Intonations of disjunctive questions

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Abstract

Starting from the observation that for *disjunctive questions* the choice of an *intonation pattern* has both semantic and pragmatic implications, this paper has a three-fold aim: (i) to systematically *describe* and *classify* the effects of the different intonation patterns, (ii) to isolate the properties of the intonation patterns which *cause* these effects, (iii) to *formalize* the intonations as operators in a model for questions, in a framework based on the 'inquisitive possibility semantics' developed by Groenendijk, Roelofsen and Ciardelli.

1 Three intonation patterns

We observe that there are three intonation patterns for disjunctive questions, each of which has different implications. Consider for example the question

(1) Is John or Bill coming?

The three intonation patterns that we consider here[1] will be represented as follows:

(2) (F) Is John or Bill coming↑ ?
(O) Is John↑ or Bill↑ coming?
(C) Is John↑ or Bill↓ coming?

Here, ↑ and ↓ signify rising and falling pitch, respectively, on the word preceding the arrow.

We name these intonation patterns as follows: (F) is the **flat** pattern, which, as we shall see, corresponds to a question that expects a yes/no-answer. We will call (O) and (C) **open** and **closed** intonation patterns of the alternative question, respectively.

The difference between the three patterns becomes clear when they are put in small dialogues. In the next subsections, we will observe that the intonation patterns have different implications.

[1] This list of intonation patterns is exhaustive for the English language. However, in languages where changing word order in questions is not obligatory, e.g., in Italian, a sentence such as

(1-It) Gianni o Roberto è venuto [. or ?]

would have at least one more intonation patterns, corresponding to the assertive meaning of the sentence. We refer the interested reader to http://homepage.mac.com/samvg/intonation.html for some sound samples of the intonation patterns in different languages.

1.1 Coherence effects

We can observe some coherence effects by considering whether affirmative or negative answers are allowed after the different intonation patterns. For example,

(3) a. Is John or Bill coming↑ ?
b. Yes, John or Bill is coming.

is a normal answer to the question, whereas

(4) a. Is John↑ or Bill↓ coming?
b. † Yes, John or Bill is coming.

is uncooperative and wrong: the person who asked (a) would feel the person who replied with (b) did not understand his question correctly, or, if he did, that he was joking.

For the open intonation pattern, intuitions are subtle: giving an affirmative answer as in

(5) a. Is John↑ or Bill↑ coming?
b. ? Yes, John or Bill is coming.

is not wrong in general, but its appropriateness is context-dependent. The conversation might occur in a context where the person who asks (a) is doubting that anyone will come at all, and the reply in (b) is meant to take away this doubt, even though the answerer does not know exactly who will come. On the other hand, if the person who asks (a) is sure that a lot of people are coming, but is now asking for information from someone who knows John and Bill very well, he would be disappointed by the affirmative answer in (b).

In (3), (4) and (5), we have observed that pattern (F) has a clear *affirmation effect*: the pattern allows for an affirmative answer, while, by contrast, pattern (C) has an *anti-affirmation effect*. Pattern (O) does not have any of the two effects by default, but may have an affirmation effect in certain contexts.

Similarly, we can observe that pattern (F) has a *denial effect*:

(6) a. Is John or Bill coming↑ ?
b. No, neither of the two is coming.

Interestingly, although the open intonation pattern (O) was a trouble child for the affirmation effects, it is not at all ambiguous with respect to a negative answer: the exchange

(7) a. Is John↑ or Bill↑ coming?
b. No, neither of the two is coming.

is perfectly normal, so we say that (O) also has a *denial effect*.

As with affirmative answers, pattern (C) has an *anti-denial effect*: it does not allow for the answer 'no' without repair. Consider

(8) a. Is John↑ or Bill↓ coming?

b. † No, neither of the two is coming.
c. Actually, I'm afraid none of the two is coming.

Here, answer (b) is rude: if in fact both John and Bill are not coming, then a more empathic answer is (c), which first denies the apparent expectation of the question (a) that at least one is coming. This relates to the existence effect, which we will discuss in the next subsection.

