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DIALOGUE LOGIC AS DYNAMIC LOGIC

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Abstract

There are several formal systems for persuasive dialogue. Dialogue systems are multi-agent systems, and this contrasts with the general lack of any agency in standard logics other than in the case of epistemic and deontic logics. Dialogue systems have been called *logics*. A logic usually has a semantics and a proof system, and questions of soundness and completeness arise. Any dialogue conducted according to the rules of a dialogue logic is a complex process. Dynamic Logic is a logic of processes, with a possible world semantics. This paper is a preliminary exploration of transforming the dialogues of dialogue logic into complex Dynamic Logic processes with emphasis on semantic models. The transformation gives rise to many questions, three of which are discussed. Dialogue logic includes *commitment sets* which behave in a way similar to belief sets and undergo changes during any dialogue. There are issues as to the relationship between belief and commitment, and whether the logics of belief change apply to commitment stores. There is also the issue of the logical nature of the evaluation of dialogues as legal or illegal.

Keywords: Dialogue Logic, Dynamic Logic, possible world semantics, commitment sets.

1. Introduction

Dialogue systems need to be set in a context of controversies about argumentation analysis. There is an ongoing debate in Argumentation Theory about the best methodology for the analysis and evaluation of argumentative discourse. The methodology which dominates argumentation analysis is the traditional analysis based on the Demonstrative Theory of argumentation. This can be referred to as the *demonstrative methodology*.

The demonstrative methodology dismisses all but the propositional content of argumentation and considers premise-conclusion argumentation alone. It is, in a strong sense, a *set piece* methodology of propositional premises and conclusions. There is a deliberate abstraction from agents, context, questions, commands and promises. [5] The focus is on both proof theoretic and semantic accounts of logical consequence, and the metalogical relationships of soundness and completeness. Even the formal pragmatics to be found in such as Gabbay and Woods [7] focus on reasoning from one proposition to another.

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This demonstrative methodology is by no means the only method of argument analysis. There is a formidable list of alternative methodologies to be found in van Eemeren and Grootendorst. [5] But it is probable that the most challenging alternatives are the *rhetorical methodology* [16] and the *dialogical* or *dialectical methodology* [4].

This paper focusses on the dialogical methodology. The focus is on argumentative discourse in which participants actually argue with each other. It is, in a strong sense, a *process* methodology, a methodology which concentrates on the process of argumentation. The issue is well stated by Carlson:

> "the fundamental problem of discourse analysis is to show how one utterance follows another in a rational, rule-governed manner — in other words, how we understand coherent discourse." to explain *what is coherent* (*i.e., well formed*) *discourse.*
>
> In my approach, the fundamental unit [… is] called a *dialogue game*. (pp. xiii-xiv [2])

We turn to the Hamblin and Mackenzie [11, 16] method for the analysis of argumentative discourse where one person attempts to persuade another of some point of view.

Mackenzie and others [11] give formal models for persuasive dialogue. The result is a regulated system of multi-agent interactive reasoning. It provides a formal and normative model for persuasive discourse. There are other models proposed for other forms of dialogue such as inquiry and negotiation. These models are sometimes referred to as *Dialogue Game Systems*.

There are at least *six types* of dialogue commonly found in the literature (pg. 66 [20]):

- Information exchange
- Persuasive
- Inquiry
- Negotiation
- Command
- Eristic

These systems seem to have neither a semantics nor a proof theory. Without either a semantics or a proof system there will be neither soundness nor completeness. But things might not be as they seem.

Whatever the dialogue type, any dialogue is a *complex process* involving participating agents. Seeing a dialogue as a complex process raises the question of whether dialogues can be understood in terms of a *logic of complex processes*. One standard logic for complex processes is Dynamic Logic, the logic explored by Harel [14].

This paper begins by setting out a formal persuasive dialogue system. Second, we discuss some of the issues arising from the contrast with

standard demonstrative systems, particularly with respect to metalogic. Third, we show how one might transform the dialogue logic into a multi-agent Dynamic Logic with belief revision features. The paper finishes with some comment on the outcome.

2. Dialogue Logic (DL3sub)

There are many formal dialogue systems. Despite differences between the systems, they have several things in common. In this paper we do not set out a full Dialogue Logic as such. Our aim is to explore the relationship between Dialogue Logic and Demonstrative Logic. For that reason we only to set out a sub-system of a **DL3** style logic for just two agents. The full **DL3** system together with its expansion to a command dialogue system is to be found in [11]. **DL3** is based on the systems **DL** [9], **DL2** [10], and **BQD** [15, 16].

There are four main elements in most persuasive dialogue logics. The first element is a formal language of *locutions*. The language of **DL3sub** contains statements of two kinds, withdrawls, questions of two kinds, and commands. There are *categorical statements* and *statements of reasons*. There are two kinds of questions: *reasons challenges* and *true-false questions*, Reasons challenges are requests for reasons for some statement. A typical example is, "Why do you say that *S*?" We distinguish one special command called the *resolution demand*. This is a demand where one agent requires the other agent to deal with an inconsistency revealed by their statements. These locutions are uttered by an agent and addressed to the other participant in the dialogue. We have a formal language as follows:

two agents: *a, b*
statements: *p, q, r, …*
operators: $> < \therefore ? \bot \Rightarrow !$

and a standard set of propositional connectives: $\sim$ & $\vee$ $\rightarrow$ plus the monadic operator: ι

The last is an agnostic epistemic operator on first order formulas and is read as "I don't know whether …" or "I have no opinion about whether …"

There are six sorts of locutions allowed: *categorical statements, reasons statements, withdrawals, tf-questions, challenge questions,* and *resolution demands*.

