Dialogue games as dialogue models for interacting with, and via, computers

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Abstract: The purpose of this paper is to discuss some ways in which dialectical models can be put to computational use. In particular, we consider means of facilitating human-computer debate, means of catering for a wider range of dialogue types than purely debate and means of providing dialectical support for group dialogues. We also suggest how the computational use of dialectical theories may help to illuminate research issues in the field of dialectic itself.

Résumé: Le but de cet article est de présenter quelques façons par lesquelles des modèles dialectiques peuvent s'appliquer à certaines programmations d'ordinateur. Nous examinons en particulier les moyens par lesquels ces modèles peuvent faciliter des débats entre des personnes et des ordinateurs, pourvoir à une plus large variété de dialogues autres que des débats, et apporter un appui dialectique aux dialogues de groupe. Nous décrivons aussi comment cet usage des théories dialectiques peut aider à suggérer des projets de recherche dans la dialectique elle-même.

Keywords: dialogue games; human-computer debate; multimedia; computer supported collaborative argumentation; computational dialectics

1. Introduction

An earlier paper (Moore and Hobbs 1996) considered means of utilising dialogue game theories developed within the field of Informal Logic to form the dialogue model of a computer system designed to engage in debate with an individual user. Here we seek to further that investigation in four ways. First, we rehearse the argument for the use of dialogue games to facilitate debate between a computer and an individual user, and outline our recent work in this area. Second, we discuss means of catering for types of human-computer dialogue other than debate. We then consider how a system based on dialogue games could operate within a multimedia environment. Finally, we propose ways in which a computer could use dialogue game theories within the new and rapidly growing field of computer supported collaborative argumentation.

In his recent book on the "new dialectic", Walton (1998) writes:

> One of the primary uses of the new dialectic is to show people how to avoid common errors and fallacies in arguments. But the influence that will lead more directly to the acceptance of the new dialectic as a normative model of argumentation is its adoption in the field of computer science, especially in Artificial Intelligence, in the field of human-computer interactions (developing user-friendly computers), and in the use of computers to assist group deliberations and argumentative dialogues.

We hope that the work reported in the current paper will be of some assistance in realizing such an adoption of dialectic within human-computer interactions.

2. Human-computer debate

An important aspect of modern education is the adoption of a constructivist approach (e.g. Jones 1995). There is a recognition of a need to teach people to think critically (e.g. Hatcher 1999, Quinn 1997) and this has led to much interest in computational support of such an approach, for example by allowing for knowledge negotiation (Moyse and Elsom-Cook 1992, Baker 1994) and computer based tutoring of argumentation skills (Suthers *et al.* 1995, Aleven and Ashley 1994, Lajoie *et al.* 1995). We are seeking to contribute to this endeavour by designing a system that will engage its students in educative debates on controversial issues such as capital punishment. This, it is held, may foster the student's debating skills and level of critical awareness, and make him more aware of the substantive issues involved (Moore and Hobbs 1996, Bouwer 1998, 1999, Quignard and Baker 1997). The educational benefit of such a system seems clear, since "the importance of discussion and debate in education is frequently stressed at primary (e.g. National Curriculum Council 1990a), secondary (e.g. National Curriculum Council 1990b), and tertiary (e.g. Garrison 1991) levels" (Moore and Hobbs 1996, p. 132). The argument is given extra force by Laurillard's (1995) mention of an "emphasis on whole-class teaching.... at the expense of opportunities for discussion and interaction", and her claim that "reflection is too often neglected in the teaching-learning process". The scope for application is wide, we argue, for as Self points out: "... it is rarely possible to define a unique 'correct' viewpoint to be communicated to a student" (Self 1992, p. 40, *cf.* Bouwer 1998).

A fundamental element of any computer dialogue system is the dialogue model. A common approach is to use *dialogue games* as a basis for suitable dialogue interactions. A dialogue game can be seen as a prescriptive set of rules, regulating the participants as they make moves in the dialogues. These rules legislate as to permissible sequences of moves, and also as to the effect of moves on participants' "commitment stores", conceived as records of statements made or accepted. The essential argument for adoption of such a framework is that since "the games purport to be models of 'what is fair and reasonable in argument and criticism' (Walton 1985), .. [adopting] .. such a game will, if the game is valid, yield 'fair and reasonable' dialogue" (Moore and Hobbs 1996, p. 135). This in turn can be expected to yield discussions of the sort argued for earlier. Further, by constraining dialogue to a specific set of move types, each defined in terms of its effect on commitment stores, a model based on dialogue games is able to bypass the need for complex pragmatic parsing (Pilkington 1992) while still providing an opportunity for educationally useful interactions (Moore 1993).

There are many precedents for the use of dialogue game theory in a computational context. Gordon (1994), for example, speaks of "Computational Dialectics" as a new subfield of Artificial Intelligence and proposes a model of civil pleading, the "pleading games", where plaintiff and defendant confront each other. Reed (1998, p. 253) argues that "commitment-based dialogue logics ... provide an attractive approach to dealing with the thorny problem of agent rationality, as they constrain the possible dialogical moves an agent is permitted to make at any point on the basis of the previous utterances of the two agents." Amgoud and Maudet (2000) use an amended version of Mackenzie's DC system (Mackenzie 1979) to design an argumentation system to help agents solve intra-agent and inter-agent conflicts; the system is able to build dynamically arguments for and against a fact from the knowledge base, and eventually to select the most acceptable. Grasso *et al*.(2000) discuss "Daphne," a computational agent capable of providing advice in the domain of health promotion. Daphne adopts a dialectical argumentation approach using schemas from the *New Rhetoric* (Perelman and Olbrechts-Tyteca 1969) as the basis for its contributions to the dialogue. Again, the use of dialogue games is seen by Bench-Capon *et al.* (1991) as a useful model of interaction with knowledge-based systems, and Girle (1986, *cf.* Stewart-Zerba and Girle 1993) and Hartley and Hintze (1990) see the use of dialogue games as a potential means of widening the communication channel of computer based learning systems.