We gather some implications about the knowledge of a person who utters a disjunctive question under the name *epistemic coherence effects*. For example, a person who says

(9) I know that either John or Bill is coming.

can not follow up with the disjunctive question intonation pattern (F): he has just mentioned in (9) that he knows the answer is 'yes'. However, pattern (C) is fine after (9): the speaker may know that one of John or Bill is coming, but not which one (or maybe both, see below). Pattern (O) is doubtful after (9), in a similar way as the "yes" answer was doubtful after (O).

None of the patterns is possible after saying

(10) I know that John is coming.

Clearly, after this piece of knowledge has been states, all of the disjunctive questions become superfluous.

Summing up, we will say that all intonation patterns have *ignorance* implications, but about different things: the closed pattern implies ignorance only with respect to the *individual* facts "John is coming" and "Bill is coming", whereas the open and flat patterns imply ignorance about the truth of the *disjunction* "John or Bill is coming".

Conversely, after saying

(11) a. I don't know whether at least one of John and Bill is coming.
b. I don't know whether at most one of John and Bill is coming.

it is impossible to continue with pattern (C), while patterns (O) and (F) are fine after (11-a) and (11-b). For this reason, we say that (C) has a *knowledge* implication about the existence and uniqueness of a person who is coming.

As a result, after

(12) I don't know whether anyone is coming.

the Closed pattern is clearly impossible. Whether or not the Open pattern is possible after saying (12) is, again, context-dependent. We say that (O) has a *weak* knowledge implication about *existence*.

We will see in the next subsection that these knowledge implications are related to existence and uniqueness effects which occur with the different intonation patterns.

1.2 Implication effects

As we already observed above in the discussion of the denial effect, the closed intonation pattern (C) has the implication that at least one of John and Bill is coming. This is a presupposition, as is witnessed by

(13) a. Is John↑ or Bill↓ coming?
b. Hey, wait a minute! I didn't know that one of the two was coming.

We will call this the *existence effect*, since the implication of (C) is that there exists an individual x in the list of options in the disjunction such that "x is coming" is true. The effect becomes even clearer in the variation

(14) a. Is John↑, Mary↑, Eve↑, Carla↑, or Bill↓ coming?
b. Hey, wait a minute! I didn't know that one of them was coming.

By contrast, patterns (F) and (O) lack the existence effect:

(15) a. Is John↑ or Bill↑ coming?
b. † Hey, wait a minute! I didn't know that one of the two was coming.
c. Is John or Bill coming↑ ?
d. † Hey, wait a minute! I didn't know that one of the two was coming.

In some situations, we know from the context or general facts about the world that the answer can not be 'both'. We call this effect *external uniqueness*. Compare, for example, the open intonations of the following two questions:

(16) a. Is John↑ or Bill↑ coming?
b. Both of them are coming.

(17) a. Did John↑ or Bill↑ win the poker game?
b. † Both of them won.

We call this type of uniqueness 'external', because whether or not the answer 'both' is licensed seems to depend on real-world knowledge: usually, more than one person attends a party, but not more than one person wins a particular poker game.

Another type of implied uniqueness, which occurs only with the closed intonation, is what we will call *domain uniqueness*. Consider the natural exchange:

(18) a. Is John↑ or Bill↓ coming?
b. Hey, wait a minute! I didn't know that not both of them could come.

Here, we observe that the closed intonation pattern carries the presupposition that, *among those possibilities that are mentioned*, only one of the disjuncts satisfies the predicate ('is coming'). The flat and open pattern lack this presupposition.

As a last effect, we mention *domain restriction*. The closed pattern has this effect in a strong sense: it has the implication that the speaker is only interested in John and Bill's

attendance; the answer "Mary is coming" to the closed intonation feels irrelevant: the asker only expressed interest in John and Bill, not in Mary.

The open pattern has a similar effect, but in a weaker form, the implication being that the speaker is particularly interested in those disjuncts he mentions, but he may also be interested in others.

The flat pattern lacks domain restriction: it simply asks about the possibility that John or Bill is coming, but does not express nor imply disinterest in others.

1.3 A wide scope variation

Note that the open and closed intonation patterns have an overt wide scope alternative:

(19) (O') Is John↑ coming, or Bill↑?
(C') Is John↑ coming, or Bill↓?