Where *x* and *y* are agents we represent the locutions in *action statements*:

Where *p* is a formula of propositional logic extended by ι we have:

categorical statement	$>_x p$	*x states p*
reasons statement	$\therefore_x p$	*x states reasons for p*

withdrawal	$<_x p$	*x withdraws p*
question (t/f)	$?_x p$	*x asks is p true*
challenge question	$?_x \Rightarrow p$	*x asks for reasons for p*
resolution demand:	$!_x \perp p$	*x demands resolution of p*

In the formal analysis of dialogue, action statements are numbered to indicate their order in the dialogue. These numbers are analogous to the numberings of formulas in a proof. A *move* is a numbered action statement, called a "locution event". A dialogue is a *sequence of moves*. A dialogue example with translation to action statements is:

(1)

1.	***a*** *I am overweight.*	$>_a O$	*categorical statement*
2.	***b*** *Why do you think that* ?	$?_b \Rightarrow O$	*challenge question*
3.	***a*** *Because I cannot fit into my jeans.*	$\therefore_a \sim F$	*reasons statement*
4.	***b*** *Why do think it follows that if you cannot fit into your jeans then you are overweight?*	$?_b \Rightarrow(\sim F \rightarrow O)$	*challenge question*

This is a dialogue of four moves. Moves are designated by an ordered pair of the number of the move in the dialogue sequence and the content of the move. The first move above is $\langle 1, >_a O\rangle$. It is a number with an action statement.

More complex persuasive dialogue logic or a dialogue logic for inquiry, command or negotiation dialogue, would have to be extended with more kinds of locutions.

The **second element** is a *profile* for each participant. Each participant, x, in a dialogue has a *profile* of explicit commitments, and of questions either pending answer or answered. The profiles of the agents provide an explicit context within which the dialogue proceeds. Each agent's profile changes after every move. *After move n* the profile for agent x is $Profile^n_x = \langle x, C^n_x, Q^n_x\rangle$, where C^n_x is x's *propositional commitment set after move n,* and Q^n_x is x's *question set after move n*.

Many writers have a "commitment store" as the equivalent of this complex, and in most systems the commitment store contains not only propositional commitments but also questions and responses to them. The propositional subsets of commitment stores are often treated like belief sets, subject to revision or update. We adopt separate propositional commitment sets and question sets. We also use the non-classical belief revision logic as set out in [12] transposed to propositional commitments. This allows for both non-commitment about beliefs and for the logical toleration of contradictory commitment. We discuss issues about commitment sets in section 5 below, especially the question of the relationship between commitment and belief, and transparency of dialogue.

The **third element** is a set of *Profile Rules*. Each participant's profile is modified according to what statements, questions, answers and withdrawals are used by participants in the dialogue. For example, if a participant asserts that p, then p is added to everyone's commitment set. If anyone disagrees, then they must explicitly disagree with p. Such a condition gives expression to the notion that we mostly accept what people say.

The **fourth element** is a set of *Interaction Rules* to stipulate the legal sequence of locution events.

For example, a question of the form

"Why do you say that p?" must be followed either by the reasons from which one is to draw the conclusion that p, or an explicit disagreement with p.

For **DL3sub** there are just two participants, a and b.

There are five **Profile Rules**.

We adopt terminology analogous to the AGM [8] belief revision terminology. "*expanding* a commitment set by p" means adding p to a commitment set, "*contracting* a commitment set by p" means removing p and all that entails p from a commitment set, and "*revising* a commitment set by p" means first contracting a commitment set by the negation of p and then expanding with p. It will be useful to use the same terminology for question sets. Commitment sets are not deductively closed, nor need they be consistent. We will use often use the shorter "commitments" for "commitment set."

(C1) **Statements:** *After each move* $\langle n, >_x p\rangle$*, every agent's commitments are expanded by p.*

(Rule C1 is the *Credulity Principle*. It is based on the observation that most people, most of the time, accept what they are told [3]. This rule requires any participant who disagrees with a statement to declare disagreement explicitly. One of the issues arising from the *Credulity Principle* is the extent to which acceptance is commitment. This is discussed in section 5 with the issue of the relationship between commitment and belief.)

(C2) **Reasons:** *After each move* $\langle n, \therefore_x q\rangle$ *where the previous move is* $\langle n\text{-}1, ?_y \Rightarrow p\rangle$*, the commitments of both x and y are expanded by q and* $(q \rightarrow p)$ *and both x's and y's question sets are contracted by the challenge* $?_a \Rightarrow p$ *and both participant's question sets are expanded by a justification triple* $\langle >_x p, ?_y \Rightarrow p, \therefore_x q\rangle$.

(The conditional $(q \rightarrow p)$, is the *reasons conditional* which is *associated with* the justification triple. If someone gives reasons for a statement p, then the reason, its conditional connection, and exactly what is justified go into the profiles of both participants. This allows us to keep track of why reasons statements are in commitment sets.)