Pilkington (1998, *cf.* Pilkington and Parker-Jones 1996) demonstrates enhancements to a medical simulation-based learning system brought about partly by the adoption of dialogue games. Ravenscroft and Hartley (1999) use a dialogue game framework to facilitate a "structured and constrained dialectic" which in turn aids the student to improve explanatory domain models. Their dialogue game framework is able to simulate the tutorial tactics of an expert (human) tutor within a "collaborative argumentation" approach to "learning as knowledge refinement". An empirical study has shown the effectiveness of the dialogue game framework (Ravenscroft 1999). The use of dialogue games in a context of legal education is investigated by Bench-Capon *et al.* (1998). They argue that "the rule governed environment of a dialogue game can provide the necessary structured context for a quasi-courtroom argument", and develop "TDG", a dialogue game based on Toulmin's argument schema, for this purpose (Bench-Capon *et al.* 1998). This game can be used to mediate discussions between human participants and seeks to ensure that the argument resulting from the dialogue has an appropriate (Toulmin-based) structure (Bench-Capon 1998).

A number of other dialogue games have been proposed for argumentation systems (see Maudet and Evrard 1998, Moore and Hobbs 1996, Prakken 2000). Our current prototype argumentation system adopts a framework based on a somewhat modified version of Mackenzie's dialectical system "DC" (Mackenzie 1979); see Moore (1993) for a discussion of the amendments. The computer system (C) starts by asking the student (S) a direct question about their view on a controversial topic (for example, "do you believe in capital punishment?"). C then adopts the opposing view to whichever one is favored by S and engages S in debate, regulating the dialogue in line with DC (*cf.* Moore and Hobbs 1996, p. 151).

To play its part in such a dialogue, C needs to adopt a suitable strategy (cf. Bench-Capon 1998). Such a strategy will enable a link between the logic of argumentation, as modelled by the dialogue game, and the semantics of discourse (Moore 1993). For example, strategic considerations are needed to enable C to select between legally available move types and propositional contents. A suitable strategy is also seen as the means of allowing C to maintain relevance, in line with Walton's dialectical definition of relevance (Walton 1998, *cf.* Prakken 2000).

We argue, on the basis of experimental studies of people using the DC framework, that there are three levels of strategic decisions to consider (*cf.* Moore and Hobbs 1996, p.147-8). At *level 1* the issue is whether to retain or change the current focus, where "retain the focus" is taken to mean "continuing to attempt to substantiate or undermine a particular proposition." At *level 2* there are again two alternatives. On the one hand C can attempt to *demolish* S's position, seeking to remove any support S has put forward for his thesis (*cf.* Carbogim *et al.*'s notion (2000, p. 125) of "undermining"). C can, on the other hand, attempt to *build* its own position, by persuading S to commit to statements that imply the truth of C's thesis. At *level 3* the decision involves which *method* to adopt in fulfillment of the objective set at levels 1 and 2.

In order to engage in debate, C's knowledge base must be represented in such a way as to provide for a supply of statements that can be used in response to questions, and of statements that can be used to support other statements. Satisfaction of these two requirements will provide the knowledge necessary to enable C to operationalize the strategies just discussed. There is a variety of ways of representing the system's domain knowledge to provide these services, e.g. via rhetorical structure theory (Pilkington et al 1992), a truth-maintenance system (Quignard and Baker 1997, Grasso *et al.* 2000) or "viewpoints" (Finch 1998).

Our current debate prototype, however, borrows from Bench-Capon *et al.*'s utilisation of Toulmin's argument schema (Bench-Capon *et al.* 1990); essentially the schema requires propositions to be linked through "evidence" or "rebuttal" relationships. Nodes are created to hold the propositions that may be used in the dialogue. These are then linked using constructs from Bench-Capon *et al.*'s schema. The result is that C has a set of propositions, with evidence and rebuttal relationships, which it can use as its knowledge base for the debate. (Retalis *et al.* (1996)

take a similar approach to knowledge representation in their "devil's advocate" system, albeit with different relations between propositions.) The set of propositions is made available to S in a separate "dialogue choice" window. S (and indeed C) is restricted to these propositions during the debate. A blank node is available to enable S to enter a "new" proposition, and although C cannot respond to such a proposition in the debate, the domain "author" may want to add it to the knowledge base for future debates.

This, then, is our current human-computer debate prototype. Empirical observation of the system in use by learners is required. In the meantime, preliminary formative evaluation through a cognitive walkthrough by an educational expert (Trott 1999), though generally encouraging, raises two important issues, currently under investigation. First, there is a danger that dialogues produced using DC could tend to become overly formal or rigid, thus supporting Bench-Capon's concern that such dialogues can be "rather stilted" (Bench-Capon 1998). Taking into account other dialogue types might help to minimize this problem (see section 3 below). Another possible way to enliven the debate and contribute to maintaining the student's interest is to integrate the dialogue game system within a multimedia context. Means of achieving this will be considered in section 4 below.

