goals, some (though possibly incomplete) knowledge of its circumstances, and the capability of acting to alter those circumstances and to perceive (some of) the consequences of so acting.

Basic Form of Practical Inference

> I have a goal, G.
> Carrying out this action A is a means to realize G.
> Therefore, I ought (practically speaking) to carry out this action A.

This basic form of practical inference is very simple, yet we all recognize its importance as a kind of reasoning we use in daily life, and especially in technology of all sorts.

Of course, as we will see, this form of inference is much too simple to represent all the kinds of complications that arise in everyday cases of practical reasoning and that need to be taken into account in any reconstruction of this form of argument. An agent may have many goals, and there may be many ways to carry out a goal. Also, practical reasoning is used in explanations as well as arguments, and thus contexts of use can vary. Still, it is best to start with the simple form of inference above as representing the most basic kind of practical reasoning. The reason is that this simple form of inference has the most explanatory power.[3] After explaining all the complicating factors that make the basic form too simplistic to work on its own, in the end we will return to something like it.

The basic form of practical inference can be represented as a process of rational deliberation in which an agent reasons from a goal to an action as shown in Figure 1 below. There are two choice points. First, the agent decides if it has a goal. If the answer is 'yes', then it decides whether there is an action that is a means to carry out the goal. If so, the agent immediately carries out the action.

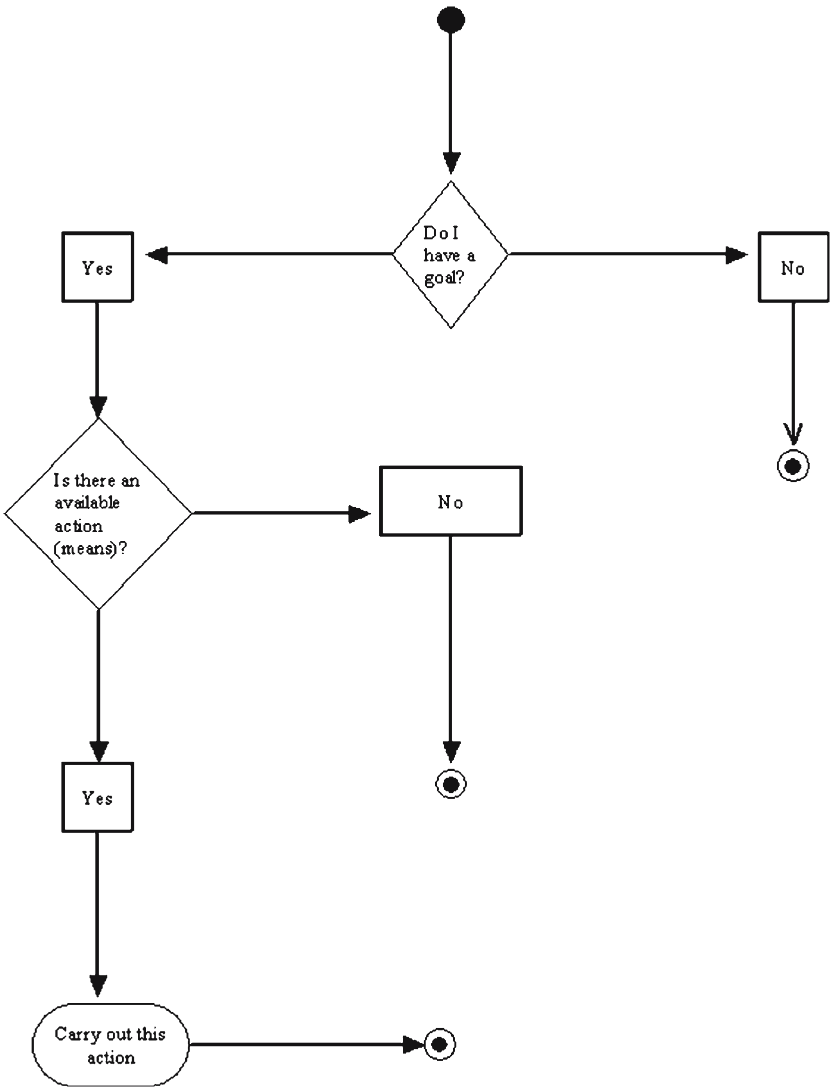

Figure 1. The basic structure of simple practical reasoning.

It is easy to see that this most basic form of practical reasoning is too simplistic to represent even the most ordinary kinds of cases that admit of some complexity. The following example of practical inference from Aristotle (*De Motu Animalium* 701 a 18) illustrates the simplistic nature of the basic form. The use of the word 'good' indicates that the reasoning is based on values as well as purely instrumental goals.

I should make something good.
A house is something good.
At once I make a house.

The reasoning in this example could be described as "breathless", because the agent immediately leaps to the conclusion to take action. It could even be seen as leaping to a conclusion too quickly, a kind of fallacious reasoning. The fallacy is one of leaping to action immediately without carefully considering the options and costs. This example shows that the basic form, on its own is inadequate as an argumentation scheme that can be used to represent practical reasoning.

A more complex form of practical reasoning is achieved by chaining together a sequence of practical inferences. The sequence leads towards an ultimate goal, and concludes in a practical directive recommending a course of action to take in a given initial situation, as an agent sees that situation. For example, my goal may be to get to Arnhem this afternoon. The means to get there is for me to take the train that leaves the station at 3 o'clock. The way to get to the train station by 3 o'clock is to take the number 9 bus that leaves the university at 2:30. But in order to take this bus, it may be necessary for me to leave my house by 2:15. It may also be best to get a train ticket. To get the train ticket, I may have to pay some money. Thus there is a lengthy sequence of actions I have to carry out in order to fulfill my goal of getting to Arnhem this afternoon. The practical reasoning at first looked simple, but once I begin to examine it carefully, it breaks down into a complex sequence of connected actions that have to be performed in a particular order. The whole sequence aims at the goal state.

An example from Aristotle represents a kind of chaining of practical inferences with two steps. The first inference postulates an agent stating a need as a premise, and then finding a means that fulfills the need. In a second step, the agent sees that attaining this means is itself something that requires an action (*De Motu Animalium* 701 a 19).

> I need covering.
> A cloak is a covering.
> Therefore, I need a cloak.
> But, what I need I have to make.
> And [as concluded above], I need a cloak.
> Therefore, I have to make a cloak.

In this case, two practical inferences are joined together to make a chain of practical reasoning. The conclusion of the first inference becomes a premise in the second one.

This kind of case can be generalized. In a sequence of practical reasoning, a series of practical inferences are connected one to the other, as shown in Figure 2 below.

Practical reasoning as represented in Figure 2 represents the typical kind of forward chaining that takes place when an agent looks forward in deliberation to try to achieve a goal in the future by carrying out an action now, or before the realization of the future event contemplated. This could be called the projective use of practical reasoning. A simple example has been given in (Walton 1990, p. 89). An agent has the goal of balancing his budget, and decides to try to reduce his heating bill by cutting some firewood with his chain saw. He thus goes through a complex sequence of actions. He gets the chain saw and puts it in the trunk of his car. He hitches his trailer to the car. He gets in the car and reaches the woods. Once he has gotten the chain saw out of the car in the spot he has chosen he starts it up. The long sequence of how to start the saw is described in the instruction manual. He follows this sequence. He switches on the ignition. He pulls out the choke control. He pushes down the safety catch. He opens the throttle. He puts his foot on the plate behind the rear handle. He grasps the starter handle with the other hand. An ordinary example like this one shows how complex a chain of practical reasoning in even the simplest and most everyday case. We all know now that the early attempts in AI to model everyday common sense reasoning were confounded by the realization of how complex the most everyday kind of practical reasoning can be.

In addition to the forward or projective kind of practical reasoning illustrated in the chain saw case, there is also an abductive or backward use of practical reasoning. In this use, a set of data

