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Contrast and Implication in Natural Language

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Abstract

In this paper we introduce a theoretical framework and a logical application for analyzing the semantics and pragmatics of contrastive conjunctions in natural language. It is shown how expressions like *although, nevertheless, yet* and *but* are semantically definable as connectives using an operator for implication in natural language and how similar pragmatic principles affect the behaviour of both contrastive conjunctions and indicative conditionals. Following previous proposals, conditions on contrast in a conjunction are analyzed as presuppositions of the conjunction. Further linguistic evidence leads to a distinction between restrictive and non-restrictive connectives of contrast, and consequently between direct and indirect contrast, which are given a precise definition.

A general interface for a theory of contrast using possible world semantics for implication is then presented. As a test case, we show how this interface is applicable to the semantics for conditionals that was introduced by Veltman in his article "Data Semantics and the Pragmatics of Indicative Conditionals" (1986). This application yields an extension of Veltman's Data Logic, called Contrastive Data Logic. Once appropriate modifications are added to Veltman's pragmatic considerations, we show that contrastive data logic provides an adequate tool for the analysis of substantial linguistic data concerning contrast and implication in natural language.

1 Introduction

Natural languages support their speakers with many ways of expressing contrast between elements in a sentence or in a discourse. Particles like (*al*)*though, but, yet, nevertheless* are some of the common expressions in English used for this purpose. Still, a formal semantic theory may find the notion of 'contrast' quite obscure. The difficulty was wonderfully expressed by Frege in "On Sense and Reference":

> "Subsidiary clauses beginning with '*although*' also express complete thoughts. This conjunction actually has no sense and does not change the sense of the clause but only illuminates it in peculiar fashion (similarly in the case of '*but*','*yet*'). We could indeed replace the concessive clause without harm to the truth of the whole by another of the same truth value; but the light in which the clause is placed by the conjunction might then easily appear unsuitable, as if a song with a sad subject were to be sung in a lively fashion."
>
> (Frege, G., "On Sense and Reference", Geach and Black(eds.)(1970), pp. 73–74)

Here we would like to maintain that what was called by Frege "the light in which the clause is placed by the conjunction" can be explained using less mysterious terms from contemporary semantic and pragmatic theories. Sharing linguistic intuitions with some previous works, especially Anscombre & Ducrot(1977) and Lang(1984), we try to establish a logical framework that captures these intuitions. Essentially, we claim that the restrictions on contrastive conjunctions and the information they convey can be formulated as presuppositions of the conjunction. These presuppositions are stated using a schema that assumes a definition for the relation of implication between sentences/utterances in the language. Therefore, what we first propose is a reduction of the problem of contrast in natural language into the much more investigated problem of implication, a manifold puzzle that was discussed in the large literature on indicative conditionals, counterfactuals and pragmatic implicatures. Then, our next step is to restrict this reduction– to find and to spell out general meaning (/use) postulates for the connectives of contrast and the implication operator they involve. The postulates are stated using the possibility and necessity operators of modal logic. The presuppositions for contrast together with these restrictions constitute what we call an "*interface*" to a formal theory of implication in possible world semantics. An interesting version of such a theory was presented by Veltman in his article "Data Semantics and the Pragmatics of Indicative Conditionals" (Veltman(1986)). We use the proposed interface to incorporate the connectives of contrast into Veltman's Data Logic and prove the extended semantics for *Contrastive Data Logic* (CDL) to satisfy the restrictions of the interface, hence also the basic linguistic motivations.

Many theories for implication in natural language are sensitive to the well-known "paradoxes" of implication: the counter-intuitive inferences that establish the truth of a conditional from the falsehood of the antecedent or truth of the consequent. We show how similar "paradoxes" of contrast are entailed by these problems. To account for such counter-intuitive results on implication in Data Logic Veltman uses a principle of "*pragmatic unsoundness*". We add a principle of "*pragmatic insufficiency*", that together with more specific pragmatic assumptions deals properly with the "paradoxes" of contrast, as well as other interactions in natural language between conditionals and modalities or contrastive elements. Some examples for this application of CDL are analyzed.

The paper is organized as follows: Section 2 brings the essential linguistic data and presents a general intuitive definition for the presuppositions for contrast in a conjunction. In section 3 we formalize these intuitive ideas and establish the restrictions in an interface to a theory of implication, based on some more involved linguistic evidence. The "paradoxes" of contrast and their connection to the "paradoxes" of implication are presented and analyzed. In section 4, CDL, the application of the semantic interface to Data Logic is presented, and the required features in the interface are proved. Section 5 includes the proposed generalization to Veltman's pragmatic framework. It is shown how the pragmatic principles are applied to handle the "paradoxes" of contrast and further linguistic evidence on the use of contrastive conjunctions in natural language.

2 Linguistic evidence and some primary motivations

Let the notation **CON²** stand for the class of the **CON**nectives of **CON**trast, which consists at least of the following members: *but, nevertheless, yet, although, though, even though*. If we try to follow Frege's line of thought in the above quotation, then the truth conditions of a contrastive conjunction p *con* q [1] are identical to those of the parallel conjunction p *and* q . One part of this identity is certainly true– by no doubt sentences like (1a) logically entail their *and* counterpart (1b):

(1) a. I love Venice *but* I would *not* like to be there again.
b. I love Venice *and* I would *not* like to be there again.

Then we come to the question of whether boolean conjunction is the only truth conditional content of the **CON²** members. For instance- what is the problem in (1c), by contrast to the acceptable (1d):

(1) c. **?** I love Venice *but* I would like to be there again.
d. I love Venice *and* I would like to be there again.

It seems plausible to claim that examples like (1c) cannot be considered a case where some truth condition of the sentence is false, at least not in the traditional definition for truth conditions. This claim is the essence of Frege's remark and conclusions in the same spirit were drawn later in Grice(1961:pp.127-9), Kempson(1975:p.57), Wilson(1975:pp.118-20) and Gazdar(1979:p.38), to name just a few. There are some convincing arguments to support such a conclusion. Here are two of them:

1. The sentence (1c) and similar "odd" contrastive conjunctions can become highly acceptable in a specific "strange" context like:

(2) You know, I always hated to visit again cities that I love. Not in the case of Venice: *I love it but I would like to be there again.*

It is hard to see how the change in the context in (2) could affect the truth value of a statement that the *but* sentence conveys.

2. Negation of (1c) does not ameliorate it (to say the least), as would have been expected if it was to be considered as representing a false statement. For example:

(3) **?** It is not true that [I love Venice *but* I would like to be there again].

Similarly, acceptable *but* sentences like (1a) cannot be negated in order to indicate that the *but* connective is misplaced and only an *and* conjunction is true, as would have been expected if a *but* conjunction was to be analyzed as logically stronger than the parallel *and* conjunction. For example:

(4) It is not true that [I love Venice *but* I wouldn't like to be there again]. **?** Actually, I like it and I hate to visit again cities that I like.

Similar observations hold with other members of CON^2. [2]

A conclusion in the lines of Frege's remark seems then to be most plausible:

The truth conditions of any contrastive conjunction p *con* q are exactly the same as those of p *and* q.

If instead of a truth conditional analysis we consider utterances like (1c) to be a case of *presupposition failure* then (2) and (3) can be explained using two known features of presuppositions: one by their context dependency, the other by their preservation under negation (cf. Gazdar(1979: chapter 5), for example, for a discussion of these issues and bibliography). Following Gazdar, we refer to utterances like (1c) as *infelicitous*.

Some researchers consider the non-truth functional part of the meaning of *but* as a *conventional implicature* of the conjunction. This view is brought in Grice(1961:p.129) [3] and more explicitly in Gazdar(1979:p.38). Given the range of examples in the literature for conventional implicatures and presuppositions, it seems that the phenomenon at stack is more close to what was classified as conventional implicature. However, as we share with Karttunen and Peters(1979) the view that there is much overlapping between the phenomena classified using these two terms, we henceforth use only the term *presupposition* in referring to the non-truth-functional part of meaning which is in focus.

The question is then *what* are the presuppositions for contrast which are induced by the members of CON^2. An attempt to answer this question could be started by considering first some simple examples:

(5) a. **?** ^{a}[It was cloudy], *yet* ^{b}[it was raining.]
b. ^{a}[It was cloudy], *yet* $^{not(b)}$[it was *not* raining.]
c. **?** ^{b}[It was raining] *although* ^{a}[it was cloudy.]
d. $^{not(b)}$[It was *not* raining] *although* ^{b}[it was cloudy.]

Reasonably, a rough formulation of the contrastive presupposition of a sentence in the form p *yet* q or q *although* p can be stated simply as:

(A) p implies *not*(q)

In (5a), p (= a= "it was cloudy") does not imply *not*(q) (= *not*(b) = "it was *not* raining"), so (A) does not hold and therefore the sentence is infelicitous. In (5b) p does imply *not*(q) (= b = "it *was* raining") and the sentence is felicitous. The same is with respect to (5c) and (5d).

At this stage we are still not trying to explain what exactly do we mean in the relation "imply" between two sentences. The reader can think of this relation for the moment as something akin to "default" implication (as in an indicative conditional, e.g. "Normally, if it's cloudy then it rains."). The recognized advantage of this vague notion is its intuitive appeal to speakers, and thus it may help us when trying to outline the informal presupposition schemata for members of CON[2]. Later, when we use these schemata within a formal framework, the elusive nature of the notion "implication" will become our main concern.

Clearly, (A) is too strong to account for certain other examples of contrastive conjunctions. For example:

(6) a. ^{p}[We were hungry] *but* ^{q}[the restaurants were closed.]
    b. **?** ^{p}[We were hungry] *yet* ^{q}[the restaurants were closed.]
    c. **?** ^{q}[The restaurants were closed] *although* ^{p}[we were hungry.]

In a "standard" context for (6a-c) p does not imply *not*(q), and as predicted by (A), (6b) and (6c) are indeed infelicitous. [4]The *but* conjunction in (6a), however, is still felicitous.

Another example for this difference between *but* and other connectives of contrast is:

(7) a. It is raining *but* I took an umbrella. (Therefore, I won't get wet).
    b. **?** It is raining; *nevertheless*, I took an umbrella. (Therefore, I won't get wet).
    c. **?** I took an umbrella *even though* it is raining. (Therefore, I won't get wet).

Once again, (A) is too strong for a *but* sentence like (7a) while it does predict the infelicity of (7b) and (7c). Also, the way it accounts for their infelicity is very intuitive; for instance- an expected reaction from a hearer of a sentence like (7b) or (7c) is: "What, for heaven's sake, is so special in taking an umbrella when it rains outside ?".

In the same way condition (A) also explains why when one of the conjuncts is negated in (7b) or (7c) the sentence becomes highly acceptable:

(7) d. It is *not* raining; *nevertheless*, I took an umbrella.
    e. It is raining; *nevertheless*, I did *not* take an umbrella.

Sentences as in (6) and (7) show that the case of *but* is different from those of *yet, although, nevertheless, even though* and other connectives of contrast. While the later require, as (A) claims, a direct relation between the conjuncts, in the former only some kind of an indirect relation between the conjuncts may be sufficient for coherence. In our proposed formalization for this "indirect contrast" we follow (independently) ideas of Lang in his discussion of German *aber* (see Lang(1984:pp.169-175)) and Anscombre & Ducrot in their account for the French *mais* (see Anscombre and Ducrot(1977), Ducrot et. al.(1980:pp.93-130)). [5]

The basic idea is this: for a contrastive conjunction p *con* q to be felicitous in a given context there should be some statement which p implies and q denies. Let us use the notation r to represent the negation of such a statement. The statement p then implies *not*(r) and q implies r (q denies *not*(r)). The statement r is an overall implication of the whole contrastive sentence. Consider for example (6a): a possible r is *"we didn't eat"*, as p (= "we wanted to eat") can imply "we ate" (= *not*(r)) and q (= "the restaurants were closed") implies "we didn't eat" (r).

Similarly, in sentence (7a) a possible r can be "*I will not get wet*". The conjunct p (rain) implies the possibility of getting wet (*not*(r)). The conjunct q (umbrella) implies r, the negation of this possibility.