A second issue that arose from the preliminary evaluation concerns a need for extra sophistication in the strategic heuristics. Currently C will adopt a devil's advocate role for all propositions. This can be discouraging to a user and, worse, may be misleading where the object of C's attack is to all practical purposes a matter of indisputable fact. Rather, it may be encouraging for the student to get confirmation of the existence of support for his arguments where further factual evidence that supports them is available in the knowledge base. The aim would be that C is more supportive to the student by providing support for arguments where possible, but remains argumentative in that it adopts a devil's advocate approach to widen the debate where appropriate. We hope to take some steps along this route by extending the dialogue model to other types of dialogue, in addition to debate.

3. Other dialogue types

Whilst debate, we have argued, is important, other types of interaction are also required in an educational context. Pilkington's study of simulation-based learning, for example, identified two types of dialogue game, an inquiry dialogue with asymmetrical participant roles and a more collaborative game generating cognitive conflict and reflection (Pilkington 1998, Pilkington and Parker-Jones 1996, Pilkington and Mallen 1996). Similarly, Ravenscroft and Hartley (1999) discuss a prescriptive dialogue game involving asymmetrical participant roles, the computer being a "facilitating tutor" and the student the "explainer". And Bench-Capon's TDG game is also seen as co-operative rather than competitive, in that participants seek to arrive at an agreed position (Bench-Capon 1998). Indeed, Walton and

Krabbe (1995) identify six basic types of dialogue in which people reason together: persuasion, negotiation, inquiry, deliberation, information-seeking and eristic.

We argue that such diverse dialogue types can be modelled within a generic dialogue game framework which allows games to be part of a larger structure reflecting the global coherence of dialogue. To do this we postulate (Maudet and Evard, 1998) that a dialogue game between two players A and B can be defined as a tuple

$$<<G_A,G_B>,<R_A,R_B>>.$$

Here, G_A stands for the goal of player A, G_B for the goal of player B. R_A stands for the rules regulating the dialogical behaviour of player A, R_B for rules regulating player B. Note the assumption here that a dialogue participant has a single goal. This might seem an unrealistic simplification. However, if the model is accurate in seeing an extended dialogue as a series of dialogue games, distinguished by goal type, the single goal assumption is a simplification only if it is possible for a single move to be part of more than one game. We assume, that is, that although a player may have more than one goal, any one dialogue game (and hence any one move) will be addressing only one of the goals. Whether this simplification is warranted is an issue for investigation.

The generic dialogue game framework, however, enables us to identify a number of different game types, representing different forms of dialogue (*cf.* also Reed's (1998) notion of dialogue frames). The game types may or may not have the property of symmetry—the rules may or may not be the same for both players. Similarly, the game types may or may not have the property of collaborativity. We see a game as collaborative if the desired end-goal is the same for both players. We draw here on Walton and Krabbe's distinction between the goal of the dialogue and the aims of the individual players (Walton and Krabbe 1995, p. 83, p. 135, *cf.* Reed 1998). The goal of an argumentation game, common to both players, can be seen as convincing the other player of the truth of one's own point of view. Although the players share this same dialogue goal they do not have identical end goals (aims)—in a computational context C's aim is to persuade S of the truth of C's thesis, S's aim is to persuade C of the truth of S's (opposing) thesis. The properties of symmetry and collaborativity are independent of each other: one game type may be symmetrical and collaborative, another may be symmetrical and non-collaborative. For example, an argumentation game is symmetrical and non-collaborative. Elsewhere (Maudet and Evrard 1998), we used the term "cooperativity". Now we prefer "collaborative", in order to distinguish it from the "higher" level of cooperativity of playing the game.

We argue that the various dialogue games proposed in the literature fit into this generic model. As well as allowing for more than one game type, the extended model is able to model a global dialogue which may be made up of a number of different types of dialogue. See Maudet and Evrard (1998) for an example of the model being used in the context of a dialogue comprising Beun's game for collaborative question answering and Mackenzie's argumentation game. As a further illustration, consider the following dialogue fragment:

(A1) Do you think I have chance to get a place for the concert?
(B2) Only if you hold a season ticket, as usual...
(A3) Not for this concert!
(B4) Why?
(A5) It's an extra concert.
(B6) So you're right....

Our analysis of this dialogue is as follows. The overall game is a collaborative question game with two friends trying to determine whether A has any chance of finding a place for a concert. Within this game is an argumentation game, where A contradicts B about the necessity for a season ticket. In sum, the hierarchical structure of this dialogue is seen as

[A1;B2;[A3;B4;A5;B6]...].

To account for such structures, we allow for "nested games" (*cf.* also Mann 1988). For example games G_1 and G_2 may be played at the same time, with G_2 nested in G_1, denoted as G_1>>G_2. Playing G_1>>G_2 is to be playing G_{12} whose rules are comprised of the union of the two sets of rules, with priority to the rules of G_2 in case of rule conflict. This is a similar approach to Walton and Krabbe's notion of "embedding dialogues of a certain type as subdialogues into a structure of some other type" (Walton and Krabbe 1995, p.82, *cf.* Reed 1998). As in the Walton and Krabbe analysis, our model is in principle capable of allowing for a number of shifts, to form a "cascading effect" (Walton and Krabbe 1995, p.106).

An important consequence of the model is to impose an appropriate structure upon the "gameboard" representation of the on-going dialogue. Ginzburg (1997), for example, introduces a partially ordered set "question under discussion", and Gordon's pleading games require "open", "conceded" or "denied" statements (Gordon 1994). As a generalization of these concepts, we propose the notion of "Games Under Discussion" (GUD), i.e. games currently opened in the dialogue. For the sake of simplicity, we can imagine the GUD as a stack (the current game being the top element). However, richer structures like trees or partially ordered sets can also be used.