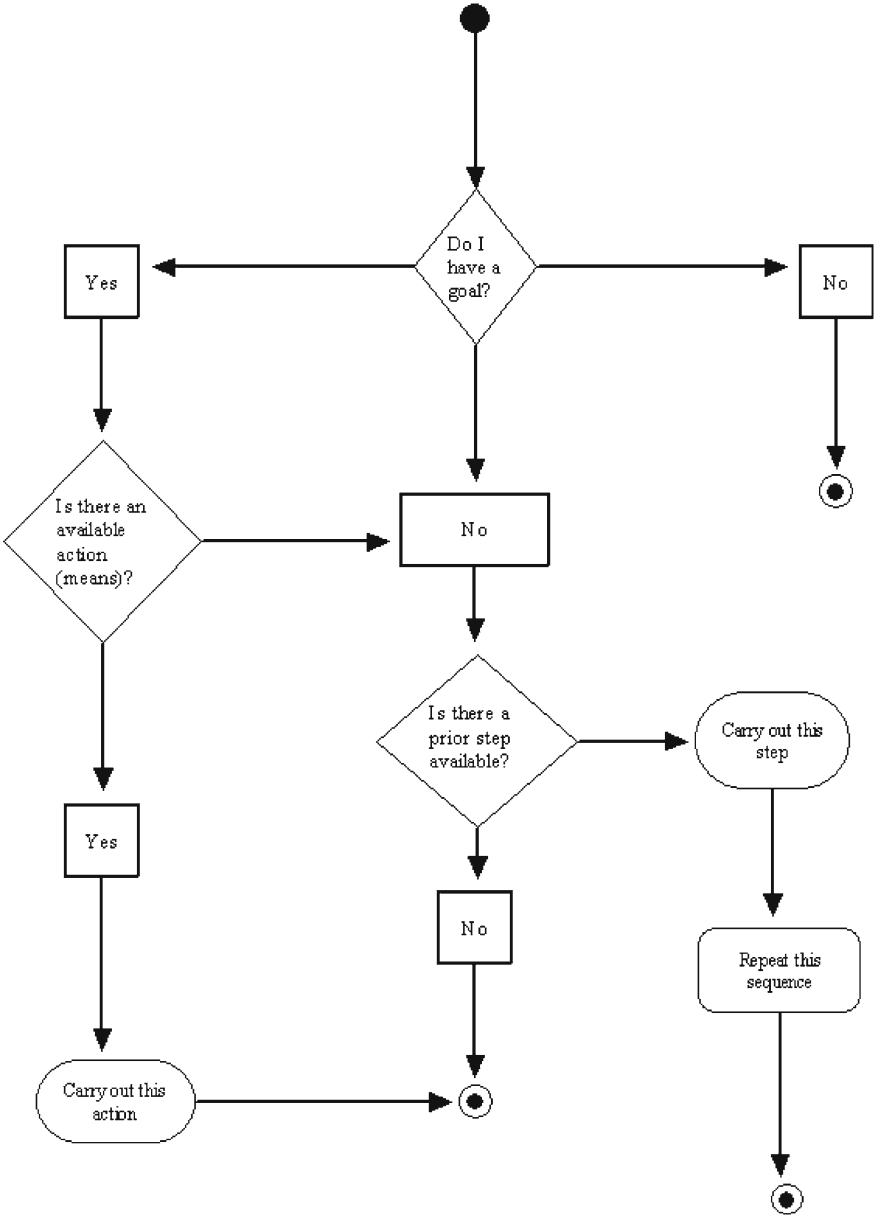

Figure 2. Chaining of practical inferences.

describing the actions of one agent is known to a second agent or observer. The second agent then concludes to a best explanation of the data, using practical reasoning (Walton 2004). Typically, the second agent uses a sequence of practical reasoning to connect the first agent's observed actions and presumed goals, putting the whole thing together in what could be called an account. The account serves as the basis of an explanation. There can be several competing explanations that are possible or plausible, and the second agent tries to pick out the best or most plausible one. This is the retrospective or abductive use of practical reasoning. It is very common in law and history.

What has been shown so far is that there have to be more complex forms of practical reasoning in which other relevant considerations are taken into account before drawing a conclusion and closing the case. We now go on to consider these various more complex forms of practical reasoning.

3. VARIANTS ON THE BASIC FORM

The structure of the practical inference can be brought out in a more useful way if we represent the outcomes of actions as propositions, *A*, *B*, *C*, . . . , so that carrying out an action can be described as bringing about a proposition, or "making it true". Using this way of speaking, the structure of the practical inference can be represented by the following scheme, a variant on the basic form cited above.

My goal is to bring about *A*.
Bringing about *B* is the way to bring about *A*.
Therefore, I should bring about *B*.

It is controversial whether this model represents the right approach however. According to one theory of action, an action may be analyzed as the bringing about of an event or state of affairs, something like a proposition that is made true or false by an agent (Horty and Belnap, 1995). As shown in an overview of formal action systems (Segerberg 1984) some have argued for an opposed approach that sees actions as species of events.

There are two more specific ways of representing practical inferences, depending on what is meant by the expression 'means' when it is said that an action is a means to achieve a goal. Typically what is referred to is a necessary condition for bringing about something, but in some cases what is referred to is a sufficient condition for bringing about something. For example, paying tuition is a means of graduating, in the sense that it is a necessary, but not a sufficient condition of graduating. My swatting a mosquito may be a sufficient condition of the mosquito's being dead. But it is not a necessary condition, assuming that the mosquito could have died in some other way.

Audi (1989, p. 86) recognized the distinction between necessary condition schemes and sufficient conditions schemes for practical reasoning. He offered the following example of a sufficient condition scheme (p. 87).

> I really need a peaceful visit in the country. Accepting their invitation for a weekend in the Catskills would be a good way to have such a visit, so I'll accept it.

The assumption made in this example is that accepting the invitation for a weekend in the Catskills would provide a sufficient condition for having a peaceful visit in the country.

The train to Arnhem example above suggests, however, that in many common cases of practical reasoning, the means refers to a necessary condition. Von Wright (1963a) used the following variant on this sort of example.

> X wants to reach the train on time.
> Unless X runs he will not reach the train on time.
> Therefore, X must run.

In another early essay (1963a, 1983, p. 3), von Wright, describing practical reasoning as using the means mentioned in the second premise in order to attain the end mentioned in the first premise, offered this example.

> I want to make the hut habitable.
> Unless I heat the hut, it will not become habitable.
> Therefore, I must heat the hut.

This example, like the train example, suggests that the means being described is meant to be a necessary condition of achieving the goal.

The formulation of the goal premise has been a longstanding controversy. One group of theorists hold that the goal premise should be an expression of the agent's intentions described as wants (desires). For example, Clarke (1985, p. 17) offered this kind of formulation in which E is an end (goal), M is the means (an action), and C is the set of circumstances beyond the control of the agent.

> I want E
> My doing M is a means to attaining E if C obtains
> I should (ought to) do M

He cited the following example (p. 3). I want to keep dry. Taking this umbrella is a means of keeping dry if it rains. It will rain. I may conclude then that I should take the umbrella. This version expressing the major premise as a want fits the BDI (belief-desire intention) model. Audi (1989, p. 87) presented a version of the sufficient condition scheme for practical reasoning that also fits the BDI model.

> I want this goal.
> Carrying out this action is a way for me to bring about this goal under these circumstances.
> There is no other way to bring about this goal now which is as preferable to me as, or more preferable to me than carrying out this action.
> There is no sufficient reason for me not to bring about this action under these circumstances.
> Therefore, let me carry out this action.

Others have expressed the view that the first premise should express the agent's goal described as a commitment. Walton (1990) based the analysis of practical reasoning on a commitment model. Von Wright, at different places, seemed to accept both models. In his first paper (1963a, 1983) he used the term 'want' predominantly. However in his (1972, 1983) paper, he started out using 'wants' as the key word, but then (1972, 1983, p. 20) described intending to pursue an end as being "resolved" to go after something in the future. This usage seems more like the language of commitment.

Von Wright did not appear to see practical reasoning as a deductive form of inference, given that he wrote (1972, p. 59) that the premises do not entail the behavior stated in the conclusion. Instead, as he put it, the agent is logically bound to his intention "within the teleological frame . . . for his prospective action". But what does that mean? It seems to imply that the binding nature of practical inference is something other than deductive validity. Perhaps it suggests that a prudent agent should adopt a consistent plan of action. But what sort of consistency is this? This question has led to a lot of philosophical theorizing about weakness of will. Suppose the agent has the goal of doing his homework, and has the means to do it, but is just too lazy? Does that mean the agent is inconsistent, in some sense? This problem remains unsolved (Walton 1997), relating to problems of retraction of commitments in plans.

Thus there are two different philosophical theories about how practical reasoning should be modeled. The commitment-based theory (Walton 1989) can be contrasted with the BDI (belief-desire-intention) theory (Bratman 1987; Bratman et al. 1988; Wooldridge 2002; Paglieri and Castelfranchi 2005). In the commitment theory, two agents (in the simplest case) interact with each other in a dialogue in which each contributes speech acts. Each has a commitment set, and as the one asks questions that the other answers, commitments are inserted into or retracted from each set, depending on the type of move (speech act) each speaker makes. A commitment is a proposition that an agent has gone on record as accepting. One type of speech act is the putting forward of an argument. When the one agent puts forward an argument, the other can reply, either by asking critical questions or by putting forward a counter-argument. According to the BDI theory, an agent has a set of beliefs that are constantly being updated by sensory input from its environment that continually updates its previous beliefs. From these beliefs, the agent builds up desires (wants) that are then evaluated by desirability and achievability to form intentions. An intention is persistent goal that is not easily given up. The two models are centrally different because a commitment is not necessarily a belief. Belief implies commitment but not vice versa. Belief is a psychological notion whereas commitment is a procedural notion based on dialogue rules.

A nice outline of the main features of the BDI model and the thematic variations in the approaches of its chief exponents has been given by Hitchcock (2002). According to Hitchcock, the BDI model was first articulated by Aristotle (*Nicomacheam Ethics* III.31112b15-20) who wrote that good deliberation begins with a wish for some end and follows through with a means for attaining it, and with other means that may be needed to carry out the first one. The conclusion of this process, according to Aristotle, is a decision to take action. On Bratman's (1987) variation of the BDI model, to form an intention to do something is to adopt a plan, and thus intentions, as well as desires (wants) and beliefs, need to added in to the model. Pollock (1995) but added what he called "likings", as well as desires, that need to work in combinations with beliefs and intentions. Hitchcock argued that although Pollock's system has many advantages, it is incomplete in three important respects: (1) it is solipsistic, in that it does not allow for back-and-forth discussion between agents, (2) it is egoistic, in that it does not take community values or likings into account, and (3) it is unsocial, in that it does not take groups of agents with governance structure into account.

Searle (2001) also advocated the BDI model of practical reasoning, but, like Bratman, often shifts to the language of commitment. The problem for the BDI model is that it is hard to model practical inference because beliefs are not transferred from the premises to the conclusion of a practical inference. If I believe that proposition *A*, and proposition *B* is logical consequence of *B*, it need not follow that I believe that *B*. Searle (2001, p. 241) poses the problem as one of seeking patterns of practical validity such that acceptance of the premises of the valid practical argument commits one to acceptance of the conclusion. However, acceptance, another word for commitment, does not equate with, or necessarily imply, belief. Bratman, who often expresses his view of practical reasoning in terms of commitment (1987. chapter 7), is however, also seen as an advocate of the BDI model. Bratman et al. (1988, p. 347) wrote, "The fundamental observation of our approach is that a rational agent is committed to doing what she plans". These remarks suggest that advocates of the BDI model tend to shift to the language of commitment when they address problems of studying the inferential link between the premises and conclusion of a practical inference. In practice then, the BDI model and the commitment are tangled together, and this failure to distinguish clearly between them is a problem.

