The mechanics of causal discourse expectations

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Overview

1. Implicit Causality basics
2. Semantic theory of implicit causality
3. Discourse continuation experiments
Establishing causal connections between discourse units is central for discourse coherence (e.g. Graesser et al. 1994).

We observe causal connections at the discourse level, but also in encoded in lexical elements.

ongoing cooperation on “processing causality in discourse”:

- Centre of Advanced Study (Oslo) “Meaning and understanding across languages” (PI: Cathrine Fabricius-Hansen)
- cooperation between projects B4, SFB 732 (Stuttgart) and project B1, SFB 833 (Tübingen)
- PPP project “The structure and processing of explanatory discourse in German and Norwegian” (Solstad/Bott)
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What kind of discourse relation is most likely to come next?
Which referent(s) are most likely to be mentioned next?

(1) a. Peter fascinates Mary. He is very clever. (explanation)
b. Peter fascinates Mary because he is so clever.
Implicit Causality Bias (IC Bias)

(2) a. **Peter** impressed Mary because **he** sang beautifully.
b. Peter admired **Mary** because **she** sang beautifully.
c. Peter impressed **Mary**. That’s why **she** started to write romantic poems.
d. **Peter** admired Mary. That’s why **he** started to write romantic poems.

A number of psycholinguistic experiments show (e.g. Fukumura & van Gompel 2010):

- Depending on the verb, participants prefer to produce/perceive an explanation associated with NP1 or NP2
- This preference is affected by the discourse relation: result relation shifts the bias
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Implicit Verb Causality: preferences in production

Kehler et al. (2008):

- IC verbs: explanation is the default

- coreference: explicitly marked = implicit explanations (continuations after a full stop without *because*)

- coreference varies with discourse relation

<table>
<thead>
<tr>
<th>Coherence relation</th>
<th>Full stop</th>
<th>because prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P(CR) (%)</td>
<td>P(Subj</td>
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<tr>
<td>Explanation</td>
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<td>0.81</td>
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<tr>
<td>Result</td>
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<tr>
<td>Elaboration</td>
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<td>0.61</td>
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Table 5 Probabilities from Experiment 3 (IC-NP1 verbs)

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<tr>
<th>Coherence relation</th>
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<tbody>
<tr>
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<tr>
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<td>62</td>
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<tr>
<td>Result</td>
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<tr>
<td>Elaboration</td>
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</table>

Table 6 Probabilities from Experiment 3 (IC-NP2 verbs)

<table>
<thead>
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<th>Coherence relation</th>
<th>Full stop</th>
<th>because prompt</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>P(CR) (%)</td>
<td>P(Subj</td>
</tr>
<tr>
<td>Explanation</td>
<td>24</td>
<td>0.57</td>
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<tr>
<td>Elaboration</td>
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<td>0.58</td>
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<tr>
<td>Result</td>
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<td>0.24</td>
</tr>
<tr>
<td>Violated Expectation</td>
<td>13</td>
<td>0.40</td>
</tr>
<tr>
<td>Occasion</td>
<td>9</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Table 7 Probabilities from Experiment 3 (non-IC verbs)
Pykkönen & Järvikivi (2010): visual world eyetracking experiment on implicit causality in Finnish

(3) a. **The guitarist** frightened the butler in the dining room because...
    b. The guitarist feared **the butler** in the dining room because...
Implicit Verb Causality: online processing II

(4)  a. The guitarist frightened the butler...
    b. The guitarist feared the butler...
Implicit Verb Causality: online processing III

(5)  

a. The **guitarist** frightened the butler...  

b. The guitarist feared the **butler**...  

▷ immediate activation of the expected referent
What is implicit causality?

- It’s hard to detect a decisive semantic feature

**NP1 bias:**
*amuse*, apologize to, fascinate, bore, confess to, telephone, ... 

(6) Mary amused Jerry because *she* danced clumsily. 

**NP2 bias:**
admire, pity, *congratulate*, thank, praise, hate, ... 

(7) John congratulated *Sarah* because *she* won the race. 

