Negation and alternatives in counterfactual antecedents

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(1) If you had taken the train or the metro, you would have arrived on time.
Alternatives in counterfactual antecedents

(1) If you had taken the train or the metro, you would have arrived on time.

(2) If Mary and her ex had not both come to the party, we would’ve had more fun.
Alternatives in counterfactual antecedents

(1) If you had taken the train or the metro, you would have arrived on time.

(2) If Mary and her ex had not both come to the party, we would’ve had more fun.

Contemporary semantics of conditionals distinguish

1. the alternatives raised by a conditional antecedent
2. the mechanism used to hypothetically assume each alternative

(3) Ciardelli (2016): $A > C$ is true at a state $s$ just in case for every $p \in \text{alt}(A)$ there is a $q \in \text{alt}(C)$ such that $s \subseteq p \Rightarrow q$
Recent work on conditional antecedents
Recent work on the semantics of conditionals

- Ciardelli et al. (2018) inquisitive semantics
- Fine (2012) truthmaker semantics
- Santorio (2018) truthmaker/alternative semantics
- Willer (2018) dynamic semantics
- Schulz (2018) novel semantics of negation
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Each paper has a different semantic entry for negation

<table>
<thead>
<tr>
<th>Negation flattens alternatives</th>
<th>Alternatives survive negation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Schulz (2018)</td>
</tr>
</tbody>
</table>
Experiment on what negation does to alternatives
Recent work on conditional antecedents

Experiment on what negation does to alternatives

Experimental design

Predictions

Results

Discussion
Experimental design

Figure 1: Scenario used in the experiment
**False:** Currently, switch A is in the middle and switch B is down. If that wasn’t the case, the light would be on.

**True:** Currently, switch A is not up. If that was the case, the light would be on.
Control: Currently, switch B is down. If that wasn’t the case, the light would be on.

- Tests how much the participant keeps fixed
**T1:** Currently, neither switch is up. If that wasn’t the case, the light would be on.

**T2:** Currently, switch A is in the middle and switch B is down. If switch A was up or switch B was up, the light would be on.
T3: If switch B was up but not switch A, the light would be on.
Recent work on conditional antecedents

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Alternatives survive negation just in case $\neg A$ can contain multiple elements.

Do alternatives survive negation?
Alternatives survive negation just in case $[\neg A]$ can contain multiple elements.

Do alternatives survive negation?

(4) Kratzer and Shimoyama (2002):

$[\text{Neg}(A)] = \{\text{the proposition that is true in all worlds in which no proposition in } A \text{ is true}\}$
If alternatives do not survive negation...

\[ \neg \neg \neg (A \uparrow \lor B \uparrow) > ON \quad (T1) \]

\[ \not\equiv \]

\[ A \uparrow \lor B \uparrow > ON \quad (T2) \]
If alternatives survive negation...

Disjunction introduces alternatives

Validate De Morgan’s law \( \neg(A \land B) \equiv \neg A \lor \neg B \)

\[ \Rightarrow \text{Negation introduces alternatives} \]

(5) \( \neg
(\neg(A \lor B)) \equiv \neg(\neg \neg A \land \neg \neg B) \equiv \neg \neg A \lor \neg \neg B \equiv A \lor B \)

**T1:** Currently, neither switch is up. If that wasn’t the case, the light would be on.

\( \neg \neg (A \uparrow \lor B \uparrow) > \text{ON} \)

**T2:** Currently, switch A is in the middle and switch B is down. If switch A was up or switch B was up, the light would be on.

\( A \uparrow \lor B \uparrow > \text{ON} \)
If alternatives do not survive negation...

