# Stability: computing alternatives in conditional antecents[1]

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## 1 Overview

**The goal for today**:

- Give an account of so-called Simplification of Disjunctive Antecedents that exploits a new algorithm for manipulating syntactic alternatives.
- Show that the algorithm compares favorably to (some) accounts that rely on a nonboolean semantics for disjunction, in particular Alonso-Ovalle 2006, 2009, and (perhaps!) Willer 2016 and Ciardelli 2016.

**Larger background goals**:

- Develop an algorithm covering various phenomena, including free choice under existentials.
- Make a case for a global (≈ clause-level) rather than a local (≈ lexical-item-level) theory of alternative computation for disjunctive sentences.

## 2 The phenomenon: Simplification of Disjunctive Antecedents

### 2.1 The basic phenomenon

The empirical observation: conditionals with disjunctive antecedents (henceforth, DA) seem to entail the conditionals with the two individual disjuncts as antecedents (Fine 1975, Nute 1975).

(1) If Alice or Bob went to the party, the party would be fun.
  a. ⇝ If Alice went to the party, the party would be fun.
  b. ⇝ If Bob went to the party, the party would be fun.

This seems to suggests that the following rule is valid in natural language:

**SDA** $p \vee q > r \vDash p > r, q > r$

In support of this: the corresponding Sobel sequences are infelicitous:

(2) #If Alice or Bob went to the party, the party would be fun.
If Bob went, the party would be dreary.

1 Thanks to Ana Arregui, Rachael Briggs, Andy Egan, Andreas Haida, Mathias Jenny, Nathan Klinedinst, Matthew Mandelkern, Clemens Mayr, Dilip Ninan, Wolfgang Schwarz, Raj Singh, Tue Trinh, Malte Willer, Steve Yablo, and audiences at Edinburgh, Syracuse, Carnegie Mellon, the 2016 Pacific APA and UT Austin. Special thanks to Luis Alonso-Ovalle for very extended discussion and for pointing out key data.



The seeming validity of SDA is unexpected on standard conditional semantics.

Recall **comparative closeness semantics** (Stalnaker 1968, Lewis 1973a, 1973b).[2]

- The key feature: a comparative closeness relation $\leq_w$.
- The function of $\leq_w$: single out a set of 'maximally close' worlds to $w$.
($w'$ is maximally close$_{\leq_w}$ to $w$ iff, for all $w''$, $w' \leq_w w''$.)

The resulting truth conditions:

$$[\![A > C]\!]^{\leq, w} = 1 \text{ iff for all } w' \in \mathsf{max}_{\leq_w}([\![A]\!]^{\leq, w}),\ [\![C]\!]^{\leq, w'} = 1$$

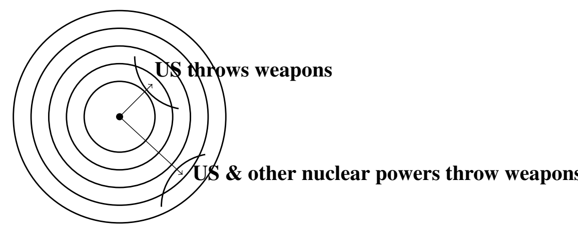
This semantics is designed to validate the consistency of Sobel sequences like (3):

(3) If the US threw its weapons into the sea, there would be war.
If the US and all other nuclear powers threw their weapons into the sea, there would not be war.

In so doing, it invalidates antecedent strengthening:

**AS** $p > q \nvDash p^+ > q$

The explanation for AS failure: **stronger antecedents may take us to further-off regions**.




The problem posed by the alleged validity of SDA:

- Semantically: the conditionals in (2) are predicted to be consistent, and we should be able to generate a model for them, in the same way as we can generate a model for (3).
- Logically: Simplification immediately entails Antecedent Strengthening (assuming a rule of substitution of logical equivalents, and a boolean semantics for disjunction).

$$p > q \quad \vDash \quad ((p \wedge r) \vee (p \wedge \neg r)) > q \quad \vDash \quad (p \wedge r) > q$$

2 Some versions of comparative closeness semantics (e.g. Veltman 1976, or Kratzer 1981a, Kratzer 1981b, 1986, 1991, 2012) exploit so-called premise sets rather than a closeness ordering. Others (for example, von Fintel 2001 and Gillies 2007) remove some crucial elements from the semantics proper and place them in a dynamic account of contextual information. These differences won't matter for my purposes.