The intention of a speaker in uttering any CON² sentence is always to make an argument in favour of a certain r. In the case of *yet*, *although* and most other members of CON², r should be expressed explicitly as the conjunct q. In the case of *but*, r can also be introduced implicitly, using the context of utterance, as in (6a) and (7a). A general condition, presupposed for all the CON² sentences is therefore:

There exists a statement r s.t. in the context of utterance:

(**C1**) p implies *not*(r) and q implies r.

For a large sub-class of CON² (including *nevertheless, although*, etc.) (**C1**) should be restricted as follows:

(**C1**)[restricted] r = q

Condition (**C1**)[restricted] is exactly (A), since under any sense we can use "imply", it is certainly a reflexive relation, and then the requirement "q implies r" in (**C1**) is trivially satisfied when r= q.

In general, (**C1**) by no way requires that r is unique. A *but* utterance may be vague with respect to the r that is intended to be implied. For example: both following inferences in (8) are felicitous:

(8) a. We were hungry *but* the restaurants were closed. *Therefore,* r[we didn't eat.]
b. We were hungry *but* the restaurants were closed. *Therefore,* r[we didn't eat in a restaurant.]

The "*therefore*" context is a crucial test to distinguish between a possible r and an impossible one. For example:

(9) a. John is tall *but* he is clumsy. *Therefore,* r[he is a lousy basketball player.]
b. John is tall *but* he is clumsy. **?** *Therefore,* *not*(r)[he is a good basketball player.]

The "*therefore*" contexts in (9) are interesting also from another respect. We see here that as we claimed, r, which is implied by q, is an acceptable conclusion from the whole *but* conjunction. On the other hand, *not*(r) is implied by p, and both p and q are true, so what is the principle that allows r as a conclusion from p *but* q and does not allow r's negation ? We must conclude, as Anscombre and Ducrot observe too, that in some sense the implication "q implies r" is "stronger" than the implication "p implies *not*(r)" and an application of a principle like Modus Ponens is allowed only for the "stronger" implication. Another way to look at this fact is to say that q *denies not*(r) or that application of Modus Ponens to the second implication *cancels* conclusions obtained by Modus Ponens applied to the first implication. Whatever notion we choose, "strength" (of implications) or "cancellation" (of conclusions) should be explained formally. For the meantime, let us only state this as another informal condition on CON² sentences:

(**C2**) q's implication of r is "stronger" than / "cancels" p's implication of *not*(r).

Note that (**C2**) should be trivially satisfied when (**C1**)[restricted] holds, since it should be guaranteed that the logical entailment between q and itself is a "stronger" implication than p's implication of *not*(q). Evidently, p cannot logically entail *not*(q), to avoid a contradiction caused by the truth condition p *and* q.

(**C2**) can easily account for the strong asymmetries in the romantic implications between (10a) and (10b)[6]:

(10) a. There are many girls around *but* YOU are special.
b. You ARE special *but* there are many girls around.

and for similar asymmetries in the more prosaic (11a-d):

(11) a. It was cloudy *but* it did not rain. So we went for a walk.
b. It was cloudy *but* it did not rain. **?** So we did not go for a walk.
c. It did not rain *but* it was cloudy. **?** So we went for a walk.
d. It did not rain *but* it was cloudy. So we did not go for a walk.

One interesting feature of the correlating r, and another evidence for its significance in contrastive conjunctions is that even in *but* conjunctions, where it can be distinct from q, it should obey general principles of discourse. Consider for example the following fragments of discourse:

(12) a. A: Why did you take John and not Bill to your basketball team ?
(1) B: Bill is very quick *but* John is taller than him.
(2) B: John is a better player than Bill.
b. A: Why did you take Bill and not John ?
(1) B: **?** Bill is very quick *but* John is taller than him.
(2) B: **?** John is a better player than Bill.
(3) B: John is taller than Bill *but* Bill is very quick.

In (12b)(1) the *but* sentence is incoherent, since any possible r like "John is a better player than Bill" is irrelevant/uninformative to the conversation, as observed in (12b)(2). In (12a), by contrast, the relevance of this r, which is evident from the coherence of (12a)(2), makes the same *but* sentence (12a)(1) coherent. The incoherence of (12b)(1) does not have to do with the relevance of the conjuncts themselves, because (12b)(3), the linear inversion of the conjuncts, is completely coherent.

Such facts on "relevance" to discourse are not, evidently, special to contrastive conjunctions, and therefore any theory of discourse that may explain what is "to be relevant", "to be informative" etc., should handle these examples, to guarantee that r is "relevant" and "informative" in the conversation. It is not, we conclude, something that should be stated in the presuppositions of contrastive conjunctions. We will get back to this point when we discuss "paradoxes" of implication and contrast in sub-section 3.3.

An interesting fact about conjunctions, which is somewhat surprising with respect to contrastive conjunctions, is that the mood of the conjuncts should not be the indicative and furthermore- each conjunct may be of a different mood or illocutionary force. Here are some examples:

(13) Take a chair, *but* don't sit.

(14) *Although* I won't be able to stay for very long, I promise you to come.

(15) Thanks for the ride, *yet* don't expect me to pay for it.

(16) You're the biggest idiot I've ever met, *but* don't be offended.

(17) John is here *but* why isn't Bill here too ?

In this paper we discuss only conjunctions where both conjuncts are in the indicative mood.

The conjunction *but* deserves special attention because of its diverse features and broad circumstances of use. First, it is important to notice that throughout this work we discuss only one of the uses of the morpheme *but* in English, the *contrastive* (concessive/adversative) use as in:

(18) John did not waste his money *but* he bought three books on the history of Lapland.

Here the books are implicated to be a waste of money, in contrast to the statement in the first conjunct.

A second use of *but* is for *rectification*(/correction):

(19) He is not intelligent, *but* just a grind.

(20) John did not waste his money *but* bought three books on the history of Lapland.

Sentence (20), opposed to (18), implies that the books that John bought were not a waste of money (rectification of the predicate in the first conjunct).

There are also some evident syntactic differences between these two uses of *but*. To name just two of them: the gapping effects in conjunctions with *but* for rectification, and the requirement that the first conjunct includes an overt negation in such constructions. In some languages such as Spanish, German and Hebrew these two uses of *but* involve distinct lexical entries: *pero*/*sino*, *aber*/*sondern*, *aval*/*ela*, respectively. This distinction is discussed extensively in previous works including: Tobler(1896), Melander(1916), Abraham(1977), Anscombre and Ducrot(1977), Dascal and Katriel(1977), Horn(1985) and Horn(1989:pp.402-413), which contains a detailed bibliographic survey.

Yet another use for *but* is in *exceptive* constructions. For example:

(21) Everyone *but* John came to the party.

For a semantic analysis of exceptive constructions see Hoeksema(1991) and von Fintel(1991) and their detailed bibliographic remarks. For a syntactic account see Reinhart(1991).

These facts may suggest that the morpheme *but* in English is at least three-way lexically ambiguous. However, there are some strong relations between these three senses of *but*, which suggest that the last word on this issue has not yet been given. [7]

Some writers (e.g. R. Lakoff(1971), Blakemore(1989)) have maintained that there are even two distinct senses for the use of *but* we labeled as *contrastive*[8]. The distinction made is between using *but* for "semantic opposition" and *but* as marking "denial of expectation". The two alleged senses can be exemplified by the following sentences, slight variations of examples from Lang(1984):

(22) John is quick *but* Bill is slow.

(23) John is quick *but* he is no good at football.

While (22) was described as a "semantic opposition" use of *but*, which does not require any kind of world knowledge or contextual factors, (23) was considered as involving some further knowledge for modeling the "denial of expectation" in the second conjunct. We share with Lang the opinion that this distinction is theoretically problematic and not fully motivated by empirical data. For example: (22) might become infelicitous in cases where we are looking for a couple of persons, one quick and the other slow, and the sentence is given as an argument for John and Bill as an appropriate couple. It becomes hard to explain such facts with a theory that considers *but* ambiguous between "contrast" and "denial", since it has to be assumed then that the "contrastive" meaning of the connective disappears somehow in a situation like the above. Instead, we tend to prefer, with Lang, a theory that assigns *but* the same interpretation in all situations. Taking such a position, we have to show that sentences like (22) satisfy (**C1**) and (**C2**) in "normal" contexts. For example, if someone indicates that all the players in a team are quick, (22) can be used to deny this indication, provided that John and Bill are in the team. (**C1**) and (**C2**) are then satisfied with r= "not all the players in the team are quick". Thus, there are good reasons to stick to the null hypothesis (pace R. Lakoff and Blakemore) that no ambiguity whatsoever is to be attributed to the contrastive *but*. [9]

An interesting discussion of the French connective *mais*, with which we share many linguistic intuitions (but not methodological assumptions or descriptive tools) appears in Anscombre and Ducrot(1977). A&D discuss *mais* within their framework of *argumentative scales* (echèlles argumentatives). As defined in Ducrot(1980:pp.15-18), two sentences p_1 and p_2 are placed by the speaker in the same argumentative scale if there is a third sentence r for which he/she considers p_1 and p_2 as arguments. p_1 is said to be argumentatively superior to p_2 with respect to r if accepting r as a conclusion from p_2 implies that r is accepted as a conclusion from p_1, but not the opposite. For A&D, an utterance of a sentence p *mais* q is possible if p and q are on "opposite" argumentative scales, where p is an argument in favour of r and q is an argument in favour of r's negation.

Clearly, our analysis of *but* is on the same lines of A&D. Our main objection to A&D's proposal is a conceptual one: it seems that argumentation in natural language is a name for a linguistic phenomenon and A&D's framework is more like a detailed and careful description of this phenomenon. To say that a sentence like "she is tall" is an argument in favour of the sentence "she is a good basketball player" is simply to restate the intuitions based on our world knowledge. It is not an explanatory model of the facts. In A&D's works it is assumed that argumentative scales exist but nothing in their discussion predicts which sentences are arguments in favour of which sentences in which contexts. Consequently, A&D's framework is rather informal.

What we try to do in the following sections is to use the linguistic intuitions (on which we agree with A&D in most cases) in order to provide a formal account of the informal notions "implication" and "strength of implication" in (**C1**) and (**C2**). We will try to show that there are strong relations between the kind of implication that exists in indicative conditionals and the implication operator that is needed to model contrast. In general, it is assumed that A&D's description of argumentative scales should be predicted by comprehensive semantic and pragmatic theories of contrast and implication in natural language.

Before going on, we may summarize the main ideas of this section. The class of connectives of contrast can be divided into two sub-classes- *restrictive* and *non-restrictive*. Some examples follow (non-exhaustive):

1. Restrictive:
   (a) *yet, nevertheless* – conjunctions denoted p *con* q .
   (b) *although*, (*even*) *though* – conjunctions denoted q *con* p .
2. Non-Restrictive: *but* – conjunctions denoted p *con* q .

A presupposition for CON² conjunctions guarantees a relation of *contrast* between p and q:

There exists a statement r s.t. in the context of utterance:

(**C1**) p implies *not*(r) and q implies r.

(**C2**) q's implication of r is "stronger" than / "cancels" p's implication of *not*(r).

For the restrictive sub-class of CON², *direct contrast* must exist between the conjuncts. Direct contrast is established when conditions (**C1**) and (**C2**) hold with an r that is logically equivalent to q. Under this restriction (**C1**) and (**C2**) should boil down to:

(**C1**)[restricted] p implies *not*(q)

A relation of contrast which is not direct is called *indirect contrast*. The non-restrictive members of CON² allow also indirect contrast between the conjuncts. In English, the most typical representative for the non-restrictive subclass of CON² is the connective *but* [10], when it is used in a sentential contrastive conjunction[11].

These are the key notions which we are going to need in order to provide a formal theory of contrast in natural language.

3 An interface to a theory of implication

In this section we introduce our first step in the formalization of the intuitive discussion of the previous section. The following steps are made in sections 4 and 5. As may be concluded from the discussion in section 2, the operator of implication we use should certainly be distinct from logical entailment (as it is cancellable and context depended) and still identifies neither with conversational implicature (as it emerges from the use of a specific contrastive connective) nor with conventional implicature (as each conjunct by itself does not conventionally implicates r or it's negation). It is closer to "default implication" as in a conditional like "*Normally, if ... then ...*", or to Anscombre and Ducrot's notion of argumentative scales.

