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Discourse ‘Major Continuatives’ in a Non-Monotonic Framework

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Abstract :

Delattre (1966) proposed a classification of French basic melodic contours. He defined in particular ‘major continuatives’ as melodic rises that mark the frontier between higher constituents in a hierarchy of clausal and sentential constituents. Although Delattre’s empirical basis for his classification has been discussed, there is a strong intuition that some sort of melodic rise can be used in French at the frontier between discourse constituents.

The goal of this paper is to explore this possibility in two directions. First, we provide experimental evidence that, taken in isolation, major continuatives are not significantly discriminated from interrogative contours by ‘naïve’ subjects, having no training in phonetics. Second, we try to account for the fact that, in real discourse, people do *not* confuse major continuatives and interrogative contours, by controlling the interactions between interpretation constraints using a non-monotonic logic in the general framework of Answer Set Programming.

1. Introduction

In a famous paper (Delattre 1966), the French phonetician Delattre proposed to distinguish ten basic melodic contours in French. He introduced two continuative contours, that he called *minor* (mc’s) and *major* continuatives (MC’s). The discrimination between mc’s and MC’s is based on physical and functional differences. Physically, Delattre uses a four step melodic scale¹. mc’s span the 2-3 zone, whereas MC’s, like question contours, span the 2-4 zone. mc’s can be rising or falling, whereas MC’s are rises. Finally, MC’s are ‘convex’, whereas question contours are ‘concave’. Mathematically, what Delattre calls concave (convex) is actually convex (concave). These properties are summarised in figure 1.

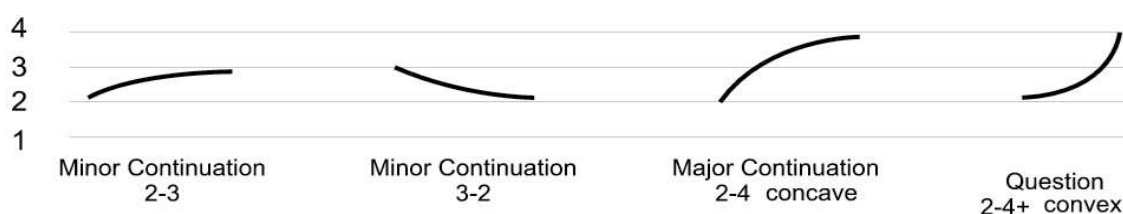


Figure 6 : After Delattre (1966)

¹ An analogous melodic division had been proposed by Pike (1945) for English; see also Trager & Smith 1951.

Functionally, mc's occur at the frontier between elementary constituents. In contrast, MC's signal that (i) a number of smaller meaningful constituents have been grouped together into a bigger one and (ii) a new 'big' (= non-elementary) constituent is about to begin. This is illustrated in (1) with one of Delattre's examples. '↑' marks a mc and '↑↑' a MC.

- (1) *Si ces ↑oeufs étaient ↑↑frais j' en prendrais*
 If those eggs were fresh I of them would take
 'If those eggs were fresh I'd take some'

Recent literature provides evidence in favour of the existence of continuatives. The existence of continuative rises has been attested in English (Pierrehumbert & Hirschberg 1990) and in other languages (Jasinskaja 2006, Chen 2007). Not every continuative is strictly 'rising', though. For instance, Chen (2007:sec.1.1) mentions the case of English continuatives, for which some studies identify a pitch fall on the stressed syllable before a final rise. It is more difficult to assess the relevance of the mc vs. MC distinction to recent work. In particular, many models, following (Pierrehumbert 1980), distinguish between two kinds of unit. The 'big' ones, called or corresponding to *Intonation Phrases* (IPs) in Pierrehumbert's terminology, are separated by *boundary tones*, located on the last syllable of the IP, or, in certain cases, on the last syllable of the focal/rhematic part of the IP. Typically, boundary tones convey information that helps determine the speech act type or discourse change potential of a sentence or clause. The existence and nature of 'smaller' units has given rise to more discussions (see, for instance, Di Cristo 1999, Jun & Fougeron 1995, 2000, 2002, D'imperio et al. 2007) and is more difficult to assess empirically in a theory-independent way. The reader is referred to Jun (2003), Frazier et al. (2006), Millotte et al. (2008) and Carlson (2009) for recent research connecting phrasal boundaries and cognitive processing.

Returning to Delattre, whereas the identification of its MC's with IP boundary tones is admissible, it is much less clear whether mc's can be paired with small units. For one thing, as we just saw, the status of such units is still a matter of debate (see Rossi 1981, Delais-Roussarie 2005, chap. 8:104 and Portes & Bertrand 2005: 3-4). In addition, the mc vs. MC distinction suffers from the general imprecision of Delattre's acoustic descriptions. For instance, Roméas (1992, cited in Di Cristo 1998) discussed the convexity-concavity criterion and showed that the difference is not systematically associated with the question-continuation distinction. Ideally, the convex vs. concave distinction, should be checked in terms of convexity (concavity) 'rate'. Drawing a segment between the endpoints of the melodic curve under consideration, and assuming a constant time step, one can count how many time-stepped segments are under (over) the main segment and how much they depart from it (angular distance). For n (resp. m) segments below (over) the main segment, one can calculate the quotient $C = (\sum_{i=1...n} \alpha_i / \sum_{j=1...m} \beta_j)$. C gives an indication of the relative quantity of angular distance. To our best knowledge, this has never been carried out systematically for Delattre's distinction. Nor has the cognitive relevance of such measures been estimated.