### 2.2 Complications

Two reasons to think Simplification is not exactly a semantic entailment.

- Counterexamples that are hard to explain away.

(4) If Spain had fought with the Axis or the Allies, she would have fought with the Axis. (McKay & Van Inwagen 1977)

- Embedding conditionals with disjunctive antecedents in DE environments, we observe a sort of homogeneity effect. (Santorio 2016a)

(5) It's not the case that, if Alice or Bob went, the party would be fun.
  a. $\rightsquigarrow$ It's not the case that, if Alice went, the party would be fun.
  b. $\rightsquigarrow$ It's not the case that, if Bob went, the party would be fun.

(6) I doubt that, if Alice or Bob went, the party would be fun.
  a. $\rightsquigarrow$ I doubt that, if Alice went, the party would be fun.
  b. $\rightsquigarrow$ I doubt that, if Bob went, the party would be fun.

(7) None of my friends would have fun at the party if Alice or Bob went.
  a. $\rightsquigarrow$ None of my friends would have fun at the party if Alice went.
  b. $\rightsquigarrow$ None of my friends would have fun at the party if Bob went.

(There is much to say about this. Here I'm just making the minimal point that we cannot simply take Simplification to be a pure semantic entailment and leave it at that.)

Here I will ignore these points and focus on how to predict Simplification in the first place.

## 3 A survey of the options

Three main options in the literature.

**#1. A scalar/pragmatic account.** We strengthen (via implicature) the proposition expressed by a DA. The resulting conditional entails the simplified conditionals. (Klinedinst 2007, 2009)

$$p \vee q > r \rightsquigarrow (p \vee q)^+ > r \quad \text{(with } (p \vee q)^+ > r \vDash p > r, q > r\text{)}$$

**#2. Alternative/inquisitive semantics.** We build alternatives in the denotations of disjunction; disjunctive clauses denote sets of propositions. (Alonso-Ovalle 2006, Willer 2016, Ciardelli 2016).

$$[[\text{if } A \text{ or } B]] = \{a, b\} \quad \text{(where the set-forming mechanism is built into the meaning of } \textit{or}\text{)}$$

**#3. Truthmakers.** We switch framework to a truthmaker semantics (Briggs 2012, Fine 2012b,a). Disjunctions are analyzed as having (or at least, making available) two truthmakers.

My proposal combines elements from all of #1–3.



## 4 An argument against scalar accounts (if time allows): *probably*-conditionals

Scalar accounts (in particular, Klinedinst 2007, 2009) work by deriving the following as a scalar implicature in the antecedent of the conditional:

> **Diversity Condition** (DC): The worlds that count as closest for the purposes of evaluating a conditional of the form $\ulcorner A \vee B > C \urcorner$ include both $A$- and $B$-worlds.

The semantics in §2 (as any semantics exploiting universal quantification) validates:

> **Persistence.** If the closest $A$-or-$B$-worlds include a set of $A$-worlds, then the latter also count as the set of closest $A$-worlds (ditto for $B$-worlds).[3]

Persistence ensures that, given DC, the truth of $(A \vee B)^+ > C$ guarantees the truth of $A > C$ and $B > C$.

**The problem**: even assuming DC, we can't derive Simplification with non-universal conditionals. For a crisp illustration, consider:

(8) If Alice or Bob went to the party, probably Mary went too.
  a. $\rightsquigarrow$ If Alice went to the party, probably Mary went too.
  b. $\rightsquigarrow$ If Bob went to the party, probably Mary went too.

I make the following (vanilla) assumptions:

- *If*-clauses work as restrictors, Lewis-Kratzer-style (Lewis 1975, Kratzer 1986).
- *Probably* has a probabilistic (and hence nonmonotonic) semantics (Yalcin 2010, Lassiter 2011); roughly:

(9) $[\![\text{probably } A]\!]^{w,\langle E,Pr\rangle} = \text{true iff } Pr_E(\{w' : [\![A]\!]^{w',\langle E,Pr\rangle} = 1\}) > .5$

One consequence of these assumptions: *probably*-conditionals make claims about the conditional probability of the consequent, given the antecedent:

(10) $[\![\text{if } A, \text{ probably } C]\!]^{w,\langle E,Pr\rangle} = \text{true iff } Pr_{E \cap [\![A]\!]}(\{w' : [\![C]\!]^{w',\langle E,Pr\rangle} = 1\}) > .5$

Now, assume that we derive the following counterpart of DC:

> **Diversity Condition*** (DC*): The worlds quantified over by a conditional of the form $\ulcorner$ if $A$ or $B$, probably $C \urcorner$ include both $A$- and $B$-worlds.

