Talking about Causing Events

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Big questions

What is the nature of our linguistic capacity?

How does our linguistic capacity interact with extralinguistic cognition?

What methods do we have for evaluating specific hypotheses?
Answers to explore

What is the nature of our linguistic capacity?

- In part: a logical vocabulary

How does our linguistic capacity interact with extralinguistic cognition?

- Transparently

What methods do we have for evaluating specific hypotheses?

- Traditional, *and* psychological
Methodology in natural language semantics

Traditional: ask native speakers for offline truth value judgments

**Context:** Al left the toaster on; his house burned down the next day.

(1) Al burnt his house down. \hspace{1cm} \text{FALSE}
(2) Al caused his house to burn down. \hspace{1cm} \text{TRUE}

Such judgments can give us insight into the logical properties of sentences.
Emerging standard: ask how sentence understanding interacts with extralinguistic perception and cognition

**Context**: Short animations of a red ball and a blue ball moving.

(3) The red ball moved the blue ball.

(4) The red ball caused the blue ball to move.

Such judgments can distinguish fine-grained hypotheses about logical form
Semantic theory offers a number of hypotheses about the logical form of “causative sentences” like (5a) and their entailments like (5b)

(5)  a. The red ball moved the blue ball.
     b. The blue ball moved.

Can we find evidence for the logical form of causative sentences by manipulating causal perception?
Outline

1 Motivation

2 Event language
   - Defining causativity
   - Classical, Davidsonian, Neodavidsonian

3 A transparency thesis

4 Michotte’s tradition
   - Experiment

5 Discussion
2 Event language
   ■ Defining causativity
   ■ Classical, Davidsonian, Neodavidsonian
Certain verbs are capable of systematically appearing both in a transitive (7a) and intransitive frame (7b)

(6) a. The red ball moved the blue ball.
b. The blue ball moved.

This is referred to as the “causative-inchoative alternation”
Other verbs, that, importantly, do not appear so different on the surface, do not show the same alternation

(7)  a. The red ball pushed the blue ball.
    b. * The blue ball pushed.
The classical semantics of *move* and *push* do not formally distinguish them:

(8)  
  a. \texttt{MOVE}(Red, Blue)  
  b. \texttt{PUSH}(Red, Blue)

Any difference is just a matter of syntactic or lexical idiosyncrasy.
Introducing events

Davidson 1967 was impressed by the “diamond-shaped” pattern of inferences observed amongst sentences like (9)

(9) a. Brutus stabbed Caesar with a knife in the kitchen.
    b. Brutus stabbed Caesar with a knife.
    c. Brutus stabbed Caesar in the kitchen.
    d. Brutus stabbed Caesar.

To capture these logical properties, he introduced the “event analysis”
Diamond-shaped entailments

On the Davidsonian picture, verbs come with an extra argument which can be used as an anchor for conjunctive modifiers

(10)  

a. $\exists e [\text{STAB}(e, \text{Brutus, Caesar}) \& \text{WITH-A-KNIFE}(e) \& \text{IN-THE-KITCHEN}(e)]$

b. $\exists e [\text{STAB}(e, \text{Brutus, Caesar}) \& \text{WITH-A-KNIFE}(e)]$

c. $\exists e [\text{STAB}(e, \text{Brutus, Caesar}) \& \text{IN-THE-KITCHEN}(e)]$

d. $\exists e [\text{STAB}(e, \text{Brutus, Caesar})]$

Diamond-shaped entailments obtain by conjunction reduction
Yet, just as with the classical view, Davidson’s theory does not formally distinguish causative *move* from non-causative *push*

(11) a. \( \exists e [\text{MOVE}(e, \text{Red}, \text{Blue})] \)

b. \( \exists e [\text{PUSH}(e, \text{Red}, \text{Blue})] \)
Parsons 1990 was impressed that we can refer to events nominally

(12) Al expected that the clerks would move the office supplies to the new workspace soon.

(13) Al expects the moving of the office supplies to the new workspace by the clerks to happen soon.
Unlike with the verbal construction, arguments in the nominal construction are introduced separately, and optionally

(14) Al expected that [the clerks$_{Agent}$ would move the office supplies$_{Theme}$ (to the new workspace) soon].