As we see it, in order to be more useful, a formalization of a theory for phenomena as complex as contrast and implication should start by spelling out the restrictions on a formal system that is to be used as a model for the linguistic facts. Therefore, in this section we still do not present a complete definition for the relation "implies" between two sentences. Instead, we propose an "interface" for a theory of the semantics and pragmatics of implication within possible world semantics. This interface consists of the following parts:

1. Semantic definitions for the connectives of contrast in terms of the modal operators and the operators of implication and presupposition.

2. Restrictions on the operator of implication that emerge from its usage in the description of linguistic contrast.

3. Pragmatic requirements, especially due to the relations we find between the pragmatics of contrast and pragmatic accounts for the "paradoxes" of implication.

In sections 4 and 5 we present a specific implementation of this interface using Veltman's Data Logic, which is to exemplify one possible formal theory of contrast and implication.

3.1 Restatement of (C1) and (C2) in possible world semantics

Conditions (**C1**) and (**C2**) are an informal intuitive way to account for the restrictions on contrastive conjunctions. The possibility to state these conditions in completely formal terms depends on a full theory for two major notions in semantics and pragmatics: implication and presupposition. Suppose, for the sake of the discussion in this section, that we indeed have such a full unified theory. We use the notations $x \rightarrow y$ to stand for "x implies y" and *pres*(x) = y for "x presupposes y" without giving them a complete definition in this section (as explained in the introductory remarks above). The connectives *but* and *nevertheless* (abbreviated as *nvs*) are used as representatives for the non-restrictive and restrictive subclasses of **CON**[2], respectively.

How then could (**C1**) and (**C2**) be used to incorporate the two connectives *but* and *nvs* into such a theory, and what are the linguistic predictions of such an incorporation ?

The first question that comes to mind is with respect to the meaning of (**C2**): what is for *not*(r) to be "weakly implied" from p ? "Weak" semantic implication is something that has been extensively discussed in many works of formal semantics. Two major trends to analyze the problem in this respect are:

1. *Non-monotonic reasoning:* If $\rightarrow$ is understood as a non-monotonic operator then a weak implication is simply an implication that can be canceled. A sentence p *con* q, therefore, can be analyzed as a containing two implications: $p \rightarrow \neg r$ and $q \rightarrow r$, where some general "contrast" principle should *cancel* the first implication (or, alternatively, disallow any application of Modus Ponens to this implication).

2. *Possible world semantics:* A weak implication is an implication in another possible world: x weakly implies y in a world w iff $x \rightarrow y$ in some world w' accessible to w.

In what follows we investigate only the second option. There is of course a lot to say also on the first one. We do not attempt to do it in this paper.

We are talking then possible worlds. Let us use the notations $\Diamond$ and $\Box$ as the possibility and necessity operators, $\wedge, \vee, \neg$ as usual, and $\Rightarrow$ as logical entailment (in terms of truth conditions). From (**C1**) and (**C2**) we can draw the following definition:

($\mathbf{D}_1$) **The contrast relation:** A proposition r *establishes contrast* between two (ordered) propositions p and q iff $\Diamond(p \rightarrow \neg r) \wedge (q \rightarrow r)$ is true. This relation is denoted by $\Theta_r(p,q)$.

Definition ($\mathbf{D}_1$) introduces the notion of contrast in terms of the implication connective and the modal operator $\Diamond$. We will not pay much attention to the "kind" of world where the weak implication is realized. For instance, in (5b) this world can be called "standard", in (6), "expected". We maintain that such typology of possible worlds is linguistically meaningful only with a theory of how certain expressions (*to want*, *to expect*, etc.) affect the accessibility relations of the "actual" world. We do not wish to impose this problem on the other major problems with respect to CON². Therefore we only use the possibility operator $\Diamond$ with no specification of the type of possible worlds quantified over.

Definition ($\mathbf{D}_1$) can now be applied to derive from (**C1**) and (**C2**) the definitions of the truth conditions and the presuppositions of contrastive conjunctions [12].

($\mathbf{D}_2$) p *but* q $\Leftrightarrow$ $p \wedge q$
pres(p *but* q) = exists r s.t. $\Theta_r(p,q)$

($\mathbf{D}_3$) p *nvs* q $\Leftrightarrow$ $p \wedge q$
pres(p *nvs* q) = $\Theta_q(p,q)$

How are these definitions interpreted in a certain semantics depends on the exact definitions for the notations used (*pres*, $\rightarrow$, $\Diamond$). Obviously, in proposing an "interface" one should take into account the restrictions on the interpretation of these notions that stem from linguistic evidence. Such restrictions should guarantee that any proposed semantics that uses this interface is adequate to linguistic data and not just a sterile formal machinery.

We therefore turn now to show some motivations or meaning postulates ("**M**'s") that the above definitions for the truth conditions and presuppositions of *but* and *nvs* conjunctions should satisfy within any specific proposed semantic structure.

3.2 Semantic restrictions on the interpretation of ($\mathbf{D}_1$) -($\mathbf{D}_3$)

The first restriction is quite abstract: in order to guarantee that the intuition in (**C2**) is satisfied we must make sure that whenever the truth condition $p \wedge q$ and the presupposition $\Theta_r(p,q)$ of a contrastive conjunction are satisfied, $\neg r$ is only a weak implication of p, and not (accidentally) a strong one:

($\mathbf{M}_1$) $\Theta_r(p,q) \wedge p \wedge q \Rightarrow \neg(p \rightarrow \neg r)$ (if r establishes contrast between true p and q then p does not imply $\neg r$)

This should follow trivially from definitions if $\rightarrow$ satisfies Modus Ponens.

A second more concrete M is based on the linguistic fact that any *restrictive* member of CON² (represented by *nvs*) can always be replaced by a non-restrictive *but*, while the opposite is not necessarily true (witness (6) and (7)):

($\mathbf{M}_2$) $pres(\mathsf{p}\ nvs\ \mathsf{q}) \Rightarrow pres(\mathsf{p}\ but\ \mathsf{q})$ (the presupposition for direct contrast between p and q entails the presupposition for indirect contrast)

$pres(\mathsf{p}\ but\ \mathsf{q}) \not\Rightarrow pres(\mathsf{p}\ nvs\ \mathsf{q})$ (the converse is not necessarily true)

The first entailment is of course immediate by definition, the second is not. Restriction ($\mathbf{M}_1$) together with ($\mathbf{M}_2$) guarantee that the intuition spelled out in (**C2**) is satisfied by both ($\mathbf{D}_2$) and ($\mathbf{D}_3$): ($\mathbf{M}_1$) entails that definition ($\mathbf{D}_2$) satisfies (**C2**) and ($\mathbf{M}_2$) claims that ($\mathbf{D}_3$) is stronger than ($\mathbf{D}_2$) .

The next M is on the interactions between the connectives of contrast and the possibility and necessity operators. Consider for example the sentences:

(24) a. It is possible for us to swim; *nevertheless*, we don't.
b. It is possible for us to swim; *nevertheless*, it isn't necessary.

(25) a. The coin wasn't in the drawer *even though* it could have been there.
b. The coin didn't have to be in the drawer *even though* it could have been there.

The pattern of the a sentences above is $(\Diamond \mathsf{p})\ nvs\ \neg \mathsf{p}$ and the pattern of the b's is $(\Diamond \mathsf{p})\ nvs\ \neg\Box \mathsf{p}$ (the corresponding *but* patterns are consequences, respectively, of these two by ($\mathbf{M}_2$)). It seems very plausible to conclude that these two patterns are always felicitous whenever their conjuncts are true:

($\mathbf{M}_3$) $(\Diamond \mathsf{p}) \wedge \neg \mathsf{p} \Rightarrow pres((\Diamond \mathsf{p})\ nvs\ \neg \mathsf{p})$

or alternatively:

($\mathbf{M}_3$') $(\Diamond \mathsf{p}) \wedge \neg\Box \mathsf{p} \Rightarrow pres((\Diamond \mathsf{p})\ nvs\ \neg\Box \mathsf{p})$

The reason we provide here two alternatives for ($\mathbf{M}_3$) is that although in most possible world semantics ($\mathbf{M}_3$) is more general than ($\mathbf{M}_3$') since usually $\Box \mathsf{p} \Rightarrow \mathsf{p}$ and then $\neg \mathsf{p} \Rightarrow \neg\Box \mathsf{p}$, in Veltman's data semantics that we use in section 4, the opposite ($\mathsf{p} \Rightarrow \Box \mathsf{p}$) holds for descriptive (= non-modal) p's. We want the more general among the ($\mathbf{M}_3$)'s to hold, whatever possible world semantics is used.

We turn now to some restrictions on the implication connective ($\rightarrow$). The first restriction is trivial: In section 2 we required that (**C1**) holds whenever (**C1**)[restricted] (p weakly implies ¬q) is satisfied. This means we claim that $\Theta_{\mathsf{q}}(\mathsf{p}, \mathsf{q})$ is entailed by $\Diamond(\mathsf{p} \rightarrow \neg \mathsf{q})$ (the converse is by definition). Therefore we require that the proposition $(\mathsf{q} \rightarrow \mathsf{q})$ in $\Theta_{\mathsf{q}}(\mathsf{p}, \mathsf{q})$ is vacuously satisfied, so $\rightarrow$ must be a reflexive operator. This is a reasonable assumption to make in any other respect we can think of.

A more interesting restriction on $\rightarrow$ is motivated by the following example:

(26) (F, John's father, to D, a doctor, after D operated John's leg)
F: John walks now very slowly, doctor.
D: Yes indeed, ^{p}[your son walks slowly] *but* ^{q}[he walks !]

The plausible interpretation of the reply of the doctor is with an r as "the operation was successful"[13]. We are faced then with the following puzzle: How comes $\mathsf{p} \Rightarrow \mathsf{q}$ ("John walks slowly" logically entails "John walks"), $\mathsf{q} \rightarrow \mathsf{r}$ ("John walks" implies that "the operation was a success"), and still, we cannot conclude that $\mathsf{p} \rightarrow \mathsf{r}$ (certainly, "John walks slowly" does not imply here that "the operation was successful").

Two conclusions are possible: One possibility is that logical entailment is not a special case of $\rightarrow$, i.e. there can be sentences p and q s.t. $\mathsf{p} \Rightarrow \mathsf{q}$ and still in some possible world $(\mathsf{p} \rightarrow \mathsf{q})$ is false. An alternative conclusion can be that $\rightarrow$ is not transitive. Actually, both these possibilities might seem plausible (but see sub-section 5.4): if we think of $\rightarrow$ as some kind of a "cognitive reasoning" relation, then it should be neither transitive (why should we be capable of obtaining all the transitive closure of implications that we already know ?) nor containing the relation of logical entailment (why should we be capable of obtaining all the logical consequences of a statement ?). We may conclude that the analysis of contrast provides us with the following restriction on implication:

($\mathbf{M}_4$) The connective $\rightarrow$ is a reflexive relation between sentences s.t. either $\rightarrow$ is not transitive or logical entailment ($\Rightarrow$) is not a special case of $\rightarrow$. [14]

The *but* sentence in (26) is a case of "redundant" affirmation, which is discussed extensively in Horn(1991). Horn considers many cases of p *but* q conjunctions where p presupposes q (e.g. (27), (28)) or logically entails q (e.g. (29) and similarly (26) above):

(27) It's odd that dogs eat cheese *but* they do.

(28) He regrets that he said it *but* he did say it.

(29) While she was dying, and I knew she was dying, I wrote my best book. I wrote it in agony *but* I wrote it.

"Redundant" affirmation like in these sentences shows that the fact that the sentence q is presupposed or even logically entailed by p is not enough to make sure that all the information it conveys arrives to the addressee. When q is added "redundantly" as a *but* conjunct the rhetorical contrast (in Horn's terms) or the indirect contrast established by r (as in our analysis of (26)) is conveyed and changes the information that p alone would convey. For some further points concerning contrast and "redundant" affirmation see conjecture 1 in the following sub-section and also the discussion in sub-section 5.4.

