Probabilistic Discourse Markers

Abduction and Adversative Conjunctions

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Summary

- In some circumstances, it is possible to contrast a content A with either a content B or $\neg B$:

(1) a. Lemmy plays the bass, but Ritchie does too.
    b. Lemmy plays the bass, but Ritchie does not.

- A probabilistic account of linguistic **argumentation** can account for this observation by appealing to different (default) pivot inferences involved in the interpretation of the connective **but**, but does not predict any difference between (1-a) and (1-b).
- I consider how to approach the abduction process of the pivot, which captures the fact that some pivot inferences are preferred to others and which predicts that (1-b) might be easier to process than (1-a) (hence preferred).

What is an argument?

Most treatments of argumentation (e.g. in philosophy, AI, psychology or linguistics) agree on the following:

- An argument is an attempt to **persuade** an agent
- An argument targets a **conclusion** (a **goal**)
- An argument is potentially **defeasible**, i.e. arguments can:
  - be compared
  - undercut, refute, undermine each other

  ⇒ an argument has a given **strength** in favor of its conclusion

What is a good argument?

- **Classical view**: a good argument is **(logically) valid**
  - it is an acceptable form of deduction or induction
  - it avoids fallacies and non-valid reasoning
- **Practical view**: an argument is as good as it is **persuasive**.
- In Bayesian terms: a good argument **raises the degree of belief** in its conclusion.
- This can be achieved in any way, as long as it is effective.
  - Hahn & Oaksford (2007): fallacies such as the argument from ignorance or the *petitio principii* can prove quite convincing in the right situation.

Probabilistic Argumentation

- An utterance of content p is an (positive) argument for a conclusion H iff $P(H|p) > P(H)$.
  - P is interpreted as a measure of degree of belief of the interpreter, in usual Bayesian fashion.
- The strength of an argument can be measured by a variety of means (Merin, 1999; van Rooij, 2004):
  - A usual measure is **relevance** (not the same as in Relevance Theory (Sperber & Wilson, 1986; Merin, 1999)).
  - p is an argument for H iff $r(p, H) > 0$, the higher $r(p, H)$ the better the argument.
  - If $r(p, H)$ is negative, then p is a **counter-argument** for H.
- The Bayesian treatment of argumentation might appear rather trivial for a linguist:
  - Everything is handled by the **update mechanism**, captured via **conditionalization**, supposing that priors and joint probability distributions are known.
  - Argumentation might just be some **side effect** of the more general probabilistic take on meaning; linguistics have little to say in the matter.

Linguistic Argumentation

- Anscombre & Ducrot (1983) fostered an argumentative approach to discourse:

  > *The argumentative possibilities in a discourse are tied to the global linguistic structure of the utterances and* ***not just to the content they convey****.*

- (2-a) and (2-b) have the same informational content, but (2-a) is a better argument for selling a broadband plan:

(2) a. Starting at only 29.9$ a month!
    b. At least 29.9$ a month!

- **Hypothesis**: the semantic contribution of some linguistic items is best described in argumentative terms.
  - The description of those items can be done in probabilistic terms (Merin, 1999).

Two levels of Bayesianism

- Argumentation uses two kinds of Bayesianism:
  1. **Probabilistic semantics**: utterances update degrees of belief.
  2. **Bayesian interpretation**: by reasoning on probabilistic update, the most likely argumentative goal is found. Linguistic cues constrain the space of possibilities for the argumentative goal.
- A basic tenet of argumentation is that two utterances with the same truth-conditional content can argue differently (cf. (2-a) vs. (2-b)).
- How to reconcile this with the update mechanism?
- By doing two things:
  1. Describe the general **mechanism** of argumentative interpretation
  2. Describe the **argumentative constraints** encoded by some linguistic expressions

Adversative conjunctions: background

- The meaning of adversative connectives like **but** is often described in terms of **contrast** (Lakoff, 1971).
- **Inferential** approaches consider that the semantics of **but** always involve some kind of inference that is "disputed" by its conjuncts (Anscombre & Ducrot, 1977; Winterstein, 2012).

(3) a. Lemmy smokes, but is in very good health.
    b. Lemmy is tall, but Lars is short.

- This **pivot** inference has different status:
  - **Relevance theory**: an assumption made **accessible** by the first conjunct (Blakemore, 2002).
  - **LDRT**: an inference of the same type as **particularized implicatures** (Spenader & Maier, 2009).
  - **Argumentation**: cf. infra.