A related issue is to describe how games are established in the course of dialogue, i.e. how they are added to the GUD. This requires a means of allowing the bidding of games and of dealing with such bids. Our starting position is to include explicit dialogue moves to propose/accept the entry into or the exit from a game.

We thus obtain what might be seen as a "Meta-Dialogue Game", a 4-phase process, as follows:

(i) Entry proposal
(ii) Entry acceptance/refusal
(iii) Exit proposal
(iv) Exit acceptance/refusal

Obviously, requiring explicit moves at each turn would generate an excessive number of dialogues. To relax these constraints, we propose to adopt the notion of *de facto* commitment (see Mackenzie 1979) for the acceptance phase. A player, that is, will accept a game unless he explicitly rejects it. In other words, the proposal of a game includes the game in the GUD.

A particularly important game type is the *basic game*, so called because information exchange is seen as the ultimate function of dialogue (cf. Levinson 1979) and the basic game is designed to ensure the maximisation of information exchange and game-level co-operation. In the model players are always, therefore, committed to the basic game. Although our model caters for this by defining different levels of commitment (Maudet and Evrard 1998, Maudet 2000), we will consider for the sake of simplicity that once a game is open, both players accept their goal in the game (s-commitment) and attempt to play within the game's rules (r-commitment).

We are now in position to give an illustration of these ideas through our concert example.

We use the following abbreviations: p = 'having chance to get a place', s = 'holding a season ticket', e = 'the concert is an extra concert'. The definitions of moves and their update consequences for the commitment stores (CSs) are in line with our amended DC model. The moves also have consequences for the GUD structure (set out on the next page):

The example illustrates how the argumentation game is embedded within the question game. The important steps are as follows. Move 1 establishes the collaborative question game (note that B could have merely refused the game: "I don't want to answer that question"; in this event, the question game would have been immediately removed from the GUD). During this game, a contradiction appears: move 3 bids an argumentation game, since it is not an expected move in the question game. Move 6 closes the argumentation game since B retracts his original thesis.

Let us now turn to the highly problematic issue of enabling a computer to operate as a dialogue participant in line with this model. First, we propose an additional, extra-game, level of strategy in the light of our extended model. The additional level of strategy is concerned with the issue of whether to retain or change the on-going game. Having made a strategic choice at this level, and as-

	MOVES	CSa	GUD	CSb	MOVES
1	question(p)		[Question(p)]		
2		s→p	[Question(p)]	s→p	assert(s→p)
3	retract(s→p)		[Question(p)] [Argum(s→p)]	s→p	
4		¬(s→p)	[Question(p)] [Argum(s→p)]	s→p	chall (¬(s→p))
5	assert(e)	¬(s→p), e, e→(¬(s→p))	[Question(p)] [Argum(s→p)]	s→p, e, e→(¬(s→p))	
6		¬(s→p), e, e→(¬(s→p))	[Question(p)]	¬(s→p), e, e→(¬(s→p))	retract(s→p)

suming that any change of game is accepted by the dialogue partner(s), strategies specific to that game will be adopted (e.g. for a debate game the three level strategy proposed by Moore and Hobbs (1996) will be adopted).

This additional level of strategy enables us to distinguish two kinds of computational behaviour:

- A reactive agent: the computer (C) merely adopts a stance with regard to the incoming game bids. C does not plan for or bid new games. Nevertheless, C recognizes games when they are bid by a partner and makes a strategic decision whether to accept that bid or attempt to continue the current game. The issue of bid recognition is, however, complex. It is tempting to propose that use by P_1 at time T_1 of a move type not catered for by the game type being played at T_1, bids a new game type and forms the first move in a new game of that type. However the proposal would have the consequence that any move can be made at any point, or at least that it will be impossible to distinguish between an illegal move in the current game and a game bid. Further, a move may appear to be a (legal) move in the current game type but in fact be intended as a new game bid. Given these complexities we currently insist, in our computational model, on explicit game bids. Walton and Krabbe (1995, p.102) distinguish between "licit" shifts of dialogue, in some of which the different dialogues may be functionally related and hence "embedded", and illicit shifts of dialogue, often associated with fallacies. The formulation of strategic rules enabling C to distinguish between such shifts in real time is complex and forms the subject of current investigation.

- A deliberative agent: C has the ability to plan games. In other words, it attempts to bid and enter into games. A computational agent able to handle these structures may need to process mental attitudes such as intention or desires, in addition to the "commitments" of our current prototypes. A straightforward option is to adopt the popular Belief-Desire-Intention (BDI) architecture, as also proposed by Burton and Brna (1996).

The importance of intention in its relation to the linguistic structure has been emphasized in Artificial Intelligence research by the influential work of Grosz (1977). However, we might be prudent not to overstate its importance in the current context. The conclusions of Grosz are highly dependent on the goal-oriented dialogues she considers. It has been widely shown that linguistic structure is not necessarily isomorphic with the intentional structure, at least when merely understood as the underlying task structure. For instance, in our concert example, the argumentation game was not "planned". Sub-dialogues tend, that is, to emerge during a dialogue rather than being planned for in advance. This we believe complicates the task of building a deliberative agent. Indeed, Dahlback (1997) claims that depending on the type of dialogue considered, the "dialogue-task" distance can vary greatly. We argue that in our current context, this distance is rather large. Consequently, our current work focuses on the issue of a reactive computational player, leaving the deliberative approach for future work.

This section, then, has considered means of enhancing our debating system by catering for types of dialogue beyond debate. A complementary means of enhancement is to integrate the dialogue game system within a multimedia environment. This possibility will now be discussed.

