Imperatives in Dialogue

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Abstract

In this paper, we offer a semantic analysis of imperatives. We explore the effects of context on their interpretation, particularly on the content of the action to be performed, and whether or not the imperative is commanded. We demonstrate that by utilising a dynamic, discourse semantics which features rhetorical relations such as Narration, Elaboration and Correction, we can capture the discourse effects as a byproduct of discourse update (i.e., the dynamic construction of logical forms). We argue that this has a number of advantages over static approaches and over plan-recognition techniques for interpreting imperatives.

1 Introduction

An adequate theory of dialogue interpretation requires a satisfactory account of imperatives. In this paper, we will address two inter-related questions. What is their compositional semantics? And how does the discourse context affect their content?

There are several puzzles which need to be addressed. The first concerns compositional semantics. Ross (1941) observed that imperatives aren’t closed under classical logical consequence: post the letter does not entail post or burn the letter, even though the proposition that the letter is posted entails that it is posted or burned. This makes a straightforward analysis within modal logic problematic: if ! is a ‘standard’ modal operator and !A means A is commanded, then A → B will incorrectly entail !A → !B, regardless of the accessibility constraints on the !-worlds.¹ Segerberg (1990) bypasses this paradox via a modal logic of action. But the base language is propositional, thereby requiring extensions to deal with imperatives that feature quantifiers. Furthermore, Segerberg’s semantics is static, and we’ll show that by making the semantics dynamic, the account can be significantly simplified.

The second puzzle concerns the interaction between context and imperatives. How does context—both linguistic and non-linguistic—affect the content of imperatives, particularly the content of the action, and whether or not the imperative is commanded? Consider, for example, the discourses (1), adapted from Webber et al. (1995):

(1)  a. Go to Fred’s office and get the red file folder.
    b. Go to Fred’s office and refile the red file folder.
    c. John went to Fred’s office. He got the red file folder.
    d. John went to Fred’s office. He refiled the red file folder.

Discourses (1ab) both implicate that the actions should be performed in the order described and the second action is performed in Fred’s office. (1a) implicates that the red file folder is in

¹A similar problem holds for deontic statements: You must post the letter doesn’t entail You must post the letter or burn the letter.
Fred's office whereas (1b) doesn't implicate this. Similar spatio-temporal implicatures hold of the indicatives versions (1cd).

Segmented Discourse Representation Theory (SDRT, Asher 1993, Lascarides and Asher 1993) accounts for the implicatures in (1cd) by stipulating within a dynamic semantic setting how one computes the rhetorical relation which connects the propositions (namely, Narration for (1cd)), and stipulating how such relations constrain the content of its arguments (e.g., the spatio-temporal content described above follows from the semantics of Narration). We aim to model imperatives in a similar manner. That is, we aim to account for their implicatures by identifying their rhetorical role. This involves specifying the semantics of the relations that take imperatives as arguments, and providing a precise default axiomatisation of how such rhetorical relations are computed on the basis of both linguistic and non-linguistic knowledge sources.

We will show that SDRT can provide an entirely uniform analysis of the imperative vs indicative examples in (1), which is desirable given their similar implicatures. The uniformity rests on the fact that the SDRT axioms of interpretation that apply to these discourses are neutral with respect to sentence mood, instead relying on other compositional and lexical semantic features. In contrast, it would be hard to achieve such a uniform analysis with plan recognition approaches (e.g., Grosz and Sidner 1986, 1990, Litman and Allen 1990, Lochbaum 1998), where interpreting the current utterance utilises only the goals of the prior utterances, rather than their compositional and lexical semantics directly. This is because the goals of indicatives (typically, that the interpreter believe the proposition) are radically different from imperatives (typically, that the interpreter perform the action). The similar interpretations of (1a/c) and (1b/d) suggest that the goal of the prior clause isn't primary in these cases.

This is not to deny the importance of beliefs and goals in interpretation, however. The fact that falling downstairs is undesirable whereas going to the hardware store is not underlies the difference between (2a) (where the imperative is not commanded) and (2b) (where it is):

(2)  a. Go straight on and you'll fall down the stairs.
    b. Come home by 5pm and we can go to the hardware store before it closes.

(3)  a. A: How does one make lasagne?
    b. B: Chop onions and fry with mince and tomatoes, boil the pasta, make a cheese sauce, assemble it, and bake in the oven for 30 minutes.

(4)  a. A: Go straight on for 5cm.
    b. B: That takes me right into the crevasse.
    c. A: Go left then.

Similarly, the inference that the rhetorical role of (3b) is to provide sufficient information that A can compute an answer to his question (3a) is calculable from Gricean style principles of rationality and cooperativity (e.g., Cohen and Levesque 1990, Lascarides and Asher, 1999). And whether or not such responses to questions are commanded depends on the content of the question: (3b) is not commanded; but an imperative is commanded if it serves as a response to a question whose answers all implicate that the questioner is the agent of a deontic attitude (e.g., Where should I go now?). Finally, in (4), taken from the HCRC map task corpus, the undesirability of falling into the crevasse helps one infer that the request (4a) is 'cancelled' and replaced by (4c).

Our hypothesis is that for all these examples, the interplay between content, domain knowledge and cognitive states can be captured within the semantics of the rhetorical relations and the axioms one uses to compute them during the construction of the discourse's logical form. We will test this by incorporating a semantic analysis of imperatives into SDRT. In an attempt to do justice to the complexity of interaction between the different information sources that contribute to interpretation—both conventional and non-conventional—many theories assume a radically unmodular framework, so that a single reasoning process can access the different kinds of information at any time (e.g., Hobbs et al, 1993). SDRT takes a different approach, assuming a high degree of modularity: reasoning with conventional clues about interpretation is kept separate from reasoning with non-conventional clues, but there are interactions between them.
2 The Compositional Semantics of Imperatives

Segerberg (1990) offers a semantics of imperatives which bypasses Ross’ paradox. He augments a propositional language with two operators. First, the action operator δ takes formulae into action terms: e.g., if \( p \) is a propositional variable, then \( \delta p \) is an action term, corresponding to the action of seeing to it that \( p \) is true. Second, the command operator ! takes action terms into practical formulae; these are the translations of imperatives. So \( \delta p \) is a well-formed practical formula standing for “making \( p \) true is commanded”; \( q \rightarrow \delta p \) is also a practical formula standing for the conditional imperative “if \( q \) is true then making \( p \) true is commanded”; and \( \neg p \) is ill-formed.

An action term \( \delta p \) denotes a set of pairs of possible worlds. Intuitively, the first world of each pair corresponds to a possible state of affairs in which the action can be performed, and the second world describes a possible outcome of performing the action in that first world. Furthermore, for each action \( a \) there is a corresponding modal operator \( [a] \): \( [a]p \) is true in a model \( M \) at a world \( w \) just in case \( p \) is true at all worlds \( w' \) such that \( \langle w, w' \rangle \in [a]M \) (as we’ll see shortly, \( [a]M \) is a rigid designator). In other words, \( p \) is a necessary postcondition of \( a \). \( !p \) is a precondition if \( \neg p \rightarrow [a]_\perp \).