The argumentative meaning of **but**

- Anscombre & Ducrot (1977): an utterance "p **but** q" is such that:
  - p argues for a conclusion H
  - q argues against H, i.e. for $\neg H$
  - q must be a better argument for $\neg H$ than p is for H (this can be dropped, van Rooij (2004))
- In probabilistic terms:
  - $r(p, H) > 0$
  - $r(q, H) < 0$
  - $|r(q, H)| > |r(p, H)|$
- **Example**:

(4) This car is nice but expensive.

  - $H =$ *We should buy the car*
  - p makes H more probable
  - q makes H less probable and "wins" over p: the speaker will (probably) not buy the car after uttering (4).

Core examples

(1) a. Lemmy plays the bass, but Ritchie does too.
    b. Lemmy plays the bass, but Ritchie does not.

- **Puzzle**: how can both q and $\neg q$ contrast with p?
- Two kind of approaches to **but**:
  - **Non-inferential** (contrastive) ones (Sæbø, 2003; Umbach, 2005)
  - **Inferential ones** (Blakemore, 2002; Spenader & Maier, 2009; Anscombre & Ducrot, 1977; Winterstein, 2012).

Non-inferential approaches

(1) a. Lemmy plays the bass, but Ritchie does too.
b. Lemmy plays the bass, but Ritchie does not.

- Non-inferential approaches assume that **but** requires conjuncts such that second one negates an "alternative" to the first one, where *a* and *b* are alternatives if:

> *[. . .] inter alia: a gives reason to assume b, a and b pull in the same direction in some respect, both a and b are good, or bad.* *(Sæbø, 2003)*

- This entails that if *b* is an alternative to *a*, it is difficult to conceive $\neg b$ as another alternative to *a*.
- Furthermore, those approaches analyze additives such as **too** in (1) in dual terms, i.e. that the second conjunct asserts the truth of an alternative to the first one, which contradicts the semantics of **but** (Sæbø, 2003).

Inferential approaches

(1) a. Lemmy plays the bass, but Ritchie does too.
 b. Lemmy plays the bass, but Ritchie does not.

- Inferential approaches postulate a pivot inference.
- An analysis of the pivot as an implicature is problematic
  - it assumes that contradictory implicatures can be drawn out of the blue from the same utterance
  - not all implicatures work as pivots, i.e. **quantity implicatures**:

    (5) #Lemmy ate some of the cookies, but all of them.

- **Relevance Theory**: the pivot needs to be **accessible**. Contradictory elements can be made accessible by the same utterance.
- This also predicts than in (5) the quantity implicature of the first conjunct should be able to serve as pivot since it is accessible (Carston, 1998).

Taking stock

(1) a. Lemmy plays the bass, but Ritchie does too.
    b. Lemmy plays the bass, but Ritchie does not.

- The reviewed approaches have a problem with (1)
  - Contrastive approaches are too restrictive and do not predict that both versions are possible
  - Most inferential approaches are too permissive and predict that "anything" should be possible.

⇒ the probabilistic argumentative approach provides the right amount of leeway to deal with these.

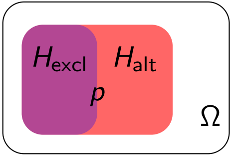
Context and Abduction

- To interpret an occurrence of the connective **but**, it is necessary to determine the pivot inference H (the **goal**).
- Goals are determined via a Bayesian process of **abduction**:
    - **Assumption**: the higher the posterior, the more accessible the goal
    - if $P(S|H_i) \times P(H_i) > P(S|H_j) \times P(H_j)$, then H_i is more likely to be targeted by the speaker than H_j ($S =$ the signal sent by the speaker)
- Where does $\mathcal{G}_S = \{H|r(S,H) > 0\}$, the set of potential goals associated with S, come from?
    - For A&D this is not a question for linguistics but only a matter of world-knowledge and lexical semantics (e.g. *hungry* $\underset{arg}{\rightsquigarrow}$ *eat*)
    - Formally, the set of goals whose probability is affected by an assertion is potentially **infinite**.
    - **Hypothesis**: context, purely probabilistic effects, and discursive cues such as information structure define the contents of $\mathcal{G}_S$ (Winterstein, 2010, 2012).

Potential goals

(6) Lemmy plays the bass.

- The set of **potential goals** of (6) is $\mathcal{G}_p = \{H | r(p, H) > 0\}$.
- Some elements of $\mathcal{G}_p$ are **context dependent**.
- Others are **"mechanically" present**, notably:
  - H_{excl} = *Lemmy is the only one who plays the bass*
  - H_{alt} = *Lemmy is not the only one who plays the bass*



- Even though H_{alt} and H_{excl} are contradictory, they both are potential goals for p.
- They are compatible pivots for (1-a) and (1-b).