4. Multimedia enhancements

It is clear that multimedia has much to offer education (e.g. Boyle 1997, Bagui 1998, Stoney and Oliver 1998). Use of multimedia in an educational context, however, is prone to the danger mentioned earlier, that the teaching interaction will become unduly didactic. Laurillard, for example, argues "too often the multimedia products on offer to education use the narrative mode, or unguided discovery, neither of which supports the learner well, nor exploits the capability of the medium" (Laurillard 1995, *cf.* Montgomery 1997, Retalis *et al.* 1996). Consequently, we are examining means of utilising the dialogue game framework discussed in previous sections within such a multimedia context. We suggest that educational multimedia systems and computer-based dialogue games can work to each other's mutual advantage in four ways (*cf.* Moore 2000).

First, multimedia may be used as an initial stimulus to encourage students to enter the dialogue game in the first place (cf. Moore and Hobbs 1996, p.159). Footage of philosophers in discussion might engender a philosophical debate, for example. Extracts from a video documentary about abortion might set the scene for, and encourage participation in, a debate about whether and under what circumstances abortion should be allowed. This is an example of what Laurillard (1995) sees as the computer "[supporting] the learner in what is otherwise only possible through real-world experience", and as video offering "at least vicarious experience of the world". Secondly, during the dialogue game per se, hypermedia principles can be used to enable the student to clarify points and lines of argument he does not understand, and to look up relevant facts about empirical matters. A *prima facie* weakness of our current DC-based framework is the restricted range of question types it allows. However, arranging for key points of C's dialogue contribution to be represented as hypermedia nodes, so that in effect the debate is suspended whilst points are clarified and empirical matters are pursued, in a manner similar to Walton's "interludes" in negotiation dialogue (Walton 1998), is expected to overcome this problem. The situation is analogous to that in Gordon's "Zeno" system (Gordon 1996), where hypertext links are seen as potentially able to "reduce the 'rigidity' of Zeno's formal logic". Suitable hypermedia links may also enable users to clarify their understanding of concepts used in the debate, such that they enter the "cognitive environment" (Tindale 1992) required for the dialogue game to work.

These two approaches to using multimedia within argumentation systems can be seen as use of the multimedia facility to enhance the service provided by the dialogue facility. Conversely, we can see the next approach as using the dialogue facility provided by dialogue games to enhance a standard multimedia presentation. For the approach here is to seek to cater for *reflection* by the student during and after presentation of material from a multimedia package. Hartley (1993) refers to the need for "interactive debriefs", as does Laurillard (1995), and the use of the dialogue game framework discussed in sections 2 and 3 above promises online provision of at least part of such a reflective debrief process.

The final way in which educational multimedia systems and the computer-based dialogue game framework can work to each other's mutual advantage, we refer to as "full integration". Here C will use, where appropriate, a range of media as its contribution to the dialogue, so that C will, on its various turns, use text, audio, graphics, video, or some combination thereof, as its dialogue contribution. An important issue here will be how C will determine the content of this contribution. In a multimedia context this issue resolves, we argue, into two: deciding on the semantic content of the move, and deciding on the media to use to express the move.

The former can be decided on the basis of the strategic considerations discussed earlier. Concerning the latter, generally applicable guidelines for choice of media in different circumstances are not yet known (Alty 1993). Indeed, it might well be that experimenting with different policies in the current context could in itself prove illuminating. As an interim measure, however, one might suggest favouring relatively information-rich media (e.g. video) whenever they are available; this would be in line with Maybury's "preference metrics" (Maybury 1993).

Such an approach can readily be catered for by the Toulmin-based approach mentioned earlier. For all that is required is that individual nodes be modified to encapsulate, where appropriate, calls to the relevant selection of media output. The nodes would thus be acting not as purely receptacles of text, but also as what is referred to in the knowledge representation literature (e.g. Hopgood 2001) as "demons", i.e. invocations of procedural routines—in the current context, invocations of routines for playing video clips, for example. Arranging for appropriate demons to be encapsulated in the nodes would be the responsibility of the domain "author", just as the propositions are with the text-based version. In effect, then, the procedure involves the creation of argumentation-based hyperdocuments, along the lines of Schuler and Smith's (1993) "Author's Argumentation Assistant", and enriching the document with appropriate calls to varied media types.

Current work involves moving towards a full implementation of this proposed integration of our dialogue game framework with multimedia. The aim is to enhance the current text-based prototype such that C announces and then plays the appropriate multimedia material as its dialogue move. There are, however, several issues of theoretical and practical importance to be addressed.

The first concerns student input. It might be felt that the proposed multimedia arrangement would disadvantage S in that C has a range of types of media available at its disposal, whereas S can merely select from a given set of propositions. An interesting approach might be to allow S to select fragments of the computer's stored media content as his move; indeed this approach might substantially increase the flexibility of student input over the current text based arrangement.

A related concern is that the issue of what propositional content is being put to the user may be complicated by the fact that C is making some of its dialogue contributions via multimedia. In the purely text-based system the position is clear—S becomes committed to whatever proposition is contained in the written message from the computer. This is, of course, a function of the dialogue game's commitment rules; in our current system its effect is displayed to the user via updates to the "commitment windows". In the multimedia environment, however, the richness of the output may make it less obvious what commitment store updates are required. Our current design caters for this by a simple announcement of the proposition the video footage (say) is taken to be putting forward – in effect "summing up" the propositional message of the video.

This leads, though, to a third issue, namely whether the multimedia context will necessitate changes to the dialogue model, for it may be that the strict record of commitments required by a dialogue game model is inappropriate in a multimedia environment. Similarly, the game's restriction to one proposition per turn may rule out some of the longer dialogue turns that might be warranted by the availability of differing media types.