Definitions ($\mathbf{D}_1$)-($\mathbf{D}_3$) together with the restrictions ($\mathbf{M}_1$)-($\mathbf{M}_4$) form a general framework for a formal theory of connectives of contrast within possible world semantics. By this by no means we intend to imply that the notion of contrast is a pure semantic one. Definitions ($\mathbf{D}_1$)–($\mathbf{D}_3$) should be adopted within a theory of the semantic *and pragmatic* aspects of implication and modal operators. We also do not assume that the operator of presuppositions is in a *linguistic* semantic level. It is only important to notice that unlike other kinds of presuppositions, the *schemata* in ($\mathbf{D}_2$) and ($\mathbf{D}_3$) cannot be canceled in a contrastive conjunction: contrast between the conjuncts should be established under *any* linguistic context. This was noted already by Grice in Grice(1961:p.129), when discussing the peculiarity of utterances like:

(30) She is poor *but* she is honest, **?** though I don't want to imply there is any contrast between poverty and honesty.

Therefore, our notation *pres* stands for a presupposition more in the sense of Karttunen and Peters' conventional implicature and is quite distinct from Gazdar's view of presupposition. The non-cancelablity of contrast makes it easier to incorporate ($\mathbf{D}_2$) and ($\mathbf{D}_3$) to a formal semantic logical mechanism.

By ($\mathbf{M}_1$)–($\mathbf{M}_4$) we are trying to draw some restrictions on the way the definitions are incorporated into a semantic structure. There can still be other restrictions to be drawn and there are certainly further *pragmatic* restrictions (as in (12)). One last remark: ($\mathbf{D}_1$)–($\mathbf{D}_3$) do not have to remain exactly the same in any kind of possible world semantics; they are a basis for principled variations. In section 4 we investigate an implementation of this general interface within Veltman's possible world semantics for conditionals, and then it will be evident that one slight variation of the static ($\mathbf{D}_1$) is needed due to the "dynamic" nature of this specific semantics.

3.3 "Paradoxes" of contrast, further restrictions on ($\mathbf{D}_1$)-($\mathbf{D}_3$)

A theory of contrast in the lines that were drawn, which leans heavily on an operator of implication in natural language, is threatened by the well-known (so-called) "paradoxes" of implication. Such "paradoxes" occur, for example, when $\rightarrow$ is interpreted as the *material* implication ($x \rightarrow y$ iff $\neg x \vee y$): assume that you want to convince someone that $x \rightarrow y$ is true. Will it indeed be enough for you to convince him either that x is false or that y is true ?

For instance: why do the following inferences look suspicious ?

(31) John sneezes.
a. **?** *Therefore, if* John does not sneeze *then* Eric Satie is a German philosopher.
b. **?** *Therefore, if* John does not sneeze *then* Eric Satie is a French composer.

(32) Eric Satie is a French composer.
a. **?** *Therefore, if* John sneezes *then* Eric Satie is a French composer.
b. **?** *Therefore, if* John does not sneeze *then* Eric Satie is a French composer.

In general: the problem is to account for what is wrong (if anything) in the following inferences:

$$(I_1) \quad \frac{\neg x}{x \rightarrow y}$$

$$(I_2) \quad \frac{y}{x \rightarrow y}$$

These are problems for material implication[15], but they are shared by many other common accounts of implication in natural language. Our point is that when this kind of puzzle is created by the definition for the *meaning* of $\rightarrow$ it causes similar problems for the analysis of the *felicity* of contrastive conjunctions. For instance: suppose that someone knows that there is a possibility that a statement p is false ($\Diamond\neg p$). Will (s)he then be willing to accept any sentence of the form p *nvs* q as felicitous, as the trivial satisfaction of (**D**$_3$) ($\Diamond(p \rightarrow \neg q)$) predicts ? Suppose you know there exists a possibility that John does not sneeze and you tell it to somebody. Will you be ready to accept the following response as felicitous ?

(33) **?** Generally, there's a possibility that John doesn't sneeze. Actually, he sneezes; *nevertheless*, Hans Eisler was a German composer.

The inferences in question, which in most possible world semantics are derivable from (I_1) and (I_2) are:

$$(I_3) \quad \frac{\Diamond\neg x}{\Diamond(x \rightarrow y)}$$

$$(I_4) \quad \frac{\Diamond y}{\Diamond(x \rightarrow y)}$$

There is independent linguistic evidence for the implausibility of inferences rules (I_3)-(I_4) in natural language. Consider for example the following variation on (31a):

(34) *Maybe* John does not sneeze. **?** *Therefore, maybe* if John sneezes then Eric Satie is a German philosopher.

What is disturbing us in the context of contrastive conjunctions is that (I_3) and (I_4) entail according to definitions (**D**$_1$)-(**D**$_3$) the following inferences, respectively:

$$(I_5) \quad \frac{\Diamond\neg p}{\Theta_q(p, q)} \qquad (= pres(p \ nvs \ q))$$

$$(I_6) \quad \frac{\Diamond\neg \mathsf{q}}{\Theta_{\mathsf{q}}(\mathsf{p},\mathsf{q})} \qquad (= pres(\mathsf{p}\ nvs\ \mathsf{q}))$$

This is while examples like (33) suggest that in cases where the only data is that $\Diamond\neg\mathsf{p}$ or $\Diamond\neg\mathsf{q}$ it is not automatically guaranteed that the presupposition of contrast for p *nvs* q is satisfied.

Even less digestible are the inference patterns that material implication creates for the non-restrictive *but*:

$$(I_7) \quad \frac{\mathsf{r}\wedge\Diamond\neg \mathsf{r}}{\Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})} \qquad (= pres(\mathsf{p}\ but\ \mathsf{q}))$$

This seems quite traumatic: how can evidence on $\mathsf{r}\wedge\Diamond\neg\mathsf{r}$ allow automatically *any but* conjunction, with no respect to identity of the conjuncts ? The problem looks even harder as one notices that according to most possible world semantics the existence of a proposition r such that $\mathsf{r}\wedge\Diamond\neg\mathsf{r}$ holds is something that should happen in usual linguistic contexts: it only requires the existence of one possible world distinct from the "actual" one !

As (I_5)-(I_7) are closely related to the well-known (I_1)-(I_2), we will refer to them as *the "paradoxes" of contrast* (an alternative name could be *'"paradoxes" of weak implication'*).

Note also the similarity between utterances like (33) and ones like (12b)(1) (section 2). In (12) the problem seemed to be the (missing) "relevance" of r to the context. In (33) the problem is the "relevance" of the conjuncts p and q to each other. However, (33) is problematic only for treatments of $\rightarrow$ that allow for inferences (I_1) and (I_2) and do not have an explanation for their alleged unsoundness.

So, the origins of the problem are the well-discussed "paradoxes" (I_1) and (I_2) for (material) implication. Basically, there are two main trends in the literature to deal with this kind of problems: one possible strategy claims that (I_1) and (I_2) are *semantic* problems for any operator of implication for which they are valid. Therefore, according to this point of view, material implication and many other implication operators are not very relevant for the semantics of implication in natural language (and also in mathematics, if accepting the paradigm of Relevance Logic). Another trend maintains that (I_1) and (I_2) are to be considered *logically* valid, and that the question why human beings do not tend to accept these inferences as generally sound should be answered using *pragmatic* considerations.

Whatever position to be taken, we do not consider possible restrictions on $\rightarrow$ that are designed to cope with the "paradoxes" of implication to be part of the semantic interface for CON^2 . This should be done by any specific semantic and pragmatic application proposed for the interface. It should be clear, though, that any substantial semantic *or* pragmatic theory that deals with the problems that (I_1) and (I_2) raise should explain what is wrong with (I_3) and (I_4), thus also with (I_5)-(I_7), the "paradoxes" of contrast.

In sections 4 and 5 we apply the interface to Veltman's theory of indicative conditionals, and there it will be our job to explain how these problems are overcome (see 5.3).

A closely related question that comes to mind is whether there are any inherent restrictions on the conjuncts, which should prevent sentences like:

(35) **?** Isaac won the elections in Jamaica *but* it is not raining today in Paris.

Generally speaking, when (35) is uttered with no further information it surely sounds like nonsense. After all, what can be the contrast between the results of the elections in Jamaica and the rain in Paris. But consider now the following context:

A and B made a bet: if *both* Isaac wins the elections in Jamaica *and* it rains today in Paris, then B pays A a hundred dollars. Now imagine the following conversation:

A: Hi B, I've just heard in the radio that Isaac won the elections in Jamaica. You know this means that you owe me a hundred dollars.

B: Come on, Isaac won the elections in Jamaica *but* it is not raining today in Paris. I don't owe you anything.

Here the "bet" context supplies an admissible r to the *but* conjunction; namely "*B does not owe A a hundred dollars*". The possibility to create such a context almost for every two sentences is an evidence in favour of the following conjecture:

Conjecture 1: For any two sentences that represent the (non-contradictory) statements p and q, contrast between p and q can be established using certain r and context.

The requirement that p and q are not contradictory is only because we restrict ourselves to contrast in CON² conjunctions, and it is hard to find linguistic evidence from these conjunctions for contrast between contradictory statements (funny as it may sound) because of the truth conditions for CON² conjunctions.

Note that even when p logically entails q, contrast between p and q can be established, as witnessed by (26)[16]. However, probably not a *direct* contrast: similar examples with *restrictive* members of CON² seem to be infelicitous [17]:

(26') a. **?** Your son walks slowly; *nevertheless,* he walks.
b. **?** Your son walks *although* he walks slowly.

Such facts suggest the following possible restriction on the presupposition of contrast for the restrictive subclass of CON²:

Conjecture 2: $p \rightarrow \neg q$ cannot be established when $p \Rightarrow q$.

There is a strong connection between this last conjecture and the discussed "paradoxes" of implication: In classical propositional logic, for instance, whenever $p \Rightarrow q$ the proposition $p \rightarrow \neg q$ can be true if and only if p is false, and then a semantic/pragmatic theory that explains what is wrong with (I_1) should also predict that our conjecture 2 is true.

To summarize what has been done in this section: an *admissible* possible world semantics for contrast is any semantics with definitions for implication ($\rightarrow$), presuppositions and the possibility and necessity operators, in which definitions $(\mathbf{D}_1)$-$(\mathbf{D}_3)$ satisfy the restrictions $(\mathbf{M}_1)$-$(\mathbf{M}_4)$. These D's and M's constitute the "semantic interface" for a theory of implication in possible world semantics. The so-called "paradoxes" of contrast should be handled by the same semantic or pragmatic mechanisms that handle the "paradoxes" of implication.

In sections 4 and 5 we are going to show that Veltman's Data Logic is such an admissible semantics. We also claim that the pragmatic principles introduced by Veltman are the key to handle the "paradoxes" of contrast in this framework, and that together with the application of the interface to Data Logic they are capable of explaining a large portion of contrastive phenomena in natural language.

Former proposals for a logical analysis of contrastive conjunctions are included in Francez(1991) and Meyer & van der Hoek(1991). Our proposal here is inspired by the two works, but see footnote for some central points of disagreement. [18]

Interlude - Nesting of contrast operators

A subtle empirical question raised by the works of Francez and Meyer & van der Hoek, which is extremely important for a complete formalization of contrast, is the question of nesting of contrast operators. Meyer & van der Hoek consider the following sentence an example for that:

(36) Tweety is a bird *but* she does not fly *but* she is high up in the air (in an airplane, for instance).

We are not completely sure that this is an acceptable example in English, but this should not obscure the point here: various kinds of *iteration* of contrast are quite acceptable in conversation. For example:

(37) A: Did you know it ? Tweety is high up in the air !
B: How can it be ? Tweety is a bird *but* she cannot fly !?
A: *But* she is in an airplane. Ha Ha !

However, to convince ourselves that unfunny jokes like (37) are indeed a case of *nesting* we must become sure that it is indeed the *contrast* in what B says that A tries to contrast in his reaction. Here Meyer & van der Hoek's arguments do not seem very persuasive: A's reaction may be equally analyzed as contrasting only the second conjunct ("Tweety cannot fly") in B's utterance.

We were not successful in finding a clear-cut example for a genuine nesting of contrastive operators. Even in the almost artificial (38a) the contrast in the second sentence can be analyzed with respect to the *boolean* conjunction in the first one, as observed in (38b):

(38) a. It was cloudy *but* it did not rain. *Nevertheless*, we were not surprised.
b. It was cloudy *and* it did not rain. *Nevertheless*, we were not surprised.

We therefore tend to think that members of $\textsc{con}^2$ cannot be used "meta-linguistically"– to convey contrast to implications from linguistic conditions on an utterance (e.g. conditions on contrast between elements within one of the conjuncts). It seems that a similar conclusion can be drawn from a remark in the appendix in Horn(1985). However, the empirical status of "genuine" nesting of contrast is not completely clear to us.