The BDI model and commitment model are working along parallel but independent lines, but formulating the precise difference between them is a recurring problem. An excellent research project, but full of philosophical difficulties, would be to attempt to integrate the two approaches. The commitment model uses argumentation schemes, based on a dialogue format. Its best asset is that it accounts for communication between agents. Because commitments are part of the dialogue framework, perhaps they are best seen as essentially involving communicative relations between rational agents, or in groups of them. Intentions and beliefs, as well as likings and desires, seem to be individual and psychological. Whatever the advantages of each theory are, certainly the biggest problem at present is to clarify the relationship between them more clearly and precisely. Girle et al. (2003) considered some tentative ways of bringing these two theories together. One of these is to extend the narrowly instrumental models of practical reasoning that dominated the early literature. Another is to expand the borders of traditional logic beyond deductive and Bayesian models of reasoning to include defeasible argumentation schemes that need a dialogue format.

4. COMPLEX PRACTICAL REASONING

The next complication to be considered is that an agent can often have a choice between two or more different actions, each of which by itself could be a means to obtaining the goal. For example (Walton 1990, p. 96) suppose the agent wants to be healthy, and sees that he needs to engage in some athletic form of physical activity in order to achieve this goal. A wide range of such activities is available. He narrows the choice down to jogging, judo and badminton. How can he choose the best means? He can refine his goals a bit better, look into related goals like costs and time available, he can look at how each of these activities would contribute to his health in ways that might differ, and so forth. The complication is that there is no single way that the agent can immediately fix on what would achieve his goal. Instead, he must compare a number of alternative means and try to decide which would best or most efficiently do the job.

To take the possibility of several alternative means into account, a more complex model of practical reasoning called practical reasoning with several alternative actions needs to be considered. In this kind of reasoning, the agent must search to find a set of alternative actions to the one initially being considered, and then pick the best of these as the action to carry out. Obviously such a model of practical reasoning presupposes some criterion by which the alternative means can be compared on a scale from worst to better to best. Such a criterion in turn presupposes some notion of value whereby the actions can be ranked in this way. The structure of this richer notion of practical reasoning is displayed in Figure 3 below.

The problem with this kind of practical reasoning is similar to the problem of abductive reasoning modeled as inference to the best explanation. The agent must choose among several possibilities to choose the best one. Different criteria, some purely instrumental, and some more frankly ethical, could be used to define what 'best' means. But 'best' does not always refer to the best possible means. In maximizing, the agent seeks to choose the one action that is better than all the others. In what is called satisficing (not a spelling error), the agent keeps trying to find a means to achieve the

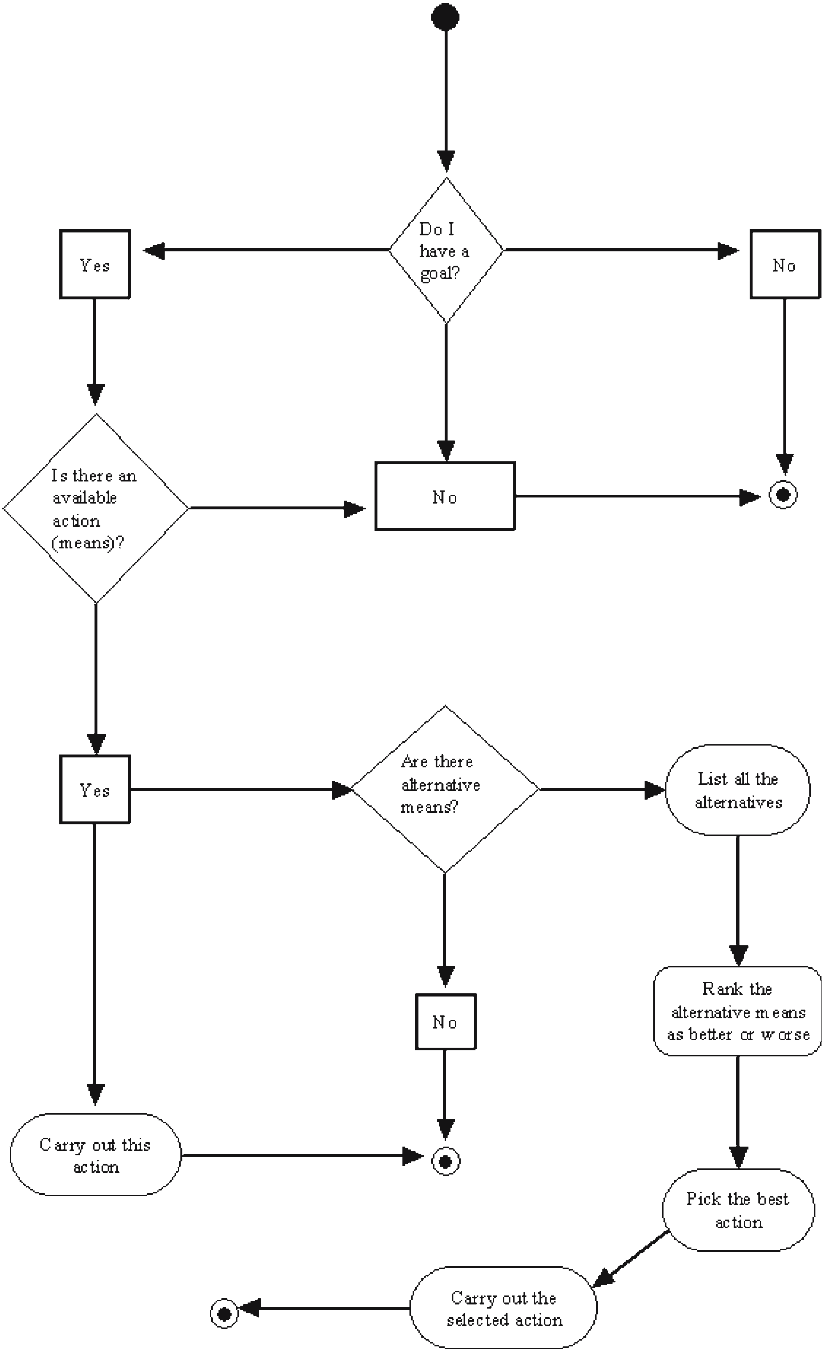

Figure 3. Practical reasoning with several alternative actions.

goal, and stops and selects one, as soon as it finds one that is good enough to realize the goal.

In addition, as shown in (Walton 1990) there are other complications of practical reasoning to be considered. In some cases, multiple goals have to be considered. In some cases, one goal might conflict with another and the agent has a problem of trying to resolve inconsistent goals. These are all serious problems, but we refrain from further comment on them here. Suffice it to say that the simple model of the previous section has to be made more complex in various dimensions before an adequate account of the structure of practical reasoning can be built up.

In a book published fifteen years ago (Walton 1990) I set out an argumentation scheme for a form of goal-directed, knowledge-based reasoning that concludes in an action, called practical reasoning. In this analysis, two argumentation schemes for practical reasoning were postulated: a necessary condition scheme and a sufficient condition scheme. Here is the necessary condition scheme (Walton 1990, p. 48).

Practical Reasoning: The 1990 Necessary Condition Scheme

(*N1*) My goal is to bring about *A (**Goal Premise**).*
(*N2*) I reasonably consider on the given information that bringing about at least one of [B_0, B_1,...,B_n] *is* necessary to bring about *A (**Alternatives Premise**).*
(*N3*) I have selected one member B_i as an acceptable, or as the most acceptable necessary condition for *A (**Selection Premise**).*
(*N4*) Nothing unchangeable prevents me from bringing about B_i as far as I know *(**Practicality Premise**).*
(*N5*) Bringing about *A* is more acceptable to me than not bringing about *Bi (**Side Effects Premise**).*
Therefore, it is required that I bring about B_i *(**Conclusion**).*

The sufficient condition scheme is the same (1990), except that in its premises (N2) and (N3), the expression ‘sufficient condition’ must be substituted for ‘necessary condition’.

The 1990 scheme is quite useful because it enables us to identify the characteristic premises and conclusion of an argument that is an instance of practical reasoning, but there are four problems with it. One is that it makes practical reasoning look quite complex, and while it is true that practical reasoning is generally quite complex, a simpler model would have more explanatory power. What would be good is to start with a simpler basic model, and then work up by steps to more complex models. To some extent, this task has already been accomplished by separating the three models in Sections 2, 3 and 4. The second problem is that we need a way of evaluating the scheme in relation to the data and context of use in a given case. Conditions for evaluation may be simpler if the database is closed, and all the information the agent can find has been collected. But in the typical case, practical reasoning is a defeasible form of argument. Not all the relevant data has been collected yet, and the agent needs to act under uncertainty instead of collecting more data. The device used in (Walton 1990) to evaluate practical reasoning in such cases was the matching set of critical questions. But the problem of how such questions act as undercutters or rebuttals of arguments of the practical reasoning kind has never been entirely solved. We return to this problem in Section 6. The third problem is that the 1990 scheme doesn't deal explicitly with cases where an agent has several goals that need to be considered, goals that may even be in conflict. However, there are extensive studies (Walton 1990, pp. 64–83) of incompatible goals and practical conflicts arising from them, including a case study (pp. 64–68).[4] The fourth problem is that values enter into the 1990 scheme at various points, but no distinction is made between goals and values. In premise (N3), one of the means is described as the best, or most acceptable one. In premise (N5), bad side effects are taken as reason not to carry out an action by valuing some consequences as more acceptable (or less acceptable) than others. The famous example of making a house from Aristotle cited in Section 2 has already made it evident that values can sometimes be central to practical reasoning in an explicit way. Thus next we turn to this fourth problem.