In this paper, we won't delve into such complicated and empirically unexplored issues. We will be concerned only with continuative boundary tones of IP phrases and will ignore the informational and semantics status of other tones and contours. Our official terminology for the tones under study will be *Discourse Continuative Rises* or DCR's for short.

Our main goals are (i) to see whether there is any cognitive basis, i.e. uniform response, to DCR's and (ii) to discuss how to integrate DCR's in a general description of discourse in view of the findings related to (i). In section 2, we describe the general experimental design, the statistical tests and their interpretation. In section 3, we exploit the non-monotonic

'answer set programming' framework and implement the discourse default interpretation we associate with DCR's in the DLV system.

2. An experimental setting

2.1 Description

22 native speakers of French between 19 and 25 years old² were collectively presented with 16 sentences of four different discourse types: Assertion, Question, Exclamation and Continuation. Continuation sentences were 'artificial'. They had been obtained by cutting the signal corresponding to a S1S2 structure, where S1 ended with a DCR; there was no break (pause) between S1 and S2 and S1S2 formed a meaningful unit. For instance, the unit *Jean a raté son examen, il avait rien fichu* ('John has failed his exam, he had done bugger all') was shortened to the first part (*Jean a raté son examen*, 'John has failed his exam'). Each sentence had been pre-recorded and was played twice. 8 sentences were read by a female speaker and 8 by a male speaker. The 16 sentences were randomised. Subjects were instructed to assign to each sentence at least one of the labels Assertion, Question, Exclamation and Indeterminate. They were not aware of the goal of the experiment.

We wanted to test whether subjects discriminate DCR's and questions. In order not to multiply sources of confusion, exclamations were realised as (relatively) end-falling. For instance, sentence 2 (*Jean a gagné au loto*) was realised as in figure 2a, not as in 2b.

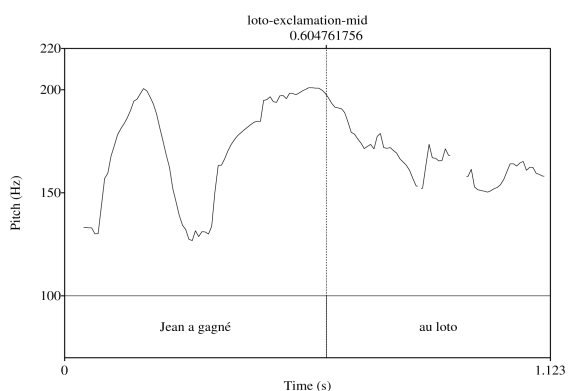


Figure 7a : mid-rising exclamation

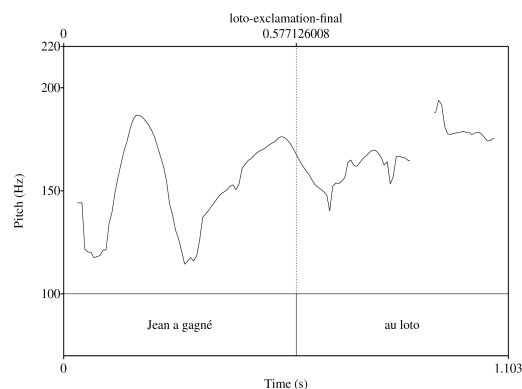


Figure 2b : end-rising exclamation

As noted by a reviewer, under the present setting, exclamations 'are' assertions³. This is potentially misleading for subjects and it turns out that there is a significant effect on the distinction between exclamations and assertions (see the results in figure 7 and the final remark of section 2.2). However, our main goal was to determine how DCR's are categorised. In this respect, the fact that exclamations and assertions are not quite distinct would be a problem only if DCR's were significantly classified as exclamations or assertions by subjects, thus creating an additional ambiguity (in short, are DCR's perceived as 'neutral' assertions or 'exclamative' assertions?).

² We thank the Linguistics Master2 students and the French Language and Communication L1 students of Nancy University for their participation.

³ We do not claim that exclamations are assertions in general. The type of exclamation used in the experiment corresponds to the 'proposition exclamations' studied by Rett (2008), that is, declarative sentences that express surprise at a salient proposition. Importantly, proposition exclamations entail that the speaker is committed to the truth of the proposition, like with an assertion.

The sentences are shown in figure 3, in their order of presentation.

1	Assertion	<i>Jean a attrapé la grippe</i>	John has got the flu
2	Exclamation	<i>Jean a gagné au loto</i>	John has won the lottery
3	Continuation	<i>Jean a raté son examen</i>	John has failed his exam
4	Question	<i>Jean a rangé son bureau</i>	John has tidied his office
5	Question	<i>Jean a changé de voiture</i>	John has got a new car
6	Exclamation	<i>Jean a repeint son appartement</i>	John has repainted his flat
7	Assertion	<i>Jean a fait un cauchemar</i>	John has had a nightmare
8	Continuation	<i>Jean a adopté un chien</i>	John has adopted a dog
9	Question	<i>Jean a pris le train de nuit</i>	John has taken the night train
10	Exclamation	<i>Jean s'est fait opérer</i>	John has got an operation
11	Continuation	<i>Jean a démissionné</i>	John has resigned
12	Assertion	<i>Jean est tombé en panne</i>	John has had a breakdown
13	Question	<i>Jean est allé en Chine</i>	John has gone to China
14	Exclamation	<i>Jean a acheté une maison</i>	John has bought a house
15	Continuation	<i>Jean a revu Marie</i>	John has met Mary again
16	Assertion	<i>Jean a été au ski</i>	John has gone skiing

Figure 8 : The sentences

2.2 Results and analysis

	Assertion Answers	Question Answers	Exclamation Answers	Ind Answers
Assertions	81	0	4	3
Questions	1	86	0	1
DCR's	7	72	3	6
Exclamations	19	2	65	2

Figure 9 : Summary of the results

In view of table 4, there is a strong correlation between the initial type assigned to a sentence by the experimenter and the type assigned by subjects. The type tends to be identical in both cases, except for DCR's, where the preferred response type is Question. In order to assess more precisely the significance of these figures, one may try several kinds of tests.⁴

First, one may run a multinomial (or 'polytomous') logistic regression on the whole set of data, interpreting the type chosen by subjects as a four-level response variable. We used the VGAM package (Yee 2006) and obtained quite clear results. For instance, the predicted probabilities of answer type are as follows (the \checkmark sign marks the winner).