Schulz (2018): according to both the similarity approach and Ciardelli et al. (2018)’s background semantics, if $A$ has one alternative and $B$ is true at $w$, then

$$w \models (A \land B) > C \iff w \models B > C.$$ 

**T3** If switch B was up but not switch A, the light would be on. 

$$B \uparrow \land \neg A \uparrow > \text{ON}$$

$$B \uparrow \land \neg A \uparrow > \text{ON} \equiv B \uparrow > \text{ON}$$
(6) Switch A is not up $\equiv$ Switch A is in the middle or down.

$$(B\uparrow \land \lnot A\uparrow) > O_N$$

$\equiv B\uparrow \land (A\bullet \lor A\downarrow) > O_N$

$\equiv (B\uparrow \land A\bullet) \lor (B\uparrow \land A\downarrow) > O_N$  \hspace{1cm} (Dist $\land$ over $\lor$)

$\Rightarrow (B\uparrow \land A\downarrow) > O_N$  \hspace{1cm} (SDA)

$B\uparrow \land \lnot A\uparrow > O_N \neq B\uparrow > O_N$
Schulz negation

a. $L(\varphi) = \{a : a \text{ is an atomic sentence appearing in } \varphi\}$

b. $w \sim_\varphi v$ iff $w(a) = v(a)$ for every $a \in L(\varphi)$
   (i) Binary version: $w(a) \in \{0, 1\}$ for every world $w$ and atomic sentence $a$.
   (ii) $n$-ary version: $w(a)$ can be outside $\{0, 1\}$.

c. For any information state $p \subseteq W$,
   (i) $p \models Q(\varphi)$ iff $w \sim_\varphi v$ for every $w, v \in p$ ($p$ ‘answers the question raised by $\varphi$’)
   (ii) $p \perp \varphi$ iff $p \cap \models |\varphi|$ is empty ($p$ and $\varphi$ are mutually exclusive)

d. For any proposition $P \subseteq \wp(W)$, $P \models \neg \varphi$ iff $p \models Q(\varphi)$ and $p \perp \varphi$ for every $p \in P$

e. $[\text{not } \varphi] = \{p \subseteq W : Q(\varphi) \text{ and } p \perp \varphi\}$
Figure 2: $T_1, \neg\neg(A \uparrow \lor B \uparrow)$, in Schulz’s framework
# Overview of predictions

<table>
<thead>
<tr>
<th>Theory / Antecedent</th>
<th>T1 (\neg\neg(A\uparrow \lor B\uparrow))</th>
<th>T2 (A\uparrow \lor B\uparrow)</th>
<th>T3 (B\uparrow \land \neg A\uparrow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alonso-Ovalle (2006)</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ciardelli et al. (2018)</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fine (2012)</td>
<td>✓</td>
<td>✓</td>
<td>❌</td>
</tr>
<tr>
<td>Santorino (2018)</td>
<td>✓</td>
<td>✓</td>
<td>❌</td>
</tr>
<tr>
<td>Willer (2018)</td>
<td>✓</td>
<td>✓</td>
<td>❌</td>
</tr>
<tr>
<td>Schulz (2018) binary</td>
<td>✓</td>
<td>✓</td>
<td>❌</td>
</tr>
<tr>
<td>Schulz (2018) n-ary</td>
<td>❌</td>
<td>✓</td>
<td>❌</td>
</tr>
</tbody>
</table>

Table 1: Overview of predictions
Experimental setup

- 192 Mechanical Turk participants, excluding:
  - 74 participants who responded $\leq 4$ on the True filler;
  - 3 participants who didn’t report English as native language
- Each participant only saw one of T1 and T2, in random order with the True and False filler and the Control item, T3 presented last
Recent work on conditional antecedents

Experiment on what negation does to alternatives
   Experimental design
   Predictions
   Results

Discussion
Results

Mean acceptability (SE)

<table>
<thead>
<tr>
<th>Sentence</th>
<th>False</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>Control</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
<td>C</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>¬(A \land B \downarrow)</td>
<td>¬(A \uparrow \lor B \uparrow)</td>
<td>A \uparrow \lor B \uparrow</td>
<td>B \uparrow \land \neg A \uparrow</td>
<td>\neg B \downarrow</td>
<td>A \uparrow</td>
</tr>
</tbody>
</table>
Box plot