5. VALUES AND GOALS

An issue that is of concern, especially in the context of ethical and political deliberation, is whether practical reasoning is purely instrumental or takes values into account. In practical reasoning an agent carries out an action as a means to fulfilling a goal. Based on such a sequence of reasoning, the agent's having carried out that action can be said to be practically reasonable. This conclusion seems like a positive form of evaluation of the action. But what if the agent's goal is antisocial, or represents something we would consider to be morally wrong? Can the action be positively evaluated as practically reasonable in such a case? Some might say not, on the grounds that carrying out such an action would conflict with worthy goals that should be taken into account. Generally speaking an agent has a plurality of goals. Some of these goals might conflict with others. Some goals might be deemed more worthy or more socially productive than others. In such cases, values play a role.

Atkinson et al. (2004a, p. 88) cited two comparable examples of practical reasoning. In the first example the goal stated in the first premise is a specific event or state.

> I want to be in London before 4:30.
> The 2:30 train arrives in London at 4:15.
> So, I shall catch the 2:30 train.

But consider another instance of practical reasoning where the goal stated in the first premise is more general.

> Friendship requires that I see John before he leaves London.
> The 2:30 train arrives in London at 4:15.
> So, I shall catch the 2:30 train.

As Atkinson et al. (2004a, p. 88) pointed out, the action in the conclusion is justified in the second case not in terms of its consequences or results, but in terms of an underlying general social value, friendship. On their account (Atkinson et al. 2005), three elements need to be considered as the result of performing an action: the state of affairs brought about by carrying out the action, the subset of this set that forms the desired features (the goal), and the reason why the goal is desired (the value). They do not describe values as states of the world that are desirable, but as social interests that explain why goals are desirable.

It can be argued on these grounds that there are two notions of practical reasoning that ought to be considered. One is a narrower and simpler instrumental notion of practical reasoning. The other, a broader conception, takes values into account. It could be seen as an ethical notion of practical reasoning, or at least a notion of practical reasoning that takes moral values into account.[5] The instrumental account is simpler, because it views values as a species of goals. It doesn't see anything special about values, as kinds of goals, and simply evaluates them in the same way other goals would be evaluated. On the broader conception however, values are defined separately from goals. There are several reasons for this approach. One is that in ethical and political deliberations, ethical goals tend to be implicit and in the background, yet they are vitally important in evaluating actions, and in persuading other agents to undertake a course of action as the conclusion of the deliberation dialogue. In political deliberation, an arguer is typically trying to persuade an audience to see a course of action as practically reasonable for the group to adopt. Implicit in such a discussion is the assumption that both the group and the arguer share some broad social values. In this kind of context it may be important to take values is into account, even if they're not clearly articulated goals that can be precisely specified. To consider how practical reasoning should be modeled as a form of rational argumentation in such contexts, let's examine a simple example involving both deliberation and persuasion.

In this case, I have been having problems with my car, and as a way of solving the problem I decide to look for a new one. My goal is to buy a new car. But, of course, it is not that simple. I will not just go into the nearest dealership and buy the first car I find there for sale. Cost is involved, and I have certain requirements in mind, based on my situation. Nearly all of my driving is in the city, and so I am looking for a car that will fit these circumstances and do the job at the least cost. I also have factors like style and comfort in mind. Another factor that is very important for me is concern for the environment. All these factors narrow down the search to a car that will not use too much fuel, and so I concentrate on small cars. As I discuss matters with a salesperson in a showroom, she argues, "The Smart Car uses less fuel than the other cars you are considering. Also, it has style and comfort." Let's call this example the Smart Car case.

To identify the argumentation in the Smart Car case, we begin with a key list that identifies all the propositions that are premises or conclusions. A is the conclusion of the salesperson's argument, while B, C, and D are the explicit premises.

(A) Your goal is to buy a car.
(B) The Smart Car uses less fuel than the other cars you are considering.

(C) The Smart Car has style.
(D) The Smart Car has comfort.
(E) Any car that uses less fuel than the other you are considering is less harmful to the environment.
(F) You should buy the Smart Car.

We could also add some implicit premises to the argument that show how each of the three explicit premises is based on a value of the buyer.

(V1) Concern for the environment is a value of yours.
(V2) Style is a value for you.
(V3) Comfort is a value for you.

These values could also be weighted, or assigned an order of importance, but to keep the example simple, we will not consider this possibility here. Bench-Capon (2003a) gives a formal account of how values can be given a preference ordering in practical argument. How should these values be represented as having some role in the argumentation? There are three possible ways of representing them that need to be discussed.

The automated tool we will use, called *Araucaria* (Reed and Rowe 2005) aids a user to diagram an argument using a simple point-and-click interface. The user inserts the text containing the argument as a set of propositions into *Araucaria*, and he/she can then use the software to draw in lines representing inferences from the premises to the conclusion. The user loads a text document into *Arauacaria* where it appears in the left window, and highlights and clicks onto each statement (premise or conclusion) in the argument, which moves them to a right window. Once all the propositions in the argument have been represented, the user then draws an arrow from each premise, or set of premises, to its conclusion. The result is an argument diagram, representing an analysis of the argument.[6]

One way of representing the structure of the argumentation in the Smart Car case is displayed in the argument diagram in Figure 4 below. According to this analysis, each of the values acts as further support or justification for a premise. The structure of the two arguments on the left is not analyzed as deeply as that of the one on the right. The argument on the right is shown as an instance of practical reasoning. It is a linked argument with three premises, A, B, and E. The argumentation scheme for practical reasoning is shown binding the three premises together as linked support for the

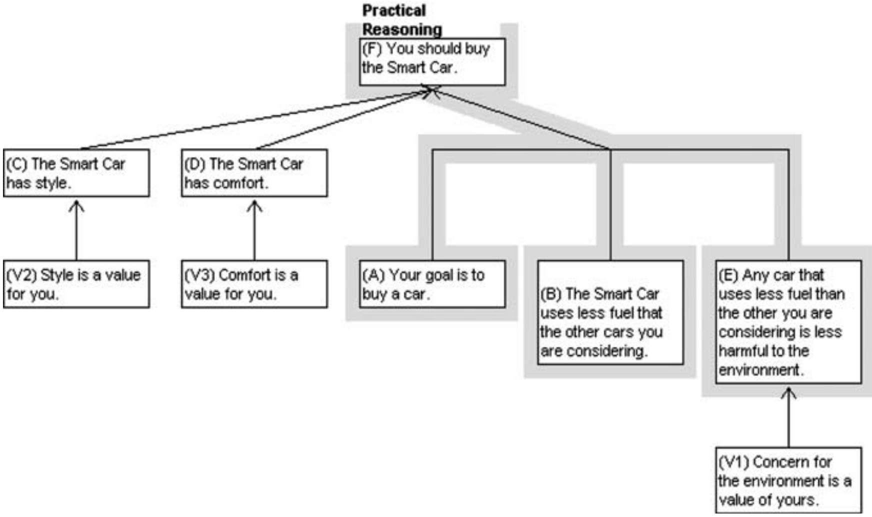

Figure 4. Araucaria diagram of Analysis 1 of the Smart Car argument.

conclusion F. V1 is analyzed as a value that supports E. Alternatively, perhaps V1 could be seen as a value that supports the goal stated in A.

On this analysis, each value is an underlying basis for a premise that supports the conclusion. But there is also a second analysis that needs to be considered.

On the second analysis, displayed in the diagram in Figure 5 below, each value acts together with a premise in a linked argument that supports the conclusion.

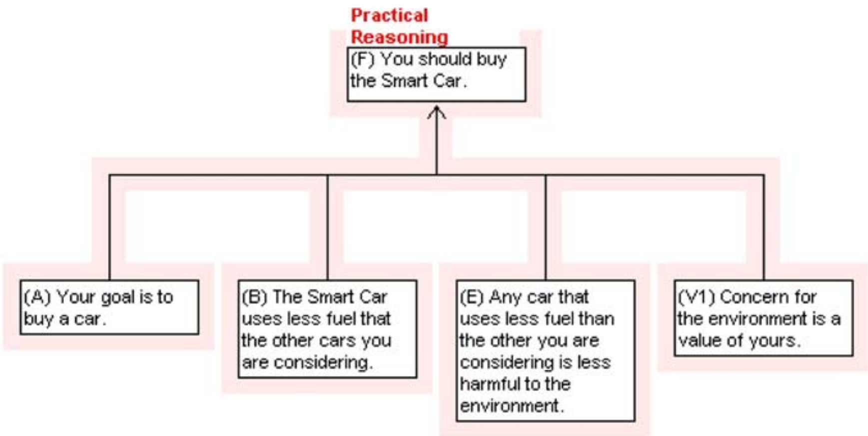

Figure 5. Araucaria diagram of Analysis 2 of the Smart Car argument.

On this analysis, B is a factual claim, while E and V1 play a role that could be described as that of generalization or Toulmin warrant (Toulmin 1958) that fits with the factual premise in a linked argument structure. However, E and V1 are somewhat different from each other. E is a universal generalization that has to do with both values and consequences, while V1 is a value statement. The two other arguments are not shown in the diagram. In one, C and V2 are premises in one linked argument supporting F, while D and V3 are premises in another linked argument, also supporting F.

The third analysis is explicitly based on the Toulmin (1958) model of argument. On this model all three values, as well as the generalization E, are analyzed as warrants, and diagrammed as supports for the inference from a set of premises to a conclusion. This analysis is shown in Figure 6 below.