(8) **no bias:**
interrupt, hit, murder, ... 

- **linguistic factors:** *argument structure*, intentionality, lexical aspect 
- **social psychology:** social hierarchies, gender stereotypes
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Implicit Causality: Our story in a nutshell

- Implicit Causality: Lexically triggered preference for specific types of explanations.
- IC bias: Epi-phenomenon of explanatory strategies.
- Association of explanation with one of the participants.

(9)  

a. **Bias-congruent**
   John congratulated **Sarah** because . . . **she** won the race.

b. **Bias-incongruent**
   John congratulated Sarah because . . . **he** was very impressed by her performance.

- Rooted in verb semantics, our theory allows for systematic manipulation of the IC bias.
Previous verb-based accounts of Implicit Causality

- Other ‘verb semantic’ accounts have focused on argument structure classes
- Stimuli and ‘evocators’ are strong bias attractors
  - **stimuli:**
    - *NP1 bias:* STIM amused EXP
    - *NP2 bias:* EXP admired STIM
  - **evocators:**
    - *NP2 bias:* AGENT congratulated EVOCATOR
- Agents and patients do not attract the bias in a systematic way
- No *explanation* of patterns, mere correlation between bias and verb classes as defined by argument structure
- Which semantic properties of stimuli and evocator arguments trigger the bias?
Questions to be answered in a theory of Implicit Causality

- What determines the bias?
- Why do some verbs have a clear bias and others not?
- How does the expectation of an explanation come about?
- Why does there exist a correspondence between explanation patterns and coreference?
- How can we provide a unified account of discourse expectations (explanations) and verb semantics?
Implicit Causality ingredients

Main claim

Implicit Causality verbs trigger specific kinds of explanations associated with one of the two participants

(10)  a. John disturbed Mary because ... he sang loudly.
     b. John congratulated Mary because ... she won the race.

- IC bias may be observed when a because clause can specify a semantic entity associated with (only) one of the participants
- IC bias is dependent on
  - Causal elaboration possibilities in NP1 verb-ed NP2
  - Semantic properties of because (clauses)
- Consequently, we need a suitable theory of verb semantics and a typology of explanations (as introduced by because)
because: causes and reasons

- **Simple causes** are causes of (attitudinal) states or events

  (11) **Simple (direct) cause:**
  
  John disturbed Mary because *he* sang loudly.

- **Reasons** are causes of attitudinal states involving intentionality

  (12) **Externally anchored reason:**
  
  John disturbed *Mary* because *she* had stolen his textbook.

  (13) **Internally anchored reason:**
  
  John disturbed *Mary* because *he* was angry at *her*.

- **Backgrounds** are necessary, but not sufficient causes

  (14) **Background:**
  
  John disturbed Mary because she needed silence to concentrate.

- The bias patterns depend on the availability of these explanation types
Explanatory slots I: Stimulus arguments

- **annoy** \( \rightsquigarrow f \) **CAUSE** \( s_{\text{att}} \)
  
  Some fact brings about the attitudinal state of \( y \) being annoyed

- Default explanations are **simple causes**

(15) **Peter** annoyed **Mary** because he sang loudly.

\[
\begin{array}{c|c|c}
\lambda f \lambda y & s_{\text{att}} & s_{\text{att}}: \text{annoyed}(y) \\
--- & f \text{ CAUSE } s_{\text{att}} & \text{annoy} \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
 & e \times y f s_{\text{att}} & & f \text{ CAUSE } s_{\text{att}} \\
--- & e=? & \text{PART}(e)=x & \text{sing}(e) \text{ loud}(e) \\
\end{array}
\]

\[
\begin{array}{c|c|c|c}
 & s_{\text{att}}: \text{annoyed}(y) & & s_{\text{att}}: \text{annoyed}(y) \\
\text{Mary}(y) & \text{Peter}(x) & \text{Peter}(x) & \text{Mary}(y) \\
\end{array}
\]

