

# Corpus-based Semantics of Concession: Where do Expectations Come from?

Livio Robaldo\*, Eleni Miltsakaki<sup>+</sup>, Alessia Bianchini\*

\*Department of Computer Science, University of Turin, Italy.

<sup>+</sup>Institute for Research in Cognitive Science, University of Pennsylvania, USA.  
robaldo@di.unito.it, elenimi@seas.upenn.edu, alessia.bianchini84@gmail.com

## Abstract

In this paper, we discuss our analysis and resulting new annotations of Penn Discourse Treebank (PDTB) data tagged as Concession. Concession arises whenever one of the two arguments creates an expectation, and the other ones denies it. In Natural Languages, typical discourse connectives conveying Concession are ‘but’, ‘although’, ‘nevertheless’, etc. Extending previous theoretical accounts, our corpus analysis reveals that concessive interpretations are due to different sources of expectation, each giving rise to critical inferences about the relationship of the involved eventualities. We identify four different sources of expectation: Causality, Implication, Correlation, and Implicature. The reliability of these categories is supported by a high inter-annotator agreement score, computed over a sample of one thousand tokens of explicit connectives annotated as Concession in PDTB. Following earlier work of (Hobbs, 1998) and (Davidson, 1967) notion of reification, we extend the logical account of Concession originally proposed in (Robaldo et al., 2008) to provide refined formal descriptions for the first three mentioned sources of expectations in Concessive relations.

## 1. Introduction

Progress in pushing the state of the art in major text processing areas such as information extraction, summarization, and question-answering is hindered by a lack of practical algorithms for deep semantic processing. Recent releases of richly annotated corpora will facilitate advances in the development of more sophisticated NLP technologies ((Carlson et al., 2001), (Gaizauskas et al., 2003), (Palmer et al., 2005), (Wolf et al., 2005), (Hovy et al., 2006), (Poesio and Artstein, 2008) among others). The Penn Discourse Treebank 2.0 (Prasad et al., 2008), is, to date, the largest annotation effort at the discourse level, including approximately 40,000 annotations of discourse connectives and their arguments, sense labels, and speaker attribution. Processing discourse relations in free text and deriving appropriate inferences remain one of the most challenging areas in natural language understanding. Discourse relations can be explicitly expressed by the use of connectives such as ‘because’ and ‘although’ but often they are implicit and must be inferred. Research efforts to identify discourse relations automatically using shallow features are moderately successful and are limited in their ability to infer implicit relations ((Marcu and Echiabi, 2002), (Wellner and Pustejovsky, 2007)). In order to advance performance of systems processing discourse relations in free text, deeper semantic representations are needed for the interpretation of connectives and the semantic contributions of their arguments.

In this paper, we focus on the Concessive interpretation of connectives such as ‘although’, ‘but’ and ‘nevertheless’. Concession is a particular semantic relation between the interpretation of one argument that creates an expectation and the second argument which explicitly denies it. Previous theoretical work on formalizing the semantics of Concession recognizes and analyzes two types, direct and indirect, which we will discuss in more detail in Section 2. However, for lack of groundtruth data, so far it has been hard to evaluate the validity and coverage of the proposed semantics.

With the release of the large scale annotated corpora such

as the PDTB, we are, finally, able to a) evaluate empirically previous accounts of Concession and b) develop corpus-based semantic descriptions for connectives and the relations they represent. Building on the work of (Miltsakaki et al., 2008) which gives rough semantic descriptions of all the PDTB sense labels, we analyze PDTB data labelled with Concessive sense tags. The paper makes two contributions a) we show that the distinction between direct and indirect Concession is insufficient to account for the substantially richer variety of ‘sources of expectation’, and b) using basic concepts from Hobbs’ logic framework, we offer an empirically tested account of Concessive relation triggered by different sources of expectation. This line of work is novel in developing corpus-based and empirically tested semantic descriptions for discourse relations.

The paper is organized as follows. Section 2. gives a brief overview of prior work using logic formalisms to describe the meaning of Concessive relations. Section 3. focuses on Hobbs’ logic framework and describes the concepts that we use in our proposed semantics of Concession. Section 4. reports our empirical analysis and classification of sources of expectation, using Concessive data from PDTB 2.0. This analysis motivates our proposed semantics of Concession presented in detail in section 5. and compared with closely related work in 5.1. To evaluate the reliability of the new sources of expectation, we conducted a scale annotation study. We report inter-annotator agreement and statistics on PDTB data in Section 6.