These three analyses of the Smart Car case provide examples of three distinct hypotheses on how values can be modeled in practical reasoning. The justification hypothesis is that values are independent supporting reasons (justifications) for premises used in

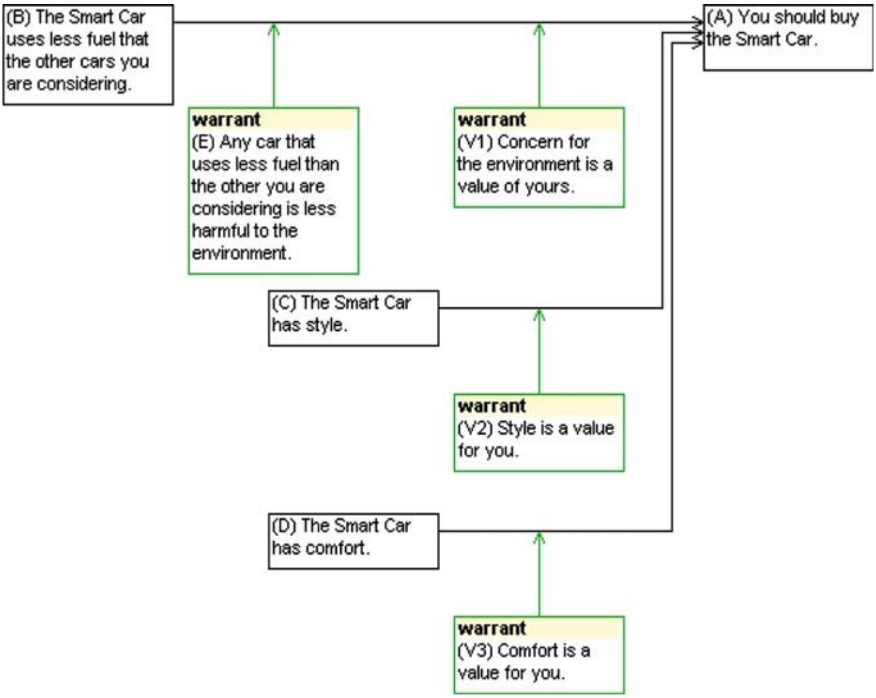

Figure 6. Araucaria diagram of Analysis 3 of the Smart Car argument.

practical reasoning. The linked premise hypothesis is that values are additional (often implicit) premises that go together in a linked argument structure with other premises (often explicit) of practical reasoning. The warrant hypothesis, displayed in the example in Figure 6, is that values are Toulmin warrants that support the inferential link between the premises and conclusion of a practical inference. On the warrant hypothesis, a value is modeled on an argument diagram as an arrow leading from a proposition (displayed in a text box) to another arrow representing an argument step (inferential step). This type of diagram is illustrated in Figure 6. In normal argument diagrams of the kind so widely used, arrows can only go from premises (propositions) to conclusions (also propositions). It should be added that there is a fourth hypothesis. According to Atkinson et al. (2005), values are linked only with goals, and provide reasons why goals are held to be desirable.

The problem posed by the three hypotheses in the Smart Car example turns out to be a general one for evaluating practical reasoning. For as mentioned at the end of section 4, critical questions of the kind used in the analysis of practical reasoning of (Walton 1990) act as undercutters that temporarily attack, or provide weak reasons to withdraw support from the practical argument that was put forward by an agent. The problem of evaluation of practical reasoning thus takes us to considering how practical reasoning should be refuted. What kind of evidence should count against this type of argument, and how should it be judged as stronger or weaker?

6. THREE WAYS OF ATTACKING PRACTICAL REASONING

There are three ways (methods) of attacking practical reasoning. The first is to attack one of the premises of the argumentation scheme, arguing that the premise has not been adequately justified. The second is to attempt to undercut the argument by asking critical questions. The third is to mount a counter-argument designed to rebut (refute) the original argument from practical reasoning. The distinction between the second and third methods corresponds to one already widely known in the AI literature. Pollock (1995) drew an influential distinction between two ways of attacking an argument called undercutters and rebuttals. A rebuttal is a strong form of defeat of a given argument utilizing is a stronger opposed argument, one that has the negation (opposite) of the original conclusion as its conclusion. An undercutter is a weaker, or more temporary form of defeat of an original argument that attacks the inferential link of the original argument to derive the conclusion from the premises.

The second method of attack on an instance of practical reasoning featured in is to ask critical questions. The key device for evaluating practical reasoning presented in (Walton 1990) was a set of critical questions matching the scheme. The two devices, the scheme and the matching critical questions were fitted into a dialogue framework representing a multi-agent context of use. In such a context, practical reasoning is used by one agent to argue for a conclusion to take a specified action. The argument is then communicated to another agent with the capability of asking critical questions that might undercut or even defeat the argument.

Critical Questions for Practical Reasoning

CQ1: Are there alternative means of realizing *A*, other than *B*? [***Alternative Means Question***]
CQ2: Is *B* an acceptable (or the best) alternative? [***Acceptable/Best Option Question***]
CQ3: Is it possible for agent *a* to do *B*? [***Possibility Question***]
CQ4: Are there negative side effects of *a*'s bringing about *B* that ought to be considered? [***Negative Side Effects Question***]
CQ5: Does *a* have the goals other than *A*, which have the potential to conflict with *a*'s realizing *A*? [***Conflicting Goals Question***]

Each of the critical questions acts as an undercutter that, when asked, defeats the inferential link between the premises and conclusion of a argument based on practical reasoning. It is a general method of argumentation theory that each scheme has a distinct set of matching critical questions attached to it. The solution to the problem of how to evaluate a given case in which practical reasoning occurs set out in 1990 was to study the text of the case to see (1) whether the requirements for the practical reasoning scheme are met by the given argument and (2) to judge how adequately the critical questions were asked and answered according to the evidence in the given case. There does appear to be agreement that practical reasoning is a defeasible form of argument in most typical cases of the kind we want to model, as opposed to being deductive or inductive. It would seem that the right way to evaluate it would be through the use of critical questions. But here there has been some divergence of opinions.

The set of critical questions above was devised for a commitment model, while a different set has been adopted in a recent computing system using a BDI model. Atkinson et al. (2004a, p. 89) devised the following set of 16 critical questions for the argumentation scheme for the sufficient condition type of practical reasoning for use in an e-democracy system.

1. Disagree with the description of the current situation.
2. Disagree with the consequences of the proposed action.
3. Disagree that the desired features are part of the consequences.
4. Disagree that these features promote the desired value.
5. Believe the consequences can be realized by some alternative action.
6. Believe the desired features can be realized through some alternative action.
7. Believe that the desired value can be realized in an alternative way.
8. Believe the action has undesirable side effects which demote the desired value.
9. Believe the action has undesirable side effects which demote some other value.
10. Agree that the action should be performed but for different reasons.
11. Believe that the action will preclude some more desirable action.
12. Believe that the circumstances as described are not possible.
13. Believe that the action is impossible.
14. Believe that the consequences as described are not possible.
15. Believe that the desired features cannot be realized.
16. Disagree that the desired value is a legitimate value.

This list fits the prior set of critical questions above very well, but one can see differences. For one thing, these critical questions appear to represent ways of attacking an argument that fits the scheme of practical reasoning by mounting counter-arguments. Such a system raises some questions about the function of critical questions as tools that can be used to evaluate practical reasoning. We return to these evaluation questions below, and in the end, based on these considerations, a different argumentation scheme for practical reasoning will be proposed. What will change is the relationship between the scheme and the critical questions.

The third way to attack practical reasoning is to mount a counter-argument that has the opposite conclusion of the original argument from practical reasoning. It can be hard to separate a rebuttal attempt from questioning that is merely skeptical, in some instances, because opposed forms of argument are related to some of the critical questions appropriate for criticizing practical reasoning. Practical reasoning is about taking some course of action in the future, but there is uncertainty about what will happen in the future, in complex situations of economics, politics, ethics and business. Thus one common and important critical question for many cases of practical reasoning is that pertaining to known or possible side effects of the action selected.

Are there negative consequences of bringing about the thing in question that should be considered?

This form of argumentation is so common it is called *argumentum ad consequentiam,* or argument from consequences. This form of reasoning is used in a negative way, as an argument to attack a proposal previously selected as representing the best course of action in a situation. However, it has a positive counterpart as well. In argument from positive consequences, a policy or course of action can be supported by citing favorable consequences of carrying it out. These two forms of argument were defined as argumentation schemes in (Walton 1995, pp.155–156).

Argument from Positive Consequences

MAJOR PREMISE: If *A* is brought about, then good consequences will occur.
CONCLUSION: Therefore *A* should be brought about.

Argument from Negative Consequences
MAJOR PREMISE: If *A* is brought about, then bad consequences will occur.
CONCLUSION: Therefore *A* should not be brought about.

Both forms of argument from consequences can be attacked by the asking of the same set of critical questions (Walton 1995, pp. 155–156).

Critical Questions for Argument from Consequences

CQ1: How strong is the likelihood that the cited consequences will (may, must) occur?
CQ2: What evidence supports the claim that the cited consequences will (may, must) occur, and is it sufficient to support the strength of the claim adequately?
CQ3: Are there other opposite consequences (bad as opposed to good, for example) that should be taken into account?

But now a number of controversies about how to evaluate practical reasoning arise. In order to refute an argument based on practical reasoning, is it enough to ask one of the critical questions in the list fitting the scheme for practical reasoning? Or should it be required to mount a counter-argument, for example, an argument from negative consequences? On which side should the burden of proof lie, when an argument based on practical reasoning is being evaluated as weak or strong, reasonable or fallacious? The answer may depend on what you want to use practical reasoning for, because it may need to be implemented differently in different AI systems.