⁴ All the tests we mention have been carried out in R (R Development Core Team 2009)

	Assertion Answers	Question Answers	Exclamation Answers	Ind Answers
Assertions	92% ✓	0.00000535 %	4.54%	3.40%
Questions	1.13%	97.72% ✓	0.00000420%	1.136%
DCR's	7.954%	81.818% ✓	3.409%	6.818%
Exclamations	21.590%	2.272%	73.863% ✓	2.272%

Figure 10 : Predicted probabilities

However, this method is open to the pseudo-replication problem, because the same individual is taken into account several times on the same kind of stimulus (e.g. assertions), which possibly creates spurious degrees of freedom. We used two clustering procedures to provide evidence that DCR's are associated with a particular effect. The first one (figure 6, left) is standard and aggregates the multinomial responses that are the most similar. The second one (figure 6, right) uses a probabilistic algorithm provided by the R package `pvclust`, co-authored by Ryota Suzuki and Hidetoshi Shimodaira (<http://www.is.titech.ac.jp/~shimo/prog/pvclust/>). We first transformed the responses into binary ones. An answer was counted as a success (TRUE) whenever the subject had guessed the 'correct' category, i.e. assertion for assertions and DCR's, question for questions and exclamation for exclamations. We also counted "indeterminate" answers as correct when they corresponded to DCR's. This is motivated by the desire to detect any potential trace of an identification of DCR's. The numbers appearing in the clusters correspond to the categories in the following way: A = 1, 7, 12, 16, Q = 4, 5, 9, 13, E = 2, 6, 10, 14, C (i.e. DCR's) = 3, 8, 11, 15. With the standard clustering, the higher leftmost cluster gathers the question and DCR groups. With the probabilistic clustering applied to binary responses, the higher leftward cluster gathers the DCR's. The (red) rectangles indicate the clusters for which the p-value on the A(pproximately) U(nbiased) method is superior or equal to 0.95. Whereas the standard clustering separates assertions and exclamations, the probabilistic clustering puts exclamation 6 next to assertions 7 and 16 and question 5. This is to be expected since the latter procedure is based on the distribution of 'good' answers, not on the identification of the category assigned by the experimenter.

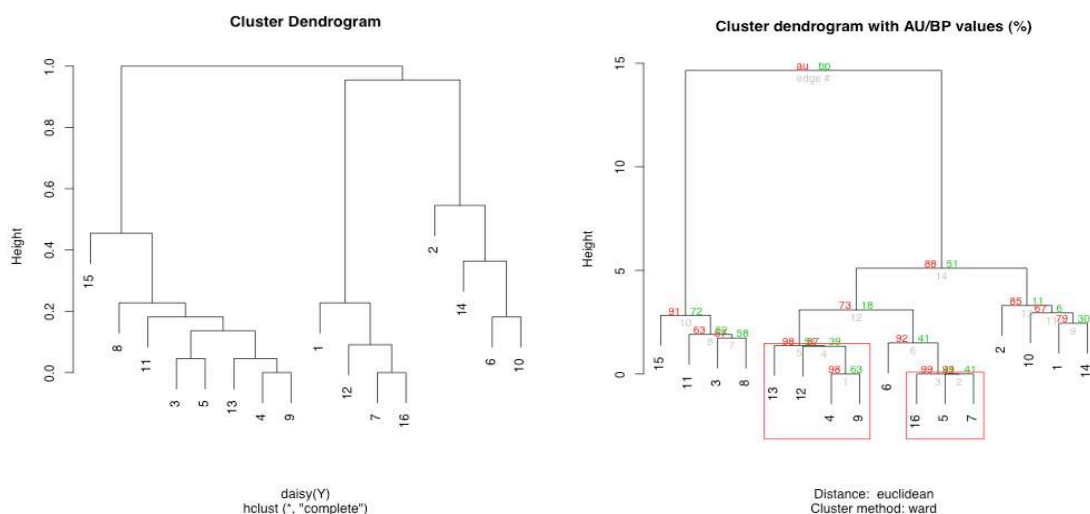


Figure 11 : Multinomial standard and binary probabilistic clustering

Another strategy is to fit a *mixed model*, that is, a model that incorporates random variation on the variables of interest, subjects in our case. There is a strong suspicion that subjects react in an homogeneous way. The binary responses analysed with the lme4 package, coauthored by Douglas Bates and Martin Maechler (<http://cran.r-project.org/web/packages/lme4/index.html>), see (Bates 2009). The AGQ parameter was fixed to 2, to force an Adaptive Gauss-Hermite Quadrature, appropriate for unique grouping factors (subjects in the present case). The results are as follows.