## 2. Background and related work

Studies of Concession can be traced back in the early seventies across several disciplines, including linguistics, philosophy and computer science (Lakoff, 1971), (Blakemore, 1989), (Anscombe and Ducrot, 1977), (Spooren, 1989), (Winter and Rimón, 1994), (Grote et al., 1997), (Lagerwerf, 1998), (Korbayova and Webber, 2007), and (Izutsu, 2008), among others. As is natural when the body of the literature is large and coming from different disciplines, the interpretation of Concessive relations has been addressed from sev-

eral viewpoints. Mann & Thompson’s influential Rhetorical Structure Theory (Mann and Thompson., 1988), views relations from a functional perspective and the proposed interpretations include the speaker’s intention and the effect that the relation is intended to achieve on the hearer. Following (Moore and Pollack., 1992), we find it problematic that the RST framework presumes a single relation between two discourse segments, thus conflating the *intentional* and *informational* levels of interpretation. We recognize this distinction and, here, we aim at developing semantic descriptions at the informational level, i.e., we are interested in deriving inferences that would help NLP extract knowledge from the text. In this spirit, our work extends prior work in developing formal representations of the semantics of discourse relations.

In prior work, two types of Concession are often discussed which instantiate a direct and an indirect relation between the triggered expectation and the content of the textual span that denies it (Abraham, 1991), (Winter and Rimon, 1994), (Lagerwerf, 1998), (Grote et al., 1997), (Korbyova and Webber, 2007). Let us first look at some *direct*, (1.a), and *indirect*, (1.b), examples to illustrate the distinction. In all the examples below, the connective is underlined, the argument in boldface is the one that creates the expectation, while the one in italics is the one that denies it. We refer to them as  $Arg_c$  and  $Arg_a$ , respectively.

- (1) a. Although **Greta Garbo was considered the yardstick of beauty**, *she never married*.  
 b. Although **he does not have a car**, *he has a bike*.

According to (Winter and Rimon, 1994) and other researchers, (1.a) presupposes a general rule, paraphrasable as “Beautiful women usually get married”. Because of this rule, the sentence “Great Garbo was considered the yardstick of beauty” directly triggers the expectation that she is married. This expectation is explicitly denied in  $Arg_a$ .

(1.b) is different. In this case, “not having a car” does not imply “not having a bike”. Instead, the general rule is probably “not having a car implies being less mobile”, an expectation that is indirectly denied in  $Arg_a$ , since having a bike implies being mobile. In other words, in (1.b) the contrast between expectation and denial of expectation is indirect, i.e., it involves an intermediate proposition, termed by (Lagerwerf, 1998) as ‘Tertium Comparationis’, implied by one argument while its negation is implied by the other.

How can this basic intuition on the relationship between expectation and denied expectation be formalized? (Francez, 1995) proposes bilogic which uses two semantic structures, the standard and the actual world. The contrast between the two worlds gives rise to what we characterize here as Concession and models the difference between Concession and contradiction in terms of whether the statements are evaluated in different worlds. (Winter and Rimon, 1994) agree with (Francez, 1995) on the basic intuition but propose to analyze Concession as presupposition failure. They combine presupposition failure and the possibility and necessity operators of modal logic to define the semantics of ‘restrictive’ (‘although’, ‘even though’, ‘yet’, ‘nevertheless’) and ‘non-restrictive’ connectives (‘but’).<sup>1</sup>

<sup>1</sup>Interestingly, for (Winter and Rimon, 1994), ‘although’,

Finally, (Lagerwerf, 1998) discusses cases of Concession when the defeasible rule is accessed abductively rather than deductively and the eventualities creating/denying the expectation are those associated with the *Speech Acts* of  $Arg_c$  and  $Arg_a$ . Two examples are shown in (2):

- (2) a. **Theo was not exhausted**, although *he was gasping for breath*. (Denial of Expectation - Epistemic)  
 b. **Mary loves you very much**, although *you already know that*. (Denial of Expectation - Speech Act)

In (2.a), the defeasible (causal) rule is not “gasping for breath causes being exhausted”. Rather, the directionality of the trigger of expectation is reversed: “being exhausted causes gasping for breath”. the expectation is thus created *abductively*: by observing that Theo was gasping for breath, it may be concluded that he was exhausted.

On the other hand, in (2.b) the expectation is denied by the illocution of  $Arg_a$ , i.e. its Speech Act, rather than by its locutionary meaning. It is *the fact that I tell you*  $Arg_a$ , and not  $Arg_a$  itself, that is inconsistent with the expectation, created by the defeasible rule “If (I know that) you already know something, I do not tell you it”.

In sum, so far logical accounts of Concession have mainly focused on how the expectation is denied, e.g., directly rather than indirectly. We are interested instead in how the expectation is *created*, i.e., in the “general defeasible entailment” that must hold in the context in order to trigger the expectation. In our view, characterizing such an entailment is crucial to deriving appropriate inferences.

The present paper aims at exploring this line of research with one important methodological strategy. Our goal is to develop semantic representations that are based on empirical data. We want to bridge the gap between corpus data and logic, starting from the bottom (the connectives and their semantic contribution) and building up more abstract models for deriving appropriate inferences. Using Hobbs’ logic, we argue that a general semantics of Concession is possible, which can be further refined to account for the at-tested range of sources of expectation. Specifically, four different sources are identified which allow for ‘denied expectation’ without giving rise to contradiction: **Causality, Implication, Correlation, and Implicature**.