7. WHEN CAN PRACTICAL REASONING BE CLOSED OFF?

Practical reasoning is about what to do by taking some course of action in the future that appears prudent now, as a way of realizing a goal. But one problem is that we are never really sure what is going to happen in the future, especially in complex situations relating to social and economic policies, political decisions, or business planning. In simple cases of practical reasoning, such openness of the database can be closed off by an assumption. In simple cases, like the famous blocks world example, the closed world assumption, meaning that the agent knows all there is to know, is held to apply. This assumption requires that all the data external to the given situation of the agent postulated is held constant. It can be applied to a case of the listing of flights on a televised flight monitor in an air terminal, for example (Reiter 1980, p. 69). The assumption implies that if a flight being searched for is not listed, it can be concluded that there is no such flight.

These observations suggest the hypothesis that practical reasoning can be viewed as a deductive form of argumentation if the knowledge base is closed.[7] However, in the vast majority of real instances, the closed world assumption is not realistic, because there is lack of knowledge of what will happen in the future, and the reasoning must be carried out under conditions of uncertainty. This form of argumentation, called a lack of knowledge inference, is a commonly used and reasonable kind of defeasible reasoning. It fits the argumentation scheme below (Walton 1996, p. 254).

Argumentation Scheme for Argument from Ignorance

> If *A* were true, *A* would be known to be true.
> *A* is not known to be true.
> Therefore, *A* is (presumably) false.

Even though a knowledge base is incomplete, the argument from ignorance can be a reasonable defeasible form of argument, holding tentatively as the search through the knowledge base proceeds. Three appropriate critical questions match the argumentation scheme.

Critical Questions Matching the Scheme for Argument from Ignorance

CQ1: How far along the search for evidence has progressed?
CQ2: Which side has this burden in the dialogue as a whole? In other words, what is the ultimate *probandum* and who is supposed to prove it?
CQ3: How strong does the proof need to be in order for this party to be successful in fulfilling the burden?

CQ1 concerns depth-of-search in the knowledge base. Argument from ignorance is a necessary type of reasoning, for example, in law, and in deliberation in all areas of practical life. Nevertheless, it can also be dangerous. In some cases the closed world assumption can be invoked artificially, or without real justification, in order to silence opposition and force a wrong conclusion. In cases where no real search of the database has been made, and yet the closed world assumption is made, the argument from ignorance may be fallacious. The classic case is that of the witch hunt, like the McCarthy trials, where a database is closed off peremptorily, when it should remain open. Such fallacious cases are notorious where a charge, like being in league with the devil, is vague, and hard to refute by factual evidence. In most cases of practical reasoning, the database should be seen as open and the argument defeasible. In evaluating

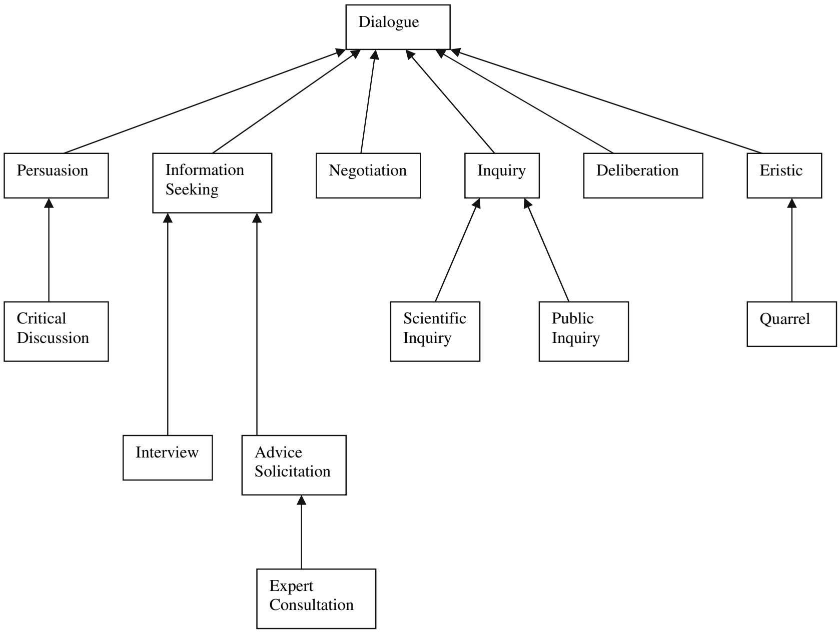

Figure 7. Dialogue typology.

lack of knowledge inferences, there is always the question of how reasonable the assumption of closure of the database is. Whether the assumption should hold is an important critical question.

In (Walton 1990) it was argued that process of deliberation should be seen as a process of dialogue. In a dialogue one agent asks questions, and another agent responds with answers that are supplied from a knowledge base they partly share. As noted above, commitment is a procedural notion based on a framework of dialogue in which two parties take turns making moves that have the form of speech acts. On this model, deliberation is seen as a form of dialogue that is related to other types of dialogue containing argumentation and reasoning. A classification of six such basic types of dialogue, along with several subtypes included in a diagram of Gordon (2003), is presented in Figure 7 below. Each type of dialogue has four stages, and each has a distinctive goal that can normatively be used to judge whether a move, or series of moves, contributes to the dialogue or not. In a critical discussion, for example, a sequence of argumentation can be judged fallacious if it seriously interferes with or blocks the progress of the dialogue towards its goal.

Practical reasoning is used in all six types of dialogue, but it needs to be evaluated differently, depending on the type of dialogue in which it was used in a given case. For example, the conditions for closure, affecting the closed world assumption, can be different. Also, there can be shifts from one dialogue to another that may need to be taken into account. For example, a parliament may be deliberating on whether to pass legislation funding a dam project. But there may be a shift to information-seeking dialogue as engineers and other experts give advice on the cost of the dam, what its requirements should be, and how it should be built. There may then be a shift to a persuasion dialogue as the elected representatives debate whether the project should be funded or not. Party politics may enter, and they may start to attack each other and quarrel. If they can't agree, they may begin to negotiate on some way of moving forward to a compromise. If a big problem or even a scandal ensues about mismanagement of government funds, an official inquiry may be launched.

Hitchcock et al. (2001) formulated a formal model of deliberation dialogue in which two participants make proposals and counter-proposals to solve a common problem. In their model, deliberation is set in motion by the asking of what they call a governing question like, "How should we respond to the prospect of global warming?" First there is an opening stage, and as the dialogue proceeds (Hitchcock et al. 2001, p. 7) an "inform" stage is reached, where goals and constraints on actions are considered. Next, at a proposal formulation stage, possible action-options appropriate to the governing question are formulated as proposals. Next, proposals can be revised, in light of information-gathering and fact-checking. Next, there is a stage where each option for action is recommended for acceptance or non-acceptance. At the closure stage, all participants must confirm their acceptance of a recommended option for normal termination for the deliberation dialogue to be properly closed off. There are dialogue rules for the speech acts that can be made at each move, and unanimity is required at the closure stage for a decision on a course of action to be made.

Practical reasoning can vary in strength, depending on the stage the dialogue has reached. In some cases, practical reasoning has to be conducted under conditions of uncertainty in which conditions are changing fast. Here a weak argument could be a reasonable basis for arriving at a decision on what to do now. The plan could always be revised later as new data comes in, but too much collecting of data could mean that the decision to act is useless because too much time has lapsed without any action. In other cases, we might want to be very sure before taking action. For example, if the cost of taking a wrong action is very high, it may be best to study the situation and examine the consequences very carefully before rushing to an action. The problem is when the deliberation should be closed so that the premises of a practical inference can be evaluated as providing enough support for the conclusion.

8. EVALUATING PRACTICAL REASONING

The necessary and sufficient condition argumentation schemes indicated above do not seem to be controversial in the literature on practical reasoning since 1990. It seems to be broadly accepted that there are two such schemes, and that they have at least roughly the forms set out above. Thus the problems of how to identify and analyze practical reasoning as a distinctive form of rational argumentation appear to be solved. What remains open to dispute is how practical reasoning should be evaluated as weak or strong in a given instance. There is no simple solution to the evaluation problem that fits all cases with a simple formula. As shown in Section 7, evaluation needs to depend on the set of standards of closure appropriate for the context and stage of the investigation or framework of deliberation the practical reasoning is part of. The basic device to be used in all cases is the set of critical questions matching the practical reasoning. These questions function as what Pollock (1995) called undercutters of defeasible argument. But there are also rebuttals, or counterarguments that defeat the original argument, to be considered. Exactly how these undercutters and rebuttals should be employed in evaluating practical reasoning, and how they work in shifting burden of proof, are currently unsolved problems (Walton and Godden 2005). Even so, there is quite a bit that can be said about how to solve these problems that provides useful advice on how to implement practical reasoning in automated systems.

The problem of evaluation is a general one for using argumentation in AI that has been implicit all along (Prakken et al. 2005; Walton and Gordon 2005). In his system for using argument diagrams to assist for legal argumentation Verheij (2005) modeled critical questions as undercutters, represented on a diagram by entanglement. In entanglement, the undercutter is drawn as an arrow pointing to the arrow in the target argument representing the inference from the premises to the conclusion.[8] This way of modeling argumentation enables us to represent critical questions as undercutters on a diagram. Thus it is a step forward, because we can now represent critical questions on argument diagrams, using them to evaluate the given argument.

However, exactly how the program should be carried out remains somewhat problematic. For as Verheij (2003) pointed out, critical questions perform four different roles.

(1) criticizing a scheme's premises,
(2) pointing to exceptional situations in which the scheme should not be used,
(3) setting conditions for a scheme's use, and
(4) pointing to other possible arguments relevant to a scheme's conclusion.