(C3) **Withdrawals:** *After any of the following four moves:*

$\langle n, <_x p\rangle$ or
$\langle n, >_x \sim p\rangle$ or
$\langle n, >_x q\rangle$ (*where q entails* $\sim p$) or
$\langle n, >_x \iota\, p\rangle$, *where p is one of x's commitments, then*

(a) *the statement p is contracted from x's commitments, and*

(b) *if the withdrawal was of form* $\sim p$ *or q* (*where q entails* $\sim p$), *then the commitments of both participants are expanded by the withdrawal, and*

(c) *if the withdrawal was of form* $\iota\, p$, *then the commitments of x are expanded by the withdrawal, and*

(d) *if the withdrawal was preceded by the move* $\langle n\text{-}1, ?\Rightarrow_x p\rangle$, *then the question sets of both participants are contracted by* $?\Rightarrow_x p$, *and*

(e) *if x's question set contains* $\langle >_x p, ?_y \Rightarrow p, \therefore_x q\rangle$, *then it is contracted by* $\langle >_x p, ?_y \Rightarrow p, \therefore_x q\rangle$; *and both participants' commitments are contracted by q*

(f) *if p is a reasons conditional* $(r \rightarrow t)$, *then both question sets are contracted by* $\langle >_x t, ?_y \Rightarrow t, \therefore_x r\rangle$.

(Disagreement is a form of withdrawal. There can be either strong or weak disagreement. *Strong disagreement* is where a participant states belief in either a contrary or contradictory statement. *Weak disagreement* is where a participant either declares they neither accept nor reject, or issues a reasons challenge as in C4. A reasons challenge, therefore, results in the challenged statement being withdrawn from the challenger's commitments. Given that commitment sets are neither deductively closed nor essentially consistent, only the obvious justification is withdrawn. A more ruthless recursive withdrawal rule is discussed in [10]. A far more complex approach is in [20].)

(C4) **Challenges:** *After the move* $\langle n, ?\Rightarrow_x p\rangle$, *the question sets of both participants are expanded by the challenge*, $?\Rightarrow_x p$.

x's commitments are contracted by p

y's commitments are expanded by p

if x's question set contains $\langle >_x p, ?_y \Rightarrow p, \therefore_x q\rangle$, *then it is contracted by* $\langle >_x p, ?_y \Rightarrow p, \therefore_x q\rangle$, *and*

if p is a reasons conditional $(r \rightarrow t)$, *and x's question set contains* $\langle >_x t, ?_y \Rightarrow t, \therefore_x r\rangle$, *then it is contracted by* $\langle >_x t, ?_y \Rightarrow t, \therefore_x r\rangle$.

(Although it might seem strange to put *p* into *y*'*s* commitment set, *y* can withdraw it or deny it (see (v)(a) below and C3 above). If *p* is already in *y*'s commitment set then the expansion is vacuous. Also, if *p* is in the *x's*

commitment set it is withdrawn because, if x has no problem about the statement, the challenge should not have been issued. If a reasons conditional is challenged then the justification triple associated with it should be considered to be challenged also)

(C5) **True/false:** *After the move* $\langle n, ?_x p\rangle$, *x's commitments are contracted by p and both agents' question sets are expanded by* $?_x p$.

The following, **Table 1**, shows the application of these rules to the commitment sets of the agents for dialogue (1) above. The question set for agent b is also included.

move	C_a^n	C_b^n	Q_b^n
$\langle 1, >_a O\rangle$	$\{O\} = C_a^1$	$\{O\} = C_b^1$	$\varnothing = Q_b^1$
$\langle 2, ?_b \Rightarrow O\rangle$	$\{O\} = C_a^2$	$\varnothing = C_b^2$	$\{?_b \Rightarrow O\} = Q_b^2$
$\langle 3, \therefore_a \sim F\rangle$	$\{O, \sim F, (\sim F \rightarrow O)\} = C_a^3$	$\{\sim F, (\sim F \rightarrow O)\} = C_b^3$	$\{\langle >_a O, ?_b \Rightarrow O, \therefore_a \sim F\rangle\} = Q_b^3$
$\langle 4, ?_b \Rightarrow (\sim F \rightarrow O)\rangle$	$C_a^4 = C_a^3$	$\{\sim F\} = C_b^4$	$\{?_b \Rightarrow (\sim F \rightarrow O)\} = Q_b^4$

Table 1

Comment: Move 1 shows the application of C1 so that a's categorical statement, O, is added to both commitment sets. Move 2 shows the application of C4 where, since reasons for O are requested by b, O is removed from b's commitment set. The question is added to b's (and a's) question set. Move 3 shows the application of C2 where a's reasons statement, $\sim F$, is added to both commitment sets. The challenge question is removed from both question sets and the justification triple is added to both. The reasons conditional, $(\sim F \rightarrow O)$, displays the acceptance that the reason, $\sim F$, implies or entails O; and the justification triple is added to a's and b's question sets. Move 4 is a challenge question addressed to a's reasons conditional, and by rule C4, the justification triple is removed from b's question set because it is under challenge.

There are all sorts of reasonable possibilities open for the continuation of the dialogue. Agent b could challenge either the statement that $\sim F$ or challenge the reasons conditional. The former challenge is virtually equivalent to testing the soundness of a premise-conclusion argument and the latter challenge is something like testing the validity of a premise-conclusion argument. Other options are either to agree and concede that a is overweight, or to state strong disagreement, or to offer counter-argument, or to change the subject and opt out of the argument. (see [15])

A dialogue is *evaluated* as *legal* or *illegal* in accordance with a set of interaction rules. If the interaction breaches any of these rules the dialogue is illegal.