Plans are also terms, constituting a sequence of actions \( a_1; a_2; \ldots a_n \). These also denote sets of pairs of worlds: \( \langle w, w' \rangle \in [a_1; \ldots a_n] \) iff \( \exists w_1, \ldots, w_{n-1} \) such that \( \langle w, w_1 \rangle \in [a_1], \ldots, \langle w_{n-1}, w' \rangle \in [a_n] \). So the possible consequences of doing \( a_n \) must be compatible with the preconditions of \( a_{n+1} \). Finally, one express free choice: \( [a_1; a_2] = [a_1] \cup [a_2] \).

The formula \( \delta p \) receives its model-theoretic denotation via a function \( D \) in the model which takes propositions (i.e., a set of worlds) to actions, i.e., \( [\delta p]_M =_w D([p]_M) \). \( D \) satisfies the following constraint:

\[
D([p]_M) \subseteq \{ \langle w, w' \rangle : w' \in [p]_M \}
\]

This makes \( \delta p \) true at all worlds in all models, i.e., making \( p \) true guarantees that \( p \) is true.

Since the above constraint on \( D \) uses \( \subseteq \) rather than \( = \), the logical relationships among actions is almost entirely impotent, in the sense that it’s not the case that if \( A \models B \), then \( [\delta A] \subseteq [\delta B] \) (i.e., all the actions for making \( A \) true aren’t necessarily also actions for making \( B \) true). This is problematic, because reasoning with these action terms, and hence planning, becomes impractical because of their weak logic.

The semantics for theoretical formulas (i.e., formulas that contain no ! operator) is essentially Kripkean, and a logic of satisfaction \( \models \) for theoretical formulas is defined in the usual way. Practical formulae have their own distinct but related logic: the logic \( \models_r \) of requirement or ‘commanding’. This logical consequence relation exploits the notion of a command system \( \Gamma \) requiring a formula; written \( \Gamma \models_r M, w, A \), where \( A \) now is either theoretical or practical. A command system \( \Gamma \) is a semantic primitive, which stipulates which actions the authority commands; or more accurately, which action he commands in which situations.

More formally, a command system \( \Gamma \) is a set of command sets, one for each possible world in the model. And a command set \( \Gamma_w \) is a set of actions; intuitively, the actions that the authority commands in the world \( w \) (and any one of these actions may in fact only be describable by several imperatives). One can now define the semantic relation \( \Gamma \models_r M, w, A \) of the command system \( \Gamma \) requiring a formula \( A \) at the world \( w \) in the model \( M \). We present highlights here:

1. \( \Gamma \models_r M, w, p \iff w \in \{p\}_M \).
2. \( \Gamma \models_r M, w, A \rightarrow B \iff \Gamma \models_r M, w, A, \text{ then } \Gamma \models_r M, w, B \).
3. \( \Gamma \models_r M, w, [a]B \iff \text{ for all } w' \text{ such that } \langle w, w' \rangle \in [a]_M, \Gamma \models_r M, w', B \).
4. \( \Gamma \models_r M, w, !a \iff [a]_M \in \Gamma_w \).

Note that for any theoretical formula \( A, \Gamma \models_r M, w, A \iff M \models_r A \), reflecting the intuition that wishful thinking can’t make things true. Furthermore, even if \( A \models_r M, w, B \) in the logic of satisfaction and \( [\delta A]_M \in \Gamma_w \), it does not follow that \( [\delta B]_M \in \Gamma_w \). So \( \Gamma \models_r M, w, \delta p \) doesn’t entail \( \Gamma \models_r M, w, \delta (p \lor q) \),

\(^2\text{This is a standard way of interpreting actions in the dynamic modal logic of Pratt (1979) and Haré (1984).}\)
thereby bypassing Ross’ paradox. Unfortunately, it’s also the case that \( \Gamma \models M, w \vdash \delta (p \land q) \) doesn’t entail \( \Gamma \models M, w \vdash \delta p \), indicating that the logic of commanding, as well as of actions and plans, is perhaps weaker than it should be.

This account is at best incomplete. It cannot be used to analyse imperatives with quantifiers, since its base language is propositional. And it cannot be used to explore the interaction between content and anaphora since it’s static. In fact, the static semantics would yield a highly complex translation from natural language imperatives in discourse into logical form. For note that one of the highly salient interpretations of (5) is not adequately expressed by (5’), where \( A \) represents the proposition that you go to the traffic lights and \( B \) represents the proposition that there’s a roundabout to your right.

(5) Go to the traffic lights. There’s a roundabout to your right.

(5’) \( \delta A \land B \)

(5’’) \( \delta A \land [\delta A] B \)

This is because (5’) entails that the roundabout is to your right now (i.e., before the action is performed), rather than being conditional on the action being performed. In fact, this intuitively compelling ‘conditional’ interpretation of (5) is captured in Segerberg’s semantics by the formula (5’’). But constructing such a formula on the syntax/semantics interface is impractical.

We’ll shortly see that incorporating action terms into a dynamic discourse semantics simplifies this analysis. Not only will we achieve a uniform semantic construction procedure within the grammar (cf. example (5) above). But we can also abandon altogether Segerberg’s command system and the logic of requirement. Whether or not an imperative is commanded will not be determined by a semantic primitive (i.e., the command system), but rather by the semantic consequences of its rhetorical connection to the context, which in turn is inferred from a wide variety of knowledge sources, both linguistic and non-linguistic.

Finally, as we mentioned before, avoiding Ross’ paradox by sacrificing the capacity to reason about actions and commands is problematic. Hale (1967) takes a different view, arguing that one shouldn’t avoid Ross’ paradox at all. He suggests that \( A \vdash A \lor B \) is in fact valid when \( A \) and \( B \) are requests. But it doesn’t appear to be valid because of Gricean-style scalar implicatures. But this is unsatisfactory too, because no details are given of how scalar implicatures would have the desired effect. An alternative solution is to include some contextually determined formula \( \phi \) within the postconditions of the action:

(6) \[ [\delta p]_M^w = \{ (w, w') : w' \in [p \land \phi] \} \]

The problem now is to compute the value of \( \phi \) for different examples, in different contexts, in a systematic way. We’ll argue that reasoning about the rhetorical role of the imperative within the logic of discourse interpretation goes some way towards solving this problem; for the the value of \( \phi \) is determined, at least partly, by the implicatures which arise due to the demands on interpretation that are imposed by the rhetorical relations such as Narration (for example, the spatiotemporal implicatures generated by Narration for examples (1ab)). The rhetorical function of an imperative also reveals information about why it was uttered, and for what purpose, both of which influence the value of \( \phi \).