From a logical point of view, this is not to say that the problem of nesting of contrast operators is uninteresting, on the contrary. Still, a full analysis of the formal aspects of nesting would have dictated an entirely different approach to this work, and we must defer it to another occasion.

4 Contrastive Data Logic – an incorporation of the connectives of contrast into Veltman's data semantics for conditionals

In this section a possible application of the "semantic interface" proposed in the previous section is investigated. The connectives *but* and *nvs* are incorporated into the syntax and semantics of the formalism of Data Logic proposed in Veltman(1986). The resulting extended logic will be called *Contrastive Data Logic* (CDL).

We chose to use Veltman's data semantics as a case study because of its formal elegance and the interesting pragmatic part of his analysis for indicative conditionals. Another interesting aspect of Veltman's data semantics is its "dynamic" conception of knowledge, which dictates some recapitulation in the proposed static definition for contrast ($\mathbf{D}_1$).

For the convenience of the reader we first briefly summarize the main ideas and definitions in Veltman(1986) that are needed for our purposes. However, in order to understand also the linguistic and philosophical motivations behind Veltman's theory, familiarity with his brief and stimulating work is recommended.

4.1 Data semantics - the basic definitions

Let the logical language L have a vocabulary that consists of a set P of atomic propositions, parentheses, the one-place operators $\neg$, *may* and *must*, and the two-place connectives $\wedge, \vee$ and $\rightarrow$. The syntax of L is defined using the standard formation rules for these operators.

The operators *may* and *must* stand for the *epistemic* readings of the corresponding modalities in English, $\rightarrow$ stands for the *indicative* conditional *if...then*.

A model for L is a partially ordered set S of *information states* and a valuation function V per state for the atomic propositions in P. Each state represents information (possibly partial) on the truth values of the atomic propositions. Growth of information is modeled by requiring that for any two states $s_1 \leq s_2$, $V_{s_1} \subseteq V_{s_2}$. It is also assumed that each state can grow into a complete information state and therefore it is required that for each chain of ordered states there is a maximal state s, which is assigned a total valuation function V_s. Formally:

An *information model* is a triple $< \mathsf{S}, \leq, \mathsf{V} >$ with the following properties:

(i) $\mathsf{S} \neq \phi$

(ii) $\leq$ is a partial ordering of S. Each chain in $< \mathsf{S}, \leq >$ contains a maximal element.

(iii) V is a function with a domain S:

- (a) for each $s \in$S, V_s is a *partial* function $\mathsf{P} \rightarrow \{0, 1\}$.
- (b) if $s \leq s'$ then $V_s \subseteq V_{s'}$
- (c) if s is a maximal element of $< \mathsf{S}, \leq >$ then V_s is total and s is called a *complete* state of information.

The semantics for L is defined in quite a natural way, where $\models$ and $\dashv$ are the satisfaction/falsification relations between an information state in an information model and propositions in L:

Let $M =< \mathsf{S}, \leq, \mathsf{V} >$ be an information model and $s \in \mathsf{S}$. For every proposition A is L:

If A is atomic then
(M,s) $\models A$ iff $V_s(A) = 1$
(M,s) $\dashv A$ iff $V_s(A) = 0$

Otherwise, recursively:

(M,s) $\models \neg A$ iff (M,s) $\dashv A$
(M,s) $\dashv \neg A$ iff (M,s) $\models A$

(M,s) $\models \mathit{may} A$ iff for some information state $s' \geq s$, (M,s') $\models A$
(M,s) $\dashv \mathit{may} A$ iff for no information state $s' \geq s$, (M,s') $\models A$

(M,s) $\models \mathit{must} A$ iff for no information state $s' \geq s$, (M,s') $\dashv A$
(M,s) $\dashv \mathit{must} A$ iff for some information state $s' \geq s$, (M,s') $\dashv A$

(M,s) $\models A \wedge B$ iff (M,s) $\models A$ and (M,s) $\models B$
(M,s) $\dashv A \wedge B$ iff (M,s) $\dashv A$ or (M,s) $\dashv B$

(M,s) $\models A \vee B$ iff (M,s) $\models A$ or (M,s) $\models B$
(M,s) $\dashv A \vee B$ iff (M,s) $\dashv A$ and (M,s) $\dashv B$

(M,s) $\models A \rightarrow B$ iff for no information state $s' \geq s$, (M,s') $\models A$ and (M,s') $\dashv B$
(M,s) $\dashv A \rightarrow B$ iff for some information state $s' \geq s$, (M,s') $\models A$ and (M,s') $\dashv B$

We use the notations $(\mathsf{M},s) \not\models A$, $(\mathsf{M},s) \not\dashv A$ when it is not the case that $(\mathsf{M},s) \models A$, $(\mathsf{M},s) \dashv A$, respectively.

Veltman's definition for *stability* of propositions is important in order to understand some of the basic features of this semantics. For a proposition A:

> A is *T-stable* iff for every model $\mathsf{M} =< \mathsf{S}, \leq, \mathsf{V} >$ and information state $s \in \mathsf{S}$, if $(\mathsf{M},s) \models A$ then $(\mathsf{M},s') \models A$ for every information state $s' \geq s$.
>
> A is *F-stable* iff $\neg A$ is T-stable.
>
> A is *stable* iff A is both T-stable and F-stable.

We also define logical entailment between propositions as usual:

> $A \Rightarrow B$ iff for every model $\mathsf{M} =< \mathsf{S}, \leq, \mathsf{V} >$ and every $s \in \mathsf{S}$, if $(\mathsf{M},s) \models A$ then $(\mathsf{M},s) \models B$

One more definition:

> A proposition A in Data Logic is a *description* (*test*) iff A is an atomic proposition or can be obtained from atomic propositions using only the operators $\neg$, $\wedge$ and $\vee$.

The following properties can now be easily verified:

- $\boldsymbol{must}A \Leftrightarrow \neg\boldsymbol{may}\neg A$ for every proposition A.
- Any proposition $\boldsymbol{may}A$ is F-stable (not necessarily T-stable)
- (Therefore:) Any proposition $\boldsymbol{must}A$ is T-stable (not necessarily F-stable)
- Any description in Data Logic is stable.
- $A \Rightarrow \boldsymbol{must}A$ for every description A. (not necessarily the opposite)
- *Weak Modus Ponens*: For descriptions A, B: $A \wedge (A \to B) \;\Rightarrow\; \boldsymbol{must}B$
- *Weak Modus Tollens*: For descriptions A, B: $\neg B \wedge (A \to B) \;\Rightarrow\; \boldsymbol{must}\neg A$
- If we define *material* implication traditionally as $\neg A \vee B$, and denote $A \supset B$, then $(A \to B) \Leftrightarrow \boldsymbol{must}(A \supset B)$
- (Therefore:) Any proposition $A \to B$ is T-stable (not necessarily F-stable)

An interesting aspect of Veltman's notion of truth is that it is a relative one: a description A is true in an information state s if there is *direct* evidence in favour of A. A non-description like $\boldsymbol{must}A$ can be true in s on the basis of indirect evidence (for example: knowledge of the laws of nature, rules of a game, etc.) while the truth value of A itself is still undefined in s. Veltman's paper brings a more elaborated discussion of this point.

4.2 Incorporation of *but* and *nvs* – Contrastive Data Logic

We add now the two-place connectives *but* and *nvs* to the vocabulary of L, with the expected formation rules.

In order to define the semantics of these two connectives in data semantics we should adopt a "dynamic" notion of contrast, which is more appropriate here. This requires a slight modification in the straightforward translation of ($\mathbf{D}_1$): instead of saying that p "weakly implies" $\neg$r and q implies r on the *same* state of information, we use a dynamic notion: if in a state of information s' there is a possibility that p implies $\neg$r, and s' grows into an information state $s \geq s'$ where q implies r, then the contrast between p and q is established in s. Contrast then is understood as a transition in implications. This agrees with the intuition that in a contrastive conjunction there is some "cancellation" effect of what p might have implicated, if not for the presence of q. Formally:

$(\mathsf{M},s) \models \Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$ (read: r establishes contrast between p and q) iff
$(\mathsf{M},s) \models \mathsf{q} \rightarrow \mathsf{r}$ and there is some state of information $s' \leq s$, s.t. $(\mathsf{M},s') \models may(\mathsf{p} \rightarrow \neg\mathsf{r})$

This definition can be illustrated as follows (an arrow from a state s_1 to a state s_2 represents the relation $s_1 \leq s_2$):

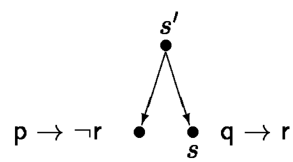

Figure 1: Satisfaction of $\Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$ in a state s

Contrast is *un-established* in the complementary case:

$(\mathsf{M},s) \dashv \Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$ iff
$(\mathsf{M},s) \not\models \mathsf{q} \rightarrow \mathsf{r}$ or there is no state of information $s' \leq s$ s.t. $(\mathsf{M},s') \models may(\mathsf{p} \rightarrow \neg\mathsf{r})$

Presuppositions can be incorporated into data semantics by using the undefined truth value also to represent a case of presupposition failure. We use here a common semantic definition for presuppositions in multi-valued semantics:

$B = pres(A)$ iff $A \Rightarrow B$ and $\neg A \Rightarrow B$

Therefore, if $(\mathsf{M},s) \not\models A$ and $(\mathsf{M},s) \not\dashv A$ (A's truth value is undefined in s) then we can say that either (as in Veltman's original framework) there is no direct evidence in s for A, or that a presupposition of A is false in s. The difference between the two cases is that in the case of presupposition failure, even in a complete state of information A's truth value can remain undefined.

Now we can define the truth-functional content of p *but* q and p *nvs* q as $\mathsf{p} \wedge \mathsf{q}$, and their presuppositional content as $\Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$ and $\Theta_{\mathsf{q}}(\mathsf{p},\mathsf{q})$, respectively:

$(\mathsf{M},s) \models \mathsf{p}\ but\ \mathsf{q}$ iff $(\mathsf{M},s) \models \mathsf{p} \wedge \mathsf{q}$ and there is a proposition r s.t. $(\mathsf{M},s) \models \Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$.
$(\mathsf{M},s) \dashv \mathsf{p}\ but\ \mathsf{q}$ iff $(\mathsf{M},s) \dashv \mathsf{p} \wedge \mathsf{q}$ and there is a proposition r s.t. $(\mathsf{M},s) \models \Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$.

$(\mathsf{M},s) \models \mathsf{p}\ nvs\ \mathsf{q}$ iff $(\mathsf{M},s) \models \mathsf{p} \wedge \mathsf{q}$ and $(\mathsf{M},s) \models \Theta_{\mathsf{q}}(\mathsf{p},\mathsf{q})$.
$(\mathsf{M},s) \dashv \mathsf{p}\ nvs\ \mathsf{q}$ iff $(\mathsf{M},s) \dashv \mathsf{p} \wedge \mathsf{q}$ and $(\mathsf{M},s) \models \Theta_{\mathsf{q}}(\mathsf{p},\mathsf{q})$.

This definition for the semantics of the formal connectives *but* and *nvs* guarantees that the presupposition for contrast $\Theta_r(p,q)$ is preserved under negation, which agrees with the linguistic intuitions presented in section 2. We do not try here to cope with other linguistic problems of presupposition accommodation, cancellation or modification. Our goal here in this respect is only to incorporate presuppositions into Data Logic with minimal technical complications. A better notion of presupposition in Data Logic can be achieved using orthogonal mechanisms of truth and presupposition-satisfaction assignments (four truth values) or using van Eijck's novel dynamic error state semantics (see van Eijck(1993)).

4.3 Satisfaction of ($\mathbf{M}_1$)–($\mathbf{M}_4$) within CDL

In order to count CDL as an admissible application of the interface we presented, we should verify that the restrictions ($\mathbf{M}_1$)–($\mathbf{M}_4$) are satisfied in CDL.

Proposition 1: For *descriptive* propositions p,q, and r, ($\mathbf{M}_1$) is satisfied:

$\Theta_r(p,q) \wedge p \wedge q \;\Rightarrow\; \neg(p \to \neg r)$

Proof: By definition: assume by negation that (M,s) $\models \Theta_r(p,q) \wedge p \wedge q \wedge (p \to \neg r)$.