Model1 Pair.type with 4 levels A, C, E, Q	Fixed effects: Estimate Std. Error z value Pr(> z) (Intercept) 2.4747 0.4015 6.164 7.09e-10 *** pair.typeC -5.1164 0.5842 -8.758 < 2e-16 *** pair.typeE -1.4208 0.4665 -3.046 0.00232 ** pair.typeQ 1.3159 0.8264 1.592 0.11132 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Model2 Pair.type with 3 levels C, E, Q	Fixed effects: Estimate Std. Error z value Pr(> z) (Intercept) -2.6150 0.4229 -6.183 6.29e-10 *** pair.typeE 3.6539 0.4876 7.494 6.68e-14 *** pair.typeQ 6.3760 0.8309 7.673 1.67e-14 *** --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Model3 Pair.type with 3 levels A, E, Q	Fixed effects: Estimate Std. Error z value Pr(> z) (Intercept) 2.6861 0.4491 5.981 2.22e-09 *** pair.typeE -1.5201 0.4868 -3.123 0.00179 ** pair.typeQ 1.3517 0.8663 1.560 0.11871 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Model4 Pair.type with 3 levels A, C, Q	Fixed effects: Estimate Std. Error z value Pr(> z) (Intercept) 2.4485 0.3940 6.215 5.12e-10 *** pair.typeC -5.0635 0.5780 -8.761 < 2e-16 *** pair.typeQ 1.3126 0.8166 1.607 0.108 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Model5 Pair.type with 3 levels A, C, E	Fixed effects: Estimate Std. Error z value Pr(> z) (Intercept) 2.4589 0.3970 6.193 5.9e-10 *** pair.typeC -5.0845 0.5805 -8.759 < 2e-16 *** pair.typeE -1.4141 0.4643 -3.046 0.00232 ** --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Figure 7 : mixed effect linear regression

Models take into account all or some of the levels of the pair type factor, assertions (A), exclamations (E), DCR's (C) and questions (Q). The first factor in the list is the reference factor and the remaining factors are compared to it. In model1, E's and C's are significantly different from A's (look at the stars) and have a negative influence on the proportion of positive (= TRUE) answers. Q's are not significantly different from A's, which is to be expected since questions and assertions are identified as such by most subjects. model2 shows

that E's are significantly different from DCR's and comparatively positive (they indeed cause less error). Model3, model4 and model5 confirm model1. The global result is that DCR's and exclamations facilitate errors, unlike assertions and questions. The clusters shown in figure 6 indicates that the errors associated with DCR's are confusions with questions. As noted in section 2.1, exclamations cause a significant amount of errors (they are categorised as assertions), when compared to assertions and questions.

2.3 Discussion

There are obviously a lot of variants and additions that one can consider on the basis of this simple experiment, but we will mention only two of them. The exclamation part of the experiment could be redesigned, either by adding final exclamative contours and studying possible confusions with questions and DCR's or by suppressing exclamations altogether. Another, more radical, change would consist in adopting a *gating* methodology (see for instance Vion & Colas 2006). Gating amounts to presenting the signal stepwise and registering the reactions of subjects at each step. In our case, it would be interesting to determine whether there are significant differences in early recognition for questions and DCRs and whether there is a judgement inversion (from question to assertion) at some point in the incremental presentation of two sentence pair with a DCR.

3. A non-monotonic approach

3.1 Introduction

The problem we address in this section is to provide an explicit description of the fact that DCR's receive different interpretations in different discourse settings. They favour a question interpretation when considered in isolation, but may contribute an assertion, question, or command interpretation in other environments. This suggests that the inferences that allow hearers to assign an interpretation are governed by non-monotonic procedures.

Non-monotonic inference is concerned with defeasible reasoning. In standard logical inference, a conclusion derived from a set of premises is considered to be stable with respect to the addition of new premises. In everyday reasoning, conclusions are very often provisional. They are based on partial evidence and can be suspended in the presence of new information. Non-monotonicity is compatible with the existence of competing conclusions, which are selected on the basis of extra information. The existence of multiple unstable conclusions is probably the hallmark of interpretation and plays a crucial role in systems where elements carry several values and are disambiguated as information grows.

This seems to be the case with prosodic contours. In the previous section, we have seen that DCR's are not intrinsically reliable indicators of continuation. In fact, they are intrinsically misleading in isolation, since they favour a question interpretation. More generally, rises in general may be associated with quite different aspects of interpretation. For instance, they may convey emotions like surprise, speech act types like question, and an epistemic or interactional bias (see Gunlogson 2003, Jasinskaja 2006, Marandin 2006, Nilsenova 2006, Reese 2007 for various illustrations).

A simple way to represent symbolically non-monotonic inferences is to use a non-monotonic logic. Such logics are exploited on a large scale to construct big reasoning systems, in particular for planning or diagnosis. They can also be used, as here, to describe limited systems of constraints in an orderly way. The problem of non-monotonicity in discourse interpretation has been studied in the framework of SDRT (Asher 1993, Asher and Lascarides 2003) and we have shown how it can be applied to DCR's in (Jayez and Dargnat

2008b). However, in its present state, SDRT does not support prioritized rules, that is, rule ordering according to plausibility. This prompted us to move to the DLV system (Leone et al. 2006) which includes facilities for expressing priorities.⁵

3.2 The DLV system. Basics

The DLV system has two main features. Like other non-monotonic implementations, it extends the expressiveness of traditional Prolog-style logic programming by using stable model semantics to build non-monotonicity into the resolution engine of logic programming. In addition, it offers also functionalities for organising a competition between constraints. We won't try to present DLV in detail in this paper but will discuss these two features in the context of our problem.