3 Going Dynamic

The whole notion of meaning is reconstrued in dynamic semantics as a relation between an input context and an output context; this is known as the context change potential or CCP of a formula. These contexts can be characterised extensionally as assignment functions, which map the formula’s variables to individuals in the model. However, to analyse imperatives and modal action operators, we also need an intensional dimension. So we make contexts a world assignment pair \( (w, f) \). Thus the truth definition of a formula \( \phi \) relative to a model \( M \) will define exactly when \( \phi \) relates an input context \( (w, f) \) to an output context \( (w', g) \).
In Discourse Representation Theory (DRT, Kamp and Reyle 1993), a discourse is represented by a discourse representation structure or DRS, which is a pair \( \langle U_K, C_K \rangle \) consisting of a set \( U_K \) of discourse referents (i.e., the individuals and events that the discourse is about) and a set \( C_K \) of DRS-conditions (these convey properties and relations among the discourse referents). Since DRS-conditions can themselves include DRSs, DRSSs are recursive. The syntax and semantics is as follows (where \( K \cap \gamma = \text{def} \langle U_K, C_K \cup \gamma \rangle \)):

**Syntax of DRT**
Suppose \( U \subseteq \text{Discourse-Referents} \). Then the well-formed DRS \( K \) and DRS conditions \( \gamma \) are defined recursively:

\[
K := \langle U, \emptyset \rangle | K \cap \gamma
\]

Let \( R \in \text{Predicates} \) be an \( n \)-ary predicate and \( x_1, \ldots, x_n \) be discourse referents.

\[
\gamma := R(x_1, \ldots, x_n) | \neg K | K_1 \Rightarrow K_2 | K_1 \lor K_2.
\]

**The Semantics of DRSs**
The truth definition involves embedding DRSs into a standard Tarskian model \( M \); so \( M = \langle A_M, W_M, I_M \rangle \), where \( A_M \) is a set of individuals; \( W_M \) is a set of worlds, and \( I_M \) is a function which assigns \( n \)-ary predicates at a world \( w \) a set of \( n \)-tuples of \( A_M \). We define simultaneously the model theoretic transition \( P \) and the satisfaction of conditions \( V \) relative to the model \( M \). From a dynamic logic perspective, \( P \) yields a change in the assignment function, extending the input over newly introduced discourse referents, while \( V \) treats the other DRS elements as tests.

**The Truth Definition:**

\[
(w, f)P_M(U, \emptyset)(w', g) \iff w = w' \land f \subseteq g \land \text{dom}(g) = \text{dom}(f) \cup U
\]

\[
(w, f) \in V_M(R(x_1, \ldots, x_n)) \iff (f(x_1), \ldots, f(x_n)) \in I_M(R)(w)
\]

\[
(w, f) \in V_M(\neg K) \iff \neg \exists g (w, f)P_M(K)(w, g)
\]

\[
(w, f) \in V_M(K \Rightarrow K') \iff \forall g ((w, f)P_M(K)(w, g) \rightarrow \exists h (w, g)P_M(K')(w, h))
\]

\[
(w, f) \in V_M(K \lor K') \iff \exists g (w, f)P_M(K)(w, g) \lor \exists h (w, f)P_M(K')(w, h)
\]

\[
(w, f)P_M(K \cap \gamma)(w', g) \iff w = w' \land (w, f)P_M(K)(w', g) \land (w, g) \in V_M(\gamma)
\]

As yet, we've not exploited the possible world component. We exploit that for interpreting action terms. Whereas the interpretation of DRSs (with nonempty universes) transform the assignment component of the input, action terms will transform the possible world (as well). The dynamic semantics of DRS conditions of the form \( [a]K \) invokes quantification over worlds.

More formally, we extend the language as follows:

1. If \( K \) is a DRS, then \( \delta K \) is an action term;
2. If \( a_1 \) and \( a_2 \) are action terms, then so are \( a_1; a_2 \) and \( a_1 + a_2 \).
3. If \( a \) is an action term and \( K \) is a DRS condition, then \( [a]K \) is a DRS condition.
4. If \( K \) is a DRS and \( a \) is an action term, then \( K \Rightarrow a \) is a DRS condition.

The truth conditions of these new action terms and formulae are again defined in terms of a model theoretic transition \( P_M \) and satisfiability conditions \( V_M \). The characteristic CCP of action terms is that they change the world parameter (see clause 1. below):

1. \( (w, f)P_M(\delta K)(w', g) \iff (w', f)P_M(K)(w', g) \)
2. \([a_1; a_2]^M = [a_1]^M \circ [a_2]^M\)
   (i.e., \((w, f)P_M(a_1; a_2)(w'', h)\) iff there is a pair \((w', g)\) such that \((w, f)P_M(a_1)(w', g)\) and
   \((w', g)P_M(a_2)(w'', h)\)).
   \(\cdot\) is dynamic and \(\cdot\). In view of this, we’ll allow \(\cdot\), as well as action terms, to be connected
   with \(\cdot\); so \(K_1; K_2\) is a well formed formula and its assigned the same semantics.
   \([a_1 + a_2]^M = [a_1]^M \cup [a_2]^M\)
   (i.e., \((w, f)P_M(a_1 + a_2)(w', g)\) iff \((w, f)P_M(a_1)(w', g)\) or \((w, f)P_M(a_2)(w', g)\)).

3. \((w, f)P_M(K \Rightarrow a)(w', g)\) iff for all \(h\) such that \((w, f)P_M(K)(w, h)\) there is a \(k\) such that
   \(h \subseteq k\) and \((w, k)P_M(a)(w', g)\)

4. \((w, f) \in V_M[a]K\) iff for every \(g\) and for every \(w'\) such that \((w, f)P_M(a)(w', g)\), there is an \(h\)
   such that \((w', g)(K)^M(w', h)\).

Note that, thanks to condition 2 above, the denotation of the complex action (7) is one where the
individual who talks is the same as the individual who walks:

\[
\begin{array}{c|c|c}
\delta & x & \delta \\
\hline
\text{walk}(x) & & \text{talk}(x)
\end{array}
\]

And guarded actions (i.e., formulae of the form \(K \Rightarrow a\)) can be the basis of conditional commands:

\[(8)\quad \text{If you want to get an } A, \text{ study hard.}\]

Overall, then, we will represent imperatives in \(\text{DRS}\) as action terms. For example, we assume that
the grammar generates the action term \((9')\) for (9) (we’ve simplified slightly by ignoring temporal
information):

\[(9)\quad \text{Walk!}\]

\[(9')\quad \delta \quad \text{u,e}_u
\]

The discourse referent \(u\) is the addressee: we assume a conventional default within the grammar
which generates \(u\) from the imperative sentence mood. This conventional default can be over-
ridden when the subject is explicitly given (e.g., \(\text{Someone close the door!}\)) or in a sufficiently
rich discourse context: Lascarides and Copestake (1998) describe the logical interactions between
conventional defaults and the discourse context in detail, but we gloss over this here.

Semantically, the defining characteristic of a discourse which includes a commanded imperative is
that its \(\text{CCP}\) changes the input world into an output one where the action has been performed.
\((9')\) changes the world this way, and thus it represents a discourse where the imperative (of walking)
is commanded. The \(\text{CCP}\) of the \(\text{DRS}\) representing (8) also captures the command status of
the imperative in the required way: the dynamic semantics of guarded actions means that the
imperative is commanded if you want to get an \(A\), and it’s not commanded otherwise. This
dynamic characterisation of an imperative makes introducing a semantic primitive for stipulating
what’s commanded and what’s not redundant: we can rely instead on the signature \(\text{CCP}\) that
the world is transformed into one where the action has been performed. And so it can replace
Segerberg’s notion of a command system and the accompanying logic \(\models^M\) of requirement, thereby
considerably simplifying the semantics. We would not to bypass Ross’ paradox, however, by
including contextually specified information \(\phi\) in the semantics of action terms (cf. the definition
(6)). We return to this shortly.