There are six **Interaction Rules**:

These rules require a minimal logic in which there is one and only one rule of inference: *modus ponens. Modus ponens* is common to most logics, classical and non-classical, and can be represented as an *immediate consequence conditional*: $(p \,\&\, (p \rightarrow q)) \rightarrow q$ Given such a conditional, q is the *immediate consequence* of p and $(p \rightarrow q)$. We also define: Statements of the form $(p \,\&\, \sim p)$ are *prima face inconsistent.*

(i) **NoRepeatStatement:** *If p is a member of the commitment sets of both x and y after move n, then* $\langle n+1, >_x p\rangle$ *is* illegal

(This rule prevents vain repetition and helps prevent the *fallacy of begging the question*. From an everyday rhetorical perspective it may be unrealistic, even brutal, but in the ideal dialogue it can be accepted, at least for our purposes at the moment.)

(ii) **LogChall:** *An immediate consequence conditional must not be withdrawn.*

(This rule prevents the withdrawal or challenge of *modus ponens*)

(iii) **TF-Quest:** *After* $\langle n, ?_x p\rangle$ *the only legal move is* $\langle n+1, \mathrm{Q}\rangle$, *where* Q *is either*
- (a) $>_x p$, or
- (b) $>_x \sim p$, or
- (c) $>_x q$ (*where q is the contrary of p*) or
- (d) $<_x p$, or
- (e) $>_x \iota\, p$ (x states, "I do not know whether p").

(This rule must be read in conjunction with C1 and C3.)

(iv) **Challenge:** *After* $\langle n, ?\Rightarrow_y p\rangle$ *the only legal move is* $\langle n+1, \mathrm{Q}\rangle$, *where* Q *is* either
- (a) $>_x \sim p$, or
- (b) $>_x q$ (*where q entails* $\sim p$) or
- (c) $<_x p$, or
- (d) $>_x \iota\, p$, or
- (e) *the resolution demand of a reasons conditional whose consequent is p and whose antecedent is a conjunction of statements in y's commitment set,* or
- (f) *a statement of grounds acceptable to the challenger.*

We set out Mackenzie's definition of what an *acceptable statement of grounds* is:

> A statement of grounds, $\therefore_x p$, is *acceptable to participant y* iff either p is not under challenge by y, or if p is under challenge by y then there is a sub-set of

statements in y's commitment set to none of which has y a challenge in y's question set, and p is an immediate *modus ponens* consequence of the set.

(This definition is discussed at length in [19]. When the challenge is issued, see C4, the person challenged can either (a) deny any adherence to p, or (b) throw the challenge back to the challenger by pointing out that the challenger has an implicit belief that p, or (c) give a reason acceptable to the challenger.)

(v) **Resolve:** *The resolution demand in* $\langle n, !_x \perp p\rangle$ *is legal only if* either
  (a) *p is a statement or conjunction of statements in y's belief set which is prima face inconsistent,* or
  (b) *p is of the form* $(q \rightarrow r)$ *and q is a conjunction of statements all of which are in y's belief set, and r is an immediate consequence of q, and the previous move was either:*
  $\langle n\text{-}1, <_y r\rangle$ or $\langle n\text{-}1, ?\Rightarrow_y r\rangle$.

(This rule opens the way for keeping belief sets consistent.)

(vi) **Resolution:** *After* $\langle n, !_x \perp p\rangle$ *the only legal move is* $\langle n{+}1, \mathrm{Q}\rangle$, *where* Q *is* either
  (a) $<_y$ *q, where q is either a conjunct of p, or a conjunct of the antecedent of p, or*
  (b) $>_y$ *q, where q is the consequent of p.*

These rules are not in any way breached by Dialogue 1, so it is a legal dialogue.

3. Logical Analogies and Dysanalogies

There are strong analogies and dysanalogies between the formal dialogue systems and formal demonstrative systems. Both have a formal/artificial language. One can also see proofs as a sequence of moves in which one moves from a given context to some conclusion derived from the context. The evaluation of a proof allows certain moves by means of rules and forbids other moves.

Table 2 sets out the obvious analogies and dysanalogies at the object language level:

Dialogue Logic	Demonstrative Logic
Language	Language
Agents	(No agents)
A dialogue	A proof
moves	*formulas*
profiles	(no profiles)
evaluation	*evaluation*

Table 2

The more important issue is the contrast at the *metalogical* level. What does dialogue logic have that compares with the contrast between proof system and semantics? And if there is no comparable contrast, then the notions of completeness and soundness no longer apply.

The quick answer is that there is nothing to compare. This leaves open two possibilities, the first of which is to say that these issues are irrelevant to Dialogue Systems. Dialogue logic is just plainly different and there is no clear metalogic of dialogue logic in which to find typical topics such as completeness, soundness, complexity and decidability.

This issue is discussed in section 5 below.

But if we do assume for the moment that reason giving is subject to evaluation as valid or invalid, then we need to find a way through this metalogical contrast by transposing dialogue logic into a more traditional demonstrative system, and thus preserving it as a complete system in itself, in both the intuitive and logical senses. The obvious candidate is Dynamic Logic [14].