On the other hand, there is no way to re-phrase the flat question (1F) with an overt scope. This observation supports one of the ideas that we will formalize in the next sections, namely that in the flat intonation pattern (1F), the element 'John or Bill' is functioning as one inseparable 'block', while in both (1O) and (1C), the intonation after 'John' seperates the two names into two blocks, so that they can subsequently be put in a wide-scope form.

1.4 Table of effects

We summarize our observations about the properties of the different intonation patterns in a table below.

	Flat	**Open**	**Closed**
Affirmation	yes	weak	no
Denial	yes	yes	no
Knowledge	no	(weak) existence	existence & uniqueness
Ignorance	disjunction	(weak) disjunction	individual
Existence	no	no	yes
Domain Uniqueness	no	no	yes
Domain Restriction	no	weak	strong
Wide Scope	no	yes	yes
External Uniqueness	world knowledge	world knowledge	world knowledge

2 Informal view of intonation

Instead of directly giving an *ad hoc* formal translation of the different intonation operators, we will informally state some basic assumptions underlying our view on disjunctive questions. These assumptions will provide minimal constraints on an appropriate formalisation.

2.1 The underlying 'wh'-question

Our first basic assumption is that all disjunctive questions can be viewed as asking for information about the extension of a certain predicate, i.e., as asking for information about the answer to a 'wh'-question. We call this 'wh'-question the *underlying question*. For example, the underlying question to all the questions that we considered in the previous section (except for (17)) was

(20) Who is coming?

We do not make any further claims about the underlying question at this point, except that it is there, and it can be identified. In particular, we will also call (20) the underlying question to the closed intonation pattern (C), even though we already observed that a person who uses pattern (C) is not really interested in the full answer to the question (20).

Note that here and throughout this paper, we are assuming that the *subject* of the question has focus. It would be much harder to pin down the underlying 'wh'-question in

(21) Is John going out or staying at home tonight?

One might try "What is John doing?" as the underlying question, but for this question, the predicates "going out" and "staying home" would need to be represented as possible answers, which seems to require a formal system more complicated than the one we will develop in the next section.

If we want to make the underlying question part of our formalisation, it is more natural to use first-order syntax and semantics than a propositional one. This will be part of our proposal in the next section.

2.2 Upward intonation ↑

Comparing the Flat intonation pattern on the one hand with the Open and Closed patterns on the other hand, the main difference is in the 'scope' of the upward intonation: in (F), 'John or Bill' is highlighted as one possibility, whereas in both (O) and (C), 'John' and 'Bill' are both highlighted as separate possibilities.

This simple observation underlies the idea that we want to model the upward intonation as an 'attention operator': although upward intonation does not directly affect the *answerhood conditions* of the question, it puts *focus of attention* on the possibilities which are under the 'scope' of the intonation, and thereby highlights certain possible answers as more relevant, expected or interesting.

2.3 Downward intonation ↓

The directly observable difference between patterns (O) and (C) is that (C) has a downward intonation at the end, while (O) does not. Putting downward intonation at the end of a question seems an asker's attempt to 'force' the answer to be exclusive. Not only are 'John' and 'Bill' presented as *separate* possibilities by the upward intonation, but the downward intonation signals them as being *mutually exclusive*, so that the answerer of the question must choose precisely one of them.

Therefore, we want to formally represent the downward intonation as operating both on the focus of attention and on the answerhood conditions. The downward intonation can be seen as a two-step order to the hearer of the question:

I. **Exclusive Attention.**
"Regard the possibilities that I have brought under attention as mutually exclusive."

II. **Question Restriction.**
"Choose your answer among the possibilities which are under attention after (I)."

The ideas about the different intonation patterns expressed in this section can now be summarized in a semi-formal language as follows.

(22)
(F) Is John or Bill coming↑ ?
Who is coming? In your answer, pay attention to the possibility {John or Bill}.
(O) Is John↑ or Bill↑ coming?
Who is coming? In your answer, pay attention to the possibilities {John} and {Bill}.
(C) Is John↑ or Bill↓ coming?
Who is coming? In your answer, pay attention to the possibilities {John} and {Bill}. Regard these possibilities as exclusive, and choose one of them.