Considerable work remains, then, to bring the proposed integration of our dialogue game framework with multimedia to full fruition. However, we believe that the approach discussed has the potential to engender advantages of both multimedia systems and educational debate and thus promises a useful enhancement of our current dialectical system and hence major educational benefit. A further enhancement of the dialectical system would be to extend it to situations involving multiple participants. This will be considered next.

5. Computer Supported Collaborative Argumentation (CSCA)

Dialogue games, then, provide, we argue, a powerful means of modelling dialogue and allowing a computational agent to participate in dialogue with a user. What, though, of dialogue involving groups of participants? This is an important issue in current computer science given the growing interest in computer supported collaborative learning (CSCL) in general (Hoadley 1999, Steeples *et al.* 1996) and CSCA in particular (Veerman *et al.* 1999).

Dialogue game systems have generally been studied within the context of two participant dialogues, and there is some ambivalence in the literature about how the framework might be extended to cater for multiple participants. Walton (1989) suggests that a game will involve two players, and that although there may be games of dialogue with more than two participants, these players can be collected into two groups, one on each side. In effect, then, "one group is the proponent and the other the respondent" (p. 282). Other writers, on the other hand, are prepared to allow for varying numbers of (genuine) participants, e.g. Apostel (1982): "a discussion is the interaction between n participants. Monologues, dialogues, and polylogues may all constitute discussions" (p. 98, *cf.* Barth and Martens 1982, viii).

Unfortunately, it is not made clear precisely how these varying numbers of participants can be catered for within dialogue games. In the remainder of this paper therefore we propose an exploratory model extending dialogue games to multiple participants. We will restrict ourselves to Walton's conception of dialogue game playing by multiple participants as "teamwork". Given this, DG (T1,T2, game) is a game between two teams (T1 and T2), and teams are sets of players such that for all players p, p in Ti and p in Tj implies i=j (a player cannot be in two teams).

The team-based approach, however, raises some important questions, in particular what it means to play in a team and how teams are formed. Wooldridge and Jennings (1999) have identified four stages in what they call the cooperative problem process: (i) recognition (identification of the potential for cooperation), (ii) team formation, (iii) plan formation and (iv) execution. Following their theory, the issue becomes how these stages can be put into practice computationally.

(i) *Recognition*. The recognition of the potential for cooperation by *human* participants in the dialogue we leave to the participants themselves. How a computational agent might encourage such identification, or identify the potential for itself to cooperate, is an issue for future research.

(ii) *Team formation.* This may depend on multiple contextual factors: some teams may be defined through social roles before the beginning of the conversation (e.g. teacher/students, policemen/witness), others may emerge from the dialogue. This possibility, however, involves a complex mechanism of team formation that we have not investigated yet. An interesting possibility is that when (at least) 4 players are in the global game, one might allow for parallel dialogue games (i.e. parallel discussions).

(iii) *Plan formation.* The issue here concerns how players play together in a team. The teams may hold an intra-team meeting before the dialogue proper, to clarify their views and to enable potential team members to establish whether there is enough "common ground" (*cf.* Rosenberg and Sillince 1999). A very deliberative team may even start the dialogue with a plan ("B will ask whether p", "C will...") - a "shared plan" (Grosz and Kraus, 1993).

In a CSCA context, however, it is intuitively unlikely that players will build a shared plan to defend the team's point of view. What is needed for CSCA therefore is a more reactive process. The difficulty arises, however, that this may give rise to discrepancies within the team. Consider the following example, where A is a teacher asking a question to two students B and C (we assume that every move is multi-addressed):

Step 1 (A): Must X go to jail?
Step 2 (B): X is a thief.
Step 3 (C): And thieves must go to jail.
Step 4 (B): No!

The problem here is delicate: on the one hand, players are autonomous and have their own point of view; on the other hand, they play in a team and must follow a global policy (for instance, there may be some crucial facts which cannot be denied within the team).

The growing field of Multi-Agent Systems offers some important results and models of more flexible teamwork (see e.g. Tambe (1997), Jennings (1995)). We draw on such work to make two proposals, currently being investigated.

One approach is to consider that the step 4 above (B's "no!") opens a new game, within a team. This leads to the following analysis, at the game level. A bids for a question dialogue game (step 1). B and C form a team to try to find out the answer and step 2 and 3 are understood in the context of a question dialogue game (more precisely an exam-question dialogue game, since the teacher is presumed to know the answer). But at step 3, C claims a fact that B does not believe: they enter into an argumentation game (nested in the question game) where the teams are different (step 4: DG(<B>,<C>, argumentation)). This analysis can be represented diagrammatically as follows:

Step 1 (A)→(B C)
Step 2 (A)←(B C)
Step 3 (A)← (B C)
Step 4 (A) ((B)→(C))

Adopting this approach clearly entails dynamic team formation. This greatly complicates the issue of computational modelling of, and support for, such dialogues, given the difficulties of team formation discussed earlier.

In our second proposed approach we allow discrepancies within a team, and attempt to deal with this via differing levels of commitment. Specifically, we propose that each team gets a "collective" commitment store, a virtual list of commitments arising from the current dialogue game. How, though, should such team commitment stores be updated? The arrangement in the original DC system was "de facto commitment"—a participant has to explicitly withdraw from his commitment store those statements of his interlocutor to which he is not prepared to commit (Mackenzie 1979). The situation is, we suggest, more complex where teams are involved. For different theses can be expressed within a team and this raises the issue of how the CSs should be updated. In the current example, for instance, it is counter-intuitive that the teacher be committed to the claim "thieves go to jail", which would be the case were the DC mechanism to be applied. Here, therefore, we propose a procedural amendment, making use of the notion of "minimal consensus". The minimal consensus is the intersection of the CSs of the players of the team. The idea is that the teams (at the end of the turn) will be de facto committed only to this minimal consensus. Applied to our current example, this implies that, at step 4, the teacher (A) is committed to "X is a thief" (this claim is in the minimal consensus) but not to "thieves must go to jail". This is a relatively simple way to extend the model, and we do not see it as unduly coercive in that if a team member is not prepared for a particular commitment he can leave the game or swap sides.