Evidence: Stimuli may also be realized by *that* clauses

(16) It annoyed Mary *that* Peter sang loudly.
**Explanatory slots I: Stimulus arguments**

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  - Some fact brings about the attitudinal state of \(y\) being annoyed
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(15) *Peter annoyed Mary because he sang loudly.*

\[\lambda f \lambda y s_{att}\]

<table>
<thead>
<tr>
<th></th>
<th>(s_{att})</th>
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<tbody>
<tr>
<td>(f) <strong>CAUSE</strong> (s_{att})</td>
<td></td>
</tr>
<tr>
<td>(e=)</td>
<td></td>
</tr>
<tr>
<td><strong>PART</strong>((e)=(x))</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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\[e \times y f s_{att}\]

- **Evidence:** Stimuli may also be realized by *that* clauses

(16) *It annoyed Mary that Peter sang loudly.*
Explanatory slots II: Presuppositions

- *because* clauses may elaborate a presupposed preceding event

(17) NP2 bias:

Lars punished **Melanie**, because she stole the money.

\[
\begin{align*}
&\{ e' & z \} \\
&\{ e' \prec e & z: \text{AGENT}(e') \} \\
&z = y
\end{align*}
\]

- Agent of presupposed event identified with ‘bias argument’ of *punish*-event
- “Causes precede their effects”

- Explanations are **external reasons**

  > With both stimuli and presuppositions, **AvoidAccommodation** triggers the specification of an explanation
AP verbs: No possibility of ‘because elaboration’

- Agent-patient predicates without presuppositions don’t offer any elaboration possibilities ⇒ No obvious explanation strategy
- *because* cannot specify the causing event of all causative verbs
  - kill \(\sim\) e CAUSE s

\[(18) \quad \#\text{Louisa killed Tom because she stabbed him in the back.} \\
\ne \nequiv \#\text{Louisa killed Tom by stabbing him in the back.} \]

\[(19) \quad \#\text{It killed Tom that Louisa stabbed him in the back.} \]

- e is ‘associated with’ Louisa, who is the agent of the causing event
- Simple causes with psych verbs, **not** with causative agent-patient verbs
- Causative agent-patient verbs should not pattern with stimulus-experiencer verbs if elaboration of stimulus properties is the decisive source of the bias behaviour
With agent-patient verbs, any distribution of verb biases is possible.

(20)  *Judith bashed Richard, because* . . .

a. **External reason:**
   *he* tormented *her brother.*

b. **Internal reason:**
   *she* was very *upset.*

However: IC bias should follow from the ratio of external to internal reasons.

- External reasons $\rightsquigarrow$ NP2 bias
- Internal reasons $\rightsquigarrow$ NP1 bias
Manipulating the bias: basic intuitions

- **Underspecified information triggers systematic specification.**
- If we specify the missing information in the prompt, this should influence the preferences for explanations.
- Consequently, the bias should also change.

(21) **presupposition verb congratulate:**
   a. Pete congratulated Mary because ... she won the 1st prize.
   b. Pete congratulated Mary *on winning the first prize* because ...
      he was very impressed.

(22) Pete congratulated Mary *on winning the 1st prize* ...
    They celebrated the victory in a nice restaurant.
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From lexical semantics to discourse structure

Backward-looking integration

\[ \text{Pete congratulated Mary.}]_s \text{ } [\text{She won the race.}]_{s_{n+1}} \]

Pete congratulated Mary because she won the race.

- Implicit causality: Forward-looking perspective on discourse.
- Given discourse segment \( s_n \), which relation may be expected to be established between \( s_n \) and the following discourse segment \( s_{n+1} \)?
- Lexical sources?
- Source of NP2 bias for \textit{congratulate}: ‘cataphoric presupposition’.
Interim summary

- Implicit Causality is triggered by underspecified content
- AvoidAccommodation
  1. **Stimulus:** unspecified property
     - Causal explanation: Simple causes
     - Bias: Stimulus (NP1)
  2. **Presupposition**
     - Causal explanation: Externally anchored reasons
     - Bias: Argument associated with presupposition (NP2)
- Pronominal reference is an epi-phenomenon of explanatory strategy
Experimental study
Overall predictions