The aim of the next section is to devise a formal system in which the meaning of the different intonation patterns is precisely in accordance with these semi-formal representations.

3 DQI: Disjunctive Questions with Intonation

In this section, we propose a formalisation of the upward and downward intonations, inspired by Inquisitive Possibility Semantics with Attention (IPSA), as has been and is still being developed by Groenendijk, Ciardelli and Roelofsen[2], adding operators, in order to account for the differences brought about by the intonation patterns, which we examined in section 1.

The syntax and semantics of our formal language will diverge from IPSA in a few aspects:

[2]See: **Floris Roelofsen**, "Information, Issues and Attention" (02-02-2009), unpublished notes, and **Ivano Ciardelli, Jeroen Groenendijk, Floris Roelofsen**, "Might and Free Choice in Inquisitive Semantics" (03-04-2009), handout for SALT '09 conference.

(i) In order to make the "underlying wh-question", as discussed in the previous section, explicit, we need a first-order system.

(ii) There is a syntactic distinction between questions and answers. This may seem a disadvantage compared to IPSA, in which 'hybrid' sentences were one of the nice features. However, because of the semantic definitions of the intonation operators, we will not lose hybridity, as we will see in some examples later on.

3.1 Language

Let $P_1, \ldots, P_k$ be a collection of unary predicate letters and $c_1, \ldots, c_n$ a collection of constants, which are intended to formalize the names in our examples.

We now define the language $\mathcal{L}_{\mathsf{DQI}}$ for Disjunctive Questions with Intonation as follows.

The collection of **basic terms** is the smallest set BT such that

- $c_j \in BT$ for $j = 1, \ldots, n$
- If $s, t \in BT$, then $\neg s \in BT$, $s \vee t \in BT$ and $s \wedge t \in BT$.

The Basic Terms formalise *elements of a list*, on which we can then put intonation. For example, the basic terms in the closed intonation pattern

(23) Is John↑ or Bill↓ coming?

will be (the formalisations of) 'John' and 'Bill'. So, the basic terms are the formal representatives of the 'separate blocks' about which we reasoned when discussing the wide scope alternative to some intonation patterns in section 1.3.

The collection of **intoned terms** is the smallest set IT such that

- $\emptyset \in IT$,
- For any $t \in BT$, $(t)\uparrow \in IT$,
- If $s, t \in IT$, then $\neg s \in IT$, $(s)\downarrow \in IT$, $s \vee t \in IT$.[3]

Intoned terms are the formalisations of *intoned lists of elements*. For example, if j and b are the formal translations of 'John' and 'Bill', respectively, then $j\uparrow$ and $b\uparrow$ are intoned terms, but so are $j\uparrow \vee b\uparrow$ and $(j\uparrow \vee b\uparrow)\downarrow$.

In the definition of intoned terms, we implicitly make some assumptions about the intonation operators: $\uparrow$ only applies to basic terms, whereas $\downarrow$ applies to intoned terms as a whole. This corresponds to our intuition that downward intonation applies to a 'list' (intoned term) as a whole, whereas upward intonation applies to 'elements of the list' (basic terms).

A **question** is defined to be a formula of the form $?P_j(i)$, where i is an intoned term and P_j is a predicate letter. The reason why we included the intoned term $\emptyset$ now becomes clear: $?P_j(\emptyset)$ will be the translation of the question "Who has the property P_j?". For example, "Who is coming" will translate to $?P(\emptyset)$, where P is the formal translation of the predicate "is coming".

[3] We will often omit brackets, but sometimes they are necessary to avoid confusion. For example, $(c_1 \vee c_2)\uparrow$ is an intoned term, but $c_1 \vee c_2\uparrow$ is not, since c_1 is not an intoned term.

An **answer** is a formula of the form $!P_j(i)$. We further have two **polar answers** $!\top$ and $!\bot$, which are intended to denote the answers *yes* and *no*, respectively. The language $\mathcal{L}_{\mathsf{DQI}}$ is defined as the set of all questions and answers.