A further advantage of the dynamic view is that, unlike Segerberg’s static analysis, the
semantics of the formula \((5')\) now captures an intuitive interpretation of (5) (as before, \(A\) stands for
\(\text{you go to the traffic lights, B stands for there’s a roundabout to your right, and ; now stands for}\)
dynamic and):
(5) Go to the traffic lights. There's a roundabout to your right.

(5') $\delta A; B$

However, further investigation shows that this DRT-based analysis is flawed. As we saw earlier, not all imperatives are commanded, even when there are no linguistically explicit clues present to indicate this (e.g., (3)). In fact, maintaining the DRS language as it stands leads to one of two undesirable consequences. We either maintain a simple DRS-construction procedure for imperatives (i.e., use an action term, followed by if subsequent clauses are present), and therefore predict the wrong semantics of dialogues like (3). Similarly, this construction procedure would predict the wrong interpretation of (10a):

(10) a. Go to Fred's office. Take the file with you.

b. John went to Fred's office. He took the file with him.

The natural interpretation of (10a) is one where the actions are to be performed at the same time, rather than in sequence. The undesirable alternative is to generate several DRSs when updating the context with an imperative, one for each possible semantic contribution to the discourse. But proliferating ambiguity is undesirable.

These problems are in fact similar to the problems with DRT's analysis of temporal discourse. Kamp and Reyle (1993) note that their rules for DRS construction handle only those simple past-tensed discourses where event sentences move the time line forward (e.g., (1cd)). But not all discourses behave this way (e.g., (10b)). Here, we see that the DRT semantics of imperatives handles just those discourses where the imperative is commanded and the subsequent utterances should be interpreted with respect to a context where the action has been performed. But not all imperatives have this effect on content, as (2a), (3) and (10a) attest.

In view of these problems, we will maintain the analysis of imperatives as dynamic action terms, but incorporate it into SDRT. We'll then use SDRT's semantics of rhetorical relations to capture the various contributions imperatives can make to the overall content of the discourse. We thus take a similar approach to improving the DRT analysis of imperatives as we did to improving their analysis of temporal discourse (e.g., see Lascarides and Asher (1993)).

4 Imperatives and Rhetorical Relations

Discourse is represented in SDRT as a recursive structure of labelled DRSs with rhetorical relations between the labels. For example, the logical forms of (1a) and (1c) are shown below (in slightly simplified form, since we have ignored presuppositions, tense and anaphora):

(1) a. Go to Fred's office and get the red file folder.

\[
\begin{array}{c}
\pi_1, \pi_2 \\
\begin{array}{c}
\gamma_1 : \delta \\
\text{th:n, o:fred}, \text{of:office(o)}, \text{own}:\text{f:fred}, \text{g-to}:\text{e:u}, \text{u:office(o)}
\end{array} \\
\beta_2 : \delta
\begin{array}{c}
\text{r:fred}, \text{f:file}, \text{g-get}:\text{f:fred}, \text{u:u}, \text{r:red-file-folded(r)}
\end{array}
\end{array}
\]

b. John went to Fred's office. He got the red file folder.

\[
\begin{array}{c}
\pi_1, \pi_2 \\
\begin{array}{c}
\gamma_1 : \delta \\
\text{th:k, o:john}, \text{of:fred}, \text{of:office(o)}, \text{own}:\text{f:fred}, \text{g-to}:\text{e:u}, \text{u:office(o)}
\end{array} \\
\beta_2 : \delta
\begin{array}{c}
\text{r:fred}, \text{f:file}, \text{g-get}:\text{f:fred}, \text{u:u}, \text{r:red-file-folded(r)}
\end{array}
\end{array}
\]

Narration($\pi_1, \pi_2$)

\[\Delta_{\pi_1, \pi_2}^{\text{GET}}\]

\[\Delta_{\pi_1, \pi_2}^{\text{GET}}\]

\[\Delta_{\pi_1, \pi_2}^{\text{GET}}\]

\[\Delta_{\pi_1, \pi_2}^{\text{GET}}\]

\[\Delta_{\pi_1, \pi_2}^{\text{GET}}\]
Note that the rhetorical relation *Narration* is used in both logical forms.

But how do these rhetorical relations affect the CCP of SDRS? Well, unlike other non-logical predicates, rhetorical relations are assigned a truth definition with the capacity to change the world assignment pair. In fact, unpacking the truth definition of an SDRS amounts to unpacking the truth definitions of the rhetorical relations in it, starting with the one that has the widest scope (see Asher and Lascarides in press for details). These truth definitions determine the semantic contribution of the labelled propositions and action terms to the whole discourse. For its the rhetorical relation $R(\alpha, \beta)$ which determines whether the expressions $K_\alpha$ and $K_\beta$ that $\alpha$ and $\beta$ label transform the context or not. The fact that conditions like $R(\alpha, \beta)$ transform the context reflects their status as speech acts.\(^4\) Like other actions, it ensures that the state of affairs is not the same after a particular speech act or utterance has been performed. Furthermore, the fact that some rhetorical relations (e.g., *Narration*) will relate an input context to an output one only if the formulae they connect also do this, whereas other relations (e.g., *Correction*) lack this property, reflects the fact that some speech acts are veridical while others generate opaque contexts.

In particular, we say that a relation $R(\alpha, \beta)$ is veridical iff $(w, f)P_M(\langle \alpha, \beta \rangle)(w', g)$ entails $(w, f)P_M(K_\alpha)(w', g)$ and $(w, f)P_M(K_\beta)(w', g)$, where as before $\alpha$ labels the content $K_\alpha$ and $\beta$ labels $K_\beta$. In other words, $R(\alpha, \beta)$ is veridical if it entails $K_\alpha$ and $K_\beta$. Similarly, $R$ is left-veridical iff $(w, f)P_M(\langle \alpha, \beta \rangle)(w', g)$ entails $(w, f)P_M(K_\alpha)(w', g)$, and right-veridical if $(w, f)P_M(\langle \alpha, \beta \rangle)(w', g)$ entails $(w, f)P_M(K_\beta)(w', g)$.

Now, *Narration* is veridical; in fact, its CCP satisfies the content of its arguments in dynamic sequence, as defined by the connective "". So its truth definition in SDRS is as follows:

- **Semantics of Narration**
  
  $$(w, f)P_M(\langle \pi_1, \pi_2 \rangle)(w', g) \text{ iff } (w, f)P_M(K_1; K_\beta; \phi_{N(\alpha, \beta)})(w', g)$$

The above schema essentially means that the effect of unpacking the truth conditions of *Narration* when interpreting an SDRS is to update the context to one which satisfies the formulas $K_{\pi_1}$ and $K_{\pi_2}$, plus some 'extra' content $\phi_{N(\alpha, \beta)}$. This extra content will be determined by axioms that encode the truth conditional effects of *Narration*; e.g., $\phi_{N(\alpha, \beta)}$ will impose spatio-temporal constraints on the events and individuals which are introduced in $K_{\pi_1}$ and $K_{\pi_2}$.