4. The transformation into Dynamic Logic

The language of **PDL** already includes propositional logic. There are also processes: α, β, γ, δ, ...; modal operators: [ ] ⟨ ⟩; and process operators: **;** ∪ ∗ ¿

The proposal is that the moves of dialogue logic be seen as the complex processes of dynamic logic. We represented the basic locutions in *action statements*.

Any move $\langle n, \alpha \rangle$ gives a binary relation: $\langle n\text{-}1, n \rangle = \alpha$

Consider a possible worlds logic in which all the moves (*processes*) of a dialogue are accessibility relations and the worlds are sets of the profiles of the participants. The worlds will be in a linear order with a beginning world. The commitment sets and question sets are indexed. Let the worlds be: w_0, w_1, w_2, w_3, …

$$w_n = \{Profile_x^n, Profile_y^n\} = \{\langle x, C_x^n, Q_x^n\rangle, \langle y, C_y^n, Q_y^n\rangle\}$$

The picture for Dialogue 1 has five worlds, one to start with and one for the outcome of each move.

Start: $\{Profile_a^0, Profile_b^0\} = \{\langle a, \varnothing, \varnothing\rangle, \langle b, \varnothing, \varnothing\rangle\} = w_0$

$\langle 1, >_a O\rangle$ $\qquad\qquad$ $\langle w_0, w_1\rangle = >_a O$

$\{Profile_a^1, Profile_b^1\} = \{\langle a, \{O\}, \varnothing\rangle, \langle b, \{O\}, \varnothing\rangle\} = w_1$

$\langle 2, ?_b \Rightarrow O\rangle$ $\langle w_1, w_2\rangle = ?_b \Rightarrow O$

$\{Profile^2_a, Profile^2_b\} = \{\langle a, \{O\}, \{?_b \Rightarrow O\}\rangle, \langle b, \varnothing, \{?_b \Rightarrow O\}\rangle\} = w_2$

$\langle 3, \because_a {\sim}F\rangle$ $\langle w_2, w_3\rangle = \because_a {\sim}F$

$\{Profile^3_a, Profile^3_b\} =$
$\{\langle a, \{O, {\sim}F, ({\sim}F \rightarrow O)\}, \{\langle{>}_a O, ?_b \Rightarrow O, \because_a {\sim}F\rangle\}\rangle,$
$\langle b, \{{\sim}F, ({\sim}F \rightarrow O)\}, \{\langle{>}_a O, ?_b \Rightarrow O, \because_a {\sim}F\rangle\}\rangle\} = w_3$

$\langle 4, ?_b \Rightarrow ({\sim}F \rightarrow O)\rangle$ $\langle w_3, w_4\rangle = ?_b \Rightarrow ({\sim}F \rightarrow O)$

$\{Profile^4_a, Profile^4_b\} =$
$\{\langle a, \{O, {\sim}F, ({\sim}F \rightarrow O)\}, \{\langle{>}_a O, ?_b \Rightarrow O, \because_a {\sim}F\rangle, ?_b \Rightarrow ({\sim}F \rightarrow O)\}\rangle,$
$\langle b, \{{\sim}F\}, \{?_b \Rightarrow ({\sim}F \rightarrow O)\}\rangle\} = w_4$

This displays the application the possible worlds semantics for a dynamic logic of *complex processes* where the processes are dialogue moves. After move 1 the belief sets of both participants are expanded with *O*. After the Challenge Question at move 2, the commitment set of *b* is contracted by *O* and becomes null, and the question sets of both participants have the challenge question added. At move 3 there is application of C2. After the Challenge Question at move 4, *b*'s commitment set is contracted and the question set contracted and expanded. *a*'s question set is expanded.

We adopt the standard AGM notation for belief revision [8] with agent and move indexing, where $C^{n+}_x p$ is read as agent *x*'s commitment set at *n* is *expanded* by *p* (*p* is added), $C^{n-}_x p$ is read as agent *x*'s commitment set at *n* is *contracted* by *p* (*p* and whatever entails *p* is removed), and $C^{n*}_x p$ is read as agent *x*'s commitment set is *revised* by *p* (the negative of *p* is contracted and *p* is added). The same notation is adopted for question sets: $Q^{n+}_x \alpha$, $Q^{n-}_x \alpha$ We also set $C(\alpha)$ for "a proposition entailing ~ α"; and A^n_y is a conjunction where all the conjuncts are members of C^n_y.

We now set out the **Profile Rules** in the notation of this dynamic logic:

C1: $[{>_x}\, p\, ¿]\ (C^{n+}_x p \ \&\ C^{n+}_y p)$

C2: $[(?_y \Rightarrow p\ ;\ \because_x q)\ ¿]\ (C^{n+}_y(q\ \&\ (q{\rightarrow}p))\ \&\ C^{n+}_x(p\ \&\ q\ \&\ (q{\rightarrow}p))\ \&$
$Q^{n-}_y ?_y \Rightarrow p\ \&\ (Q^{n+}_y \langle{>_x}\, p, ?_y \Rightarrow p, \because_x q\rangle\ \&\ Q^{n+}_x\langle{>_x}\, p, ?_y \Rightarrow p, \because_x q\rangle))$

C3: $[{<_x}\, p\, ¿]\ (C^{n-}_x p\ \&\ Q^{n-}_x\langle{>_x}\, p, ?_y \Rightarrow p, \because_x r\rangle)$