Non-monotonicity can be found in every implementation of a non-monotonic engine for logic programming. It consists in adding a non-monotonic rule schema to the traditional rule schema of logic programming. Schema **R1** in (1), where the L_i 's are literals, shows the traditional head-body structure of logic programming. **R2** shows the non-monotonic format, where the 'not L_i ' literals are interpreted as negation-by-failure instances. The ':-' separator behaves like an implication, ' $X :- Y_1, \dots, Y_n$ ' being equivalent to $(Y_1 \& \dots \& Y_n) \Rightarrow X$, and meaning that X is satisfied whenever Y_1, \dots, Y_n are satisfied. (2) applies the non-monotonic schema to the case of questions. First, we have some facts (**F1**), which describe the property of a constituent called 'a'. They say that, prosodically and syntactically, 'a' can be an assertion, an exclamation or a question. It bears also a final rise. By introducing only a 'final_rise' property, we follow the conclusions mentioned in the previous section. The existence of a specific acoustic category of major continuatives has never been established. So, we prefer to use a neutral label, which does not commit us to the existence of a 'DCR object'. **R1** triggers a competition between speech act assignments. We interpret assertion as essentially distinct from exclamation. Should this choice be judged oversimplistic, we might amend **F1** and **R1** by introducing a more abstract category covering both assertions and exclamations. The result of running the program is shown under **R1**.

- (1) **R1** : head :- L_1, \dots, L_n .
R2 : head :- $L_1, \dots, L_n, \text{not } L'_1, \dots, \text{not } L'_k$.
- (2) **F1** : illof_prosody(a,assertion). illof_prosody(a,exclamation). illof_prosody(a,question).
illof_syntax(a,assertion). illof_syntax(a,exclamation). illof_syntax(a,question). final_rise(a).
R1 : illof_chosen(X,assertion) :- illof_prosody(X,assertion), illof_syntax(X,assertion), not
illof_chosen(X,question), not illof_chosen(X,exclamation).
illof_chosen(X,exclamation) :- illof_prosody(X,exclamation), illof_syntax(X,exclamation),
not illof_chosen(X,question), not illof_chosen(X,assertion).
illof_chosen(X,question) :- illof_prosody(X,question), illof_syntax(X,question),
not illof_chosen(X,assertion), not illof_chosen(X,exclamation).

Result : {illof_chosen(a,assertion)} {illof_chosen(a,exclamation)} {illof_chosen(a,question)}

At this stage, DLV cannot arbitrate between the three interpretations and constructs three equivalent 'best' models. The conclusion is clear: whereas the above rules improve on purely rigid ones, they do not allow us to express preferences. For instance, we cannot say that

⁵ We use in fact an extension of DLV, DLV-complex, which allows one to handle lists (as in standard Prolog) and sets (see <http://www.mat.unical.it/dlv-complex>). However, the example program we present here is written in 'pure' DLV.

DCR's are preferentially interpreted as questions. DLV uses a special mechanism of levels and weights for the expression of preference. Rigid constraints are then replaced by weak constraints and, unless instructed otherwise, the program selects the answer sets that, at each level, violate the less costly weak constraints and favours the less costly levels in case of an inter-level competition. The general method to create a competition based on non-monotonic rule is illustrated in (3). We posit two rules which block each other, since if **R1** is satisfied, 'blue' is true and blocks **R2**, whereas if **R2** is satisfied, 'green' is true and blocks **R1**. Then we declare that 'sea' is the case, which allows the two rules to fire. The program uses the two constraints, **R3** and **R4**, to arbitrate between the rules. In this case, 'blue' wins over 'green'. It is important to understand that inference relies on rules. Constraints by themselves do not allow one to draw conclusions from facts. They only select the less costly subset(s) of rules. So, in (3), it is not possible to dispense with **R1** and **R2**. The program can be found at <http://pagesperso-orange.fr/jjayeze/sea.dlv>.

(3) **Rules**

R1 : blue :- sea, not green.

R2 : green :- sea, not blue.

Facts

F1 : sea.

Weak constraints

R3 : ~ not green, sea. [1:1]

R4 : ~ not blue, sea. [2:1]

Elaborating on (3), we now organise the competition about illocutionary forces in a more orderly way. **R1** is declared at level 1 and costs two units, when not satisfied, whereas **R2** and **R3**, declared at the same level, cost only one unit. DLV selects **R1** and issue {question(a)} as the best answer set. It indicates that the cost was two units at level one. It is remarkable that, although the total cost for not satisfying **R2** and **R3** is the same as the cost for not satisfying **R1**, DLV prefers **R1** because, other things being equal at a given level, it protects the most costly rule. This remains true whatever the number of competitor rules is. For instance, we could add another competitor constraint declared at [1,1] with the same final result. The program is at http://pagesperso-orange.fr/jjayeze/isolated_DCR.dlv.

(4) **R1** : ~ not illocf_chosen(X,question), final_rise(X), illocf_syntax(X,question). [2:1]

R2 : ~ not illocf_chosen(X,assertion), final_rise(X), illocf_syntax(X,assertion). [1:1]

R3 : ~ not illocf_chosen(X,exclamation), final_rise(X), illocf_syntax(X,exclamation). [1:1]

Best model: {question(a)}

Cost ([Weight:Level]): <[2:1]>

3.3 Integrating DCR's

The treatment considered up to now is oversimplified. It cannot take into account discourse constituency, since it is limited to isolated 'constituents', sentences in our examples. Extending the approach is done in three steps (A), (B) and (C).

(A) First, we define the notion of constituent we rely on in the rest of the paper.