An important question raised when discussing multiple senses is whether it is advisable to make finer semantic distinctions when even coarser ones are hard to recognize automatically. Indeed, our purpose is not to build a richer taxonomy of discourse relations (cf. (Hovy, 1990), for a comprehensive presentation of discourse relations proposed in the literature). On the other hand, if the distinctions are too coarse, it may be, actually, harder to identify features that will help identify and interpret discourse relations.

‘even though’, ‘yet’, and ‘nevertheless’ have ‘restrictive’ meaning and only ‘but’ is ‘non-restrictive’. Unfortunately, this one-to-one correspondence between semantic descriptions and connectives breaks when we look at empirical data. In PDTB, several connectives have more than one interpretation. ‘But’, for example, has been annotated with seven sense tags.

### 3. Hobbs' logic

(Hobbs, 1998) proposed a wide coverage logical framework for natural language based on the notion of reification (Davidson, 1967) (Bach, 1981). Reification allows a wide variety of complex natural language statements to be expressed in first order logic. Reification is the act of identifying eventualities (events and states), as first order constants and variables. Two parallel sets of predicates are distinguished: primed and unprimed. The unprimed predicates are standard first order logic predicates. For example, (*give a b c*) asserts that *a* gives *b* to *c* in the real world. The primed predicate represents the reified eventualities. The expression (*give' e a b c*) says that *e* is a giving event by *a* of *b* to *c*. In natural language, eventualities may be possible or actual. In Hobbs', being actual is one of their properties and is denoted by the notation (*Rexist e*). To give an example cited in Hobbs, if I want to fly, my wanting really exists, but my flying does not. This is represented as

$$(Rexist e) \wedge (want' e I e_1) \wedge (fly' e_1 I)$$

Contrary to (*p x*), (*p' e x*) does not say that *e* actually occurs, only that if it did, it would be a "p" event. The relation between primed and unprimed predicates is formalized by the following axiom:

$$(forall (x) (iff (p x) (exists(e) (and (p' e x)(Rexist e))))))$$

Eventualities can be treated as the objects of human thoughts. Reified eventualities are inserted as parameters of such predicates as *believe*, *think*, *want*, etc. These predicates can be recursively applied. The fact that *John believes that Jack wants to eat an ice cream* is represented as an eventuality *e s.t.*<sup>2</sup>

$$(believe' e John e_1) \wedge (want' e_1 Jack e_2) \wedge \\ (eat' e_2 Jack Ic) \wedge (iceCream' e_3 Ic)$$

Every relation on eventualities, including logical operators, causal and temporal relations, and even tense and aspect, may be reified into another eventuality. For instance, by asserting (*imply' e e\_1 e\_2*), we reify the implication from *e\_1* to *e\_2* into an eventuality *e* and *e* is, then, thought as 'the state holding between *e\_1* and *e\_2* such that whenever *e\_1* really exists, *e\_2* really exists too'. On the other hand, negation is represented as (*not' e\_1 e\_2*): *e\_1* is the eventuality of the *e\_2*'s not existing. The predicates *imply'* and *not'* allow Hobbs to model the concept of "inconsistency". In Section 5.1., we show how this concept can be used in defining the semantics of Concession. Two eventualities *e\_1* and *e\_2* are said to be inconsistent iff they respectively imply two other eventualities *e\_3* and *e\_4* such that *e\_3* is the negation of *e\_4*:

$$(3) (forall (e_1 e_3) \\ (iff (inconsistent e_1 e_2) \\ (and (eventuality e_1) (eventuality e_2) \\ (exists (e_3 e_4) (and (imply e_1 e_3) \\ (imply e_2 e_4)(not' e_3 e_4)))))))$$

<sup>2</sup>The formula expresses the de-re reading of the sentence, where *e\_1*, *e\_2*, *e\_3*, *John*, *Jack*, *Ic* are first order constants.

#### 3.1. Typical elements, eventuality types and tokens

Among the things we can think about are both specific eventualities, like *Fido is barking*, and general or abstract types of eventualities, like *Dogs bark*. We do not want to treat these as radically different kinds of entities. We would like both, at some level, to be treated simply as eventualities that can be the content of thoughts. To this end, the logical framework includes the notion of typical element (from (Hobbs, 1995), (Hobbs, 1998)). The typical element of a set is the reification of the universally quantified variable ranging over the elements of the set (cf. (McCarthy, 1977)). Typical elements are first-order individuals. The introduction of typical elements arises from the need to move from the standard set theoretic notation

$$(forall (x) (iff (member x s) (p x)))$$

to a simple statement that *p* is true of a "typical element" of *s* by reifying typical elements. The principal property of typical elements is that all properties of typical elements are inherited by the real members of the set.