$[{>_x}\, p\, ¿]\ (C^{n*}_x p\ \&\ Q^{n-}_x\langle{>_x}\, p, ?_y \Rightarrow p, \because_x r\rangle)$

$[{>_x}\, C(p)\, ¿]\ (C^{n-}_x p\ \&\ C^{n+}_x C(p)\ \&\ Q^{n-}_x\langle{>_x}\, p, ?_y \Rightarrow p, \because_x r\rangle)$

$[{>_x}\, \iota\, p\, ¿]\ (C^{n-}_x p\ \&\ C^{n+}_x \iota\, p\ \&\ Q^{n-}_x\langle{>_x}\, p, ?_y \Rightarrow p, \because_x r\rangle)$

C4: $[?_y \Rightarrow p\ ¿]\ (C_x^{n+}p\ \&\ C_y^{n-}p\ \&\ Q_y^{n+}?_y \Rightarrow p\ \&\ Q_x^{n+}?_y \Rightarrow p\ \&$
$Q_y^{n-}\langle >_x p,\ ?_y \Rightarrow p,\ \because_x r\rangle\ \&\ Q_x^{n-}\langle >_x q,\ ?_y \Rightarrow q,\ \because_x p\rangle)$

C5: $[?_x p\ ¿](C_x^{n-}p\ \&\ Q_x^{n+}?_x p\ \&\ Q_y^{n+}?_x p)$

Now for the **Interaction Rules**:

A dialogue is legal iff for any n:

(i) If $p \in C_x^n$ and $p \in C_y^n$ then both $\langle w_n, w_{n+1}\rangle \neq >_x p$ and $\langle w_n, w_{n+1}\rangle \neq >_y p$

(ii) $\langle w_n, w_{n+1}\rangle \neq <_x ((p\ \&\ (p \rightarrow q)) \rightarrow q)$ and $\langle w_n, w_{n+1}\rangle \neq >_{\boldsymbol{x}} \sim ((p\ \&\ (p \rightarrow q)) \rightarrow q)$ and $\langle w_n, w_{n+1}\rangle \neq >_{\boldsymbol{x}} C((p\ \&\ (p \rightarrow q)) \rightarrow q)$ and $\langle w_n, w_{n+1}\rangle \neq >_{\boldsymbol{x}} \iota\ ((p\ \&\ (p \rightarrow q)) \rightarrow q)$

(iii) If $\langle w_{n\text{-}1}, w_n\rangle = ?_x p$ then either $\langle w_n, w_{n+1}\rangle = >_{\boldsymbol{x}} p$ or $\langle w_n, w_{n+1}\rangle = >_x \sim p$ or $\langle w_n, w_{n+1}\rangle = >_x C(p)$ or $\langle w_n, w_{n+1}\rangle = <_x p$ or $>_x \iota\ p$

(iv) If $\langle w_{n\text{-}1}, w_n\rangle = ?\Rightarrow_y p$ then either $\langle w_n, w_{n+1}\rangle = >_{\boldsymbol{x}} p$, or $\langle w_n, w_{n+1}\rangle = >_x \sim p$, or $\langle w_n, w_{n+1}\rangle = >_x C(p)$ or $\langle w_n, w_{n+1}\rangle = <_x p$, or $>_x \iota\ p$ or $\langle w_n, w_{n+1}\rangle = !_x \perp (A_y^n \rightarrow p)$ or $\langle w_n, w_{n+1}\rangle = \because_x r$ (*acceptable to y*)

(v) If $\langle w_n, w_{n+1}\rangle = !_x \perp p$ then **either** p is a *prima face* contradiction **or** p is of the form $(Q \rightarrow R)$ and Q is a conjunction of all statements in y's commitment set, and R is an immediate consequence of Q, and either $\langle n\text{-}1, <_y p\rangle$ or $\langle n\text{-}1, ?\Rightarrow_y p\rangle$.

(vi) If $\langle w_{n\text{-}1}, w_n\rangle = !_x \perp p$ then **either** $\langle w_n, w_{n+1}\rangle = <_y q$, where q is either a conjunct of p, or a conjunct of the antecedent of p, **or** $\langle w_n, w_{n+1}\rangle = >_y q$, where q is the consequent of p.

The Profile principles are theorems of the dynamic dialogue logic. The Interaction rules are just like the definitions used to decide whether a premise-conclusion argument is valid or invalid, or a sequence of formulas is a proof.

This makes it clear that dialogue logic **DL3sub** can be transformed into a dynamic possible worlds logic. All that remains is to set out rigorously an axiomatic system as well as possible worlds semantics. It will soon be clear whether the system is sound and complete and decidable. These are the open problems which it would be good to address.

The question of the metalogic has been addressed from a demonstrative point of view, and Dialogue Logic brought under the umbrella of demonstrative logic. But some have argued that the converse is also possible, and that transformation in the other direction would be more profitable.

5. Issues Arising

We have indicated above that there are three major issues emerging in this paper. There are others as well, but we cannot cover all topics in one paper. The issues are first, the relationship between commitments and beliefs; second, the question of the logic of commitment sets; third, the nature of evaluating reasons conditionals in Dialogue Logic.

First, we assume that everyone in debate and dialogue has a belief set. The puzzle we address is whether belief sets and commitment sets are the same thing. At first sight it would look as if the commitments of each dialogue participant are simply the beliefs they have, and that the set of their beliefs is their set of commitments. This often just assumed to be so. See, for example, [1]. But, further investigation shows that this is not clearly so. This raises the question of the relationship between the belief set of any participant in a dialogue and the commitments of that participant.