(5) **Atomic constituents**

An atomic constituent is any sentence that expresses a proposition and/or a speech act.

We limit our study to sentences because we lack empirical evidence concerning non-sentential clauses. Certain constituents convey a speech act, others convey a proposition which is involved in a speech act. The latter case may be illustrated by *pseudo-imperatives* like *Travailles dur (et) et tu réussiras* ('Work hard (and) you will succeed' = *if your work hard you will succeed*) or *pseudo-declaratives* like *Tu prends le métro tu arrives plus vite* ('You take the metro you arrive sooner' = *if you take the metro you'll arrive sooner*), see (Dargnat 2008, Franke 2008, Dargnat and Jayez 2009).

Atomic constituents may be attached together by discourse relations. They can also form complex constituents, which recursively enter discourse relations, as proposed in SDRT (Asher 1993, Asher and Lascarides 2003). Specifically, we assume the following constituency definition, adopting the SDRT constraint that no discourse relation cross the frontier of a constituent (point 6.2b).

(6) **Constituent**

Let DR be a set of discourse relations, a constituent over DR is a pair of sets $\langle nodes, dr \rangle$, where,

1. $nodes$ is a singleton and dr the empty set, or,
2. $nodes$ is a set of constituents over DR and dr a set of formulas $R(\alpha, \beta)$ with $R \in DR$ and $\alpha, \beta \in nodes$ such that: (a) for each $\alpha \in nodes$, there is a $\beta \in nodes$ such that $R(\alpha, \beta)$ or $R(\beta, \alpha)$ is in dr for some R and, (b) no constituent is in $nodes$ and occurs in some other constituent in $nodes$.

In order to reflect the formal definition, we can use the simple definition in (7). An atomic constituent has no constituent (**R1**). A complex constituent is anything which has a subconstituent. Ideally, complex constituents are defined on the basis of attachment, which is itself constrained by the 'possattach' predicate discussed below. However, this requires using lists or sets, a feature not supported in pure DLV.⁶ Since, in this paper, we focus on attachment, and constituency remains tangential to ours concerns, we have imposed particular values for 'constituent_of', thus creating the relevant literals without trying to derive them.

- (7) **R1** :- atomic_const(X), constituent_of(X,Y).
R2 :- complex_const(X) :- constituent_of(X,Y).

(B) The second point concerns the temporal structure of discourse. It follows from (6) that the representation of a 'discourse', that is of a sequence of atomic constituents, is a graph whose nodes are either atomic constituents (of the form $\langle \{\alpha\}, \emptyset \rangle$) or complex constituents (as graphs), and edges are discourse relations. Two nodes may be connected by more than one edge. Apart from the no-crossing restriction, we do not impose any constraint on attachment. In particular, we do not restrict it to the right frontier, as is done in SDRT. Attachment can be simulated in DLV by weak constraints like in (8), where Φ and Ψ stand for (possibly complex) properties of X and Y .

(8) **Attachment schema**

:- attach(X,Y,R), $\Phi(X)$, $\Psi(Y)$. [j,k]

⁶ See <http://pagesperso-orange.fr/jjayeze/const.dlv> for a small demo using sets.

The specificity of DCR's is that they 'program' an *immediate* attachment. They require that the last constituent introduced into the discourse (typically, the last sentence) be attached to the constituent that ends with the DCR. The last constituent must be attached to the penultimate constituent carrying the DCR or to a complex constituent including it. 'Back jumps' to other previous constituents are not allowed. The no back jump requirement corresponds to Delattre's intuition: a DCR signals that discourse construction is still ongoing, or, equivalently, that the constituent under construction cannot be abandoned (see Jayez & Dargnat 2008b and Dargnat & Jayez 2009 for a more detailed discussion). In order to reflect the temporal sequencing, we index the constituents through a general predicate 'd_time' which allows us to compare the temporal indices of constituents. For a complex constituent, its relevant temporal index is the one that indexes the first or last element of the constituent. Selecting the relevant index is done with the help of the '#min{x : P(x)}' or '#max{x : P(x)}' constructors, which select the minimal or maximal element of the set of elements that satisfy P. The relations of immediate succession are defined by replacing 'TX < TY' or 'TX > TY' by 'succ(TX, TY)' or 'succ(TY, TX)'. In order to save space, we give only a few examples of the rules we use. The full set can be found at <http://pagesperso-orange.fr/jjayez/dcr-pureDLV.dlv>.

(9) Discourse sequencing

R1 : d_before(X, Y) :- atomic_const(X), atomic_const(Y), d_time(X, TX), d_time(Y, TY), TX < TY.

R2 : d_after(X, Y) :- atomic_const(X), atomic_const(Y), d_time(X, TX), d_time(Y, TY), TX > TY.

R3 : d_before(X, Y) :- atomic_const(X), complex_const(Y), d_time(X, TX), TY = #min{U : const_of(Y, Q), d_time(Q, U)}, TX < TY.

... etc.

R4 : d_before(X, Y) :- complex_const(X), complex_const(Y), TX = #max{U : const_of(X, Q), d_time(Q, U)}, TY = #min{U1 : const_of(Y, Q), d_time(Q, U1)}, TX < TY.

... etc.

R5 : d_just_before(X, Y) :- atomic_const(X), atomic_const(Y), d_time(X, TX), d_time(Y, TY), succ(TX, TY).

... etc.