As a relevant example, we now show how to translate the different intonation patterns of the question (1) into the language $\mathcal{L}_{\mathsf{DQI}}$, where P represents the predicate 'is coming', j is the translation of 'John' and b the translation of 'Bill'.

(24) (F) Is John or Bill coming↑ ?
$?P((j \vee b)\uparrow)$
(O) Is John↑ or Bill↑ coming?
$?P(j\uparrow \vee b\uparrow)$
(C) Is John↑ or Bill↓ coming?
$?P((j\uparrow \vee b\uparrow)\downarrow)$

Note that the translation of the closed pattern looks a bit artificial: a more natural translation may seem to be $?P(j\uparrow \vee b\downarrow)$, but this violates the definition of our syntax: the operator↓ applies only to intoned terms, but b is a basic, non-intoned term.

3.2 Semantics

In this section, we define formal semantics for the language $\mathcal{L}_{\mathsf{DQI}}$ introduced in the previous section. We will take a dynamic perspective and represent the *meaning* of a sentence in $\mathcal{L}_{\mathsf{DQI}}$ as an operator on the space of *situations*, which will be two-dimensional objects keeping track of "possible enhancements" and "possibilities under attention".

Let D be a finite **domain**. A **world** w is a function which assigns to any predicate letter P_i a subset of the domain D. Fix a set $\mathcal{W}$ of worlds, and let $\mathcal{S} := \mathcal{P}(\mathcal{W}) \setminus \{\emptyset\}$ be the set of non-empty sets of worlds, which we will call **states**.

A **situation** is a pair $s = \langle Q, A\rangle$, where Q is a set of states which will represent the **possible enhancements**, i.e., the states which are currently still 'possible next steps' in the conversation, and A is a set of states which will keep track of the current **focus of attention**.

We first define, for any basic term t, what "the possibility that $P(t)$" is in our formal model. We denote this possibility by $[P(t)]$, and define it by induction on the complexity of the basic term t as the following state:

- If $t = c_j$, then let $[P(t)] := \{w \in \mathcal{W} : t \in w(P)\}$.
- If $t = r \vee s$ for some basic terms r, s, let $[P(t)] := [P(r)] \cup [P(s)]$.
- If $t = r \wedge s$ for some basic terms r, s, let $[P(t)] := [P(r)] \cap [P(s)]$.
- If $t = \neg s$ for some basic term s, let $[P(t)] := \mathcal{W} \setminus [P(s)]$.

We are now ready to define the meaning $[\![?P(i)]\!]$ of an arbitrary question. To model the underlying 'wh'-question, we first define the set of possible answers to $?P$ by

$$Q[\![?P]\!] := \{[P(t)] : t \text{ a basic term}\},$$

so that $Q[\![?P]\!]$ represents the set of all possible answers to the question "Who is coming?". We also put

$$A[\![?P]\!] := A,$$

since the question "Who is coming?" does not focus attention on any possible answer in particular.

Ideally, we want a compositional definition of updating with an intoned term i. However, the result of updating with i depends on the underlying question. Given that the underlying question is $?P$, we will be able to define the effect of updating with i as a function $[\![i]\!]_P$. We then put

$$\langle Q, A\rangle[\![?P(i)]\!] := \langle (Q[\![?P]\!])[\![i]\!]_P, (A[\![?P]\!])[\![i]\!]_P\rangle$$

to get the full update of Q and A with the question $?P(i)$.

So, it remains to define the result $[\![i]\!]_P$ of updating with an intoned term i inside a question starting with $?P$, by induction on the complexity of i, as follows:

- If $i = \emptyset$, simply put $Q[\![\emptyset]\!]_P = Q$ and $A[\![\emptyset]\!]_P = A$.
- If $i = t\uparrow$ for some basic term t, then we want to add the possibility that $P(t)$ to the attention set. So, we keep $Q[\![t\uparrow]\!]_P := Q$, but we put $A[\![t\uparrow]\!]_P := A \cup \{[P(t)]\}$.
- If $i = t\downarrow$ for some intoned term t, then we want to formalise the 'two-step order' of Exclusive Attention and Question Restriction. Step I is formalized by defining

  $$A[\![t\downarrow]\!]_P := \{u \cap \left(\bigcup_{v \in A[\![t]\!]_P, v \neq u} \mathcal{W} \setminus v \right) \mid u \in A[\![t]\!]_P\}.$$

  In informal terms, we take any state that is put under attention by the intoned term t, and intersect it with the negation of all other possibilities on which $?P(t)$ puts focus of attention. This precisely captures our intuition about 'Exclusive Attention'.