Then (M,s) $\models p \wedge q \wedge (p \to \neg r) \wedge (q \to r)$. So in any complete state $s' \geq s$, (M,s') $\models p \wedge q$ (p and q are descriptions, therefore stable). r's truth value must be defined in s' (it is a description), and any of the possibilities (M,s') $\models \neg r(\wedge q)$ and (M,s') $\models r(\wedge p)$ is contradictory to the assumption, by definition of $\to$.

($\mathbf{M}_1$) does not always hold in CDL when p, q or r are not descriptive. Consider for example the model M as illustrated in figure 2 ($s < s_1,\ s < s_2,\ s_1 \not< s_2,\ s_2 \not< s_1$), with A a description with an undefined truth value in s, and (M,s_1) $\models \neg A$, (M,s_2) $\models A$:

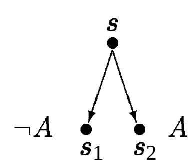

Figure 2: A model M for CDL

If we denote now $p = may\neg A$, $q = may A$ and $r = A$ then it is easy to see that (M,s) $\models (p \to \neg r) \wedge (q \to r)$ and therefore (M,s) $\models \Theta_r(p,q)$ and obviously (M,s) $\models p \wedge q$. Still, (M,s) $\models p \to \neg r$ does not agree with ($\mathbf{M}_1$) .

This is a problem for the linguistic adequacy of CDL that is to be discussed in sub-section 5.4, when the pragmatic principles are introduced.

Proposition 2: ($\mathbf{M}_2$):

a. If (M,s) $\models \Theta_q(p,q)$ then there is a proposition r s.t. (M,s) $\models \Theta_r(p,q)$.

b. There are propositions p,q and r that in some model M and a state s satisfy: (M,s) $\models \Theta_{r}(p,q)$ and still (M,s) $\not\models \Theta_{q}(p,q)$.

Proof: a is of course trivial.

b is also simple: Consider for example a model M with $< S, \leq >$ as in figure 2, p, q and r are atomic propositions and (M,s) $\models p \wedge q$, (M,s_1) $\models p \wedge q \wedge \neg r$, (M,$s_2$) $\models p \wedge q \wedge r$. Therefore: (M,$s_1$) $\models p \rightarrow \neg r$ and then (M,s) $\models may(p \rightarrow \neg r)$. In s_2 we get (M,s_2) $\models q \rightarrow r$ and then (M,s_2) $\models \Theta_{r}(p,q)$. Still, in s, s_1 and s_2 the proposition $p \rightarrow \neg q$ is false and therefore (M,s_2) $\not\models \Theta_{q}(p,q)$.

Proposition 3: (**M**$_3$): For every proposition A, $((mayA) \wedge \neg A) \Rightarrow \Theta_{\neg A}(mayA, \neg A)$

Proof: Assume (M,s) $\models (mayA) \wedge \neg A$.

Then there exists a state $s_1 > s$ s.t. (M,s_1) $\models A$. Let s_2 be a maximal state $s_2 \geq s_1$ s.t. (M,s_2) $\models A$, i.e. a state $s_2 \geq s_1$ s.t. (M,s_2) $\models A$ and for each $s' \geq s_2$ (M,s') $\not\models A$. There exists at least one such state since by definition each chain in $< S, \leq >$ contains a maximal element. Therefore (M,s_2) $\models (mayA) \rightarrow A$ because (M,s_2) $\models (mayA) \wedge A$ and for each $s_3 > s_2$, (M,s_3) $\not\models mayA$ by maximality of s_2.

We get (M,s) $\models may((mayA) \rightarrow A)$, and this means by definition that (M,s) $\models \Theta_{\neg A}(mayA, \neg A)$.

Proposition 4: (**M**$_3$'): For every proposition A, $((mayA) \wedge \neg mustA) \Rightarrow \Theta_{\neg mustA}(mayA, \neg mustA)$

Proof: Assume (M,s) $\models (mayA) \wedge \neg mustA$.

If there is a *complete* state $s' \geq s$ s.t. (M,s') $\models A$ then (M,s') $\models (mayA) \rightarrow mustA$ (by definitions).

Otherwise there is a state $s' > s$ s.t. (M,s') $\models \neg mayA$, and then because $mayA$ is F-stable we get (M,s') $\models (mayA) \rightarrow mustA$.

In both cases we get (M,s) $\models may((mayA) \rightarrow mustA)$ and therefore

(M,s) $\models \Theta_{\neg mustA}(mayA, \neg mustA)$.

Although both (**M**$_3$) and (**M**$_3$') hold in data semantics there is one property of this system, which is mentioned in Veltman(1986), that shows a problem in the generality for such cases: for every *description* A, the proposition $(mayA) \wedge \neg A$ is a logical contradiction. There is a justification for that as long as $mayA$ is used to express that "A is compatible with the evidence at the present state of information". But as witnessed by (24) and (25), this is not a reasonable consequence when *may* (or *possible*) in English is used to convey competence or ability to make A happen. Usually we can think of someone capable to do things even if those capabilities are not realized. Some kind of extension to Veltman's system is therefore due in order to capture this other use of modalities in natural language. We are not going to deal with this problem in this paper. Many discussions of the problem and related topics are present in the literature (cf. for example Karttunen(1971) and Kratzer(1977)).

Proposition 5: ($\Rightarrow$ ($\mathbf{M}_4$)): $\rightarrow$ is reflexive and not transitive.

Proof: Reflexivity is trivial by definition.

For non-transitivity: consider for example again a model M with $<$ S, $\leq >$ as in figure 2, and an atomic proposition A is with undefined truth value in s, false in s_1 and true in s_2.

It is easy to see then that (M,s) $\models ((mayA) \rightarrow A) \wedge (A \rightarrow mustA)$ and still (M,s) $=\!\mid ((mayA) \rightarrow mustA)$.

In some senses the result in proposition 5 is too weak, for as we saw in sentence (26) implication in natural language is a non-transitive operator also for *descriptive* propositions. However, it is easy to see that in CDL $\rightarrow$ *is* transitive for descriptions. This problem for CDL is to be given a pragmatic account in section 5.4.

We may turn now to linguistic applications of CDL.

5 Pragmatic principles for CDL and linguistic predictions

In the previous section a formal semantics for the presupposition of contrast was defined. In this section we first show how CDL is applicable for simple examples of CON² sentences. But as Veltman maintains: "there is little sense in discussing a semantic theory– if, at least, it presents a semantics for conditionals – without paying any attention to its ramifications for pragmatics". The same is true with respect to semantics for contrast. Especially as we are entirely not obliged to regard the *presuppositional* part of CDL as part of natural language semantic level (logical semantic mechanisms, like any other formal instrument, can be part also of a theory for natural language pragmatics !).

Thus, in the rest of this section we show how Veltman's pragmatic principles for Data Logic can be generalized and used in Contrastive Data Logic to account for the "paradoxes" of contrast, as well as more complex examples from natural language, especially the interaction between indicative conditionals and connectives of contrast.

5.1 Simple linguistic predictions of CDL

Propositions 1–5 in 4.3 showed that the semantics for CDL satisfies the essential semantic restrictions we have set in section 3. Here is a short summary of the linguistic facts that are therefore accounted for by CDL:

1. ($\mathbf{M}_1$) shows that (**C2**) (section 2) is satisfied for descriptions, which explains the validity of inferences as in (9a) and the invalidity of inferences as in (9b). We still have to consider the case of non-descriptions (see 5.4).

2. ($\mathbf{M}_2$) guarantees that a restrictive contrastive conjunction entails its non-restrictive counterpart, and that the opposite does not in general hold (witness (6), (7)).

3. The satisfaction of ($\mathbf{M}_3$) accounts for the interaction between modal operators and connectives of contrast as in sentences in the general form of (24) or (25).

4. $\rightarrow$ is not generally transitive in CDL. We still have to show how the transitivity of $\rightarrow$ for descriptions is pragmatically harmless in order to account for peculiar examples as in (26) (see 5.4).

More concretely, we may turn now to some simple contrastive conjunctions and see how they are analyzed using CDL.

Reconsider sentence (7a):

(7a) ^{p}[It is raining] *but* ^{q}[I took an umbrella.]

A possible r here is a sentence like "I won't get wet". Let us use then R(rain) to represent p, U(umbrella) to represent q, and $\neg W$(not wet) to represent r, abstracting away the tenses. The truth conditions and the presupposition of contrast for the conjunction R ***but*** U in a state of information s are represented in CDL as in the following model:

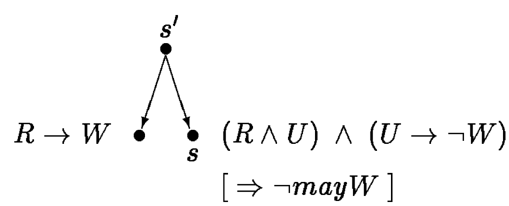

Figure 3: $(\mathsf{M}, s) \models R$ ***but*** $U \quad (\theta_{\neg W}(R, U))$

The presupposition, together with the truth condition $R \wedge U$ in s, establish (using weak Modus Ponens), that the speaker in (7a) is in a state of information s, where he/she is certain that she won't get wet, or $\neg mayW$. This can be verified linguistically as in the *therefore* context:

(7a') It is raining *but* I took an umbrella. *Therefore* I *cannot* get wet.

In data semantic notions, the sentence (7a), with r that is realized as $\neg W$ like in the context (7a'), can thus be paraphrased as something like:

> "In a previous state of information, s', the possibility of getting wet because of the rain was still open. In the actual state of information, s, this possibility is no longer open, thanks to my helpful umbrella."

Consider now another "umbrella sentence", this time with a restrictive member of CON^2:

(39) I did not get wet *although* it was raining and I had not taken an umbrella.

This inspired sentence can be formalized in CDL as $(R \wedge \neg U)$ ***nvs*** $\neg W$. The semantics of this formula in CDL also reflects the intuition behind (39):

"In a previous state of information, getting wet because of the rain and lack of umbrella was an open possibility. In the actual state, I am dry."

For the analysis of some more complex sentences we should consider also some pragmatic principles for Contrastive Data Logic.

5.2 Veltman's pragmatic unsoundness principle for Data Logic

The basic pragmatic principle for conditionals in data semantics is this: a conversational implicature of a conditional $A \to B$ states that all four possibilities of truth values for A and B are open. In formula we use $imp(\varphi)$ as the operator of conversational implicature, which accommodates φ's implicatures to φ's truth conditions [19]:

$$imp(A \to B) = (A \to B) \wedge (mayA) \wedge (may\neg A) \wedge (mayB) \wedge (may\neg B)$$

The existence of such a conversational implicature is a known fact on indicative conditionals (see also Karttunen and Peters(1979) for a discussion). In Veltman's framework it follows quite easily from traditional Gricean maxims (Grice(1975), see Veltman(1986:pp.160-1)). Intuitively, it guarantees that the fact that B is not false whenever A is true is not coincidental, but has something to do with A, B, and the present state of information.

In cases where this implicature does not hold "odd" conditionals appear, and Veltman shows how it is canceled then because of conversational effects. In such cases the speaker has to clarify that a conversational implicature has been violated. For example, in conditionals like "*if... then* I'm a monkey's uncle" the speaker is clearly violating a conversational maxim (quantity or manner, depending on the preferred analysis), since from our most basic world knowledge we can tell that the consequent is false. This cancels the conversational implicature $mayB$ above. For our purpose here it suffices to assume the conversational implicature above, and not to consider "odd" instances of conditionals that cancel it. Also, we must clarify that we consider only *indicative* conditionals (counterfactuals have entirely different implicatures, see for example Karttunen and Peters(1979)).

Using this implicature of $A \to B$ we can explain why instances of the "paradoxes" of implication, although semantically valid in Data Logic (thus in CDL), are pragmatically incorrect. Reconsider for example the inference in:

(31) John does not sneeze. **?** *Therefore, if* John sneezes *then* Eric Satie is a German philosopher.

Such patterns of inferences are semantically valid in Data Logic for *stable* propositions as the description in the statement of "*John sneezes*". But they do not agree with the following pragmatic principle that Veltman proposes:

"Any argument of which the premises cannot hold if one takes the implicatures of the conclusion into account is pragmatically unsound."