(C) Since DCR's are not distinguished from questions in isolation, their interpretation in discourse depends on the presence of other elements. However, as mentioned after definition (5), constituents may convey a speech act or a proposition, and be integrated into a structure that conveys a speech act in the latter case. This leaves two families of possibilities. Either we find a lexical element, typically a subordinating conjunction, that influences the choice of a discourse relation for attachment, or we have a juxtaposition. In both cases, discourse relations select pieces of information associated with either constituent. For instance a Justification relation can connect a question and an assertion, which, intuitively, would constitute a justification for the question. It can also connect a command and a question or two assertions. These possibilities are illustrated in (10-F1).

(10) Compatibility

F1 : illof_comp(justification, assertion, assertion). illof_comp(justification, command, assertion).
illof_comp(justification, question, assertion).

It is then relatively easy to express a standard attachment rule as in (11), where **R1** says that R can connect X et Y whenever every illocutionary force and propositional content that R admits is a member of the sets of illocutionary forces and propositional contents associated with X and Y. The illocutionary forces are assigned *via* the set of non-monotonic rules and

arbitrating constraints described above and illustrated in (2) and (4). The ‘excluded’ predicate allows for blocking by stronger rules.

(11) **Standard attachment**

R1 : possattach(X,Y,R) :- const(X), const(Y), d_before(X,Y), illof_comp(R,SA1,SA2),
 illof_chosen(X,SA1), illof_chosen(Y,SA2), prop_comp(R,PX,PY),
 express_prop(X,PX), express_prop(Y,PY), not excluded(X,Y,R).

Exclusion may be triggered by the presence of a subordinating conjunction (‘SC’), as in (12-R1). The ‘comp_sub_conj’ predicate allows one to enumerate the discourse relations that are compatible with a given subordinating conjunction, as shown in **F1** for *parce que*. **R2** is the rigid rule for subordinating conjunctions. It is just a copy of (11-**R1**) minus the ‘excluded’ last literal.

(12) **Attachment blocking**

R1 : excluded(X,Y,R) :- const(X), const(Y), disc_rel(R), sub_conj(Y,SC),
 not comp_sub_conj(SC,R).
F1 : comp_sub_conj(parce_que,cause). comp_sub_conj(parce_que,justification).
R2 : possattach(X,Y,R) :- const(X), const(Y), d_just_before(X,Y), sub_conj(Y,SC),
 comp_sub_conj(SC,R), illof_comp(R,SA1,SA2), illof_chosen(X,SA1),
 illof_chosen(Y,SA2), prop_comp(R,PX,PY), express_prop(X,PX), express_prop(Y,PY).

Finally, we come to the interpretation of DCR’s. Recall that DCR’s are preferably interpreted as questions in isolation but may be connected with immediately following constituents and lose this illocutionary status. We have used the ‘illof_prosody’ predicate, which determines which speech acts are compatible with the prosody of the constituent. Although ‘illof_prosody’ gives access to several mutually exclusive possibilities, they remain purely disjunctive (= unordered) and they do not interact with the ‘possattach’ head rules in an interesting way. What we need to obtain is the following: (i) the speech act assignment, i.e. the output of ‘illof_chosen’ should be preferably ‘question’ and (ii) the attachment chosen by ‘possattach’ should win over the local speech act assignment. The first point is a direct effect of non-monotonicity and arbitration through the system of levels and weights. The second point can be implemented similarly, by introducing a variant of the ‘possattach’ rules, ‘possattach_fr’, which uses the illocutionary forces as determined by the *syntax* –not the prosody– and checks whether the chosen force belongs to the set of forces normally compatible with a final rise. The two relevant literals are underlined in (13-**R1**). ‘illof_syntax’ is the same predicate as the one used in (2). ‘illof_dcr_comp’ enumerates all the illocutionary forces compatible with a final rise under an integrated interpretation where the constituent bearing the rise is connected to another constituent.

(13) **R1** : possattach_fr(X,Y,R,Z) :- const(X), const(Y), d_just_before(X,Y), final_rise(X),
 illof_comp(R,Z,SA2), illof_syntax(X,Z), illof_dcr_comp(Z), illof_chosen(Y,SA2),
 prop_comp(R,PX,PY), express_prop(X,PX), express_prop(Y,PY), not excluded(X,Y,R).

The introduction of ‘possattach_fr’ is not sufficient since we need to connect it to ‘illof_chosen’ and to make a fresh hierarchy of priorities to prevent the default non-integrated interpretation of final rises (i.e. question) to win. This is done in (14). **R4-R6** add the possibility of choosing the illocutionary force *via* ‘possattach_fr’; constraints **C1-C6** create a new weight (3) at the same level as before (1).

- (14) **R1** : illocf_chosen(X,assertion) :- illocf_prosody(X,assertion), illocf_syntax(X,assertion),
not illocf_chosen(X,question), not illocf_chosen(X,exclamation).
R2 : illocf_chosen(X,exclamation) :- illocf_prosody(X,exclamation), illocf_syntax(X,exclamation),
not illocf_chosen(X,question), not illocf_chosen(X,assertion).
R3 : illocf_chosen(X,question) :- illocf_prosody(X,question), illocf_syntax(X,question),
not illocf_chosen(X,assertion), not illocf_chosen(X,exclamation).
R4 : illocf_chosen(X,assertion) :- possattach_fr(X,Y,R,assertion), not illocf_chosen(X,question),
not illocf_chosen(X,exclamation).
R5 : illocf_chosen(X,exclamation) :- possattach_fr(X,Y,R,exclamation), not illocf_chosen(X,question),
not illocf_chosen(X,assertion).
R6 : illocf_chosen(X,question) :- possattach_fr(X,Y,R,question), not illocf_chosen(X,assertion),
not illocf_chosen(X,exclamation).
C1 : ~ not illocf_chosen(X,assertion), possattach_fr(X,Y,R,assertion). [3:1]
C2 : ~ not illocf_chosen(X,exclamation), possattach_fr(X,Y,R,exclamation). [3:1]
C3 : ~ not illocf_chosen(X,question), possattach_fr(X,Y,R,question). [3:1]
C4 : ~ not illocf_chosen(X,question), final_rise(X), illocf_syntax(X,question). [2:1]
C5 : ~ not illocf_chosen(X,assertion), final_rise(X), illocf_syntax(X,assertion). [1:1]
C6 : ~ not illocf_chosen(X,exclamation), final_rise(X), illocf_syntax(X,exclamation). [1:1]