(15) Al expects [the moving (of the office supplies$_{Theme}$) (to the new workspace) (by the clerks$_{Agent}$) to happen soon].
Thematic predicates

Parsons’ innovation: verb roots are 1-place predicates of events

\[(move) = \lambda e[MOVE(e)]\]

Their arguments are always introduced by thematic predicates

(17) a. The clerks moved the office supplies.
    b. \(\exists e[Agent(e, clerks) & MOVE(e) & Theme(e, supplies)]\)

(18) a. ... the moving of the office supplies by the clerks.
    b. \(\iota e[Agent(e, clerks) & MOVE(e) & Theme(e, supplies)]\)

(That thematic morphemes are sometimes covert is a syntactician’s worry)
Parsons was similarly impressed that transitive causative sentences entail the corresponding intransitive

(19)  
   a. The red ball moved the blue ball.  
   b. The blue ball moved.

(19a) adds to (19b) only what caused the state of affairs it describes.
More events

This suggests that sentences with causative verbs have an importantly different logical form from those that don’t

(20) Al moved the table.

(20) refers to two events: Al’s action, and the table’s movement
In causative sentences, a special thematic predicate Cause is introduced to relate causative and inchoative events

(21) a. The red ball moved the blue ball.
   b. \( \exists e' [\text{MOVE}(e') \& \text{Theme}(e', \text{Blue}) \& \text{Cause}(e, e')] \)

From this the intransitive entailment is straightforwardly captured

(22) a. The blue ball moved.
   b. \( \exists e' [\text{MOVE}(e') \& \text{Theme}(e', \text{Blue})] \)
Now causative and non-causative verbs are formally distinguished: non-causative sentences do not appeal to the thematic Cause predicate.

(23)  
   a. The red ball moved the blue ball.  
   b. $\exists e [\text{Agent}(e, \text{Red}) \land \exists e' [\text{MOVE}(e') \land \text{Theme}(e', \text{Blue}) \land \text{Cause}(e, e')]]$

(24)  
   a. The red ball pushed the blue ball.  
   b. $\exists e [\text{Agent}(e, \text{Red}) \land \text{PUSH}(e) \land \text{Theme}(e, \text{Blue})]$

(Don’t worry too much about ‘Agent’; see Dowty 1991 on “proto-roles”.)
Fodor (1970; also Thomson 1987, Pietroski 2005) cautioned against appeal to a ‘cause’ predicate, since e.g. (25-26) are not synonymous.

**Context:** Al set the house on fire; now a pot of water boils.

(25) Al boiled the water. FALSE

(26) Al caused the water to boil. TRUE

To reasonably make such an appeal, one must explain this difference.
We think Thomson herself suggests the way out:

“I hazard a guess that ‘x causes y’ is a latecomer in a language, and is learned late: that it comes only with whatever it is that makes us take an interest, not merely in who killed, or moved a thing, but in the death, the being broken, or the being in motion itself, perhaps together with, and perhaps in part because of, a recognition that there are other ways in which a person can be responsible for such an outcome than by killing, breaking, or moving the thing” (110)
The objection (mistakenly) presumes an identity between an implicit predicate, and an explicit one.

Our attempt: carefully distinguish open from closed class lexical items.
## Open versus closed class lexical items

<table>
<thead>
<tr>
<th></th>
<th>Open class words</th>
<th>Closed class words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
<td><em>dog, run, red, John</em></td>
<td><em>of, the, some, might, in</em></td>
</tr>
<tr>
<td><strong>Class size?</strong></td>
<td>Very large</td>
<td>Very small</td>
</tr>
<tr>
<td><strong>Critical period?</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Relational?</strong> †</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Species specific?</strong></td>
<td>No (in a sense)</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Other names</strong></td>
<td>“Contentful”</td>
<td>“Logical”</td>
</tr>
</tbody>
</table>

† *Linguistically*, not necessarily conceptually; see Pietroski 2010, in prep
Open-class \textit{CAUSE} versus closed-class \textit{Cause}

The transitive invokes a closed-class item (cf. Pylkkänen 2002)

(27) a. The red ball $\Theta_{cause}$ moved the blue ball.
   b. $[\Theta_{cause}] = \lambda P \lambda e'[\exists e[P(e) \& \text{Cause}(e', e)]]$

The periphrastic construction invokes an open-class item

(28) a. The red ball caused the blue ball to move.
   b. $[\text{cause}] = \lambda e[\text{CAUSE}(e)]$
Summary of hypothesized logical forms

Sentences with $\Theta_{cause}$ state a direct causal relation between events

(29) $\exists e [\text{Agent}(e, R) \& \exists e' [\text{MOVE}(e') \& \text{Theme}(e, B) \& \text{Cause}(e, e')]]$

Sentences with *cause* have an extra degree of freedom

(30) $\exists e [\text{Agent}(e, R) \& \text{CAUSE}(e) \& \exists e' [\text{MOVE}(e') \& \text{Theme}(e', B) \& \text{Theme}(e, e')]]$

Sentences with *push* leaves out explicit reference to causation

(31) $\exists e [\text{Agent}(e, R) \& \text{PUSH}(e) \& \text{Theme}(e, B)]$
Can we find evidence for how speakers actually represent the meaning of sentences like these?
A transparency thesis
The compositional semantics of a sentence is a recursive specification of instructions to build complex concepts/representations out of simpler ones (Pietroski 2010)

Sentences ground judgments of truth only when their semantics can be verified by correlative representations in cognition/perception
If the interface between linguistic and extralinguistic cognition is *natural* (Baker 1997) or *transparent* (Goldman 2007)...