It is important not to confuse the concept of typical element with the standard concept of "prototype", which allows defeasibility, i.e., properties that are not inherited by all of the real members of the set. Asserting a predicate on a typical element of a set is logically equivalent to the multiple assertions of that predicate on all elements of the set. Talking about typical elements of sets of eventualities leads to the distinction between eventuality types and eventuality tokens. The logic defines the following concepts, for which we omit formal details<sup>3</sup>: a) *Eventualities types* (aka *abstract eventualities*): eventualities that involve at least one typical element among their arguments or arguments of their arguments (we can call these "parameters"), b) *Partially instantiated eventuality types* (aka *partial instances*): a particular kind of eventuality type resulting from instantiating some of the parameters of the abstract eventuality either with real members of their sets or with typical elements of subsets, and c) *Eventuality tokens* (aka *instances*): a particular kind of partially instantiated eventuality type with no parameters. It is a consequence of universal instantiation that any property that holds of an eventuality type is true of any partial instance of it.

#### 3.2. Defeasible entailment, causality, and likelihood

The concept of reification used in Hobbs' logic is particularly suitable to the study of the semantics of discourse connectives, in that it allows focusing on their meaning while leaving underspecified the details about the eventualities involved. In other words, we can simply assume the existence of two eventualities *e\_1* and *e\_2*, coming from the two arguments  $Arg_c$  and  $Arg_d$  respectively, and defining the semantics of the connectives on them.

In what follows, we will briefly illustrate three basic concepts from Hobbs' logic that we use in the semantics of Concession: *Defeasibility*, *Causality*, and *Likelihood*.

**Defeasibility:** Most of our everyday knowledge is non-monotonic, i.e., only approximately correct. It is defea-

<sup>3</sup>Actually, "instance" is a more general term. In this paper we assume it to be synonymous of "eventuality token".

sible, in that we can draw a conclusion which can be defeated in the light of new information. For example, knowing that birds fly allows us to infer that if Tweety is a bird, then Tweety can fly. This conclusion will be defeated later when we learn that Tweety is actually a penguin and therefore does not fly. Hobbs, following (McCarthy, 1980), models commonsense implication via monotonic implication (meta-operator *if*), but allows for defeasibility via the introduction of the underspecified predicate *etc* in the antecedent of the implication.

$$(4) \quad (\text{forall } (x) (\text{if } (\text{and } (\text{bird } x) (\text{etc})) (\text{fly } x)))$$

The achieved interpretation is that the implication holds if the antecedent is evaluated in “normal” situation. The formula above says that if  $x$  is a bird and  $x$  has other unspecified properties encoded as *etc* (i.e.,  $x$ 's wings are robust enough), then  $x$  can fly. There are a number of ways the *etc* predicate can enter into the inference process.

The high degree of flexibility of the logic allows us to define a meta-predicate *nonMonotonicIf* that holds between two eventualities  $e_1$  and  $e_2$  and that is true iff  $e_1$  defeasibly implies  $e_2$ . According to the definition in (5), an eventuality  $e_1$  defeasibly implies  $e_2$  iff for each sub-eventuality of  $e_1$  there is a sub-eventuality of  $e_2$  for which the formula in (4) holds.  $P_1$  and  $P_2$  are the predicates indicating the types of the eventualities  $e_1$  and  $e_2$  respectively.

$$(5) \quad (\text{forall } (e_1 e_2) \\ (\text{iff } (\text{nonMonotonicIf } e_1 e_2) \\ (\text{forall } (e'_1) \\ (\text{if } (\text{partialInstance } e'_1 e_1) \\ (\text{forall } (x) \\ (\text{if } (\text{and } (P_1 e'_1 x) (\text{etc})) \\ (\text{exists } (e'_2) \\ (\text{and } (\text{partialInstance } e'_2 e_2) \\ (P_2 e'_2 x))))))))))$$

**Causality:** Besides defeasible implication, Hobbs' logic also adopts a defeasible account of causality, originally proposed in (Hobbs, 2005). This distinguishes between the monotonic notion of “causal complex” and the non-monotonic, defeasible notion of “cause”. As (Hobbs, 2005) explains, when we flip a switch to turn on a light, we say that flipping the switch “caused” the light to turn on. But for this to happen, many other factors need to be satisfied: the bulb is good, the switch is connected to the bulb, there is power in the city, etc. The set of all the states and events that are necessary for the event  $e$  to take place as a result, are called the “causal complex” of  $e$ . In a causal complex, the majority of participating eventualities are normally true and therefore presumed to hold. In the light bulb case, it is normally true that the bulb is not burnt out, the wiring is in good condition and the power is on, so the conditions are presumed to hold. What cannot be presumed to hold is whether the switch is on or off. Eventualities that are not assumed to be true under normal contexts are commonly identified as causes (Kayser and Nouioua, 2009).