In order to illustrate how (13-**R1**) works, we have defined three constituents c4, c5 and c6. c4 and c5 are attached by a causal relation triggered by *parce que*. Together, they form a complex constituent c7, which is attached to c6 by a temporal relation. To ease understanding, one may imagine an example like *Paul est arrivé (c6) [Marie venait de partir (c4) parce qu'elle était pressée (c5)] (c7)* ('Paul arrived (c6) [Mary had just left (c4) because she was in a hurry (c5)] (c7)'). The facts are given in (15).

- (15) **F1** : atomic_const(c4). atomic_const(c5). atomic_const(c6). const_of(c7,c4). const_of(c7,c5).
d_time(c6,4). d_time(c4,5). d_time(c5,6). final_rise(c6). sub_conj(c4,parce_que).
prop_comp(cause,p4,p5). prop_comp(temp,p6,p7). prop(p4). prop(p5). prop(p6). prop(p7).
illocf_dcr_comp(assertion). illocf_dcr_comp(question). illocf_dcr_comp(command).
illocf_dcr_comp(exclamation).
illocf_syntax(c4,assertion). illocf_syntax(c4,question). illocf_syntax(c4,exclamation).
Idem for c5, c6, c7
illocf_prosody(c4,assertion). illocf_prosody(c5,assertion). illocf_prosody(c6,question).
illocf_prosody(c6,exclamation). illocf_prosody(c7,assertion).
express_prop(c4,p4). express_prop(c5,p5). express_prop(c6,p6). express_prop(c7,p7).

Best model: {illocf_chosen(c4,assertion), illocf_chosen(c5,assertion), illocf_chosen(c7,assertion),
illocf_chosen(c6,assertion), possattach_fr(c6,c7,temp,assertion), possattach(c4,c5,cause),
possattach(c1,c2,justification), possattach(c6,c7,temp)}
Cost ([Weight:Level]): <[3:1]>

Running the program gives a result partially shown in (15-Best model). The c6 constituent has been interpreted as an assertion in spite of the fact that it bears a final rise. This is because, although (14-**R2**) is satisfiable and c6 can be analysed as an exclamation in a model where all rules are on a par, this is no longer the case with weighted and levelled rules. First, all things being equal, the question interpretation would dominate because of (14-**C4**). Second, the assertion interpretation will ultimately win because (14-**R4**) is satisfiable and (14-**C1**) prevents the question interpretation to win the competition. DLV counts three units for the best model. One comes from not satisfying (14-**C6**) the other two from not satisfying (14-**C4**).

In this short presentation, we have focused on the non-monotonic interactions, ignoring several issues, such as the treatment of the propositional structure, the systematic use of sets and lists instead of explicit enumerations (a feature available only in DLV-complex), or the non-monotonic treatment of constituency. However, the simulation demonstrates the possibility of dealing with DCR's in a flexible way. The facility of weak constraints allows one to order the satisfaction of rules and keep a trace of the preferences in the execution of the program. It is possible to parameterise the execution further by using the `-costbound=...` option. Instead of outputting only best models, DLV will construct and describe every model that satisfies the constraints on weights and levels indicated in the option.

4. Conclusion

This paper has addressed the general issue of associating 'meanings' with intonational contours. An influential perspective on this topic is that of *intonational meaning*, that is, the view that contours may be interpreted as conveying abstract semantic information, giving rise to specific interpretations in specific contexts (Ladd 2008:41). Evaluating the appropriateness of this perspective is difficult for several reasons. First, as we have seen for 'rises' in general, it is perhaps not feasible to define objective acoustic properties that would constitute a formal and stable counterpart of (elements of) contours. In that respect, the more or less implicit assimilation of contours to intonational 'morphemes' might be misleading and reflect a (more or less unconscious) structuralist bias (see Pierrehumbert 2001 for related issues in the context of exemplar-based categorisation). Second, the basic interpretations assigned to contours vary, a fact which might reflect the non-propositional character of intonational meaning, making it less amenable to an intuitively grounded study than phenomena such as speech acts or propositional modulations of propositional content (e.g. presuppositions). After all, similar difficulties are found in the study of discourse markers, information structure, and, perhaps most tellingly, interjections (Wharton 2003). Third, taking into account continuation phenomena leads one to adopt a more nuanced perspective in at least two respects. In contrast with meanings defined in terms of speech act or epistemic stance, continuative 'meaning' belongs in the domain of discourse structuring, and might accordingly be denied the status of 'meaning' in a more restricted sense (propositional or modal meaning), see Delais-Roussarie (2005:104) for a similar suggestion. Moreover, if discourse interpretation consists in assembling default interpretation pieces that compete or converge, it is not sufficient to use a model of underspecification where 'vague' constraints wait for the context to provide additional information. In fact, the existence of defeasible *preferences* requires that any reasonable simulation build some form of hierarchy between constraints, in order to keep to the distinction between cumulative and cancellable information.

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