This is *not* enough to derive Simplification. The reason is that the following are consistent:

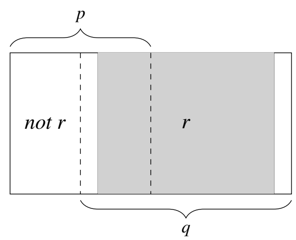
i. $Pr(r|p \vee q) > .5$

ii. either $Pr(r|p) \leq .5$ or $Pr(r|q) \leq .5$

3 A formal definition of Persistence, in the context of Lewis semantics with limit assumption:

> **Persistence.** For any set of worlds $S$, $S'$ s.t. $S' \subseteq S$: if $S' \cap \mathsf{max}_{\leq_w}(S) \neq \varnothing$, $\mathsf{max}_{\leq_w}(S') = \mathsf{max}_{\leq_w}(S) \cap S'$

As Schlenker 2004 points out, Persistence generalizes a property entailed by condition 4 of Stalnaker's 1968 semantics. Charlow 2013 also discusses Persistence (under the label 'Stability') for deontic selection functions.




Hence it might be that (i) DC* is satisfied, (ii) ⌜ if $A$ or $B$, probably $C$⌝ is true, and (iii) ⌜ if $A$, probably $C$⌝ is false. Hence scalar accounts cannot predict Simplification in *probably*-conditionals.

## 5 Sauerland/Fox's Innocent Excludability algorithm for computing implicatures

Scalar implicatures (Grice 1975) involve the exclusion of logically stronger alternatives to a sentence.

(11) a. Sarah talked to Mary or Sue.
b. ⇝ *Sarah didn't talk to both Mary and Sue*

The plan: (i) present the Sauerland/Fox algorithm; (ii) show how I adapt it.

**Background: alternatives.** All main theories of alternatives are compatible with my account. For concreteness, I will adopt Katzir-style alternatives (2007):[4]

> Alternatives to a sentence $S$ are all and only those sentences that are relevant in the context and no more complex than $S$.

**The Innocent Excludability algorithm.** (Sauerland 2004; Fox 2007)

- The central idea: we exclude as many alternatives as possible, while avoiding (a) contradictions, and (b) arbitrary choices.
- Precisely: we single out a set excl of **innocently excludable alternatives**, defined as follows:

(12) $\mathsf{excl}(S, ALT) = \bigcap\{\sigma \subseteq ALT_S : \sigma \text{ is a maximal subset in } ALT_S \text{ s.t. } \sigma^{\neg} \cup S \nvDash \bot\}$

4 Here is the formal proposal. First, we define the notion of a structure being at most as complex as another in context $c$ (represented as '$\leq_c$'):

> $S' \leq_c S$ iff $S'$ can be derived from $S$ by successive replacements of syntactic sub-constituents of $S$ with elements of the substitution source for $S$ in $c$, $SS(S,c)$

Then we define the notion of a substitution source for a sentence $S$ in a context $c$, as follows:

> The substitution source for sentence $S$ in context $c$ is the union of: (i) the lexicon; (ii) the subconstituents of $S$; (iii) the set of salient constituents in $C$.



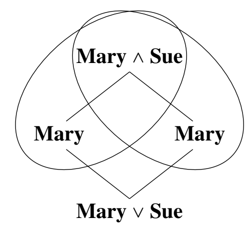
- Intuitively:
  - We consider the **maximal exclusions** in $ALT$, i.e. all the sets of alternatives whose negations can be consistently combined with the sentence asserted.
  - Innocently excludable alternatives are the ones that are in the intersection of the maximal exclusions.

From now on I assume: the substitution set for a disjunction invariably involves (at least) the disjuncts and the corresponding conjunction. For example: (11-a) has the alternatives in (13).

(11-a) Sarah talked to Mary or Sue.

(13)
$$\left\{ \begin{array}{ll} \text{Sarah talked to Mary or Sue} & \textbf{Mary} \vee \textbf{Sue} \\ \text{Sarah talked to Mary} & \textbf{Mary} \\ \text{Sarah talked to Sue} & \textbf{Sue} \\ \text{Sarah talked to Mary and Sue} & \textbf{Mary} \wedge \textbf{Sue} \end{array} \right\}$$

The two maximal exclusions in this set of alternatives:




- Only the conjunctive alternative (**Mary** ∧ **Sue**) is innocently excludable.
- Notice the role of contradictions and non-arbitrariness. If we excluded both alternatives, we would get a contradiction with the basic meaning of the sentence. If excluded only one, we would have to arbitrarily pick one of the disjuncts.