(iv) *Execution.* One would expect, of course, moves to be executed by the team members. A difficulty, however, concerns turn taking. A very attractive aspect of the dialogue game framework, particularly from a computational perspective, is the reduction of the turn-taking problem to the following equation: one move = one turn. In the context of a set of players, this definition may need to be refined. It may not be realistic to require or even allow one move for each player of the team. A possible solution could be to introduce an explicit turn-taking move, in line with Bunt's "dialogue-control-acts" (Bunt 1994, *cf.* Traum and Hinkelman 1992), so that players can hand over the turn when they want. Alternatively, it may be that a team is required to make one move only before handing over to the other team, and that the process of intra-team agreement can be modelled via recursive dialogue games within the teams. In this case, each team would have a spokesperson putting forward the team's moves.

A number of interesting and important issues remain to be solved, then, concerning computational modelling of group dialogues. We believe that such issues are well worth pursuing, not least because a dialogue game model capable of catering for group dialogues offers, we suggest, two major advantages to CSCA. One major gain would be that, by providing a computationally tractable model of polylogue, it becomes possible for a computational agent to participate in the polylogue, together with two or more human participants. This is advantageous in a number of ways. CSCL work is often of a discursive nature (Simon 1997) and the ability of the computational agent to play a "devil's advocate" role is potentially of educational value (*cf.* Retalis et al 1996), especially, perhaps, in contexts in which the human participants all agree but it is felt educationally advantageous for them to critically explore their shared view. Secondly, we are currently investigating the use of collaborative virtual environments (CVE's) for group discussion. A perception of "presence" is seen as crucial to such environments and we propose the use of computational agents as a means of enabling "presence in absence" (Gerhard and Moore 1999, Fabri *et al.* 1999) and thus allowing people to benefit from the discussions even when not directly participating themselves; a user's computational agent, that is, may be able to use its dialectical model of the dialogue to contribute to the dialogue on the user's behalf. A further advantage of computational participation is that it affords participants the possibility of their own "private" discussion with the agent. This might be used for rehearsal and practice prior to entering the group discussion (perhaps to resolve any "intra-agent conflict" (Amgoud and Maudet 2000)), and/or for reflection and analysis after a group discussion. The facility may be particularly useful for people reluctant to enter the group discussion or for people with a social disability such as autism which may restrict their participation (*cf.* Moore *et al.* 2000). A final advantage of computational participation is that it would enable a number of computers to hold discussions with each other, and, given recent claims concerning the educational benefits of vicarious learning from the dialogue of others (Stenning *et al.* 1999), the resulting transcripts might make educationally valuable study material.

A second major benefit of dialogue games to CSCA is their ability to provide a regulatory framework for interactions within the collaborative discussion. Means of suitably controlling the evolving discussion are required (*cf.* Okamoto and Inaba 1997). And given that, as suggested earlier, dialogue games purport to be models of "fair and reasonable" dialogue, the case for their adoption as the regulatory framework seems clear. Thus Finkelstein and Fuks (1990), for example, use a dialogue games model as the basis for a system for providing automated support for groups collaborating on the development of software specifications (*cf.* Bouwer 1998, Burton *et al.* 1997).

In a computational context, the inability of the computer to understand natural language will, on the face of things at least, severely constrain this regulatory role. Our debating prototype, for example, operates on the basis of a predetermined (albeit expandable) set of propositions, and the Hartley and Hintze mediating system (Hartley and Hintze 1990) operates on strings. On the other hand, one can speculate that much of the difficulty in unregulated discussions concerns semantic shifts, and that this would be largely ruled out by the propositional logic of the dialogue games. Further, the models can provide a valuable service at the propositional logic level, for example by keeping track of commitments and pointing up inconsistencies and consequences of extant positions.

A further issue concerns the computer's role in the dialogue if teams are formed. For it might appear that the computer as an agent adds a third party to the debate and hence immediately destroys the two-team arrangement. We envisage, however, that the computer will maintain a watching eye over the evolving dialogue and, in an educational setting, proffer advice to either team in the light of the reigning dialogue status. Even where teams do not form, a computational agent can play an important role. It may be the case in asynchronous computer conferences that propositions posed by one participant evoke no response (Hewitt and Teplovs 1999) and that discussion is therefore stymied. A computational agent could potentially provoke discussion in such circumstances by acting as devil's advocate or by asking for support for the dialogue contribution.

In this section, then, we have made some proposals for means of utilising dialogue games within group-based CSCA. Whilst the proposals are at this stage inevitably somewhat speculative, we believe there is a strong case for investigating them further. An important aspect of such an investigation concerns strategies for a computational agent in a group context. For example, the computer needs to decide which of the various "live" propositions to take issue with (assuming that disputation is itself a valid strategy at that stage) and when it would be appropriate to do so, i.e. when it is its "turn". Similarly, we have assumed so far that players are always committed to the same game. A suitable game adjustment process, for cases where this assumption does not hold, needs to be investigated. An interesting avenue of study concerns how knowledge of the conventional rules of a particular game type may help to coordinate the games of the interlocutors. For instance, if A notices that B violates a rule of the game type he (A) thought they were in, a "meta-communication sub-dialogue" may appear, until the adjustment is achieved (i.e. a common game is adopted).