The intuition behind this principle is the following: suppose you want to convince someone that B is true and you use as argument the statements $A_1, A_2, ..., A_n$ from which one can validly infer B. Pragmatically, it is impossible to convince anyone using this argument in cases where B must be pragmatically incoherent because one of its (realized) implicatures is contradictory to the premises. Of course, if the speaker makes clear, like in the "odd" conditional above that a conversational maxim has been violated, then the argument can become pragmatically sound, because an implicature is canceled. However, since we do not address this point in the present discussion we simplify Veltman's condition and formalize it as:

(P_1) A valid inference rule with premises $A_1, A_2, ..., A_n$ and a conclusion B is *pragmatically unsound* if $imp(B)$ contradicts the conjunction $A_1 \wedge ... \wedge A_n$.

Principle (P_1) brings only one kind of pragmatically unsound inference rules. The "if" implies that there might be also other kinds of such arguments.

For the inference in (31a) it works as follows: The implicature "*John may sneeze*" of the conclusion contradicts in its Data Logic representation the premise "*John does not sneeze*". Therefore the argument is pragmatically unsound.

Instances of the "paradox" of implication in Data Logic that is due to truth of the consequent in a conditional are explained away in a similar fashion. Generally, the inferences:

(I_1) $$\frac{\neg A}{A \rightarrow B}$$

(I_2) $$\frac{B}{A \rightarrow B}$$

are semantically valid in Data Logic when A and B are descriptions, but usually they are pragmatically unsound according to the definition of $imp(A \rightarrow B)$ and principle (P_1).

5.3 Pragmatic (in)sufficiency

Veltman pragmatic unsoundness principle (P_1) handles the "paradoxes" of implication (I_1) and (I_2) for Data Logic. As we saw in 3.3, in order to deal also with the "paradoxes" of weak implication we have to explain what is wrong with the Data Logic inferences corresponding to (I_3) and (I_4):

(I_3') $$\frac{may\neg A}{may(A \rightarrow B)}$$

(I_4') $$\frac{mayB}{may(A \rightarrow B)}$$

Unfortunately, implicatures of complex sentences in Data Logic other than $(A \rightarrow B)$ are not discussed in Veltman(1986). However, we can follow Veltman's line of thought to explain why (I_3) and (I_4) are in general pragmatically incorrect in natural language (see (34), for example): when a speaker utters a sentence of the form "*maybe if ... then ...*" she usually not only wishes to assert the Data Logic proposition $may(A \rightarrow B)$. She also assumes that the implicature for $A \rightarrow B$ is accommodated within the scope of the may operator. In formula:

$$imp(may(A \rightarrow B)) = may((A \rightarrow B) \wedge imp(A \rightarrow B)) = ^{20}$$
$$may[(A \rightarrow B) \wedge (mayA) \wedge (may\neg A) \wedge (mayB) \wedge (may\neg B)]$$

If we use this definition we realize that (I_3') and (I_4') are not pragmatically unsound according to principle (P_1), as the implicature of the conclusion contradicts the premise in neither inference. Something different is going on here: it seems that the problem is that the premise is only not pragmatically *sufficient* to convince that the conclusion is true. But further information can do that, for example:

(40) Maybe John will come. And maybe he will come because he will want to see Laura. *Therefore,* maybe if John wants to see Laura he will come.

Similar tricks cannot be done with (I_1) or (I_2), hence the term pragmatic *unsoundness* for such inferences. The inferences (I_3) and (I_4) are only pragmatically *insufficient* and further information in the premise can ameliorate them. Here is an example for one evident principle of pragmatic sufficiency:

(P_2) A valid inference rule with premises $A_1, A_2, ..., A_n$ and a conclusion B is *pragmatically sufficient* if $imp(B)$ is a logical consequence of the conjunction $A_1 \wedge ... \wedge A_n$.

Once again, as in Veltman's principle (P_1), (P_2) is not a complete definition; we do not define *all* the pragmatically sufficient inference rules. To be sure, further development of pragmatic principles should guarantee that the inference rules (I_3') and (I_4') are pragmatically insufficient, which explains the "paradoxes" of contrast in CDL, as well as the incorrectness of inferences as in (34). Such a result is reasonable and to be assumed for the sake of the analysis in 5.5, but we are not in a position that we have enough tools to predict it from more general principles. Therefore, we put it only as an ad-hoc stipulation:

Assumption 1: (I_3') and (I_4') are pragmatically insufficient.

One more pragmatic result, which we are going to need, and does not follow directly from (P_1) or (P_2) is that the following inference rule is pragmatically sufficient:

(I_8) $$\frac{may(A \wedge B)}{may(A \rightarrow B)}$$

An example for the pragmatic correctness of this inference follows in:

(41) Maybe John will come and bring his brother with him. *Therefore,* maybe if John comes he will bring his brother with him.

Our second ad-hoc stipulation is then:

Assumption 2: (I_8) is pragmatically sufficient.

The need to stipulate the pragmatic status of specific inference rules shows, evidently, that more general pragmatic principles should be added to (P_1) and (P_2). However, principles (P_1) and (P_2) and the specific assumptions, are capable to explain many effects in sentences with indicative conditionals also in interaction with contrastive elements. As we are interested here mainly in their applications, we leave the pragmatic generalizations needed to predict assumptions 1 and 2 for further research.

5.4 ($\mathbf{M}_1$) and ($\mathbf{M}_4$) and the pragmatics of CDL - Recapitulation

As we have mentioned (in sub-sections 4.3 and 5.1) the results in propositions 1 (for ($\mathbf{M}_1$)) and 5 (for ($\mathbf{M}_4$)) are somewhat unsatisfactory. We would like now to reconsider these problems in the light of the pragmatic principles brought in sub-sections 5.2 and 5.3.

Let us start with ($\mathbf{M}_4$). The motivation in this requirement was to account for contrast between sentences with "redundant" affirmation as in (26), restated here:

(26) John walks slowly *but* he walks.

The problem was to explain why in a p *but* q conjunction p can logically entail q and q can imply r (= "the operation was successful") and still p does not imply r. We concluded that either logical entailment is not necessarily always an implication or implication is not transitive ((**M**$_4$)). However, this is a "static" conclusion. It assumes that all propositions involved in the interpretation of a sentence are evaluated relative to one state of affairs. This is not the case in CDL: in CDL contrast in general is evaluated relative to two states of information: s and $s' \leq s$ (see figure 1 in sub-section 4.2). The implication r of p is evaluated relative to a state s' where $may(\mathsf{p} \to \neg\mathsf{r})$ should hold. The conjunct q is responsible for the transition to s, where the implication $\mathsf{q} \to \mathsf{r}$ is evaluated. It seems plausible that p cannot imply r before q is asserted and its implications are evaluated, but in s, after q is already asserted, the implications of p can change. So (**M**$_4$) does not have to be generally true in CDL and all we have to account for is why cannot the implication $\mathsf{p} \to \mathsf{r}$ hold in s', as in the model in figure 2. This is straightforward once we consider the implicatures of the proposition $may(\mathsf{p} \to \neg\mathsf{r})$. We assume that $(\mathsf{M},s') \models imp(may(\mathsf{p} \to \neg\mathsf{r}))$ or $(\mathsf{M},s') \models may[(\mathsf{p} \to \neg\mathsf{r}) \wedge may(\mathsf{p}) \wedge may(\neg\mathsf{p}) \wedge may(\mathsf{r}) \wedge may(\neg\mathsf{r})]$.
Assume by negation that $(\mathsf{M},s') \models \mathsf{p} \to \mathsf{r}$.
Then we get (by T-stability of p→r): $(\mathsf{M},s') \models may[(\mathsf{p} \to \mathsf{r}) \wedge (\mathsf{p} \to \neg\mathsf{r}) \wedge may\mathsf{p}]$
Then by definition: $(\mathsf{M},s') \models may[must((\neg\mathsf{p} \vee \mathsf{r}) \wedge (\neg\mathsf{p} \vee \neg\mathsf{r})) \wedge may\mathsf{p}]$
or: $(\mathsf{M},s') \models may[must(\neg\mathsf{p}) \wedge may\mathsf{p}]$ – contradiction.

This shows that pragmatically, p cannot imply r in s', in order for the implicatures of $may(\mathsf{p} \to \neg\mathsf{r})$ to hold and this explains how (**C2**) is preserved in sentences like (26).

The fact that (**M**$_1$) does not in general hold in CDL seems more like a genuine drawback of our proposal, which is a consequence of a problem for Veltman's theory to account for some interactions between conditionals and modality. (**M**$_1$) requires that p does not imply ¬r, in order for the implication of r to be "stronger" than the implication of ¬r. Proposition 1 proves this to be correct for *descriptive* propositions in CDL. However, we showed that in CDL contrast as in $may\neg A$ *but* $may A$ can be established with r = A, where $\neg A$ is (strongly) implied by p. More generally: in Data Logic, when A is a description the proposition $may(A) \to A$ is a tautology. Its implicature is $may(A) \wedge may\neg A$. This is probably not the case in natural language. For example: a conditional as in the following sentence seems unacceptable even when both possibilities concerning John's arrival are open :

(42) **?** If it is possible that John arrives then John arrives.

Veltman's theory has no explanation for why sentences like (42) are unacceptable. This is the reason CDL also fails to handle properly such cases and consequently, fails to satisfy (**M**$_1$) for non-descriptions. We have no simple explanation to offer here and must leave this question open.

5.5 Some predictions of the interactions between indicative conditionals and connectives of contrast

In this concluding sub-section we use CDL in conjunction with the pragmatic principles we introduced, to analyze some more involved examples.

Consider first the sentence:

(43) ^{p}[If it rains then you'll get wet] *but* ^{q}[maybe it will not rain after all.]
Therefore, ^{r}[maybe you won't get wet, eventually.]

Analysis: Let us represent (43) as $(R \to W)$ *but* $may\neg R$ with r = $may\neg W$.
The presupposition for contrast of p *but* q is satisfied in s, the state of information of the speaker in (43) because:

1. The *therefore* context in (43) shows that the speaker assumes that $\mathsf{q}\to\mathsf{r}$, or $(may\neg R) \to may\neg W$ – getting wet can be prevented when it is possible that it will not rain.

2. By the truth conditions, the proposition $\mathsf{p} = (R \to W)$ is true in a state $s' \leq s$ and therefore in s':

   $(R \to W) \wedge mayR$ (p and a conversational implicature of p)

   $may((R \to W) \wedge R)$ (by T-stability of $A \to B$)

   $may((R \to W) \wedge mustW)$ (application of weak Modus Ponens)

   $may((R \to W) \to mustW)$ (by assumption 2)

   $may(\mathsf{p} \to \neg\mathsf{r})$

The conclusion is that $\Theta_{\mathsf{r}}(\mathsf{p},\mathsf{q})$ is satisfied in s, and therefore $pres(\mathsf{p}\ but\ \mathsf{q})$ is satisfied in the conversation.

Now consider somewhat more complicated "umbrella" sentence:

(44) ^{p}[If you take an umbrella you won't get wet] *but* ^{q}[maybe it won't rain.]
Therefore, ^{r}[maybe you won't get wet (even) without an umbrella.]

CDL representation: $(U \to \neg W)\ but\ may\neg R, \quad \mathsf{r} = may(\neg W \wedge \neg U)$
Analysis:

1. As in (43): the inference in (44) shows that it is assumed by the speaker that when there is a possibility that it won't rain there is also a possibility that the addressee won't get wet even without an umbrella. Thus:

   in s: $(may\neg R) \to may(\neg W \wedge \neg U)$ or $(\mathsf{q} \to \mathsf{r})$

2. In $s' \leq s$:

   p holds or: $U \to \neg W$

   $(U \to \neg W) \wedge mayU$ (p and an implicature of p)

   $(U \to \neg W) \wedge may\ mustU$ (U is a description)

   $may((U \to \neg W) \wedge mustU)$ (T-stability of $A \to B$)

   $may((U \to \neg W) \wedge must(\neg W \wedge U))$ (weak Modus Ponens)

   $may((U \to \neg W) \to must(\neg W \wedge U))$ (assumption 2)

   $may((U \to \neg W) \to \neg may(\neg W \wedge \neg U))$

   $may(\mathsf{p} \to \neg\mathsf{r})$

   This means that a weak implication of p here is that one won't get wet *only* if she takes an umbrella.