  Next, to formalise step II, we restrict the possible answers by putting

  $$Q[\![t\downarrow]\!]_P := A[\![t\downarrow]\!]_P.$$

- The possible answers and attention sets for other intoned terms are easy to define. The intuition here is that operators like 'not', 'and' and 'or' have no effect on the attention set. So we put

  $$A[\![\neg t]\!]_P := A[\![t]\!]_P,$$

  and

  $$A[\![t \vee s]\!]_P = (A[\![t]\!]_P)[\![s]\!]_P, \qquad Q[\![t \vee s]\!]_P = (Q[\![t]\!]_P)[\![s]\!]_P$$

The effect of updating with an answer $!P(i)$ is now easy to define. It is simply

$$\langle Q, A\rangle[\![!P(i)]\!] := \langle Q[\![i]\!]_P, A[\![i]\!]_P\rangle.$$

It remains to formalize the effects of the special answers "yes" and "no". Our intuition

about the answer "yes" is that it accepts the states which are under attention as the possible answers. In the case of "yes", the subsets of states which are left after such an update should become the new possible enhancements. Conversely, "no" rejects the states which are under attention, and all their subsets, as the possible answers. So we formalize this as follows:

$$\langle Q, A\rangle[\![!\top]\!] := \langle \bigcup_{a\in Q\cap A} \mathcal{P}(a), A\rangle,$$

$$\langle Q, A\rangle[\![!\bot]\!] := \langle Q \setminus \left(\bigcup_{a\in A} \mathcal{P}(a)\right), A\rangle.$$

3.3 Application to data

We now calculate the result of updating a situation with our three intonation patterns.

We will start with a domain which just contains two entities $\{\mathsf{John}, \mathsf{Bill}\}$, named by constants j and b, respectively, and one predicate letter P, with intended meaning 'is coming'. Let $\mathcal{W}$ be the set of all 4 possible worlds, each of which we will denote by 11, 10, 01 and 00 according to the extension of P in the world. Let s_0 be the initial situation, in which all states are possible answers, and no states are under attention, that is, $s_0 := \langle \mathcal{S}, \emptyset\rangle$.

We first calculate

$$Q[\![?P]\!] = \{[P(t)] : t \text{ basic term } \} = \mathcal{P}(\mathcal{W}).$$

This is as expected: the possible answers to "Who is coming?" are just the four possibilities represented by the four worlds.

- **Flat.** $?P((j \vee b)\uparrow)$
  - *Attention.* $A[\![?P((j \vee b)\uparrow)]\!] = \emptyset[\![(j \vee b)\uparrow]\!]_P = \{[P(j \vee b)]\}$.
  - *Possible enhancements.* $Q[\![?P]\!][\![(j \vee b)\uparrow]\!]_P = Q[\![?P]\!]$, since the intoned term $(j \vee b)\uparrow$ does not contain the operator $\downarrow$.
- **Open.** $?P(j\uparrow \vee b\uparrow)$
  - *Attention.* $A[\![?P(j\uparrow \vee b\uparrow)]\!] = \emptyset[\![j\uparrow \vee b\uparrow]\!]_P = (\emptyset[\![j\uparrow]\!]_P)[\![b\uparrow]\!]_P = \{[P(j)]\} \cup \{[P(b)]\} = \{[P(j)], [P(b)]\}$.
  - *Possible enhancements.* $Q[\![?P]\!][\![j\uparrow \vee b\uparrow]\!]_P = Q[\![?P]\!]$, again because the intoned term does not contain a downward intonation.
- **Closed.** $?P((j\uparrow \vee b\uparrow)\downarrow)$
  - *Attention.* Recall from the calculation for the Open pattern that $A[\![?P(j\uparrow \vee b\uparrow)]\!] = \{[P(j)], [P(b)]\}$. So

    $$A[\![?P]\!][\![(j\uparrow \vee b\uparrow)\downarrow]\!]_P = \{u \cap \left(\bigcup_{v\in\{[P(j)],[P(b)]\}, v\neq u} \mathcal{W} \setminus v\right) \mid u \in \{[P(j)], [P(b)]\}\}.$$