Concerning the first role, Verheij argued that there should be no need for explicit critical questions that merely ask whether a premise of a scheme is true or not. Verheij's differentiating these four roles of critical questions suggests that in any project of formalizing argumentation, it may be useful to treat some of the questions in a different way from others. Critical questions point to exceptions that only undercut an argument while others could be seen as refuting the argument by denying implicit assumptions on which it rests, or by pointing to counter-arguments. This distinction has been built into a new system of defeasible argumentation for legal reasoning (Gordon and Walton 2005) that draws a distinction between presumptions of an argument (premises assumed to be true), and exceptions to it (premises presumed to be false). This system enables a distinction to be drawn between two ways an argument should be critically questioned.

These recent developments have shown that there are several problems in the 1990 formulation of the scheme for practical reasoning. The premises are too complicated, and it is best to use the explanatory power of the simple version of the basic scheme, and shift the considerations raised by these complications to the critical questions. Attention needs to be paid to the criticisms that the critical questions should not be simple yes-no questions (van Laar), and they should not simply repeat a premise (Verheij). Jan Albert van Laar suggested that all the critical questions should be formulated as why-questions.[9] Although I did not agree with the specifics of his proposal, I could see the merit of it, and the need to reformulate the critical questions.

In light of these developments, it made sense to reformulate the argumentation scheme and critical questions for practical reasoning as follows. In the new formulation of the basic scheme below, I have returned to something very much like the basic scheme we began with in Section 2. However, the new basic scheme represents instrumental practical reasoning of a kind that is narrower than the kind based on values.

Basic Scheme for Practical Reasoning

> I have a goal *G*.
> Bringing about *A* is necessary (or sufficient) for me to bring about *G*.
> Therefore, I should (practically ought to) bring about *A*.

This form of argument should be regarded as defeasible, and it can be undercut or defeated by asking any one of the following critical questions in a dialogue. By building the complications into the critical questions, the simplicity, and with it the explanatory power of the original scheme is retained.

Critical Questions for Basic Scheme for Practical Reasoning

(CQ1) What other goals do I have that should be considered that might conflict with *G*?
(CQ2) What alternative actions to my bringing about *A* that would also bring about *G* should be considered?
(CQ3) Among bringing about *A* and these alternative actions, which is arguably the most efficient?
(CQ4) What grounds are there for arguing that it is practically possible for me to bring about *A*?
(CQ5) What consequences of my bringing about *A* should also be taken into account?

In addition to the instrumental basic scheme for practical reasoning, a new value-based scheme is also formulated below. The difference is that the second premise, below, has been added to account for values of the agent that need to be considered.

Scheme for Value-based Practical Reasoning

> I have a goal *G*.
> *G* is supported by my set of values, *V*.
> Bringing about *A* is necessary (or sufficient) for me to bring about *G*.
> Therefore, I should (practically ought to) bring about *A*.

Critical Questions for Value-based Practical Reasoning

(CQ1) What other goals do I have that might conflict with *G*?
(CQ2) How well is *G* supported by (or at least consistent with) my values *V* ?
(CQ3) What alternative actions to my bringing about *A* that would also bring about *G* should be considered?
(CQ4) Among bringing about *A* and these alternative actions, which is arguably the best of the whole set, in light of considerations of efficiency in bringing about *G*?
(CQ5) Among bringing about *A* and these alternative actions, which is arguably the best of the whole set, in light of my values *V*?
(CQ6) What grounds are there for arguing that it is practically possible for me to bring about *A*?
(CQ7) What consequences of my bringing about *A* that might have even greater negative value than the positive value of *G* should be taken into account?

Values are often in the background in practical reasoning, or in some cases may not need to be taken into account at all. For these cases the basic scheme can be used to evaluate the practical reasoning. In other cases, like those typical in electronic democracy, values are important factors that need to be taken into account. To properly evaluate such cases, the scheme for value-based practical reasoning must be applied.

Next, two problems of how to fit the new schemes to their employment in argument diagrams need to be addressed. The first problem concerns the value-based scheme. Which of the four hypotheses proposed in the Smart Car case best fits with the value-based scheme? Any of the four can arguably fit. The values premise can be seen as supporting the goal premise. Or it can be seen as a premise in a linked argument that also contains the other two premises. Or it can be seen as a warrant that supports the linked argument from the other two premises. Or values can be treated in the manner of Atkinson et al. (2005), where they function solely as support for goals. This problem remains unsolved.

The second problem is to consider how the critical questions might be fitted into the diagram system for analysis and evaluation. Let's begin with the five critical questions for the basic scheme with the analysis of (Walton and Gordon 2005) in mind. Suppose a proponent of an argument based on practical reasoning is being critically questioned by a respondent (questioner) in a deliberation dialogue in which the two are trying to decide on a prudent course of action in a given situation. When the respondent asks one of the critical questions, does that alone refute the argument until the question has been satisfactorily answered by its proponent? Or does the questioner have to give some evidence to back up the question before the argument is defeated? Let's consider the five critical questions, one at a time. It might generally be assumed to be true that I have no other goals that should be considered that would conflict with *G*, or if I have, the respondent needs to say what they are. It might also be generally be assumed to be true that if there are alternative actions to be considered, they have been taken into account, and that bringing about *A* is the best of the set. It would generally be assumed to be true that it is possible for me bring about *A*, if I am seriously thinking of bringing *A* about. Taking this view, critical questions CQ1, CQ3 and CQ4 could be classified as assumptions. However, it can be assumed to be false that there are alternative actions that should be considered (on the basic scheme) unless the respondent can specify what they are. And it can be assumed to be false that there are consequences of the proposed action that have not been taken into account, unless the respondent can specify what they are. Taking this view, CQ2 and CQ5 could be classified as exceptions. On this view, burden of proof issues concerning the critical questions for the basic scheme can be dealt with in a standard way by diagramming additional nodes that are classified as assumptions of the original argument or exceptions to it.

This view of the matter is open to discussion, however, and may depend on the context, the type of dialogue, and the stage the dialogue is in. Some might argue that the respondent should have the burden of proof to back up all her critical questions with specifics. Others might argue that just asking any one of the questions should be enough to make the original argument default until the question has been answered satisfactorily. A similar view can be presented for the dealing with the critical questions matching the value-based scheme. Some could be classified as assumptions while others, like the value premise (CQ2), could be classified as exceptions. Still, burden of proof issues will often have to be decided on a case by case basis. But if the critical questions can be classified as either assumptions or exceptions, we can then insert them as propositions that are premises of practical reasoning on an argument diagram. Thus we could, once such a classification has been made in a given case, dispense with the dialogue concept of critical questioning, and represent the argument as a set of premises and a conclusion.

In applying this method of evaluation to a given case of practical reasoning, the critical questions needs to be seen as posed in a dialogue in which it is assumed that there is a global burden of proof, and standards are set on how strong an argument has to be to be successful to prove something at issue. The role of the questioner is to be mildly critical, and to probe into weaknesses or implicit assumptions of the argument that the practical reasoner might not have thought of, or properly taken into account. Thus, for example, the first question is not meant to be a simple yes–no question that the arguer can answer by replying "Yes, I have another goal" and then get off the hook. The arguer has to satisfy the questioner that she has thought about this. That is, she has searched around in her goal set and not found any conflicting or competing goals that might override *G* in the given circumstances.

What this shows is that in a given dialogue, there has to be a way of implementing the critical questions that works for that type of dialogue. The standards might be different in a persuasion dialogue than in an inquiry, for example. There can be shifts, as in the Smart Car case, from a deliberation dialogue to a persuasion dialogue. There may have to be a meta-dialogue in which issues of burden of proof can be sorted out. The general problem is how satisfactory an answer needs to be given to a critical question so that the argument is not defeated. There is no universal solution at present, however, that would apply to all argumentation in all contexts of use. Using critical questions and counter-arguments to evaluate practical reasoning is a task that can be carried out in various ways in different ways of modeling multi-agent argumentation in computing. There are limits to what one can do with building dialogue notions like burden of proof and critical questions into argument diagrams. After all, the diagrams are best at providing simple models to a user who draws an argument as a set of premises and a conclusion (propositions). Thus there are applications, like those to multi-agent systems and electronic democracy, in which the dialogue structure must remain fundamental to evaluation.

Evaluating real cases of practical reasoning, like other forms of argumentation based on argumentation schemes, can be a lengthy and complex task in many instances. Indeed, there is even a completeness problem, because there can be critical subquestions to each critical question. Thus in theory, the process of questioning could go on without terminating, as long as there are more critical questions to be asked. Thus the problem of epistemic closure, the problem of knowing when the closed world assumption can be applied in a given case, can reappear in any given case. In this paper, a method for evaluating practical reasoning has been given that works, provided all critical questions matching a scheme can be classified as either being a presumption or an exception. It works, meaning that the argument can be structured as a set of premises and conclusion, represented by an argument diagram, using one or more of the selected argumentation schemes for practical reasoning. So analyzed, it can be evaluated by weighing its premises as weak or strong, weighing the strength of the evidential links between the premises and the conclusion, and weighing it against the attacking counter-arguments that can also be diagrammed in the case. Such an evaluation can be carried out by attaching values (numbers, or multi-valued weights like ‘strong’ and ‘weak’) to each node and each arrow joining a pair of nodes in the argument diagram. But in cases where the classification between assumption and exception cannot be applied without raising further issues of burden of proof, epistemic closure should be seen as a pragmatic decision that is best made in relation to the type of dialogue in a case, the stage the dialogue is in, and the prior chain of practical reasoning put forward and attacked in the dialogue.

NOTES

[1] I would like to thank the Social Sciences and Humanities Research Council of Canada for a research grant that supported the work in this paper, first read at The Norms, Reasoning and Knowledge in Technology Conference, June 3–4, 2005, Boxmeer, Holland. Katie Atkinson read a commentary on this version that helped me, along with comments by other participants, to make many improvements. A revised version was read as an invited lecture for the department of

philosophy at the University of Siena in Italy on June 13, 2005. I would like to thank Christoph Lumer and Sandro Nannini for their questions and comments that were especially important by reinforcing the suggestion (earlier made by Katie Atkinson and Jesse Hughes during the Boxmeer conference) that values need to be taken into account in the model.