- Verbs with underspecified entities should trigger more explanations than verbs without slots
  - More explanations: Stimulus-experiencer and presupposition verbs
  - Less explanations: Agent-patient verbs
- Verbs where the slot is filled in the prompt should trigger significantly less explanations than in unmodified prompts.
  - Less explanations with modified stimulus-experiencer and presupposition verbs
  - No change with modified agent-patient verbs
- Correspondingly, the bias should change where a slot is filled
  - Bias change with stimulus-experiencer and presupposition verbs
  - No bias change with agent-patient verbs
Experiments 1A and 1B
Comparing Stimulus-Experiencer and Agent-Patient verbs
In German, stimulus-Experiencer verbs allow *durch* phrases to specify the stimulus

Similar to *by*+-*ing* or *with* phrases

(23) a. Bias-congruent:  
Hannah ängstigte Leo, weil ... *sie* ihm eine Gruselgeschichte erzählte.  
‘Hannah scared Leo because ... she told him a horror story.’

b. Bias-incongruent:  
Hannah ängstigte Leo *durch* die Erzählung einer Gruselgeschichte weil ... *er* ein Hasenfuß war.  
‘Hannah scared Leo with a horror story because ... he was a coward.’

*durch*: Specification of *simple* cause

Pre-emption of specification strategy

Shift away from simple cause
Modifying SE and AP verbs

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**durch:** Specification of *simple cause*

Pre-emption of specification strategy

Shift away from simple cause
Interestingly, causative agent-patient verbs also allow durch phrases specifying a simple cause.

However, given that durch and weil (‘because’) are in ‘complimentary distribution’ with these predicates, the durch phrase shouldn’t affect the explanation pattern.

(24)  

a. #Sarah killed Jacob because she shot him.  
b. Sarah killed Jacob by shooting him.

(25)  

a. Sarah tötete Jacob, weil ...sie wütend auf ihn war.  
   ‘Sarah killed Jacob because she was angry at him.’  
b. Sarah tötete Jacob durch einen Schuss, weil ...sie wütend auf ihn war.  
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No pre-emption

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Methods: Exp. 1A/B

- Between items/within participants:
  - Exp. 1A: 20 SE-verbs
    - SE) Ben amused Mia (by telling a funny story)
      a) full stop . . . b) because . . .
  - Exp. 1B: 20 causative AP-verbs
    - AP) Jasmin killed Henry (by a shot)
      a) full stop . . . b) because . . .

- Within items/participants: 2 × 2 design (connective × modification)
- Counterbalanced between NP1/2 = masc./fem.
- 40 items + 40 fillers, latin square design
- Instructions: “continue the discourse in the most natural way” (or skip it if you can’t come up with a continuation)
- Two blocks:
  - 1st block: Full stop conditions
  - 2nd block: because conditions
Discourse annotation

The resulting corpus of continuations was annotated wrt. the following categories:

- **Discourse relation** (agreement: Cohen’s $\kappa = .80$)
  - sensible continuation (skips and nonsense $\triangleright$ mis. values)
  - temporal order (event_{continuation} after event_{prompt}?)
  - explanation? (*because* test)

- **Causal annotation**: *simple cause vs. ext. reason vs. int. reason vs. background* (agreement: Cohen’s $\kappa = .74$)

- **Bias annotation** (agreement: Cohen’s $\kappa = .86$)
  - NP1 vs. NP2 vs. no anaphor
  - unequivocal vs. ambiguous (*he loved her*)
  - kind of anaphor (pronoun, DP, proper name)
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SE and AP verbs: Proportions of explanations

- For SE verbs, *durch* phrases reduce explanations from 51% to 19%
- For AP verbs without underspecified content, less explanations overall (19% vs. 11%)
- Stronger decrease in SE than in AP conditions (interaction: \( LRCS_1(1) = 6.9; p < .01 \))
Explanation types: Predictions for SE verbs and AP verbs

**SE verbs**

- **Drop in Simple causes**
- Increase in Internal reasons
- Increase in Backgrounds

**AP verbs**

- no significant changes in explanation profile

(30)  

a. *Stimulus-Experiencer*:  
Hannah scared Leo because . . . she told him a horror story.

b. *Stimulus-Experiencer modified*:  
Hannah scared Leo by telling a horror story because . . . he was a coward.