6. Concluding remarks – an interplay between informal logic and computational dialogue systems

We have outlined our work in applying dialectical theories developed within the field of informal logic to dialogue involving people and computers, i.e. "computational dialectics" (Gordon 1996). Many issues remain to be addressed, e.g. the development of suitable computational strategies, empirical investigation of the systems in use, and refinements to the dialogue game models to enable multimedia enhancements and group discussion. Fundamental to these issues, and to the research in general, is the development of suitable dialectical models. Given this, it is of interest to consider how the computational use of dialectical theories may help to illuminate research issues in the field of dialectic itself.

The crucial point, we argue, is that the computer environment can act as a test-bed in which the dialectical theories can be evaluated and refined. Walton (1998, p. 29) argues: "the formal systems of dialogue that have proliferated in recent times appear potentially useful, but they are not sharply enough focussed on the practical contexts of argument use that need to be studied in relation to the fallacies – they are too diffuse, too multiple and too abstract". And a computational test-bed is likely to provide a useful facility for rationalizing the proposed models and making them less abstract. One useful approach might be to allow two computer systems to run with a proposed system in dialogue with each other, and to study the results. As Amgoud and Maudet (2000) point out: "conversation simulation between computational agents is more and more considered as an important means to get empirical results about dialogue structures and behaviors".

Further, some specific points of investigation can be suggested. One concerns the dialogue rules. For example, the ramifications of Walton's device of a "dark side commitment set" (Walton 1998, 1984, Walton and Krabbe 1995) can be investigated in a computational environment. Some of Walton's systems require that a commitment will move from the dark to the light side if a participant retracts the proposition in question. We have argued, however, that since the dark side is, *ex hypothesi*, unknown, there appears to be no way of distinguishing such moves from those involving propositions not on the dark side, and thus no way of propositions making their way across (Moore 1993). The practicality of the notion of dark side commitments, for example, could perhaps be definitively ruled upon in a computational context.

Similarly, computational use of Mackenzie's DC system (Mackenzie 1979) has already suggested issues concerning the dialogue rules, for example the issue of potentially being prevented by the rules ($R_{REPSTAT}$) from answering a question in the desired way. Conversely, the DC model reveals weaknesses in our current computational model. In particular, the input arrangement of selecting from pre-set propositions prevents a challenge of any grounding implication acquired via previous defense moves (Trott 1999). Whilst this can be catered for computationally, albeit at the cost of extra complications at the interface, it is an interesting example of difficulties imposed by the lack of computational understanding of the propositional semantics. Indeed, it may be that attempting to work within the confines of propositional logic will turn out to be revealing about what Walton (1989) sees as the contested ground between semantics and pragmatics.

As well as dialogue rules, crucial aspects of dialogue strategy may be illuminated by computational use. One interesting possibility is to study the utilisation of Walton's argumentation schemes (Walton 1996) as a component in a computational strategy. Amgoud and Maudet (2000) suggest "meta-preferences", such as "choose the smallest argument, in order to restrict the exposure to defeaters", as a means of driving the choice of arguments in a context of dialogue. Working through such strategies is both vital to computational use of the dialectical theories and facilitated by a computational environment. Further, such strategic considerations are, we suggest, of fundamental importance to the field of informal logic itself, in that for normative dialogue models to be of practical use in generating dialogues, suitable strategies for their use are vital.

Indeed, computational utilisation may be revealing with regard to the very notion of a "normative" dialogue model. Walton (1998, p.155) suggests "the dialectical sequence of argumentation in a deliberation can be normatively represented as the opposition between ... two sides on how to solve the problem that is the issue of the deliberation". But what does "normatively represented" mean? On the face of it, it may seem to be an oxymoron. If we want to represent something we should not be normative about it, and if we are bringing in normative considerations we may not be representing the actuality. This is the view of "representation" which tends to be prevalent within the AI knowledge representation community (e.g. Bench-Capon 1990). On the other hand, it might be argued that, concerning dialogue at least, nothing can be represented without a normative stance (*cf.* Van Eemeren *et al.*'s (1993) notion of "normative pragmatics"). Normative representation involves representing a dialogue as it should be, against some ideal form; *cf.* Van Eemeren *et al.* (1993, p. 37): "a central problem for critical analysis is how to represent argumentative discourse in a way that is both relevant to the interests of normative analysis and faithful to the intentions and understanding of the ordinary actors who produce the discourse". Given this, computational realization may help to show the reasonableness and practicality of the representation, and hence the extent to which it can qualify as a "representation".

Similarly, Walton talks of "mixed dialogue", involving an overlap of types of dialogue (Walton 1998, p. 201). Again, these concepts might be illuminated in a computational context. For a computational model would seek to simplify matters by seeing extended dialogues as potentially consisting of a series of dialogue games (as discussed in section 3 above), which can be distinguished from each other by topic (different games of the same type), aim (different game types, same topic) or both (different game types and different topics) (Moore 1993). Part of the computational challenge is, as we have seen, to derive strategies for bidding games and deciding on incoming bids (*cf.* also Maudet 2000). The computational analysis, though, would be revealing as to the need for, and the practicality of, mixed dialogue in Walton's sense. Conversely, it may be that the absence of a facility for dialogue overlap represents an impoverishment within the purported computational model.

Here as elsewhere, then, there seems to be scope for an interesting and fruitful interplay between research within informal logic on the dialogue models per se, and research on their computational utilisation. The hope is that this paper will play a part in facilitating such an interplay.

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