    This simplifies to $A[\![?P]\!][\![(j\uparrow \vee b\uparrow)\downarrow]\!]_P = \{[P(j)] \cap [P(\neg b)], [P(b)] \cap [P(\neg j)]\}$.

– *Possible enhancements.* $Q[\![?P]\!][\![(j\uparrow \vee b\uparrow)\downarrow]\!]_P = A[\![?P]\!][\![(j\uparrow \vee b\uparrow)\downarrow]\!]_P = \{[P(j)] \cap [P(\neg b)], [P(b)] \cap [P(\neg j)]\} = \{[P(j \wedge \neg b)], [P(b \wedge \neg j)]\}$.

To summarize, we get the following table of results.

	Possible enhancements	Attention
Flat	'Who?'	$j \vee b$
Open	'Who?'	j, b
Closed	$j \wedge \neg b$, $b \wedge \neg j$	$j \wedge \neg b$, $b \wedge \neg j$.

We will now derive some of the observed differences between the intonation patterns from this formalisation.

3.3.1 Denial and affirmation

Let us write s_F, s_O and s_C for the updates of the empty situation with the Flat, Open and Closed disjunctive question, respectively. We now examine the effect of updating with 'yes' and 'no' in each case.

- $s_F[\![!\top]\!] = \langle \mathcal{P}(Q_F \cap A_F), A_F\rangle = \langle \mathcal{P}([P(j \vee b)]), \{[P(j \vee b)\}\rangle$.
  $s_F[\![!\bot]\!] = \langle Q_F \setminus \bigcup_{a \in A_F} \mathcal{P}(a), A_F\rangle = \langle \mathcal{P}(\mathcal{W}) \setminus \mathcal{P}([P(j \vee b)]), \{[P(j \vee b)]\}\rangle$.
- $s_O[\![!\top]\!] = \langle \mathcal{P}([P(j)]) \cup \mathcal{P}([P(b)]), \{[P(j)], [P(b)]\}\rangle$.
  $s_O[\![!\bot]\!] = \langle \mathcal{P}(\mathcal{W}) \setminus (\mathcal{P}([P(j)]) \cup \mathcal{P}([P(b)])), \{[P(j)], [P(b)]\}\rangle$.
- $s_C[\![!\top]\!] = \langle \{[P(j \wedge \neg b)], [P(b \wedge \neg j)]\}, \{[P(j \wedge \neg b)], [P(b \wedge \neg j)]\}\rangle$.
  $s_C[\![!\bot]\!] = \langle \emptyset, \{[P(j \wedge \neg b)], [P(b \wedge \neg j)]\}\rangle$.

Note in particular that updating with 'yes' ($!\top$) in the Closed pattern has no effect whatsoever, whereas updating with 'no' ($!\bot$) leaves no possible answers. This corresponds to the observation that the Closed pattern does not allow for 'yes'/'no' as an answer.

In the case of the Flat pattern, the 'yes' or 'no' answer gives full information about the states which are under attention: after 'yes', only states containing more information than the state under attention are left as a possible answer, and after 'no', all states in which the state under attention was true have been removed from the possible answers.

For the Open pattern, a similar thing happens. After the answer 'no', all the possibilities under attention are eliminated, so this answer gives full information about the states under attention. However, after the answer 'yes', there are still two states which are both under attention and a possible answer, which may explain why we observed that the Open pattern only *weakly* allows for affirmation.

3.3.2 Existence and Uniqueness, Domain Restriction

The observation that the Closed pattern has Existence and Uniqueness effects is a direct consequence from our analysis and formalisation of the downward intonation operator. The idea is that downward intonation 'causes' Existence and Uniqueness effects, which corresponds to the fact that both the downward intonation and these effects are absent in the case of the Flat and Open intonation patterns.