(31)  

a. *Agent-Patient*:  
Mia killed Ben because . . . she was angry at him.

b. *Agent-Patient modified*:  
Mia killed Ben with a shot because . . . she was angry at him.
SE verbs

- **durch-PPs reduce simple causes** ($LRCS_{1/2}(1) \leq 266; p_{1/2} < .01$)
- After *weil*, simple causes are substituted by int. reasons and backgrounds

AP verbs

- No sign. effects of *modification*
- Same explanation profiles across conditions
Bias: predictions for SE and AP verbs

SE verbs

- Explanations in unmodified conditions
  - Mainly simple causes
  - Strong NP1 bias
- Explanations after *durch*
  - no simple causes, internal reasons and backgrounds, instead
  - Bias shifts towards NP2

AP verbs

- Explanations in unmodified conditions
  - External and internal reasons
  - Balanced bias
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SE and AP verbs: Bias

Stimulus-experiencer verbs

(36) Mia amused Ben (because) . . .
(37) Mia amused Ben with a funny story (because) . . .

Agent-patient verbs

(38) Mia killed Ben (because) . . .
(39) Mia killed Ben with a shot (because) . . .

- durch phrases increase the likelihood of rementioning NP1! ($LRCS_{1/2}(1) \geq 3.9; p_{1/2} < .05$)
- Why?

- durch phrases decrease the likelihood of rementioning NP1! ($LRCS_{1/2}(1) \geq 72; p_{1/2} < .01$)
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Why?
In contrast to ordinary AP verbs, SE verbs in NP1 verb-ed NP2 sentences attract explanations.

Stimulus-Experiencer verbs trigger simple causes that specify a property of the stimulus argument.

durch modification affects explanation types and bias in a fully predictable way.

But why should durch lead to a bias effect in AP verbs?

1. John killed Mary by a shot. (= John’s shot)
2. John amused Mary by telling a joke. (= John’s joke)

Across verb types, durch-phrases should enhance salience of NP1

This influenced the specific form of the explanation sentence, but not its type!
Experiment 2
Presupposition verbs
Modifying presupposition verbs

- Similarly, the presupposition of an IC presupposition verb can be specified by means of a *für* phrase.
- Comparable to *for* phrases in English.

(40)  

a. Bias-congruent:
Maria dankte Peter, weil ... er ihr beim Umzug geholfen hat.
‘Mary thanked Peter because he helped her with the move.’

b. Bias-congruent:
Maria dankte Peter *für die Hilfe beim Umzug*, weil ... sie es ohne ihn nie geschafft hätte.
‘Mary thanked Peter for helping her with the move because she couldn’t have made it otherwise.’

- Verification/Specification of presupposition
- Pre-emption of explanatory strategy
- Shift away from external reasons
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Predictions for PSP verbs

1. Specifying missing content explicitly in the prompt should lead to a drop in the number of explanations.

2. Unmodified conditions should trigger ext. reasons.
   • modified conditions should trigger internal reasons (or backgrounds).

3. This should alter IC bias from NP2 towards NP1.
Methods: Exp. 2

- AP-verbs with a presupposition
  
  PSP)  Sebastian congratulated Jaqueline (on winning the first prize in the dancing competition)
  a) full stop ... b) because ...

- Within items/participants: 2 × 2 design (connective × modification)
- Counterbalanced between NP1/2 = masc./fem.
- Run together with Exp. 1A/B, same methods
- Annotation as in Exp. 1A/B
Results in brief

When modifying the prompt for AP verbs with (relevant) presuppositions, we observed the following:

1. Drop in explanations with ‘modified prompt’ (56% → 31%)
2. Shift away from external reasons towards internal reasons
3. Change in bias from strong NP2 bias (90% NP2) towards balanced bias (≈52% NP2)
PSP verbs: proportions of explanations

(41) Sebastian congratulated Jacqueline (because) . . .
(42) Sebastian congratulated Jacqueline on winning the race (because) . . .