If the relationship between commitment stores and belief sets is very attenuated, then dialogue logic might not be exactly what first seems, a formal model of belief acquisition. If the relationship is very close, but commitment stores are not exactly the same as belief sets, then it is important to know just what the relationship is and to what extent dialogue logic provides some account of belief acquisition. If commitment stores are belief sets of a certain kind, then dialogue logic will provide a direct and simple account of the acquisition of many of a person's beliefs.

Are commitments simply those things which are openly asserted during interaction in order to find things out, to convince others, to concede points to others, or to obtain some goal in the discourse? In other words, are they just a set of assertions taken to express commitments to argue for certain propositions in the dialogue of the moment?

This is highlighted by Feyerabend [6] who says:

> An important rule of argumentation is that an argument does not reveal the 'true belief' of its author. An argument is not a confession, it is an instrument designed to make an opponent change his mind. … If an argument uses a premise, it does not follow that the author accepts the premise. … He may deny the premise but still use it because his opponent accepts it and, accepting it, can be led to the desired conclusion. (page 156)

It might be claimed that Feyerabend is being too cynical, or that his view is descriptive rather than normative, or both descriptive and cynical. What he says might in fact be the case, but dialogue logic is normative. It sets standards for what is coherent, fair or legal, and evaluates dialogue in terms of those standards.

But in fact, lawyers are faced with this contrast in their everyday professional life. They are often committed to argue for things that are contrary

to their deepest held beliefs. Teachers will often argue for, or propose something they do not believe because they want students to be challenged. The list goes on. In a dialogue, there is no guarantee that the proponents are engaging in the sort of transparent debate in which their own most deeply held beliefs are being expressed.

The transparency of dialogue is simply that that participants hear what the others state, ask and command. In some dialogue systems this is seen as a problem. Walton and Krabbe allow for this in one system with a "Real belief" question. "Do you seriously believe that?" (page 149 [20]) This question of transparency has bearing on the next issue which is the one about the logic of commitment change.

The final problem with treating all statements, acceptances and disagreements as commitments, is that commitment carries with it much more than mere acceptance. In a dialogue system with the Credulity Principle there is a problem, not because of the questions about whether people are or should be skeptical, but because of the nature of commitments. If something is added to a participant's commitment set then, according to Walton and Krabbe, that addition places certain obligations on the committed person. That does seem to be too strong. Someone might agree to something without accepting any obligation to advocate and defend it. In fact, Walton and Krabbe distinguish between several kinds of commitment. This allows for commitments which are not fully fledged commitment. This division of the commitment store becomes quite explicit in their formal dialogue systems. (see page 149 [20]) In fact, they divide the commitments into several sub-sets.

This all means that there are unresolved issues about commitment sets in dialogue logic, and about their status with respect to belief sets.

This brings us to the second main issue. It is the question of the extent to which the logic of commitment set change is the same as that of the logic of belief set change. There do seem to be some close analogies. The basic belief set changes of expansion, contraction and revision [8] are reflected in commitment set change. It is standard in belief change systems that belief sets are classical, closed and consistent. There are some alternative non-classical systems, but the same operations of change still apply.

The important difference is deductive closure. The deductive closure of a belief set is sometimes criticised as unrealistic and impossibly ideal. Rational consistent agents do not need to be characterised with such an extreme ideal. In response it is often claimed that there is a base set of explicit belief and the fully closed set is implicit belief.

But this solution will not work for commitment sets. Commitments need to be explicit. In particular, for Rule (i) **NoRepeatStatement** to apply to dialogue and prevent the fallacy of begging the question, all commitments of all participants must be 'on the table,' accessible to everyone. Implicit commitment would make (i) an impossible rule. It should be noted that one

of the major original motivations for modern Dialogue Logic was to provide a means of preventing fallacies such as begging the question, and it has been one of the litmus tests of dialogue systems [13,17].

It might be argued that there is some level at which a rational dialogue agent could readily see some closure. For example, if there is commitment to both p and $(p \rightarrow q)$, then it is obvious that there has to be commitment to q. In this case there might be some sort of closure, but it would be restricted by some partial model account of commitment based on the idea of *prime face* deduction using only *modus ponens*. This would involve the notoriously difficult notion of *weak* closure, in contrast to complete or *strong* closure.

Strong deductive closure would also prejudge the third issue to be discussed below, the issue of the extent to which matters internal to dialogue are settled by reference to external standards. A belief set is closed by reference to or by the use of some deductive logic.

The third issue is that of evaluating reasons conditionals. This issue goes to the heart of the differences and similarities between the Dialogue and Demonstrative systems. There are two options, the *internalist* and the *externalist* approaches. The former makes for a sharp contrast between Dialogue and Demonstrative systems. The later is far more syncretistic.

The *internalist* option is that every logical move is internally evaluated. If the participants accept a reasons conditional as correct, then the testing of it in first order logic, for example, is irrelevant. In standard terms, if the participants take a reasons conditional to be either logically or contingently true, then if the participants accepting the truth of the antecedent, the reasons, that is sufficient for accepting the consequent statement.