Then meanings are non-trivially related to the cognitive processes or representations that count as ‘satisfiers’ for them (“Interface Transparency Thesis”, or ITT; Lidz et al 2011)
The set-up

On Davidsonian analyses, sentence meanings explicitly refer to events.

On Neodavidsonian analyses, causative sentences specify that a privileged Cause relation obtains between pairs of events.

Thus, one relevant extralinguistic domain for us is causal perception.
Since Michotte 1946, psychologists have investigated the psychological mechanisms employed in perceiving causality between simple events.

The emerging view is that there are event percepts that exist independently of how we think about “things that happen.”
Event percepts

These percepts discretize the continuous flow of experience into useful units that can feed other cognitive processes (Liverence & Scholl 2012).

Perceiving a causal link in particular is fast, automatic, and irresistible (and independent of animacy; see Scholl & Tremoulet’s 2000 review).
Interface hypotheses

H1: Sentences are ‘satisfied’ by event *representations*

H2: ‘Cause’ is satisfied by representing a causal link between event representations

Tactic: manipulate the availability of a causal percept between simple events, measure the effects of using different sentences to describe a task
4 Michotte’s tradition

■ Experiment
Experimental desiderata

Present participants with simple animations which are independently known to give rise to a distinctive pattern of causal perception.

Set up the animations such that two interpretations of the expected response are possible, causal and non-causal.

Rather than providing extensive instructions (or even training; e.g. Schlottman & Anderson 1993), give minimal, targeted instructions.
Michotte’s 1946 paradigm

In Michotte’s original experiments, one ball contacted another, and after a specified temporal interval, the second ball moved.

How long the temporal lag was on a given trial strongly predicted whether subjects reported perceiving a causal link.

Longer lag $\rightarrow$ less likely perceived causal link.
However, it has been shown that introducing a certain amount of spatial gap still evokes the causal percept (see Scholl & Tremoulet’s 2000 review).

By manipulating temporal lag and spatial gap, we can get two possible interpretations of the task: one demanding **CONTACT**, the other **CAUSE**.
Experiment design

Five temporal $L_A G$ levels: 0ms, 50ms, 100ms, 150ms, 200ms

Five spatial $G_A P$ levels: 0cm, .5cm, 1cm, 1.5cm, 2cm

A total of 250 trials/subject, 8 per $L_A G$-$G_A P$ combination

Balls move at 40 degrees of visual angle/sec (Scholl & Nakayama 2002)
The task was described as requiring the evaluation of whether each animation was correctly described by Target

<table>
<thead>
<tr>
<th>Cond</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>push</td>
<td>The red ball <em>pushed</em> the blue ball.</td>
</tr>
<tr>
<td>cause-move</td>
<td>The red ball <em>caused</em> the blue ball <em>to move</em>.</td>
</tr>
<tr>
<td>move</td>
<td>The red ball <em>moved</em> the blue ball.</td>
</tr>
<tr>
<td>launch</td>
<td>The red ball <em>launched</em> the blue ball.</td>
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</tbody>
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Between subjects, only the Target contained in the instructions differed
We included *launch* as it is the verb that contemporary psychology uses to talk about modern versions of the Michotte stimuli.

And it is a causative verb:

(32) a. The red ball launched the blue ball.
    b. The blue ball launched.

(And it’s a good thing we included it, as we’ll see)
Based on the literature, we posited that *cause* and *contact* should generate distinctive graphs (cf. Young & Sutherland 2009).