After a full stop, explanations dropped from 56% to 31%

\[ LRCS_{1/2}^{\geq 31; p < .01} \]
PSP verbs: Explanation types

(43) Sebastian congratulated Jacqueline (because) . . .
(44) Sebastian congratulated Jacqueline on winning the first price (because) . . .

- Unmodified conditions trigger ext. reasons
- Modification leads to a shift towards int. reasons

$\text{LRCS}_{1/2}(1) \geq 193; p < .01$
PSP verbs: Bias

(45) Sebastian congratulated Jacqueline (because) ... 

(46) Sebastian congratulated Jacqueline on winning the race (because) ... 

Unmodified conditions are strongly biased towards NP2 
Modification eliminates the bias 

\((LRCS_{1/2}(1) \geq 93; p < .01)\)
Ordinary Agent-Patient Verbs
Experiment 3: Methods

- Discourse continuation study with 100 participants
- Same methods and annotation as in Exp. 1A/B & Exp. 2
- 101 verbs: 16 SE; 18 ES; 10 AP/+PSP; 57 AP/–PSP
  - 1. block *full stop*: NP1 verbed NP2. . .
  - 2. block *because*: NP1 verbed NP2, because . . .
- 10,100 productions
Recall: With agent-patient verbs, any distribution of verb biases is possible

(47)   *Judith* bashed *Richard*, because . . .

a. **External reason:**
   *he* tormented *her brother.*

b. **Internal reason:**
   *she* was very upset.

**We claimed:** The IC bias of an AP/–PSP verb should follow from the ratio of external to internal reasons

- External reasons contribute to NP2 bias
- Internal reasons contribute to NP1 bias
The ratio internal-to-external reasons is a good predictor for IC-bias

(accounted variance: $R^2 = .75$)
Conclusions

- Our account: IC bias is due to specific discourse expectations triggered by missing causal content
- Evidence: Providing the missing information in the matrix clause fills the explanatory gap and leads to predictable shifts wrt. coherence relation, explanation types and IC bias
  - Well-established for syntactic processing (e.g. Altmann & Steedman 1988, van Berkum et al. 1999)
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The (quantum) mechanics of causal discourse expectations

deterministic expectations in a probabilistic world

1. \text{NP1 IC-verb NP2} presupposes causal content
2. Expectation of a particular explanation type
3. Explanation type associated with particular referent

- Notion of ‘mechanics’ is too strong.
- The shift away from an explanation type is not deterministic.
  - Several explanation types available
- A particular explanation type can be realized in several ways.
  1. Peter bewunderte Maria, weil…
     ‘Peter admired Mary because…’
    a. sie seiner Meinung nach einfach großartig war.
       ‘she, in his opinion, was just great’
    b. er fand, dass sie einfach großartig war.
       ‘he thought that she was just great’
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We thank you . . . for your attention
. . . and Aleks Dimitrov for helping us with the annotation!
Pretest: *durch* *(by)* vs. *weil* *(because)*

What are the restrictions imposed by *weil* *(because)* and *durch* *(by)*?

(1) Mary fascinated Peter because...
(2) Mary fascinated Peter by...
(3) Mary killed Peter because...
(4) Mary killed Peter by...

- Continuation study: 48 participants ended German sentences involving 20 SE and 20 causative AP verbs
- $2 \times 2 \times 2$ within design (SE/AP verb $\times$ *durch/weil* $\times$ male/female)
- Continuations annotated for explanation type
Pretest results: Simple causes vs. reasons

- **weil** triggers all four explanation types
- **durch** only compatible with simple causes
- **weil** can only target simple causes of SE verbs, not AP verbs

Evidence for proposed ontological restrictions
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