[2] Aristotle (384–322 BC) identified practical inference as a distinctive form of reasoning, traditionally called the practical syllogism. However, the syllogism is a form of deductive inference, and since practical reasoning generally (but subject to exceptions, as shown below) is not deductive, this terminology is misleading. What makes the issue confusing is that practical reasoning can be deductive in some instances, but normally, and in the most common cases, it is not.

[3] Jan Albert van Laar made this point in a commentary on a paper on argumentation schemes and critical questions that David Godden and I presented at the OSSA 05 Conference (Ontario Society for the Study of Argumentation) at McMaster University on May 20, 2005.

[4] This third problem is also dealt with in the critical questions that supplement the revised schemes introduced in section 8 below.

[5] See footnote 2.

[6] Argumentation schemes, including ones for practical reasoning, can be represented in an *Araucaria* diagram by selecting the scheme from a set. These could also be included in the analyses of the Smart Car case, but we do not do so there.

[7] There is no general consensus at present on whether practical reasoning can be viewed as a deductively valid form of argument if the knowledge base is closed. Searle (2001) has offered a detailed argument to show that there can be no deductive logic of practical reasoning. Part of his reasoning is linked to the concept of values, based on the assumption that rational disagreement can always arise in practical arguments in which participants have their own individual values. Bench-Capon (2003b) has discussed computational modeling of audience preferences, following up on the work of Perelman and Olbrechts-Tyteca (1969), which emphasized how acceptability of argumentation is based on the views of the audience, which is turn based on the presence of values.

[8] For an example see Figure 6.

[9] Van Laar's comments were made at the OSSA 05 meeting in Ontario in May, 2005, in a commentary on the paper on critical questions (Walton and Godden 2005) read by David Godden and I.

REFERENCES

Aristotle, *The Works of Aristotle Translated into English*, ed. W. D. Ross, Oxford, Oxford.

Atkinson Katie, Trevor Bench-Capon and P. McBurney: 2004a, 'Justifying Practical Reasoning', *Proceedings of the Fourth International Workshop on Computational–Models of Natural Argument* (CMNA 2004a), ECAI, Valencia, Spain, pp. 87–90.

Atkinson Katie, Trevor Bench-Capon and P. McBurney: 2005, 'Persuasive Political Argument', *Proceedings of the Fifth International Workshop on Computational Models of Natural Argument* (CMNA 2005), eds. F. Grasso, C. Reed and R. Kibble, Edinburgh, 2005, pp. 44–51.

Atkinson Katie, Trevor Bench-Capon and P. McBurney: 2004b, 'PARMENIDES: Facilitating Democratic Debate', *Electronic Government*, ed. R. Traunmuller, Lecture Notes in Computer Science (LNCS), 3183. Third International Conference on eGovernment (EGOV 2004), DEXA 2004, Zaragoza, Spain.

Atkinson Katie, Trevor Bench-Capon and P. McBurney: 2005, 'Agent Decision Making Using Argumentation About Actions', Technical Report ULCS-05–006, University of Liverpool, Computer Science Department.

Robert Audi: 1989, *Practical Reasoning*, London, Routledge.

Bench-Capon Trevor: 2003a, 'Persuasion in Practical Argument Using Value-based Argumentation Frameworks', *Journal of Logic and Computation* **13**, 429–448.

Bench-Capon Trevor: 2003b, 'Agreeing to Differ: Modelling Persuasive Dialogue between Parties without a Consensus about Values', *Informal Logic* **22**, 2310245.

Bratman Michael: 1987, *Intention, Plans and Practical Reason*, Cambridge, Mass., Harvard University Press, 1987.

Bratman Michael E., David J. Israel, and Martha E. Pollack: 1988, 'Plans and Resource-bounded Practical Reasoning', *Computational Intelligence* **4**, 349–355.

Clarke David S., Jr.: 1985, *Practical Inferences*, London, Routledge and Kegan Paul.

Girle Rod, David Hitchcock, Peter McBurney, and Bart Verheij: 2003, 'Decision Support for Practical Reasoning: A Theoretical and Computational Perspective', in (eds.), Chris Reed and Timothy J. Norman, *Argumentation Machines: New Frontiers in Argument and Computation*, Dordrecht, Kluwer 58–84.

Gordon Thomas F.: 2003, 'Introductory Tutorial: Artificial Intelligence Models of Legal Argumentation', ECCO Competence Center, Fraunhofer FOKUS, Berlin.

Gordon Thomas F. and Nikos Karacapilidis: 1997, 'The Zeno Argumentation Framework', *Proceedings of the Sixth International Conference on Artificial Intelligence and Law, Melbourne*, Australia, 10–18.

Gordon Thomas F. and Gernot Richter: 2002, 'Discourse Support Systems for Deliberative Democracy', in Roland Traunmuller and Lalus Lenk, (eds.), *eGovernment: State of the Art and Perspectives (EGOV),* Aix-en-Provence, Springer Verlag, pp. 248–255.

Gordon Thomas F. and Douglas Walton: 2005, 'Critical Questions in Computational Models of Legal Argument', Paper Accepted for the Workshop on Argumentation and AI, Bologna, International Conference on AI and Law.

Hitchcock David: 2002, 'Pollock on Practical Reasoning', *Informal Logic* **22**, 247–256.

Hitchcock David, Peter McBurney and S. Parsons: 2001, 'A Framework for Deliberation Dialogues', in H. V. Hansen, C. W. Tindale, J. A. Blair and R. H. Johnson (eds.), *Argument and Its Applications: Proceedings of the Fourth Biennial Conference of the Ontario Society for the Study f Argumentation (OSSA 2001),* compact disk. Also available on Peter McBurney's web page at the University of Liverpool, Department of Computer Science: http://www.csc.liv.ac.uk/~peter/

Horty John, and Nuel D. Belnap: 1995, 'The Deliberative Stit: A Study of Action, Omission, Ability and Obligation', *Journal of Philosophical Logic* **24**, 583–644.

Paglieri Fabio, and Cristiano Castelfranchi: 2005, 'Arguments as Belief Structures', in David Hitchcock (ed.), *The Uses of Argument: Proceedings of a Conference at McMaster University 18–21 May, 2005*, Hamilton, Ontario pp. 356–367.

Pereleman Chaim, and Lucie Olbrechts-Tyteca: 1969, *The New Rhetoric: A Treatise on Argumentation*, University of Notre Dame Press, Notre Dame.

Pollock, John L.: 1995, *Cognitive Carpentry*, Cambridge, Mass., The MIT Press.

Prakken Henry, Chris Reed and Douglas Walton: 2005, 'Dialogues about the Burden of Proof', *Proceedings of the Tenth International Conference on Artificial Intelligence and Law*, June 6–11, 2005, Bologna, Italy, New York, The Association for Computing Machinery (ACM), pp. 115–124.

Reed Chris, and Glenn Rowe: 2005, *Araucaria, Version 3*. Available free at http://www.computing.dundee.ac.uk/staff/creed/araucaria/.

Reed Chris, and Timothy J. Norman: 2003, *Argumentation Machines: New Frontiers in Argument and Computation*, Kluwer Dordrecht.

Reiter Raymond: 1980, 'A Logic for Default Reasoning', *Artificial Intelligence* **13**, 81–132.

Searle John R.: 2001, *Rationality in Action*, The MIT Press Cambridge, Mass.

Segerberg Krister: 1984, 'Towards an Exact Philosophy of Action', *Topoi* **3**, 75–83.

Toulmin Stephen: 1958, *The Uses of Argument*, Cambridge University Press, Cambridge.

Verheij Bart: 2003, 'Dialectical Argumentation with Argumentation Schemes: An Approach to Legal Logic', *Artificial Intelligence and Law* **11**, 167–195.

Verheij Bart: 2005, *Virtual Arguments*, The Hague, Asser Press.

von Wright Georg H.: 1963a, *The Varieties of Goodness*, Routledge and Kegan Paul, London.

von Wright Georg H.: 1963b, *Norm and Action*, Routledge and Kegan Paul, London.

von Wright Georg H.: 1972, 'On So-Called Practical Inference', *Acta Sociologica* **15**, 39–53.

Walton Douglas: 1989, *A Handbook for Critical Argumentation*, Cambridge University Press, Cambridge.

Walton Douglas: 1990, *Practical Reasoning: Goal-Driven, Knowledge-Based, Action-Guiding Argumentation*, Rowman & Littlefield Savage, Maryland.

Walton Douglas: 1995, *A Pragmatic Theory of Fallacy*, The University of Alabama Press, Tuscaloosa and London.

Walton Douglas: 1996, *Argumentation Schemes for Presumptive Reasoning (Studies in Argumentation Series),* Lawrence Erllaum Associates, Mahwah, N.J.

Walton Douglas: 1997, 'Actions and Inconsistency: the Closure Problem of Practical Reasoning', in Ghita Holmstrom-Hintikka and Raimo Tuomela (eds.), *Contemporary Action Theory*, Vol. 1., Kluwer, Dordrecht, pp. 159–175.

Walton Douglas: 2004, *Abductive Reasoning*, University of Alabama Press, Tuscaloosa.

Walton Douglas, and David Godden: 2005, 'The Nature and Status of Critical Questions in Argumentation Schemes', in David Hitchcock (eds.), *The Uses of Argument: Proceedings of a Conference at McMaster University 18–21 May, 2005*, Hamilton, Ontario, pp. 476–484.

Wooldridge Michael: 2000, *Reasoning about Rational Agents*, The MIT Press, Cambridge, Mass.

Wooldridge Michael: 2002, *MultiAgent Systems*, Wiley, Chichester.

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