The conclusion is that $pres(\mathsf{p}\ but\ \mathsf{q})$ is satisfied in (44).

The following example of interaction between conditionals and contrastive conjunctions is very common in mathematical texts:

(45) ^{p}[If A then B], *but* ^{q}[¬B]. Therefore ^{r}[¬ A].

Representation: $(A \to B)\ but\ \neg B$, $\mathsf{r} = \neg A$
Analysis:

1. $\mathsf{q} \to \mathsf{r}$ holds in s because: $\mathsf{p} = (A \to B) \Leftrightarrow (\neg B \to \neg A) = (\mathsf{q} \to \mathsf{r})$ and p holds in s.

2. In a state $s' \leq s$ the proposition $may(\mathsf{p} \to \neg\mathsf{r})$ holds because in this state holds the proposition $(A \to B) \wedge may A$ (p and an implicature of p). By similar considerations to the analysis in (43) and (44) the proposition $may((A \to B) \to B)$ holds in s': $may(\mathsf{p} \to \neg\mathsf{r})$.

We conclude that the presupposition for contrast is satisfied in (45).

There is naturally an enormous work left to be done on a formal pragmatic explanation for the variety of contrastive phenomena. Still, it seems that the correct predictions and the intuitive appeal of the analysis in this section show that the approach proposed here is on the right track and is useful for further research.

6 Conclusions

As it seems, problems of contrast in natural language reside in the twilight zone between semantics and pragmatics. The philosophical and linguistic ever-green enigma on meaning and use makes it hard to provide a full analysis for such phenomena. However, we believe that if linguistic evidence is used properly, it may lead to a comprehensive theory of the connections among notions such as contrast, implication, modal operators and presupposition.

The general paradigm we introduced in section 2 concerns these connections, especially the one between the first two notions: contrast and implication. This paradigm led us to develop the general application within possible world semantics and its specific implementation using Veltman's Data Logic and the associated line of pragmatic analysis.

We believe that Data Semantics is flexible enough to further improve our semantic and pragmatic proposals. Moreover, we believe that the paradigm on the linkage between contrast and implication is linguistically sound so it can lead us to a variety of alternative formal accounts of both phenomena and to a better insight into their puzzling nature.

Theories for contrast and implication in natural language also introduce interesting problems from a logical point of view, such as axiomatization of the contrastive connectives, nesting of contrast, and non-monotonic reasoning. Linguistic observations as presented in this work might be an important perspective for further logical inquiries. We hope to be able to concentrate on some of these issues in the future.

Evidently, answers to many questions addressed in this paper are still in the dark; nevertheless, we hope it is a contribution for placing contrast in a more "suitable light".

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Notes

1. Unless stated otherwise, we henceforth use *con* to denote only *contrastive* connectives. It is arguable whether all the expressions we label as connectives in CON[2] are to be considered also as syntactic coordinators. For the sake of the present discussion, which concentrates on the role of these words in expressing contrast between sentences, it seems preferable to leave this question beyond the scope of this paper.

2. For example, compare (i) and (ii):

   (i) It is not true that [John came *because* there was a party]. He's not a party goer at all !

   (ii) **?** It is not true that [John stayed at home *although* there was a party]. He's not a party goer at all !

   This resembles the behaviour of *even*, another well known expression which cannot simply be analyzed as truth functional. Compare (iii) and (iv):

   (iii) Not *only* John came. There were other people as well.

   (iv) **?** Not *even* John came. It was to be expected.

It should be emphasized that we do not consider here cases of metalinguistic negation (cf. Horn(1985), Horn(1989: chapter 6)), which in some sense enable cancellation of presuppositions:

(v) John didn't MANAGE to solve the question. It was quite easy for him !

With this kind of negation, which allows to negate even sentences the speaker believes to be true, just because the words or the intonation do not seem right to her, (ii) and (iv), and probably also (3) and (4) can become felicitous.

3. Grice does not classify explicitly the contrast as a conventional implicature of a *but* conjunction. This term was introduced only later in his work. However, in the light of Grice(1975) it is clear that this is his classification as he claims that the contrast in the conjunction is "detachable" and "non-cancellable".

4. Once again, a "strange" context as in:

   (i) We were used to find a restaurant open whenever we were hungry. Only yesterday...

   may establish a direct relation of implication between p and *not*(q) and allow (6b) and (6c), in agreement with (A).

5. In many senses, our intuitions are very close to Lang's proposals with respect to the basic facts concerning *but*. However, we disagree with the additional constraints Lang proposes which disallow relations of entailment between p and q. This point is to become clear in section 3 with the discussion which surrounds ($\mathbf{M}_4$).

   Anscombre and Ducrot propose an explanation for *mais* within their intuitively appealing but informal theory of argumentation in language (see Ducrot(1980), Anscombre and Ducrot(1983)). Some points on the differences between Anscombre and Ducrot's framework and ours follow.

6. which are still prosaic paraphrases of a verse in Nathan Alterman's great poem "In the Mountain of Silences".

7. To mention one important relation: Even in Hebrew, where there are overt three lexical entries for the three uses, one of these lexical entries (*ela*) can be used in different syntactic structures to convey also both other meanings discussed of the English *but*. For example:

   (i) zo eina ce'aka *ela* lexiSa.
   it isn't scream *but* whisper
   "It is not a scream *but* a whisper."

   (ii) ca'aknu *ela Se* af exad lo Sama otanu.
   we-screamed *but that* no one not heard us
   "We screamed *but* no one heard us."

   (iii) lo Sama'nu *ela* ce'akot.
   not we-heard *but* screams
   "We didn't hear anything *but* screams."

   Sentence (i) is the common use of *ela* in rectification, while (ii) and (iii) are examples for its uses in contrastive and exceptive constructions.

   More elaboration of this point and many related ones is required and left for further research.

8. It is not quite clear from the works of Lakoff and Blakemore whether they claim that there are two distinct lexical entries for the *but*'s in (22) and (23). However, Lakoff's claim that (22) is a case where the *but* signals only "semantic opposition" and in (23) also pragmatic considerations are needed for the analysis of the conjunctions, seems to favour this interpretation of her claim, to the extent that it is interpretable at all.

9. Especially misleading is Blakemore's claim that "... [R. Lakoff's] proposal would seem to find support in the fact that in some languages (for example German, Spanish and Hebrew) *but* may be translated by either of two words.". Both uses of *but* that Lakoff discusses are translated as *aber*/*pero*/*aval*, and it is completely evident that Lakoff's distinction has nothing to do with the solid distinction between the *but*'s for contrast, rectification and exception.

10. Hebrew, unlike English and French, is very rich in connectives for indirect contrast: *ax*, *ulam*, *aval*, *ela she*, are only part of the many lexical entries and syntactic constructions for conveying indirect contrast in Hebrew.

11. For our purposes, a conjunction as in (i) can be interpreted as the sentential conjunction in (i'):

    (i) Many teachers *but* few students came to the party.

    (i') Many teachers came to the party *but* few students did (come to the party).

    There is little work on the syntax of conjunctions as in (i). Barwise and Cooper(1981) consider (i) to be a case of NP-conjunction (without argumentation) and propose that the right-monotonicity features of the quantifiers denoted by the NP's are responsible for the contrast between (i) and (ii) and between (ii) and (iii):

    (ii) **?** Many teachers *but* many students came to the party.

    (iii) Many teachers *and* many students came to the party.

    B&C propose that *and* NP-conjunctions require the two quantifiers in the conjunction to be of the same (increasing/decreasing) right monotonicity, whereas *but* NP-conjunctions require mixed monotonicity. We are not sure that this is the case because other factors may improve significantly a *but* conjunction without mixed monotonicity. For example:

    (iv) Many teachers *but also* many students came to the party.

    In addition, unlike B&C's observation with respect to *and* conjunctions, *but* conjunctions do preserve their acceptability in sentential conjunctions that express the same proposition. Compare (i) with (i'), (ii) with (ii'), and (iv) with (iv'):

    (ii') **?** Many teachers came to the party *but* many students did.

    (iv') Many teachers came to the party *but also* many students did.

    This might suggest that *but* is always to be analyzed as a (possibly elliptic) sentential conjunction and contrasts as the ones between (ii) and (iii) are due to the infelicity of (ii'). We leave this question open for further research.

12. We refer of course only to the contrast presupposition and not to other possible presuppositions of the conjunction.

13. This kind of examples also shows that the restriction that Lang proposes in Lang(1984), which disallows p to entail q is not necessary. Evidently, also the (less central) requirement in Lang's proposal that q does not entail p is challenged by similar cases to (26). For instance:

    (i) (The father to the doctor) John walks *but* he walks slowly.

14. Actually, the conclusion from (26) is even stronger, namely:

    (i) There should be instances of p and q s.t. $p \Rightarrow q$, $q \rightarrow r$ and still $\neg(p \rightarrow r)$.

    We prefer the more intuitive (**M**$_4$) to this quite ad-hoc looking restriction.

15. As well known, also other inferences logically valid with classical material implication are linguistically unacceptable with indicative conditionals. For example: the inferences

    (i) $\dfrac{\neg(x \rightarrow y)}{x}$

    (ii) $\dfrac{\neg(x \rightarrow y)}{\neg y}$

    are not acceptable in the following sentences:

    (iii) It is not the case that *if* John comes *then* Mary is quiet.
    a. **?** *Therefore*, John comes.
    b. **?** *Therefore*, Mary is not quiet.

16. A relevant discussion may be found in Horn(1985). Horn notices the fact that there is probably no *but* conjunction that cannot become acceptable in some specific context. There is no elaboration of this point in Horn's paper. However, one of the sentences cited by Horn (also in Horn(1989)) poses an intriguing challenge to this conjecture:

    (i) **?** John was born in Philadelphia *but* not in Boston.

    It seems as a tough sport to invent contexts in which sentences like (i) are felicitous, but let us try:

    (ii) We needed, you remember, persons who were born in Philadelphia <u>and in Boston</u>. You suggested that we may take John alone. However, my dear lad, John was born in Philadelphia *but* not in Boston.

    Under such a heavy context, our judgment is that (i) actually becomes felicitous, though still ironical for reasons on which we can only speculate.

17. Some speakers tend to accept sentences as in (26') and consider them equivalent to the *but* conjunction in (26). However, we choose not to deal with this possibility. It seems to us that if it indeed exists, it implies that restrictive members of CON^2 can be interpreted as *non*-restrictive (presumably only) when p logically entails q.

18. Both works of Francez and Meyer & van der Hoek adopt a definition for *but* within a version of two-valued modal logic. Francez defines *but* in his novel formalism of "bi-structures", which is essentially a Kripke-structure with only two possible worlds, with the difference that in a "bi-logic", satisfaction

of a formula is defined relative to the structure as a whole, and not with respect to a specific world in the structure. Meyer & van der Hoek introduce a definition for *but* within a variant of S_5 modal logic. Both papers' point of departure is to define p *but* q in a two-valued logic as equivalent (roughly) to $p \wedge q \wedge \Diamond(p \rightarrow \neg q)$, which resembles our definition for *nvs*.

However, the discussion in the previous sections shows that there are at least three central problems for this attitude with respect to its linguistic adequacy:

(a) *but* is identified with *nvs*, so only *direct* contrast is analyzed.

(b) Implication is identified with material implication with no further account of the "paradoxes" of contrast.

(c) The definition for *but* is in truth-conditional terms, which is an over-simplification of the linguistic facts.

19. The reason we use this operator to *accommodate* implicatures and not simply define $imp(\varphi)$ as the conjunction of φ's implicatures (without φ's truth conditions) is only technical and is to become clear in the following sub-section.

20. We have here some technical inelegance: A more simple operator imp could be one that returns the implicatures of a proposition, and does not accommodate them. However, in Data Logic we cannot use such an operator if we wish to guarantee that $imp(A \rightarrow B)$ is true at the same state where $(A \rightarrow B)$ is true due to the truth of $may(A \rightarrow B)$. We tried to avoid heavy changes in Veltman's formalism for such a technical reason. A formalism along the lines of Meyer & van der Hoek(1991), with explicit indices of possible worlds for the possibility operator, can resolve this inelegance.

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