This semantics ensures that the imperatives in (1a') are commanded, for the CCP of (1a') transforms the input world $w$ into an output world $w'$ where the actions have been performed (in sequence). Similarly, the CCP of *Narration* $(\pi_1, \pi_2)$ also ensures that (1c') is true only if the propositions expressed by the indicative clauses are true.

There are meaning postulates on *Narration* which capture its spatio-temporal effects and instantiate the value of $\phi_{N(\alpha, \beta)}$ in the above truth definition:\(^5\)

- **Axiom on Narration**

  $$\phi_{N(\alpha, \beta)} \Rightarrow (\text{actor}(x, e_\alpha) \land \text{actor}(x, e_\beta)) \Rightarrow \\
  \text{overlap}((\text{loc}(x, \text{prestate}(e_\beta)), \text{loc}(x, \text{poststate}(e_\alpha))))$$

In words, this stipulates that an agent $x$ that is a participant in both events is the same place, in space and time, at the end of the first event and at the beginning of the second (thus it follows that $e_\alpha$ must precede $e_\beta$). So, in (1a), the agent is in the same place once he's finished going to the office as he is when he starts to get the file; i.e., he must start to get the file in Fred's office. And therefore, the file must be in Fred's office too, thanks to the lexical semantics of *get*.

With this semantics for *Narration* in place, consider the interpretation of (1a'). Because of the *Narration* relation, the CCP of this SDRS relates the world assignment pair $(w, f)$ to $(w', g)$ only if $(w', g)$ verifies that (a) both actions have been performed (in sequence), such that (b) $e_1 < e_2$ (i.e., $e_1$ precedes $e_2$), and (c) the red file folder is in Fred's office at the time when you get it. Similar constraints are imposed on the CCP of (1c') by the very same axioms. These constraints on rhetorical relations thus account for implicatures.

\(^4\) Uttering elaborations, explanations and corrections are all things that people do with utterances.

\(^5\) In fact, this axiom is stated here in slightly simplified form, because it ignores the role of frame adverbials. For details, see Asher and Lascarides in press.
This illustrates how in SDRT, implicatures are computed as a byproduct of computing discourse update: If one infers that a particular rhetorical relation must be used to connect the content of the current clause to the discourse context (we’ll outline shortly how one does this), and if neither the content of that context nor the compositional semantics of the current clause verify the consequences of the rhetorical relation’s meaning postulates (e.g., the spatio-temporal information of Narration), then this content is in essence accommodated, for it constrains the CCP of the updated SDRS. So SDRT predicts implicatures which are brought about by the demands of discourse coherence (i.e., the demand that we connect every bit of information in the discourse to some other bit of information with a rhetorical relation).

Computing implicatures via discourse update has two desirable consequences. First, it means that we can go some way towards axiomatising inferences about the value of \( \phi \) in the formula (6), which we suggested earlier as a basis for bypassing Ross’ paradox. Inferences about \( \phi \) are, from our perspective, inferences about the rhetorical relations that hold and their semantic effects. For example in discourse (1a), the implicature that the file is in Fred’s office would be part of the contextually specified postconditions \( \phi \) of the action. Thus rhetorical relations provide a first step towards avoiding Ross’ paradox without sacrificing logical relationships among actions in the way that Segerberg does.

The second desirable consequence is that using the same rhetorical relation in the logical forms of (1a) and (1c) helps to explain why they have similar (spatio-temporal) implicatures. The discourse (1b) and (1d) are also similar: Axiom on Narration entails that the file is refilled in Fred’s office. The uniform analysis of these discourses actually goes further than this: the logical forms of (1a) and (1c) are constructed in the same way as well. To see this, consider the way in which SDRSs are constructed in SDRT. This is done within a glue logic, which consists of default axioms for inferring which rhetorical relation one uses to attach the new information to the logical form of the discourse context that’s been constructed so far (see Asher and Lascarides (1995) for details). These default axioms encapsulate how a variety of knowledge sources provide clues about which rhetorical relations hold. So the axioms feature a default connective: \( A > B \) means If \( A \) then normally \( B \). The general schema for the axioms is given in (11): \( (\tau, \alpha, \beta) \) means that \( \beta \) (which labels an \( (\beta) \) ) is to be attached to a label \( \alpha \) with a rhetorical relation, where \( \alpha \) is part of the SDRS \( \tau \) which represents the discourse context so far; and \( \text{Info}(\tau, \beta) \) is a gloss for formulae that tell us properties of \( \tau \) and \( \beta \).6

\begin{equation}
(11) \quad ((\tau, \alpha, \beta) \land \text{Info}(\tau, \beta)) > R(\alpha, \beta)
\end{equation}

Lexical semantics, domain knowledge and maxims of conversation essentially instantiate rules like (11). But typically, the rule itself has an antecedent which contains information that’s derivable from the SDRS that \( \tau, \alpha \) and \( \beta \) label. In other words, even if the justification of the rule resides in, for example, the model of discourse participants as rational and cooperative agents, the rule itself may appeal only to linguistic information in the antecedent. We will see an example of such a rule in section 4.2.

The axiom for inferring Narration is treated as a ‘basic’ default in Asher and Lascarides (1995), and it captures aspects of Grice’s (1975) Maxim of Manner (i.e., be orderly):

- Narration: \( (\tau, \alpha, \beta) > \text{Narration}(\alpha, \beta) \)

This default axiom together with Axiom on Narration stipulates that by default, people describe things in the order in which they occur, or are to occur.

Note that this default rule is neutral with respect to sentence mood. In particular, it applies when attempting to construct the logical forms of both (1a) and (1c). And in both cases, the consequent of the rule is consistent with the monotonic information that’s available. So the underlying logic for \( > \) yields the inference that Narration holds. Hence not only do the SDRSs (1a’) and (1c’) capture the implicatures of (1a) and (1c) in a uniform way, but also, in spite of the different sentence moods, the way in which these logical forms are constructed is uniform.

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6This schema is slightly simplified, because it abstracts away from talk about exactly where in the SDRS the condition \( R(\alpha, \beta) \) should be put. Further details are given in Asher and Lascarides (in press).
This contrasts with the plan-recognition approach to discourse interpretation (e.g., Grosz and Sidner 1990, Litman and Allen 1990). These theories reason about the way new information updates the meaning of the discourse by reasoning about how the communicative intention of the current utterance relates to the communicative intentions of the prior utterances. The communicative intentions that are conventionally associated (by default) with indicatives vs. imperatives are quite different. And so it’s unclear how these theories could use the same axioms and proofs to explain their interpretations.