Based on these ontological grounds, Hobbs represents causality in terms of two predicates: (*cause' c e<sub>1</sub> e<sub>2</sub>*) and (*causalComplex s e<sub>2</sub>*). *cause'* says that  $c$  is the state

holding between  $e_1$  and  $e_2$  such that the former is a non-presumable cause of the latter. *causalComplex* says that  $s$  is the set of all presumable or non-presumable eventualities that are involved in causing  $e_2$ , including  $e_1$ . To preserve defeasibility, we need an axiom stating that the consequence really exists just in case all the eventualities in its causal complex really exist:

$$(\text{forall } (s e) \\ (\text{if } (\text{and } (\text{causalComplex } s e) \\ (\text{forall } (e_1) (\text{if } (\text{member } e_1 s) (\text{Rexist } e_1))) \\ (\text{Rexist } e)))$$

**Likelihood:** In Hobbs' logic, whether an eventuality exists in the real world or not is a property of the eventuality. Eventualities that exist in the real world are represented with the predicate *Rexist*. Real existence is one of several modes of existence. The eventuality could be part of someone's beliefs but not occur in the real world. It could be merely possible or likely but not real. It could, also, be unlikely or impossible. Possibility is one common judgment we make about eventualities in situations of uncertainty. Likelihood is intended as the commonsense notion of the mathematical version of probability. Likelihood is a qualitative notion intended to model the vague probability judgements we make in everyday life, as when we say that it's likely to rain or that the train may be late.

Likelihoods are members of a partially ordered *scale* of likelihoods. For Hobbs, such a scale  $s$  satisfies the predicate (*likelihoodScale s*). Likelihood is with respect to an implicit set of constraints defining the sample space. (*likelihood d e c*) asserts that  $d$  is the likelihood of  $e$ 's really existing, whenever the set of eventualities in  $c$  really exist. We say that a certain eventuality  $e$  is “likely” when a set of eventualities  $c$  holds, iff the likelihood of  $e$  given  $c$  is a qualitative value within the highest part of the contextually relevant likelihood scale.

$$(\text{forall } (e c) \\ (\text{iff } (\text{likely } e c) \\ (\text{exists } (s d s_1) \\ (\text{likelihood } d e c) (\text{likelihoodScale } s) \\ (\text{belong } d s_1) (\text{high } s_1 s))))$$

Likelihood is connected to other modalities via additional axioms. If the likelihood of an eventuality  $e$  with constraints  $c$  is the top of the likelihood scale, then  $e$  is *necessary* given  $c$ , i.e., it is implied from the latter. If the likelihood of  $e$  is the bottom of the likelihood scale, then it is *not possible* given  $c$ .

In the next section, we use the above definitions of causality, defeasibility and likelihood to define the semantics of Concession and the different sources of expectation that we identified in our analysis of concessive tokens in the PDTB.

#### 4. Sources of Expectation in PDTB

Concession arises whenever one of the two arguments creates an expectation, and the other ones denies it. Previous approaches are vague about what the verb ‘creates’ means here, i.e., what relation holds between the first argument and the expectation. By analyzing PDTB data, we identified four different sources: **Causality**, (non-

monotonic) **Implication, Correlation, and Implicature.** In (6) we show four constructed examples used for explanation, while in (7) are four corresponding PDTB tokens.

- (6) a. Although John studied hard, *he did not pass the exam.*  
(Causality)
- b. *Penguins are birds.* Nevertheless, they do not fly.  
(Implication)
- c. *John will finish his report,* but he'll do it at home.  
(Correlation)
- d. Although John ate a lot of pizza, *he did not eat it all.*  
(Implicature)
- (7) a. **This meeting “put in motion” procedural steps that would speed up both of these functions.** But no specific decisions were taken on either matter. (Causality)
- b. Although working for U.S. intelligence, *Mr. Noriega was hardly helping the U.S. exclusively.* (Implication)
- c. *The Treasury will raise 10 billion in fresh cash by selling 30 billion of securities [...].* But rather than sell new 30-year bonds, the Treasury will issue 10 billion of 29 year, nine-month bonds. (Correlation)
- d. Although it is not the first company to produce the thinner drives, *it is the first with an 80-megabyte drive.* (Implicature)

In (6.a), “studying hard” (defeasibly) causes “passing exams”. However, that is not true in the case of John, who failed his exam despite studying hard. Similar considerations hold in (7.a), where “the procedural steps triggered by the meeting” (defeasibly) causes “taking important decisions in both of these functions”.

The examples in (6.b) and (7.b) involve non-monotonic Implication rather than Causality. (6.b) is obvious. In (7.b), it is strange to say that *working for U.S. intelligence* normally “causes” *helping U.S. exclusively*. Rather, the latter seems to be a property or condition for working for U.S. intelligence. In other words, *working for U.S. intelligence* implies (among other things) *helping U.S. exclusively* in the same way that being a bird implies flying.

In (6.c) and (7.c), a third kind of relation seems to be involved between  $\text{Arg}_c$  and the expectation. The latter *usually* occurs whenever the eventuality denoted by the former occurs. For instance, it is likely that John will do the report in the office, on the basis that he *usually* does his reports when he is in his office. However, on this occasion this expectation does not materialize as John will finish the report at home. Similarly, in (7.b), a possible interpretation is that the Treasury usually raises money by selling new 30-year bonds, whereas on this occasion, it decided to adopt a different strategy.