It might be claimed that this means that there is an assumption of the efficacy of *modus ponens*. But there is no mere assumption of *modus ponens*, it is explicitly advanced and protected in the interaction rules. Apart from some utterly minimal definitions for *prima face* contradictions and immediate consequence, there is no external logic to refer to when testing logical matters. In particular, the internal evaluation of reasons conditionals points up the internalist position.

The *externalist* option would evaluate reasons conditionals by means of some external logic. One would, from a demonstrative point of view, see the reasons conditional as easily transposed into a premise-conclusion argument ripe for evaluation in terms of some "outside" logical system. This raises the question of whether at least some portions of dialogue logic translate into demonstrative logic. Then the metalogical questions for deductive systems, proof and semantics, completeness and soundness, and decidability arise for part of a dialogue system.

The problem with the externalist viewpoint is that it lacks the neutrality and flexibility of the internalist viewpoint. For example, if there is a debate about dialethism (the view that some, but not all, contradictions are true),

an externalist is faced with the problem of what external demonstrative logic is to be used to evaluate reasons conditionals. If it's classical, then dialethism is defeated before the debate starts. If it's dialethic, then classicism is defeated before the debate starts.

The internalist/externalist contrast is interesting in that it contrasts a complete logic with an incomplete logic, in the intuitive sense of "complete." The internalist viewpoint sees no need to go elsewhere for the evaluation of reasons conditionals. The dialogue system does not lack any capacity. The externalist viewpoint sees dialogue logic as in need of some external reference point.

6. Concluding Remarks

We have seen that the enterprise of the transformation of dialogue logic to one kind of demonstrative logic is feasible. The real benefit of the transformation is to be found in the semantic models of dialogues rather than in the conversion of dialogues to premise-conclusion arguments. Indeed, at this point it's hard to see what the relationship would be between premise-conclusion arguments and dialogues, even in dynamic logic terms. This is a topic which should be explored further.

The transformation does something else which is quite important. It shows how the semantic models might be open to use with both questions and commands in general, especially when they occur in dialogue. This use could have important implications for the logics of questions and commands.

Those who want to use dialogue systems for the practical business of argument analysis and evaluation might wish to stay with the informalities of the dialogue game itself. But the transformation gives us a theoretical background which promises to be a basis for the development of more sophisticated dialogue systems.

We leave the discussion at this point.

References

[1] Amgoud, Leila and Maudet, Nicolas (2002), "Strategic considerations for argumentative agents (preliminary report)." in S. Benferhat and E. Giunchiglia, editors, *9th International Workshop on Non-Monotonic Reasoning (NMR 2002): Special session on Argument, Dialogue and Decision*, pages 399-407.

[2] Carlson, Lauri (1983), *Dialogue Games: An approach to discourse analysis*, Reidel, Holland, 1983.

[3] Coady, C.A.J. (1992), *Testimony: A Philosophical Study*, Clarendon Press, Oxford.

[4] van Eemeren, Frans H., Grootendorst, Rob, Jackson, Sally, and Jacobs Scott (1993), *Reconstructing Argumentative Discourse*, University of Alabama Press, Tuscaloosa, 1993.

[5] van Eemeren, Frans H., Grootendorst, Rob and Snoeck Henkemans Francisca (1996), *Fundamentals of Argumentation Theory*, Lawrence Erlbaum, New Jersey.
[6] Feyerabend, Paul (1978), *Science in a Free Society*, NLB, London.
[7] Gabbay, Dov M., and John Woods (2003), *Agenda Relevance: A Study in Formal Pragmatics*, North Holland, Amsterdam.
[8] Gärdenfors, Peter (1988), *Knowledge in Flux*, London, MIT Press.
[9] Girle, R.A. (1993), "Dialogue and Entrenchment", *Proceedings of the Sixth Florida Artificial Intelligence Research Symposium*, Ft. Lauderdale, April 18-21, 1993, 185-189.
[10] Girle, R.A. (1994), "Knowledge: Organised and Disorganised", *Proceedings of the Seventh Florida Artificial Intelligence Research Symposium*, Pensacola Beach, May 5-7, 1994, 198-203.
[11] Girle, R.A. (1996), "Commands in Dialogue Logic", *Practical Reasoning: International Conference on Formal and Applied Practical Reasoning* Eds. Dov Gabbay and Hans Jurgen Ohlbach, Bonn, Germany, June 1996, 246-260, 1996.
[12] Girle, R.A. (1998), "Positive Agnosticism in Belief Revision", *International Belief Revision Workshop*, Trento, Italy, May 30-June 1, 1998.
[13] Hamblin, Charles L. (1970), *Fallacies*, Methuen, London, 1970.
[14] Harel, D. (1979), *First Order Dynamic Logic*, Springer Verlag, Berlin.
[15] Henkemans, A.F. Snoeck (1992), *Analysing Complex Argumentation*, SICSAT, The Netherlands.
[16] Levi, Don S. (2000), *In Defense of Informal Logic*, Kluwer, Dordrecht.
[17] Mackenzie, J.D. (1979), "Question-Begging in Non-Cumulative Systems", *Journal of Philosophical Logic* (8), 117-133.
[18] Mackenzie, J. (1981), "The dialectics of Logic", *Logique et Analyse*, 409-17.
[19] Mackenzie, J.D. (1984), "Begging the Question in Dialogue", *Australasian Journal of Philosophy*, 62(2), 174-181
[20] Walton, Douglas N. and Erik C.W. Krabbe (1995), *Commitment in Dialogue*, State University of New York Press, Albany.

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