(1) a. Lemmy plays the bass, but Ritchie does too. (H_{excl})
b. Lemmy plays the bass, but Ritchie does not. (H_{alt})

Abduction of the goal

(1) a. Lemmy plays the bass, but Ritchie does too. (H_{excl})
b. Lemmy plays the bass, but Ritchie does not. (H_{alt})

- H_{alt} and H_{excl} both satisfy the constraint imposed by **but** in (1-a) and (1-b) which explains why both are acceptable.
- However, (1-a) is felt to be more marked by some speakers, and is not possible in all languages (e.g. Cantonese **daan6hai6** does not seem to allow it).

⇒ H_{alt} in (1-b) is more accessible than H_{excl} in (1-a).

Abduction: optimal goal

- The abduction process seeks to select a goal (or set of probable goals) H_{opt} given a signal S.
- Notations:
  - $\mathfrak{S}$: a speech act of content S
  - $\mathcal{G}_S$: set of possible goals associated with S, i.e. $\mathcal{G}_S = \{H | \, rel(S, H) > 0\}$
- Bayes formula: $P(H|\mathfrak{S}) = \frac{P(\mathfrak{S}|H) \times P(H)}{P(\mathfrak{S})}$
- The goal(s) we are looking for is/are:

(7) $$H_{\text{opt}} = \underset{H_i \in \mathcal{G}_S}{argmax} \, (P(\mathfrak{S}|H_i) \times P(H_i))$$

Abduction: example

(8) a. **A**: What do you want to do?
b. **B**: I'm hungry.

- **A**'s question opens a set of possible answers for **B**: $\mathcal{G}_B = \{$*I want to eat, I want to sleep, . . .*$\}$
- **B**'s answer is not congruent, but helps determine $H_{\text{opt}} \in \mathcal{G}_B$ which corresponds to the answer intended by **B**.
- Here $P(\mathfrak{B}|H_{\text{eat}})$ is very high: it is very likely that **B** answers (8-b) because she wants to eat (much more likely than any other element in $\mathcal{G}_B$), hence $H_{\text{opt}} = H_{\text{eat}}$.

H_{alt} vs. H_{excl}

(9) $L =$ Lemmy plays the bass.

a. $H_{alt} =$ Lemmy is the only one to play the bass.

b. $H_{excl} =$ Lemmy is not the only one to play the bass.

- Given an assertion $\mathfrak{S}$, H_{alt} is compared with H_{excl} by looking at:

(10) $D = P(\mathfrak{S}|H_{alt}) \times P(H_{alt}) - P(\mathfrak{S}|H_{excl}) \times P(H_{excl})$

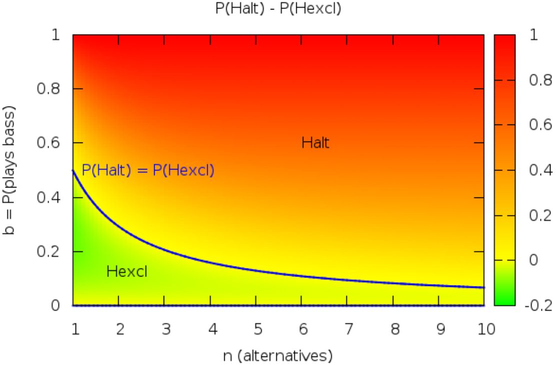
- $D > 0$ implies that H_{alt} is more likely to be the goal targeted by $\mathfrak{L}$, and vice-versa for $D < 0$.

Comparing priors

- $L = H_{excl} \cup H_{alt}$, it is straightforward to see that $D > 0$ **iff** $P(H_{\mathbf{alt}}) > P(H_{\mathbf{excl}})$, i.e. iff the prior belief in H_{alt} is higher than the prior belief about H_{excl}.
- How to compare those two probabilities?
  - Let $\mathcal{A}_{\text{Lemmy}}$ be the set of alternatives of Lemmy. Let n be the cardinality of $\mathcal{A}_{\text{Lemmy}}$, i.e. $|\mathcal{A}_{\text{Lemmy}}| = n$.
  - **Hypothesis**: everyone in $\mathcal{A}_{\text{Lemmy}}$ has the same probability b of playing the bass:
    $\forall x \in \mathcal{A}_{\text{Lemmy}} : P(x \text{ plays the bass}) = b$
- Then:
  - $P(L) = b$
  - $P(H_{excl}) = b(1-b)^n$
  - $P(H_{alt}) = P(L) - P(H_{excl}) = b - b(1-b)^n$
- And $D = 0 \Leftrightarrow b - b(1-b)^n = b(1-b)^n$, i.e. $b = 1 - 2^{-\frac{1}{n}}$

Differences in Probability

- $H_{\text{alt}} > H_{\text{excl}}$ over a majority of values for (n, b)
- H_{excl} gets more accessible for small values of n and b.