Finally, (6.d) and (7.d) do not appear to fall in neither one of the three categories, nor does it seem that the expectation is identified on semantic grounds only. Rather, it seems that the argument is insufficient/non-relevant with respect to the satisfaction of speakers intentions, i.e., communicating the hearer that there is some pizza left. We suspect that (6.d) involves violation of a Gricean Maxim. Similarly, in (7.d),  $\text{Arg}_c$  does not really create any expectation that is inconsistent with  $\text{Arg}_d$ . Rather, the latter explains the property of drivers that is really worth noticing in the context of (7.d).

## 5. A better semantics of Concession

Hobbs’ logic allows us to build logical representations for discourse interpretations that are simple to use for deciding what inferences are allowed. For example, in our proposed logical account for Causality, non-monotonic Implication and Correlation shown in (8), (9) and (10) respectively, the reified predicates *cause'*, *nonMonotonicIf'*, and *likely'* are a straightforward representation on which we can build the inferences that are licensed in each case. We show under the formulae the eventualities identified for (6.a-c). A proper logical account of the Implicature case is considered as the object of future work.

- (8)  $(\text{exist } (c_c^a c_c e_c e_e e_d)$   
 $(\text{Rexist } c_c^a) \wedge (\text{partialInstance } c_c c_c^a) \wedge$   
 $(\text{cause}' c_c e_c e_e) \wedge$   
 $(\text{Rexist } c_c) \wedge (\text{Rexist } e_c) \wedge (\text{Rexist } e_d) \wedge$   
 $(\text{inconsistent } e_e e_d))$
- $e_c = \text{“John studied hard”}$   
 $c_c^a = \text{“Studying hard causes passing exams”}$   
 $e_e = \text{“John passed the exam”}$   
 $e_d = \text{“John did not pass the exam”}$

$c_c^a$  is a general causal rule that holds in the context and instantiates in a contingent causal rule holding between  $e_c$  and  $e_e$ . The latter is inconsistent with  $e_d$ , which directly comes from  $\text{Arg}_d$ . The semantics of Implication and Correlation shown in (9) and (10) differs only in the general rule, which in these cases indicates a non-monotonic Implication and a likely trend respectively, rather than Causality.

- (9)  $(\text{exist } (i_c^a i_c e_c e_e e_d)$   
 $(\text{Rexist } i_c^a) \wedge (\text{partialInstance } i_c i_c^a) \wedge$   
 $(\text{nonMonotonicIf}' i_c e_c e_e) \wedge$   
 $(\text{Rexist } i_c) \wedge (\text{Rexist } e_c) \wedge (\text{Rexist } e_d) \wedge$   
 $(\text{inconsistent } e_e e_d))$
- $e_c = \text{“Penguins are birds”}$   
 $i_c^a = \text{“Birds fly”}$   
 $e_e = \text{“Penguins fly”}$   
 $e_d = \text{“Penguins do not fly”}$

- (10)  $(\text{exist } (l_c^a l_c e_c e_e e_d)$   
 $(\text{Rexist } l_c^a) \wedge (\text{partialInstance } l_c l_c^a) \wedge$   
 $(\text{likely}' l_c e_c e_e) \wedge$   
 $(\text{Rexist } l_c) \wedge (\text{Rexist } e_c) \wedge (\text{Rexist } e_d) \wedge$   
 $(\text{inconsistent } e_e e_d))$
- $e_c = \text{“John will do his report”}$   
 $l_c^a = \text{“John does not usually do his reports at home”}$   
 $e_e = \text{“John will not do his report at home”}$   
 $e_d = \text{“John will do his report at home”}$

Thus, (9) encodes that “birds fly” ( $i_c^a \equiv i_c$ ) is presupposed. Nevertheless, the rule is defeasible: knowing that “penguins are birds” ( $e_c$ , denoted by  $\text{Arg}_c$ ) does not ensure they fly ( $e_e$ ).  $\text{Arg}_d$  states precisely the opposite ( $e_d$ ).

Analogously, in case of formula (10), what creates the expectation is the previous history about similar eventualities. It is then assumed that “when John has a report to do, he does not usually do it at home” ( $l_d^a$ ). This partially instantiates in “John will not likely do the *present* report at home” ( $e_e$ ). But that is inconsistent with  $e_d$ , denoted by  $\text{Arg}_d$ .

### 5.1. Comparison with related work

Our proposal seems to be the proper generalization of the previous approaches to Concession mentioned in the Section 2. The predicate *inconsistent* defined in (3) deals with direct as well as indirect Concession in a straightforward, intuitive way. This is in line with the approach of (Winter and Rimon, 1994) who classify connectives as *restrictive* and *non-restrictive*, the latter being a particular case of the former, according to their ability to induce direct and indirect Concession respectively.