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**Idealized data**

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**Causal Interpretation**

**Contact Interpretation**

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**Judgment**

<table>
<thead>
<tr>
<th>gap 1</th>
<th>gap 2</th>
<th>gap 3</th>
<th>gap 4</th>
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</thead>
<tbody>
<tr>
<td>lag 1</td>
<td>lag 2</td>
<td>lag 3</td>
<td>lag 4</td>
</tr>
</tbody>
</table>
IT&T predictions

We expected **CONTACT** for non-causative *push*

We expected **CAUSE** for causative *move* and *launch*

We had no strong predictions for *cause to move*

<table>
<thead>
<tr>
<th>Cond</th>
<th>Target</th>
<th>Cause?</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>push</em></td>
<td>The red ball <strong>pushed</strong> the blue ball.</td>
<td>Low</td>
</tr>
<tr>
<td>cause-move</td>
<td>The red ball <strong>caused</strong> the blue ball <em>to move.</em></td>
<td>?</td>
</tr>
<tr>
<td><em>move</em></td>
<td>The red ball <strong>moved</strong> the blue ball.</td>
<td>High</td>
</tr>
<tr>
<td><em>launch</em></td>
<td>The red ball <strong>launched</strong> the blue ball.</td>
<td>High</td>
</tr>
</tbody>
</table>
Null hypothesis

Participants could negotiate the task instructions in all sorts of ways:

They could always choose CONTACT, they could be confused and choose randomly, they could say “no” on every trial (e.g., “it requires animacy!”)

There is no expectation that psychological factors play an important role
30 undergraduates receiving either course credit or $10, all native speakers of American English as determined in a pre-test questionnaire.

These results are thus preliminary: we want 40 participants ultimately.
Results

![Graphs showing the relationship between lag and num_responds for different events.

- **CAUSE-TO-MOVE**
  - Different colors represent different gap values.
  - The graph shows a decrease in num_responds as lag increases.

- **LAUNCH**
  - Similar to CAUSE-TO-MOVE but with different data points.

- **MOVE**
  - Graph with a slight variation in the trend compared to CAUSE-TO-MOVE.

- **PUSH**
  - Graph with the least significant change in trend.

The graphs indicate that the num_responds decreases with increasing lag for all events.
**Interpretation**

*launch* showed the highest correspondence to the causal graph.

*push* showed the lowest correspondence to the causal graph.

*move* and *cause to move* were roughly identical, but received more *CAUSE*-based responses than *push*.
Follow-up analysis

Based on qualitative inspection of individual subject data, our impression is that 2 subjects chose \textit{Cause} with \textit{move}, and 5 with \textit{launch}.

Only 1 subject chose \textit{Cause} with each of \textit{push} and \textit{cause to move}.

But why didn’t causative \textit{move} look more like \textit{launch}?
Follow-up analysis

When $\text{LAG}$ and $\text{GAP}$ are included in the statistical analysis, almost all of the predictive power for all but $\text{launch}$ is done by $\text{GAP}$.

In Michotte’s original experiments $\text{GAP}$ was set to 0; what if we look at just these trials?

- $\text{push}$: $\chi^2(1, N = 400) = 3.27, p = .071$ n.s.
- $\text{cause to move}$: $\chi^2(1, N = 400) = 7.98, p < .01$ *
- $\text{move}$: $\chi^2(1, N = 350) = 10.12, p < .01$ *
- $\text{launch}$: $\chi^2(1, N = 350) = 96.16, p < .001$ **

Only $\text{push}$ shows no effect of $\text{LAG}$ when $\text{GAP}$ is 0, suggesting that even by this more restrictive measure subjects were not tracking $\text{CAUSE}$.
Lexical idiosyncrasy?

But still, why was *move* so different from *launch*?

Maybe the velocity ratio 1:1 we used meets further lexical requirements of *launch* but fails to for *move*.

Michotte’s original experiments used a velocity ratio of 3.6:1.
Lexical idiosyncrasy?

The present experiment: velocity 1:1 for red:blue’s movements

Ongoing experiment: velocity 3.6:1 for red:blue’s movements
Discussion
Positing Cause seems like the right idea; what is the right characterization of it?

Carey 2010 shows that 6-mo-old infants possess a domain-general causal concept that they use to represent perceptual and intentional events.

If the earliest acquirers of English link causative verbs with that concept, this could begin to suggest that logical expressions track core concepts.
We presented data suggesting that English speakers’ behavior in a simple task is sensitive to quite subtle semantic features of the instructions.

We gave subjects sentences that differed little in their surface meaning (with move/push, push/launch), and two ways to interpret the scene.

Causal language, in the linguist’s sense, led subjects’ truth judgments to track the availability of a causal percept.
Our results support a transparency thesis (Lidz et al 2011), and a few suggestions about the study of language in the mind:

- Unlike the “contentful” vocabulary of language, the interpretation of the logical vocabulary is not open-ended
- Closed-class predicates transparently relate to (possibly primitive) content in extralinguistic cognition
- Psychological methods can be used to test finer-grained hypotheses about linguistic structure than can traditional methods
Jeffrey Lidz, Paul Pietroski, Brian Scholl, Alexander Williams

The PHLING at UMD (http://phling.umd.edu)

Language Science at UMD (http://languagescience.umd.edu)

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