This semantic uniformity of imperatives vs. indicatives extends to other rhetorical relations as well. For example, if .. then is a monotonic linguistic clue that the clauses are connected with the rhetorical relation Consequence, which is the SDRS equivalent of \( \Rightarrow \) in DRT, as given by the following truth definition:

- **Semantics of Consequence:**
  \[(w, f)P_M(\text{Consequence}(\alpha, \beta))(w', g) \iff (w, f)P_M(K_\alpha \Rightarrow K_\beta))(w', g)\]

Now, the axiom that encapsulates the link between if .. being present in the natural language discourse and Consequence being present in its logical form ensures that Consequence is part of the semantic representations of both (12a) and (12b):

\[(12) \quad \begin{align*}
   & \text{a. If Ewan’s in his office, then tell Johan the meeting is at 2pm.} \\
   & \text{b. If Ewan was in his office, then John told Johan that the meeting was at 2pm.}
\end{align*}
\]

So Consequence correctly predicts that (12a) is a conditional command, and it also conveys the correct semantics of the indicative discourse (12b).

The rhetorical relation Elaboration can also account for the semantics of the imperatives in (10a) and the indicatives in (10b): i.e., its semantics ensures that the action of taking documents with you is part of the action of going to the meeting.

\[(10) \quad \begin{align*}
   & \text{a. Go to Fred’s office. Take the file with you.} \\
   & \text{b. John went to Fred’s office. He took the file with him.}
\end{align*}
\]

The semantic definition of Elaboration(\(\alpha, \beta\)) has a slightly different from to that of Narration(\(\alpha, \beta\)), though for the sake of simplicity we gloss over the details here. Nevertheless, the semantics of Elaboration(\(\alpha, \beta\)) ensures that it satisfies the axioms given below, where \(\phi_E(\alpha, \beta)\) is the formula in the semantic definition of Elaboration(\(\alpha, \beta\)) that stands in for the ‘extra content’ (over and above that of \(K_\alpha\) and \(K_\beta\)) that must hold for the Elaboration relation to hold. Thus \(\phi_E(\alpha, \beta)\) is analogous to the formula \(\phi_N(\alpha, \beta)\) in the semantics of Narration given earlier.

- **Axiom on Elaboration:**
  \[(a) \quad \text{Elaboration}(\alpha, \beta) \Rightarrow K_\alpha \cap K_\beta
\]
  \[(b) \quad \phi_E(\alpha, \beta) \Rightarrow e_\alpha \subseteq e_\beta\]

Clause (a) stipulates that the CCP of Elaboration(\(\alpha, \beta\)) includes the intersection of the CCPs of the constituents that \(\alpha\) and \(\beta\) label (hence Elaboration is vertical, and imperatives connected with Elaboration are commanded). Clause (b) ensures that the events are in a part-of relation (and so Elaboration(\(\alpha, \beta\)) and Narration(\(\alpha, \beta\)) are mutually inconsistent). So representing (10ab) with Elaboration captures the desired implicatures, and makes the temporal properties distinct from (1).

One doesn’t infer Narration (via Narration) for connecting the constituents in (10), because a more specific conflicting default axiom applies in the glue logic, namely Elaboration:

- **Elaboration:** \((t, \alpha, \beta) \land \text{part-of}_D(\alpha, \beta) > \text{Elaboration}(\alpha, \beta)\)

In words, Elaboration states that if you’re connecting \(\beta\) to \(\alpha\), and there’s evidence within the discourse that they’re in a part-of relationship, then normally the rhetorical connection is Elaboration. Discourse evidence of a part-of relation is typically modelled via monotonic rules which feature linguistic information about the constituents in the antecedent; i.e., they’re axioms of the
form \( \text{Info}(\alpha, \beta) \Rightarrow \text{part-of}_D(\alpha, \beta) \) (see Asher and Lascarides (1995) for details). In (10), the monotonic rule which applies instantiates \( \text{Info}(\alpha, \beta) \) with the information that \( \alpha \) describes movement, and \( \beta \) also describes a causative movement performed by the same agent. Note that this is neutral with respect to sentence mood, and so the SDRSs for (10ab) are constructed via the same glue logic axioms.

4.1 Defeasible Conditionals and Metatalk Relations

The rhetorical relations we've considered so far constrain the contents of the constituents they connect. For example, Narration determines the temporal relations between the event discourse referents. Moore and Pollack (1992) argue convincingly that rhetorical relations can also reveal information about the cognitive states of the dialogue participants; in particular, they reveal information about their intentions. They use (13) to observe that recognising a content-level relation is sometimes necessary for recognising the intentional one and vice versa:

(13) a. Come home by 5pm.
   b. Then we can go to the hardware store before it closes.
   c. That way, we can finish the shelves tonight.

At the content level, the clauses in (13) describe events which are in consequence relations: doing the action described in (13a) normally results in (13b) being true; and (13b) being true normally means (13c) is true too. Elsewhere we have used the non-veridical relation Def-Consequence(\( \alpha, \beta \)) to mark this connection between propositions (e.g., Asher and Lascarides, 1998b). The semantics given below uses a definition of > over DRSs which extends the definition of the modal conditional > given in Asher and Morreau (1991) (see Asher and Lascarides (in press) for details):

- **Semantics of Def-Consequence**
  \[
  (w, f)[[\text{Def-Consequence}(\alpha, \beta)]_M(w, g) \text{ iff } (w, f) = (w, g) \text{ and } (w, f) \in \forall \alpha \left[ K_\alpha > K_\beta \right]
  \]

  When the first constituent is a request, however, the corresponding action term cannot be an antecedent to > directly, because it's not of the right semantic type. Rather, where \( \alpha \) labels \( \delta K'_\alpha \), the appropriate consequence relation is \( \left[ \delta K'_\alpha \right] > K_\beta \). Or, in words, any situation where the action described by the imperative \( \alpha \) is performed is normally one where the proposition \( \beta \) is true as well. We encode this content-level relationship in the rhetorical relation Def-Consequence\( _r \) (\( \alpha : ! \) means that \( \alpha \) labels an imperative and \( \beta : ! \) means that \( \beta \) labels an indicative):

- **Axiom on Def-Consequence\( _r \)**
  (a) \( \text{Def-Consequence\( _r \)}(\alpha, \beta) \Rightarrow (\alpha : ! \land \beta : !) \)
  (b) \( (\text{Def-Consequence\( _r \)}(\alpha, \beta) \land \alpha : \delta K'_\alpha) \Rightarrow (([\delta K'_\alpha] > K_\beta) \]

Like Narration, Def-Consequence\( _r \) encodes information about what results from doing the action described by \( \alpha \). But unlike Narration, Def-Consequence\( _r \) is not veridical: the imperative is not commanded since the CCP of the SDRS will not have the characteristic transformation of the world index.

Def-Consequence\( _r \) is part of the semantic representation of the discourses (2), (13) and (14):

(2) a. Go straight on and you’ll fall down the stairs.
   b. Come home by 5pm and we can go to the hardware store before it closes.

(14) Smoke 20 cigarettes a day and you will die before you’re 30.

Discourse (14) doesn’t implicate that the imperative “smoke 20 cigarettes a day” is commanded, largely because the consequent state (death) is undesirable. Similarly for (2a).