(Winter and Rimon, 1994) formalize their framework in Veltman’s Data Logic (DL) (Veltman, 1986), a particular modal logic where possible worlds are modeled as *information states*. (Winter and Rimon, 1994) introduce two operators ‘ $\rightarrow$ ’ and ‘ $\Rightarrow$ ’ to model commonsense implication and standard logical implication respectively. In practice, ‘ $\rightarrow$ ’ subsumes the predicates *cause*, *nonMonotonicIf* and *likely* of Hobbs’ logic, while ‘ $\Rightarrow$ ’ corresponds to *imply*. In Winter and Rimon, Concession is modeled by the implications ‘ $e_1 \rightarrow e_3$ ’ and ‘ $e_1 \rightarrow (\text{not } e_3)$ ’, where  $e_1$  and  $e_2$  are the eventualities associated with the two arguments, and  $e_3$  is the expectation, implied by the former but whose negation is implied by the latter. However, ‘ $\rightarrow$ ’ is not defeasible. Therefore, the two implications cannot hold in a state of information where both  $e_1$  and  $e_2$  hold, or the two opposite consequents would hold. To avoid such an inconsistency, in (Winter and Rimon, 1994) only ‘ $e_1 \rightarrow e_3$ ’ holds in the current state of information, while ‘ $e_1 \rightarrow (\text{not } e_3)$ ’ holds in a *previous* state of information, but not in the current one. Winter and Rimon, also, acknowledge that some cases are actually problematic for their account, for instance:

(11) *John walks slowly. But he walks.*

Suppose (11) is uttered in a context where John had a surgical operation.  $e_1$  may be taken as the eventuality ‘John walks slowly’,  $e_2$  as ‘John walks’, and  $e_3$  as the expectation ‘the operation was a success’. Note, however, that ‘John walks slowly’ is clearly a particular case of ‘John walks’ ( $e_1 \Rightarrow e_2$  holds). From this we infer ‘ $e_1 \rightarrow e_3$ ’ in the current state of information, i.e., that ‘John walks slowly’ implies ‘the operation was a success’, which is clearly not the case. In our proposed semantics, this problem does not arise, in that *cause*, *nonMonotonicIf*, and *likely* are defeasible, and so not all properties asserted on an abstract eventuality are inherited by all its partial instances.

More generally, the fact that ‘ $e_1 \rightarrow (\text{not } e_3)$ ’ is false in the current state of information seems to be in contrast with linguistic intuition. For instance, the proposition “the fact that the patient of an operation walks slowly causes/implies/co-occurs with the fact that the operation was unsuccessful” seems to hold even in states of information where an operation is assumed to be a success although the patient walks slowly. Analogously, in (6.a), it seems that “hard studying

causes passing exams” is true even in contexts where some student failed despite having studied hard. In (Winter and Rimon, 1994), the non-defeasibility of ‘ $\rightarrow$ ’ does not allow for such default assertions.

Furthermore, in our approach the cases of Concession studied by (Lagerwerf, 1998) are also unproblematic. To be more specific, following (Sweetser, 1990), (Lagerwerf, 1998)’s cases of ‘Epistemic Denial of Expectation’ involve arriving at the defeasible expectation abductively. In ‘Speech Act Denial of Expectation’ the concessive relation holds between the illocution of at least one of the arguments. We repeat examples (2) here for convenience.

(12) a. **Theo was not exhausted, although he was gasping for breath.** (Denial of Expectation - Epistemic)

b. **Mary loves you very much, although you already know that.** (Denial of Expectation - Speech Act)

In (12.a), the expectation is created *abductively*, i.e., by observing that Theo was gasping for breath, it may be concluded that he was exhausted.

(Lagerwerf, 1998) proposes the following formalization in Predicate Logic:

$$\forall_x [Gfb(x) > \mathbf{B}(i, Exh(x))]$$

where *Gfb* and *Exh* are predicates denoting, respectively, the set of individuals gasping for breath and the exhausted ones.  $\mathbf{B}(y, \Phi)$  is an epistemic operator asserting that  $y$  believes  $\Phi$ ,  $i$  refers to the speaker, and  $>$  is the defeasible implication operator defined in (Asher and Morreau, 1991). Lagerwerf’s intuition is correct, but the proposed formalization seems to deviate from the heart of the intuition. Firstly, it is somehow odd to assert that *the speaker* believes someone to be exhausted given that he is gasping for breath. The defeasible rule is general and therefore does not apply specifically to any particular speaker. Therefore, in the formalization,  $i$  should be most properly substituted by a universal quantification over all possible believers.