Taking stock

- I proposed a **model** for:
  - The abduction process
  - The probabilities $P(H_{\text{alt}})$ and $P(H_{\text{excl}})$ by assuming they crucially depend on two quantities: n and b.
- **Predictions**:
  - H_{alt} should be the selected outcome most of the time.
  - H_{excl} is more likely to be selected/activated if b is very small (and n low enough).
- To summarize, in an utterance like (11-a), the **but** should be easier to interpret than in (11-c), unless the property in question is "rare".

(11)
a. Lemmy plays the bass, but he's not the only one.
b. **Pivot:** H_{alt}
c. Lemmy plays the bass, but he's the only one.
d. **Pivot:** H_{excl}

Experiment

- **Goal**: confirm the predictions by manipulating b and n:
  - b: probability of having the relevant property
  - n: cardinality of the alternative set
- First experiment: variations of b, based on a intuitive choice of rare/common properties.

Speaker judgments

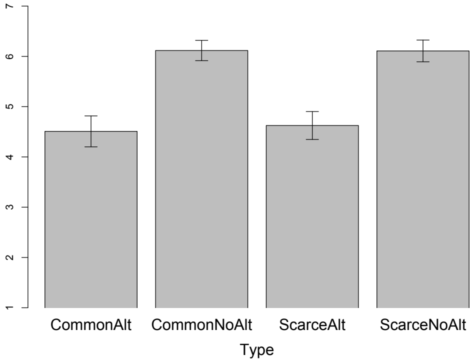
- **Participants:** 30 self declared English native speakers, recruited on *Amazon Mechanical Turk*, payed 1,5$ for their participation.
- **Material**: 16 experimental items, 32 fillers, two binary factors:
  - `IsScarce`: rarity of *b*
    - `Scarce`: rare property
    - `Common`: common property
  - `IsAlt`: nature of the second conjunct of **but**
    - `Alt`: expression which conveys H_{alt}, i.e. pivot= H_{excl}
    - `NoAlt`: expression which conveys H_{excl}, i.e. pivot= H_{alt}
- **Examples**:

(12) a. Terry is ambidextrous, but so is Bob. (`Scarce, Alt`)
b. Terry wears glasses, but Bob does not. (`Common, NoAlt`)

- **Procedure**: Speaker acceptability **judgments** (7-point Likert scale)

Results

- No effect of `IsScarce`
- Significant effect of `IsAlt` ($\chi(1) = 20.83, p < 0.01$).
- No interaction
- **Note**: the `Alt` items remain significantly better than "bad" fillers.



Discussion

- The predictions are only partially confirmed by the experiment: the versions using H_{alt} as pivot are judged more natural.
- However, the rarity of the property (i.e. the value of b) seems to have no effect
- Possible **explanations**:
  - The explicit mention of an alternative in the second conjunct might tend to set $n = 1$ and thus favor the abduction of H_{excl}.
  - The formulation *but so does Peter* might be the culprit (rather than the use of **but**).
  - The fact that usually H_{alt} is the optimal goal might create default preferences.
  - The `Scarce` properties were not rare enough.
  - One of the assumptions in the model is wrong.

Wrong assumption: a more Bayesian approach

- One of the assumptions in the model: b, the probability that someone plays the bass, is a **constant**.
- But learning that Lemmy plays the bass is likely to affect the general belief that somebody else plays it.
- Alternative model:
  - the probability that some random person plays the bass is represented by a Beta distribution (Bishop, 2006)
  - sequential observations modify the distribution; a positive observation shifts the distribution to the right: after getting the observation, we're more likely to believe that a random person plays the bass.
- In this setting, it is predicted that H_{alt} should systematically be preferred/more accessible
- This is in-line with the experiment, although it still predicts that H_{excl} should be easier to abduce in the case of rarer properties.
- **Potential prediction**: depending on the parameters of the prior distribution, H_{excl} might not fit the requirements to be a goal, i.e. $P(H_{\mathrm{excl}}|S) < P(H_{\mathrm{excl}})$

Conclusion, remarks

- The probabilistic argumentation framework is suitable to study the semantics of some items like the connective **but**.
- Bayesian mechanisms can account for the preference of some pivots over others, and make quantitative, testable predictions.
- Yet, not all factors that enter into consideration when accessing goals have been identified or evaluated:
  - Identifying an argumentative scheme may affect the accessibility of goals (Walton et al., 2008).
  - Context definitely plays a role, but not on a par with instructions with the linguistic code.
    - Winterstein et al. (2014) show that contextual information is not processed immediately in the interpretation of adversative conjunction such as:

      (13) #Thursday's exam was difficult, but more difficult than Tuesday's.

Thank You

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