However, in contrast to (14) and (2a), the request is commanded in (13) and (2b). As Moore and Pollack (1992) point out informally, the consequence relations at the ‘content-level’ in (13), together with the background knowledge that (13c) is a desirable state, yield further inferences:
these consequence relations explain why the speaker made the request. This is an example of what Polanyi (1985) calls a ‘meta-talk’ relation, for it connects the content of one utterance to the performance of uttering another. In words, the meta-talk relation Explanation* (α, β) means that β explains why Agent(α) (i.e., the person who uttered α) performed the speech act α (e.g., Explanation* is part of the representation of Close the window. I’m cold). Like Narration and Elaboration, it’s a veridical relation. So (13) is represented as (13’) for simplicity, we have glossed over detailed representations of the action terms and DRSs that represent the clauses):

<table>
<thead>
<tr>
<th>(13’)</th>
<th>$\pi_1$, $\pi'$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_1$: Come home by 5pm</td>
<td>$\pi_1$, $\pi_2$, $\pi_3$</td>
</tr>
<tr>
<td>$\pi_2$: We can go to store</td>
<td>$\pi_2$</td>
</tr>
<tr>
<td>$\pi_3$: We can finish shelves</td>
<td>$\pi_3$</td>
</tr>
<tr>
<td>Def-Consequence, ($\pi_1$, $\pi_2$)</td>
<td></td>
</tr>
<tr>
<td>Def-Consequence($\pi_2$, $\pi_3$)</td>
<td></td>
</tr>
<tr>
<td>Explanation*($\pi_1$, $\pi'$)</td>
<td></td>
</tr>
</tbody>
</table>

In words, (13’) stipulates that the following explains why the request (13a) is commanded: doing the action described by (13a) normally leads to being able to go to the hardware store before it closes, which in turn normally leads to being able to finish the bookshelves tonight. Note that (13’) represents the content of the imperative at two levels in the discourse structure: it’s the first argument in an Explanation* relation; and its also part of the representation of the second argument $\pi'$ to this relation. This reflects the fact that rhetorically, the imperative plays a ‘dual role’: its content and its default consequences motivate its own command status. Since Explanation* is veridical, the request expressed by (13a) is commanded. The DRS labelled $\pi'$ must be true as well; but because Def-Consequence isn’t veridical, this doesn’t mean that the propositions expressed by (13b) or (13c) are true.

The difference between (13) and (14) is (14) does not feature the veridical Explanation* relation, but only the Def-Consequence, one. So the imperative in (14) isn’t commanded. There’s a similar difference between (2a) and (2b). But how can one infer these differences in the glue logic for constructing logical forms? Well, the DRS that’s labelled $\pi'$ in (13’) can be inferred via monotonic axioms $\pi$ which take account of the cue phrases that way, then and punctuation. Similarly, when the cue phrase and connects an imperative to an indicative, it monotonically generates Def-Consequence,: this applies to (2ab) and (14). Finally, Explanation* would be inferred via a default axiom which states: if α is a request, Def-Consequence($\alpha$, $\beta$) holds, and $\beta$ is a desirable state, then normally Explanation*($\alpha'$, $\pi$) holds, where $\alpha'$ labels a ‘repeat’ of the content of the request α, and $\pi$ labels $\alpha$’s and $\beta$’s content and the Def-Consequence, relation between them. Such a rule will yield (13’) as the DRS for (13).

4.2 Imperative Answers

We suggested earlier that an imperative that’s an (indirect) answer to a question isn’t necessarily commanded. We follow the DRT analysis of indirect answers from Asher and Lascarides (1998a), using the relation IQAP (standing for Indirect Question Answer Pair) to represent the connection between a question and its indirect answers. Semantically, IQAP(α, β) holds only if α is a question, and the speaker of α can infer a direct answer to his question (according to the compositional semantics of questions and answers) from the content that’s labelled by β. This relation IQAP will feature in the logical form of (3), for it reflects the fact that an adverbial of manner, which constitutes the semantic type of direct answers to how-questions, can be computed from the contents of the imperatives.
(3)  
   a. A: How does one make lasagne?  
   b. B: Chop onions and fry with mince and tomatoes, boil the pasta, make a cheese sauce, assemble it, and bake in the oven for 30 minutes.

That is, one can infer the direct answer by chopping onions, and (then) frying it with mince and tomatoes... from the content of (3b). Now, we must encode within the truth definition of \( IQAP(\alpha, \beta) \) that imperative answers aren’t always commanded: i.e., \( IQAP(\alpha, \beta) \Rightarrow K_\beta \) isn’t valid when \( K_\beta \) is a request. However, this is in contrast to \( IQAP \) when it relates propositions, for these are right-verbical. i.e., \( IQAP(\alpha, \beta) \Rightarrow K_\beta \) is valid when \( K_\beta \) is a proposition (see Asher and Lascarides, 1998a).

In fact, whether or not \( IQAP(\alpha, \beta) \) makes the imperative \( \beta \) commanded depends on the compositional semantics of the question. The imperatives in (3) aren’t commanded. But if the question is about what plans should be on the questioner’s agenda, the imperative answer does seem to be commanded (e.g., (15) and (16)).

(15) a. A: Where do I go now?  
   b. B: Go to platform 1.

(16) a. A: What should I do now?  
   b. B: Own up to the police.

We need to reflect this in the semantics for \( IQAP \). First, we must have a monotonic axiom which makes \( IQAP(\alpha, \beta) \) right-verbical when \( \beta \) is a proposition:

- **Veridicality of Propositional Answers:**  
  \[ (IQAP(\alpha, \beta) \land \beta : \bot) \Rightarrow K_\beta \]

Second, when \( \beta \) is an imperative, \( \beta \) is commanded only if it is an indirect answer to a question whose direct answers implicate a deontically necessary proposition for the questioner, something that we’ll abbreviate via \([D]Answer(K_\alpha)\):

- **Veridicality of Imperative Answers:** Deontic  
  \[ (IQAP(\alpha, \beta) \land \beta : \land [D]Answer(K_\alpha)) \Rightarrow K_\beta \]

Let’s now look at an example. The logical form of (3) is (3’):

\[
\begin{array}{c}
\pi_{1} = \pi \\
\pi_{1} : [\text{How make lasagne?}] \\
\pi_{2} : [\text{Chop onions}], \pi_{3} : [\text{fry with mince}] \\
\pi_{4} : [\text{boil pasta}], \pi_{5} : [\text{make cheese sauce}] \\
\pi_{6} : [\text{assemble it}], \pi_{7} : [\text{bake}] \\
\end{array}
\]

\[
\begin{array}{c}
(3') \\
\pi : Narration(\pi_{2}, \pi_{3}), Narration(\pi_{3}, \pi_{4}), Narration(\pi_{4}, \pi_{5}), Narration(\pi_{5}, \pi_{6}), Narration(\pi_{6}, \pi_{7}) \\
IQAP(\pi_{1}, \pi) \\
\end{array}
\]

Since \( IQAP \) isn’t right-verbical, the imperatives in (3b) aren’t commanded. However, the Narration relations ensure that the complex action described in \( \pi \) has the desired temporal properties;

---

7 Actually, it’s not clear whether or not (16) is a fragment answer where its message type isn’t imperative at all, and thus not commanded. This contrasts with (3b), where constraints in the grammar determine that the base verb form isn’t a ‘fragment’ part of an adverbial of manner, an adverbial of manner being what’s required as a direct answer to a how-question (see Asher and Lascarides (1998a) for details).