The resulting prediction:

(14) a. Sarah talked to Mary or Sue.
b. ⇝ *Sarah didn't talk to both Mary and Sue*

Notice: all this is neutral wrt the choice between a semantic and a pragmatic implementation.

## 6 From innocent excludability to stability

- The innocent excludability algorithm incorporates important insights about reasoning with alternatives. (Alternatives are considered as a set rather than individually; non-arbitrariness.)
- But: the idea of *excluding* alternatives, while it is seemingly appropriate to capture the functioning of scalar implicature, is ill-suited to capture the phenomena in §1.

I suggest: we should flip the algorithm and strengthen by conjoininging alternatives rather than negating them.

### 6.1 Stability

**Observation**: some sentences are **unstable**, in the following sense: their truth provides a guarantee that one of their stronger alternatives is true.

Some examples of **stable sentences**:

$$\Diamond A \qquad \Diamond A \wedge \neg \Box A \nvDash \bot$$
$$\Box(A \vee B) \qquad \Box(A \vee B) \wedge \neg \Box(A) \wedge \neg \Box(B) \nvDash \bot$$

Some examples of **unstable sentences**:[5]

$$A \vee B > C \qquad (A \vee B > C) \wedge \neg(A > C) \wedge \neg(B > C) \vDash \bot$$
$$\Diamond(A \vee B) \qquad \Diamond(A \vee B) \wedge \neg \Diamond A \wedge \neg \Diamond B \vDash \bot$$
$$A \vee B \qquad (A \vee B) \wedge \neg A \wedge \neg B \vDash \bot$$

Instability is suboptimal from a communicative point of view.

- We know that there is (at least) one stronger alternative to the sentence uttered that is true.
- So: we know that the speaker is in a position to utter a stronger sentence.

The proposal: grammar contains an algorithm dictating to 'stabilize' an unstable assertion.

### 6.2 A strengthening algorithm

We define the notion of a **stable extension of** $S$.

(i) Stable extensions are simply the complements of Fox's maximal exclusions.

(ii) A stable extension of $S$ (with respect to $ALT_S$) is a subset of $ALT_S$ that (a) contains $S$ and (b) is **consistent with the negation of every alternative that is not a member of it**.

5 For the case of conditionals, I'm assuming the so-called RCA principle, which is validated by all conditional semantics in the Stalnaker/Lewis/Kratzer tradition. Though see Bacon 2015 and, well, Santorio 2016b for logics that don't validate this axiom.

(RCA) $\quad (p \vee q) > r \supset (p > r \vee q > r)$

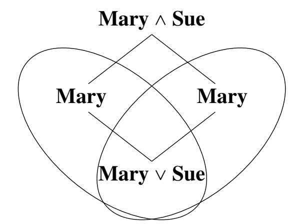


(15) $\quad$ StableExt$(S, ALT_S)$ =
$\{\sigma : S \in \sigma \wedge \sigma$ is a minimal subset of $ALT_S$ s.t. $\sigma \cup (ALT_S - \sigma)^{\neg} \nvDash \bot\}$

Going back to the usual example:

(11-a) $\quad$ Sarah talked to Mary or Sue.

The two stable extensions of **Mary** $\vee$ **Sue** in this set of alternatives:




The intuitions behind the algorithm:

- We select the minimal strengthenings of the assertion that can 'stand alone'—they don't generate inconsistency even if all the remaining alternatives turn out to be false.[6]
- As in the Sauerland/Fox algorithm, we don't pick and choose arbitrarily—we select all of these strengthenings.

These intuitions suggests that the algorithm could be motivated on principled ground. But for the moment I'm happy with taking the main motivation to be sheer empirical adequacy—using this algorithm gets us the right predictions for a large variety of cases.

### 6.3 Truthmakers in conditionals

**The step to truthmakers.** We use the Stability algorithm to capture the notion of a way for a sentence $S$ to be true—what I call a *truthmaker* of $S$.