Acceptability

Sentence

False T1 T2 T3 Control True

\[-(A \cdot \land B \downarrow) \quad -(A \uparrow \lor B \uparrow)\]
Analysis of results

- Cumulative link mixed model on data from the control and test sentences
- T1 and T3 rated significantly lower than the control (both $z < -2.5$, $p < .01$)
- T2 rated significantly higher than control ($z = 2.1$, $p = .039$)
- Posthoc comparison of targets T1 and T3 revealed no difference between the two ($z = -0.5$, $p = .62$)
Order effects

\[ \neg(A \cdot \land B \downarrow) \quad \neg\neg(A \uparrow \lor B \uparrow) \quad A \uparrow \lor B \uparrow \quad B \uparrow \land \neg A \uparrow \quad \neg B \downarrow \quad A \uparrow \]
Discussion
### Table 2: Overview of predictions, with new data

<table>
<thead>
<tr>
<th>Theory / Antecedent</th>
<th>T1 $\neg \neg (A \uparrow \lor B \uparrow)$</th>
<th>T2 $A \uparrow \lor B \uparrow$</th>
<th>T3 $B \uparrow \land \neg A \uparrow$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our data (interpreted)</td>
<td>$\times$</td>
<td>$\checkmark$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Alonso-Ovalle (2006)</td>
<td>$\times$</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
</tr>
<tr>
<td>Ciardelli et al. (2018)</td>
<td>$\times$</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
</tr>
<tr>
<td>Fine (2012)</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Santorio (2018)</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Willer (2018)</td>
<td>$\checkmark$</td>
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<td>$\times$</td>
</tr>
<tr>
<td>Schulz (2018) binary</td>
<td>$\checkmark$</td>
<td>$\checkmark$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Schulz (2018) $n$-ary</td>
<td>$\times$</td>
<td>$\checkmark$</td>
<td>$\times$</td>
</tr>
</tbody>
</table>
Summary
Summary

- Experimental evidence against Alonso-Ovalle (2006)
- Ciardelli et al. (2018)
- Fine (2012)
- Santorio (2018)
- Willer (2018)

Our results can be accounted for by adapting the semantic entry for negation.

Schulz (2018) accounts for our data by taking into account the 'question' raised in the conditional antecedent.

But our results challenge a purely semantic explanation of the data.
Summary

- Experimental evidence **against**
  - Alonso-Ovalle (2006) alternative semantics
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- Our results **can** be accounted for by adapting the semantic entry for negation
  - Schulz (2018) accounts for our data by taking into account the ‘question’ raised the conditional antecedent

- But our results challenge a **purely semantic** explanation of the data


Schulz (2018)’s experiment

Figure 3: Scenario used in Ciardelli et al. (2018)’s experiment

(8) a. If the electricity was working, then the light would be on.
    b. If the electricity was working and switch A was up, then the light would be on.
    c. If the electricity was working and switch A and switch B were not both up, then the light would (still) be off.
Results from Schulz (2018)’s experiment

<table>
<thead>
<tr>
<th>sentences</th>
<th>true</th>
<th>%</th>
<th>false</th>
<th>%</th>
<th>indet.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E \rightsquigarrow On$</td>
<td>8</td>
<td>16%</td>
<td>42</td>
<td>82%</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>$(E \land A) \rightsquigarrow On$</td>
<td>43</td>
<td>84%</td>
<td>5</td>
<td>10%</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>$[E \land \neg(A \land B)] \rightsquigarrow On$</td>
<td>14</td>
<td>27%</td>
<td>27</td>
<td>53%</td>
<td>8</td>
<td>16%</td>
</tr>
<tr>
<td>$[E \land \neg(A \land B)] \rightsquigarrow On^*$</td>
<td>9</td>
<td>26%</td>
<td>20</td>
<td>59%</td>
<td>5</td>
<td>15%</td>
</tr>
</tbody>
</table>

Figure 4: Results from Schulz (2018)’s experiment

Conclusion

- The mechanism for making hypothetical assumptions in Ciardelli et al. (2018) keeps too much fixed