The effect of Domain Restriction is reflected in our model in two ways: by the 'size' of the possible answer set and by the 'size' of the attention set. If we interpret the states in the attention set as the 'interesting' possibilities, and the states in the possible answer set as the 'permitted' possibilities, then we can see the Strong Domain Restriction effect for the Closed pattern as a consequence of the fact that the set of possible answers is restricted to the disjuncts which are mentioned. For the Open pattern, the possible answer set remains the same as for the underlying 'who'-question, but the attention set is restricted, resulting in the Weak Domain Restriction effect that we observed above.

3.3.3 Epistemic Coherence

The epistemic coherence effects that we observed can be given a pragmatic explanation, as is done by Ciardelli, Groenendijk and Roelofsen in "Might and Free Choice in Inquisitive Semantics" for disjunctive assertions. In that paper, they propose the following principle:

(25) If a cooperative speaker draws attention to a certain possibility without affirming or denying it, then she does not have sufficient information to do so.

As we have seen above, each of the intonation patterns draws attention to certain possibilities without affirming or denying it. We conclude from the principle (25) that, for example, a speaker who uses the closed pattern does not know the truth of any of the propositions "John is coming", "Bill is coming", "John is not coming" and "Bill is not coming". This argument explains the *ignorance* implications of Flat, Open and Closed intonation patterns.

The *knowledge* implications of the Closed pattern can be explained by the fact that using the Closed pattern *implies* existence and domain uniqueness, as we have seen above. Therefore, when one uses the Closed pattern, ignorance about existence or uniqueness can not be allowed to exist.

4 Conclusion

The goal of this paper was to describe, analyze and formalize the different intonation patterns of a disjunctive question with two disjuncts. We first isolated implications and properties of the different intonation patterns, and then gave a formal compositional analysis DQI ('Disjunctive Questions with Intonation'), incorporating *focus of attention* in the formalisation.

We relied heavily on the formal methods of 'inquisitive possibility semantics', but there are differences, the most important difference being that DQI is not propositional. Rather, it is an attempt at a first-order version of possibility semantics.

Another important feature of DQI is that it distinguishes, already at the syntactic level, between 'basic terms' and 'intoned terms'. In particular, the fact that an upward intonation always takes scope over a *basic term* is a direct reflection of our underlying idea that the main purpose of intonation is to mark the *separation* of elements of a list. We hope that part of our work may be relevant for studying other natural language phenomena as

well, rather than only disjunctive questions. In particular, we wonder about the following questions, left unanswered in this paper:

- Can our analysis be applied to lists in general, in which we allow both 'or' and 'and' as connectives?
- Is our analysis essentially about questions, or can a more general theory of assertions, or maybe also 'might'-sentences be extracted?

To put it more concisely, we wonder how essential the 'D' and 'Q' in DQI are.

Regarding the second point, we point to footnote 1 (page 1), in which we noted that some Romance languages do not distinguish as clearly between questions and assertions by means of word order as the English and Dutch language, possibly because Romance languages already use word order to mark topic and focus positions.

In this respect, one could regard DQI as an extreme version of a Romance language, since it actually deems the closed question and closed assertion semantically equivalent. Of course, this is a problematic feature: a clear difference in natural language between the closed question and closed assertion is apparent from the following simple examples.

(26) a. John↑ or Bill↓ is coming.
b. Oh! I didn't know that.

(27) a. Is John↑ or Bill↓ coming?
b. † Oh! I didn't know that.

Despite the fact that (26-a) and (27-a) come out semantically equivalent in DQI, there is an implicit difference: the *lists* of updates of the translations of (26-a) and (27-a) differ. One could therefore imagine a useful modification of DQI in which the meaning of a sentence is not modelled as being just the *end-result* of updating with the operators defined above, but rather as the *list* of consecutive updates with the translations of the several constituents of the sentence. In such a system, the translations of (26-a) and (27-a) would not come out equivalent anymore, since the meaning of (27-a) would then contain the underlying 'who'-question, while the meaning of (26-a) would lack this underlying question.

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