- We take the propositions denoted by the conjunction of sentences in stable extensions of $S$.

$$\{M \vee S, M\} \quad \Rightarrow \quad (M \vee S) \wedge M \quad \Rightarrow \quad \textit{Sarah talked to Mary } (m)$$
$$\{M \vee S, S\} \quad \Rightarrow \quad (M \vee S) \wedge S \quad \Rightarrow \quad \textit{Sarah talked to Sue } (s)$$

- Second, of the propositions obtained in this way, we keep only those that entail $S$.

6 Notice that, on this definition: (a) stable extensions are immediately consistent; (b) the stable extensions of $S$ are closed under weaker alternatives.

The truthmakers of (11-a) are *m* and *s*.

For current purposes, I assume that conditionals work as universal quantifiers over truthmakers. This yields the following truth conditions:

$$[\![A > C]\!]^{\leq,w} = \text{true} \approx \text{for all } p \text{ that are } \textbf{truthmakers of } A, \text{ for all } w' \in \mathsf{max}_{\leq,w}(p),\ [\![C]\!]^{\leq,w'} = 1$$

### 6.4 A prediction: truthmakers for complex antecedents

Consider a complex antecedent involving a universal scoping over disjunction:[7]

(16) If every student read Anna Karenina or War and Peace, the world would be a better place.

(16), among other things, simplifies to the 'mixed' case where some students read one novel and some students read the other:

(17) # If every student read AK or W&P, the world would be a better place.
But if half of the students read AK and the other half read W&P, the world would not be a better place.

Crucially, the Stability algorithm gets the right prediction for (16).

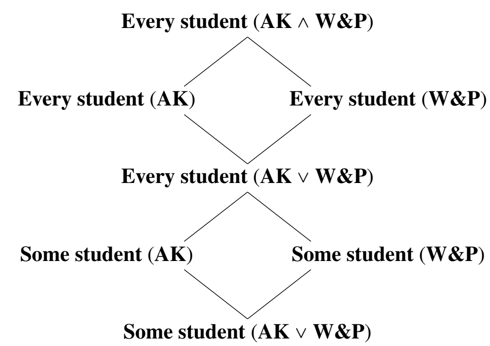
The substitution sets:

*every*: {*every*, *some*}
*AK or W&P*: {*AK and W&P*, *AK*, *W&P*, *AK or W&P*}

The alternatives, plotted by strength:[8]

7 The point I make in this section has emerged in discussion with Luis Alonso-Ovalle, who first pointed out examples like (16) to me.
8 Two notes. (i) I am leaving out the existential-conjunctive alternative *Every student(AK ∧ W&P)*, because it doesn't end up figuring in any of the stable extension of the sentence. (ii) I am assuming that the universal alternatives entail the corresponding existential ones. (On the assumption that universal determiners presuppose existence, the relevant notion of entailment is Strawson-entailment; see von Fintel 1999.)






The three stable extensions of *Every student read AK ∨ W&P*.

$$\left\{\begin{array}{l}\forall(AK)\\ \forall(AK \vee W\&P)\\ \exists(AK)\\ \exists(AK \vee W\&P)\end{array}\right\}\ \left\{\begin{array}{l}\forall(W\&P)\\ \forall(AK \vee W\&P)\\ \exists(W\&P)\\ \exists(AK \vee W\&P)\end{array}\right\}\ \left\{\begin{array}{l}\forall(AK \vee W\&P)\\ \exists(AK)\\ \exists(W\&P)\\ \exists(AK \vee W\&P)\end{array}\right\}$$

The resulting truthmakers:

- *All students read AK*
- *All students read W&P*
- *Some students read AK and some students read W&P*

This predicts, among other things, the data in (17).[9]

## 7 A comparison: alternative semantics

SDA and similar phenomena have been taken as an argument for alternative semantics, and in particular an **alternative treatment of disjunction**.

**Primer on alternative semantics.** Basic idea: basic expressions denote the singleton of their denotation in standard truth-conditional semantics.

$[[\text{Mary}]] = \{\text{Mary}\}$
$[[\text{run}]] = \{\lambda x.\ \lambda w.\ x \text{ runs in } w\}$
$[[\text{kick}]] = \{\lambda x.\ \lambda y.\ \lambda w.\ x \text{ kicks } y \text{ in } w\}$

9 As Alonso-Ovalle has pointed out (p.c.), an algorithm that uses syntactic alternatives may not generate all the permutations of students in the domain reading books. (This could be addressed by letting syntactic alternatives include different variables for picking out different domains of quantification, but the details remain to be worked out.)

The basic functional application rule is replaced by a 'pointwise' rule that instructs us to combine each member of a set with each member of another set (when we have the right types).