8 The axiom Narration is used to connect the imperatives with Narration, and the axiom IQAP which we’ll specify shortly, is used to connect the text-segment of imperatives to the question. We forgo giving details here, however, of how one chooses which labels are connected to which other labels (but see Asher and Lascarides (1998a, 1998b)).
i.e., performing the action described by $K_x$ would require the individual actions to be performed in the order they were uttered.

Note that all direct answers to (16a) are propositions that the the questioner should $\phi$, for some value of $\phi$. So the semantics of $IQAP$ correctly predicts that the imperative answer (16b) is commanded. Direct answers to the question (15a) don’t semantically entail a deontic proposition, but they do implicate one. Assuming that this implication is captured in SDRT, the imperative (15b) is commanded according to the above semantics of $IQAP$. $IQAP$ will also deal adequately with the command-status of an imperative to a conditional question:

(17)  
   a. A: If the exam is tomorrow, then what should I do?  
   b. B: Revise your notes tonight!

That is, it correctly predicts that $B$’s imperative is a conditional command; conditional on whether the exam is tomorrow.

The glue logic axiom for inferring $IQAP$ exploits Morgan’s (1975) notion of short-circuiting calculable implicatures. In Lascarides and Asher (1999), we demonstrate that a logical model of discourse participants as rational and cooperative agents validates the following: if $\beta$ is a response to a question $\alpha$, then normally $IQAP(\alpha, \beta)$ holds; i.e., $\beta$ supplies sufficient information that the questioner can infer a direct answer to $\alpha$ from it. This is represented in the glue logic via the following axiom:

- $IQAP: ((r, \alpha, \beta) \land ?) > IQAP(\alpha, \beta)$

Note that although the justification for this axiom involves inferences about the beliefs and intentions of the dialogue participants, the rule $IQAP$ itself has an antecedent which includes only information about the sentence moods; something that is given by the grammar. So in essence, $IQAP$ short-circuits the calculable inferences about when the speech act of providing an indirect answer is performed, because it allows the interpreter to entirely bypass reasoning with cognitive states, using just the sentence mood of $\alpha$ instead. This axiom plays a central role in constructing the SDRSs for (3) and (15-17).

4.3 Corrections

Consider (4), where intuitively $A$’s second imperative ‘replaces’ the first one:

(4)  
   a. A: Go straight for 5cm.
   b. B: That will take me straight into the crevasse
   c. A: Go left then.

$SDRT$ can model such non-incremental interpretations: whereas the logical form for the discourse context entails that an imperative is commanded, the logical form of the updated discourse context cancels this. Once again, the semantics of rhetorical relations is crucial to the account.

Commanding the imperative (4a) is not incompatible with its (undesirable) outcome (4b). And yet (4b) functions as a corrective move, since it brings into dispute that the imperative is commanded (or, more accurately, that it should be commanded). Now, in earlier work (e.g., Asher and Lascarides, 2001), we have used the relation Plan-Correction to model this: Plan-Correction($\alpha, \beta$) holds if $\beta$ indicates that the goal which lay behind uttering $\alpha$ is incompatible with Agent($\beta$)’s goals. This is analogous to Searle’s speech act of rejection: it features in the analysis of (4) and (18) (taken from Searle, 1969).

(18)  
   a. A: Let’s go to the movies tonight.
   b. B: I have to study for an exam.

Plan-Correction($\alpha, \beta$) is right-veridical but not left-veridical, thereby providing the non-incremental interpretation we require: if $\alpha$ labels an imperative, then an SDRS that contains Plan-Correction($\alpha, \beta$) does not have a CCP with the characteristic transformation of the world index, indicating that this
SDRS is one where the imperative is not commanded. This then leaves A free to issue a further command in response to the Plan-Correction. In fact, A requests (4c) as a result of B’s utterance (4b), as indicated by the cue phrase then. But this result relation is at the speech-act level (i.e., it’s a metatalk relation, connecting the content of B’s utterance to A’s performing the speech act of requesting (4c)). And so (4) is represented as (4’), where Result* encodes the appropriate metatalk relation:

<table>
<thead>
<tr>
<th>$\pi_1, \pi_2, \pi_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_1$: Go straight for 5cm</td>
</tr>
<tr>
<td>$\pi_2$: $e_{x_1}$ takes me into crevasse</td>
</tr>
<tr>
<td>Plan-Correction($\pi_1, \pi_2$)</td>
</tr>
<tr>
<td>$\pi_3$: [Go left then]</td>
</tr>
<tr>
<td>Result*($\pi_2, \pi_3$)</td>
</tr>
</tbody>
</table>

Like Explanation*, Result* is veridical. Therefore, (4′) entails that the imperative (4c) is commanded, but it does not entail that (4a) is commanded.

5 Some Concluding Remarks

We have examined the content of imperatives in dialogue, paying particular attention to their compositional semantics and to the ways in which the discourse context affects their interpretation. We argued that dynamic semantics provides an elegant account of their compositional semantics based on action terms: the defining characteristic of a discourse which features a commanded imperative is that its context change potential (CCP) transforms the world index into one where the action has been performed.

We observed that context can affect whether the imperative is commanded, and also the content of the action term—for example, the time at which the action is to be carried out. We argued that these contextual effects are best explained through capturing the rhetorical role of the imperative. Indeed, representing the content of discourse in terms of the rhetorical connections between the propositions and requests partly contributes to the simplicity of the compositional semantics of the imperatives, in that it makes a semantic primitive for stipulating what’s commanded unnecessary, in contrast to Segerberg’s analysis. The command status of an imperative is instead determined via the veridicality, or lack of it, of its rhetorical connection to the rest of the dialogue. And since this rhetorical relation is inferred on the basis of both linguistic and non-linguistic information, SDRS provides a framework in which the information flow between the content of an imperative, domain knowledge and goals can be modelled.

We also observed similarities in the implications of imperatives and indicatives. SDRS is distinct from plan-recognition approaches to discourse interpretation, in that the rhetorical relations are inferred on the basis of axioms which have direct access to the linguistic form of the context. We argued that this allows for a uniform analysis of these implications which would be hard to achieve through plan recognition.

There are many outstanding issues. For instance, we need to examine more closely the semantic relationships between imperatives and adverbials of manner; compare (19a) and the semantically similar (19b):

(19) a. Go to the kitchen and make a cup of coffee.
   b. Go to the kitchen to make a cup of coffee.

The interaction between imperatives, presuppositions and anaphora also deserves closer attention, as does the link between interpreting imperatives and planning (see, for example, Stone (2001)). We will examine these issues in future work.
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References

Hare, R. M. [1967] Some Alleged Differences between Imperatives and Indicatives, Mind.