Secondly, Causality (as well as non-monotonic Implication and Correlation) is a defeasible rule both in cases it is arrived at *deductively*, as in example (8), and in cases it is arrived at *abductively*. If should be asserted that the speaker believes the causes when he or she observes the effects, it should, also, be asserted that he or she believes the effects when he observes the causes. (Lagerwerf, 1998)’s intuition must be formalized exactly as it is stated: the defeasible causal rule is “being exhausted causes gasping for breath”, and it yields the expectation *abductively*. Thus, the formula associated with (12.a) is the one in (13); the only difference with respect to the formula in (8) is the assertion of the conjunct (*cause*’  $c_c e_e e_c$ ) in place of (*cause*’  $c_c e_c e_e$ ).

$$(13) \quad (\text{exist } (c_c^a c_c e_c e_e e_d) \\ (\text{Rexist } c_c^a) \wedge (\text{partialInstance } c_c c_c^a) \wedge \\ (\text{cause}' c_c e_e e_c) \wedge \\ (\text{Rexist } c_c) \wedge (\text{Rexist } e_c) \wedge (\text{Rexist } e_d) \wedge \\ (\text{inconsistent } e_e e_d))$$

$e_c$  = “Theo was gasping for breath”

$c_c^a$  = “Being exhausted causes gasping for breath”

Sem Type	Although	But	Total
Causality	65	248	416
Implication	45	125	287
Correlation	31	87	194
Implicature	13	48	103

Table 2: Distribution of the four sources of Concession.

$e_e$  = “Theo was exhausted”

$e_d$  = “Theo was not exhausted”

On the other hand, in (12.b) the expectation is denied by the illocution of  $\text{Arg}_d$ , i.e., its Speech Act, rather than by its locutionary meaning. It is *the fact that I tell you*  $\text{Arg}_d$ , and not  $\text{Arg}_d$  itself, that is inconsistent with the expectation, created by the defeasible rule “If I know that you already know something, I do not tell you it”.

The formalization of such cases does not raise particular problems in our approach and so we omit it. Consistent with Hobbs’s logic, the Speech Act of an eventuality is simply reified into a new eventuality, and the defeasible rules are asserted on the latter.

## 6. Inter-annotator agreement and PDTB statistics

PDTB 2.0 includes 1193 tokens of *explicit* connectives which are annotated as “Concession” or its subtypes “contra-expectation”, when the argument that syntactically contains the connective denies an expectation, and “expectation”, when this argument triggers an expectation<sup>4</sup>.

Table 1 shows the distribution of Concessive labels for the 1193 tokens. Explicit connectives with a Concessive label assigned to less than 10 tokens are grouped under “other”. The rest of the connectives amount to 98% of all “contra-expectation” and 95% of all “expectation” tokens. The most common concessive connective is “but” with 508 tokens (42% of all concessive labels), followed by “although” with 154 tokens (13% of all concessive labels).

We conducted an empirical analysis on 1000 of those tokens, which have been annotated independently by two annotators. Table 2 shows the distribution of the data according to the four sources of Concession identified above. The most common source of expectation comes from causal relations (41.6%), followed by Implication (28.7%), Correlation (19.4%) and Implicature (10.3%) of the data.

The kappa statistic yielded 0.8 agreement, which is within the range generally accepted as an indicator of substantial inter-annotator reliability. The formula has been calculated as follows.  $Pr(a)$  is the percentage of agreement (85% of the 1000 cases considered) while the percentage of each tag, i.e.  $Pr(e)$ , is equal to 25%, as there are four possible sources of Concession.

$$(14) \quad k = \frac{Pr(a) - Pr(e)}{1 - Pr(e)} = \frac{0.85 - 0.25}{1 - 0.25} = 0.8$$

The good kappa score suggests that the categories can be identified reliably and can, thus, be taken as an indication that the categories are real.

<sup>4</sup>A full description of the sense tags used in the PDTB is given in (Prasad et al., 2008) and (Miltsakaki et al., 2008).

## 7. Conclusion

In this paper, we analyzed Concessive data from PDTB 2.0. We found that previous semantic accounts of Concession that recognize two types of Concessive relations are insufficient for recognizing the full range of Concessive relations in real data. We identified four sources of expectation that give rise to concessive relations: Causality, Implication, Correlation and Implicature. The reliability of these categories is supported by a good kappa score on an inter-annotator agreement study with two annotators. Using basic concepts from Hobbs’ logic framework, we propose a corpus-based formal semantic representations for the range of Concessive relations attested in the corpus. The purpose for refining the semantics of concessive relations is to enable deriving useful inferences on causal and other contingency relations holding between events that may not be explicitly asserted in free text.

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CONN	“contra-exp.”	“exp.”	“Concession”	Total
although	21	132	1	154 (13%)
but	494	12	2	508 (42.5%)
even if	3	31	1	35 (3%)
even though	15	52	5	72 (6%)
however	70	2	5	77 (6.5%)
nevertheless	19	0	0	19 (1.5%)
nonetheless	17	0	0	17 (1.5%)
still	79	2	1	82 (7%)
though	30	53	1	84 (7%)
while	3	79	1	83 (7%)
yet	32	0	0	32 (2.5%)
other	13	17	0	30 (2.5%)
Total	796	380	17	1193

Table 1: Concessive labels in PDTB 2.0

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