**Pointwise functional application**
If $[[\alpha]] \subseteq D_{\langle\sigma,\tau\rangle}$ and $[[\beta]] \subseteq D_{\tau}$,
then $[[\alpha(\beta)]] = \{c \in \tau : \exists a \in [[\alpha]] \wedge \exists b \in [[\beta]] : c = a(b)\}$

A natural meaning for (sentence-level) disjunction in this framework (adapted from Alonso-Ovalle 2009):

(18) $[[\text{or}]] = \{\lambda p_{\langle s,t\rangle}.\ \lambda q_{\langle s,t\rangle}.\ \{p,q\}\}$

More in general, a type-flexible denotation for *or*:

(19) $[[\text{or}]] = \{\lambda \alpha_{\tau}.\ \lambda \beta_{\tau}.\ \{\alpha,\beta\}\}$

As a result, *or* introduces a series of propositional alternatives in the compositional derivation.
*if*-clauses operate universal quantification over alternatives:

(20) $[[\text{if } A]]^{\leq,w} = \{\lambda f_{\langle st,st\rangle}.\ \lambda w.\ \forall p \in [[A]] f(p)(w)\}$

(21) $[[\text{if Alice or Bob went}]]^{\leq,w} = \{\lambda f_{\langle st,st\rangle}.\ \lambda w.\ \forall p \in [[a,\ b]] f(p)(w)\}$

Combined with the denotation of the consequent (in (22)), this yields the expected truth conditions (in (23)).

(22) $[[\text{the party would be fun}]]^{\leq,w} = \lambda p.\ \lambda q.\ \{q \in \{\lambda w.$ for all $w' \in \max_{\leq,w}(p)$, the party is fun in $w'$ $\}\}$

(23) $[[\text{If Alice or Bob went, the party would be fun}]]^{\leq,w}$ = true iff for all $p \in \{a,\ b\}$, for all $w' \in \max_{\leq,w}(p)$, the party is fun in $w'$

**A (wrong) prediction**: complex antecedents involving embedded disjunctions.[10]

(16) If every student read Anna Karenina or War and Peace, the world would be a better place.

No existing version of alternative semantics[11] generates the crucial 'mixed' alternative for (16) (roughly: *Some read AK and some red W&P and all read AK or W&P*).

**The reason**: observe what happens on a basic semantics for universal determiners like *every student*, combined with the Alonso-Ovalle meaning for *read AK or W&P*.

I assume:

$[[\text{read AK or W\&P}]] = \{\lambda x.\ \lambda w.\ x$ read AK in $w$, $\lambda x.\ \lambda w.\ x$ read W&P in $w\}$

$[[\text{Every student}]] = \{\lambda F_{\langle e,st\rangle}.\ \lambda w.\ \forall x : x$ is a student, $F(x)(w) = 1\}$

10 The point I make in this section has emerged in discussion with Luis Alonso-Ovalle, who pointed out the empirical difficulty for his theory.

11 Without stipulating an *ad hoc* composition rule or distributivity operator, i.e.



The result:

(24) $[[\text{Every student read AK or W\&P}]] = \{\lambda w.$ Every student read AK in $w$, $\lambda w.$ Every student read W&P in $w\}$

We get only two alternatives; the 'mixed' alternative is left out.

- So far as I can see, there is no easy fix within alternative semantics.
- The reason: we want to capture a kind of variation in the domain of the determiner that concerns how the objects quantified over vary with respect to the disjuncts. It's unclear how to build this in the semantics of the universal quantifier.

The problem generalizes.

(25) #If most student read AK or W&P, ...
But if a majority of the students read one of the two and some read AK and some read W&P, $\neg A$.

(26) #If John must read AK or W&P, ...
If John must read AK or W&P and he may read AK and he may read W&P, $\neg A$

(27) #If John probably read AK or W&P,...
If John probably read AK or W&P and it's possible that he reads AK and it's possible that he reads W&P, $\neg A$.

...

## 8 Conclusion

- I have presented an account of DA that relies on the following ideas: (i) conditional antecedents are alternative-sensitive; (ii) they denote a set of propositions; (iii) the relevant propositions are derived via manipulation of syntactic alternatives.
- The basic idea behind the algorithm is to strengthen the antecedent to all 'stand-alone' sets of alternatives.
- Some empirical advantages over alternative semantics system; unclear how/whether this extends to inquisitive semantics.

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