The Processing of Events – Psycholinguistic Studies into Aspectual Coercion

Oliver Bott

Universität Tübingen
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Structure of the talk

- Two Coercion Accounts
  - Operator Based Accounts
  - Event Calculus
- Additive Coercion: Smooth Update of the Event Representation
  - ERP Study "Additive Coercion"
- Abstract Type Shift: Differences in Coercion Costs
  - Reading Time Study "Iterative Readings"
- Subtractive Coercion: Crosslinguistic Variation
  - Reading Time Study "Subtractive Coercion"
- Conclusions
The event nucleus (Moens & Steedman 1988, van Lambalgen & Hamm 2005)

An eventuality is a structure $\langle f_1, f_2, e, f_3 \rangle$, where

1. $f_1$ is a fluent which represents a **preparatory process**, something which exerts a force,
2. $f_2$ is a parametrized fluent which is driven by $f_1$, i.e. the incremental theme,
3. $e$ is the **culminating event** and
4. $f_3$ is the **resultant state**.
eventualities of type $\langle - , - , - , f_3 \rangle$

(1a) John knew the answer.
(1b) *John was knowing the answer.

“With a state, unless something happens to change that state, [it] will continue: this applies equally to *standing* and to *knowing*. With a dynamic situation, on the other hand, the situation will only continue if it is continually subject to a new input of energy.” (Comrie 1976; p. 49)
eventualities of type $\langle f_1, f_2, -, - \rangle$

(2a) John pushed a cart.
(2b) John was pushing a cart.
(2c) John pushed a cart for x time.
(2d) *John pushed a cart in x time.
(2e) *John finished to push a cart.

Activities are dynamic and energy consuming processes
eventualities of type \(\langle -, -, e, - \rangle\)

(3a) John sneezed.
(3b) John was sneezing.
(3c) John sneezed for \(x\) time.

(3d) *John sneezed in \(x\) time.
(3e) *John finished to sneeze.

Semelfactives express punctual events that leave the world as it is
eventualities of type $\langle -, -, e, f_3 \rangle$

(4a) John won the race.
(4b) John was winning the race.
(4c) *John won the race for $x$ time.
(4d) ?John won the race in $x$ time.
(4e) *John finished to win the race.

Achievements express a punctual change of state
eventualities of type $\langle f_1, f_2, e, f_3 \rangle$

(5a) John built a house.

(5b) John was building a house.

(5c) ?John built a house for $x$ time.

(5d) John built a house in $x$ time.

(5e) *John finished to build a house.

Accomplishments describe dynamic situations with a canonical goal (culmination)
Transitions between aspectual classes

Coercion: shift from one class to another without overt operator

(6) For twenty years Howard sent his son a letter (once a month).
Examples of aspectual coercion

1. John reached the top in **two hours**.
   - Achievement $\leadsto$ Accomplishment

2. John built a house for **two years**.
   - Accomplishment $\leadsto$ Activity

3. John sneezed for **two hours**.
   - Semelfactive $\leadsto$ Activity

4. John dived through the pool for **two hours**.
   - Accomplishment $\leadsto$ Activity
Given expression $A$ of type $< \beta, \gamma >$ and expression $B$ of type $\alpha \neq \beta$.

**Result:** Type mismatch for $A(B)$

**Resolve** type mismatch by introducing an operator $OP$ of type $< \alpha, \beta >$.

No type mismatch occurs in $A(OP(B))$. 
The computation of the temporal profile of a discourse is viewed as coming up with a plan that permits a non-monotonic derivation of a goal from a given initial state (van Lambalgen & Hamm 2005).

Coercion is characterized by shifts in meaning that result from the update of a plan when integrating new information. Depending on the required update, coercion can take very different forms.
(1) $s_0$ [John was walking to the store] $s_1$ [when he slipped on the icy road] $s_2$

Event Calculus models closed world reasoning:

- Initial state $s_0$: empty model
- Update with $s_1$, i.e., make the query succeed: *There is a walk-to-the-store activity by John that holds at time $t_1$ and $t_1 < \text{now}$*
  - Model after processing $s_1$: John is walking to the store at $t_1 < \text{now}$ and will reach it at $t_2 > t_1$
- Update with $s_2$, i.e., add the query: *There is a slip event by John that happens at time $t_3$ and $t_3 = t_1$*
  - Model after processing $s_2$: *slip stops John’s walking activity at $t_3$; John won’t arrive at the store*
Event Calculus I: Incremental Discourse Interpretation

(1) \( s_0 \) [John was walking to the store] \( s_1 \) [when he slipped on the icy road] \( s_2 \)

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- Update with \( s_2 \), i.e., add the query: \textit{There is a slip event by John that happens at time } \( t_3 \text{ and } t_3 = t_1 \)
  - Model after processing \( s_2 \): \textit{slip} stops John’s walking activity at \( t_3 \); John won’t arrive at the store
(2) [John reached the top]

Model after processing $e$: a \textit{reach} event (\textit{=} culmination) at $t < \text{now}$; for all $t' < t$: $\neg \text{on top}$, for all $t'' \geq t$: $\text{on top}$
(2) \[[\text{John reached the top}]_e [\text{in three hours}]_e'\]

Model for $e'$:

- $e'$: reach the top via preparation

Diagram:
- Start event
- Preparatory process
- Reach event
- Resultant state: be on top

Time line:
- On top
- Not on top
- 0
- 3 h.
- Time $t$
(2) \([\text{[John reached the top]}_e \text{[in three hours]}]_{e'}\)

- Preparatory process of \(e'\) has to be abductively inferred or chosen from context. Candidates:
  - climbing
  - riding a helicopter
  - parachuting
  - ...

▷ Additive coercion
(3) \[ \text{[Johann baute das Haus]}_e \ldots \]
'John built the house ...'

\[ e: \text{an event of building a house} \]

start event \hspace{2cm} finish event

preparatory process: a building activity \hspace{2cm} resultant state: the finished house

\[ \text{house}(c) \]
\[ \text{house}(0) \]

\text{time } t
Event Calculus II: The Basic Operations – Non-monotonic Inference

(3) \[[\text{Johann baute das Haus}]_e [\text{zwei Jahre lang}]]_p

'John built the house for two years'

\[ e: \text{an event of building a house} \]

\[ p: \text{a building activity} \]

\[ \text{house}(0) \rightarrow \text{house}(c) \]

\[ \text{stop} \]

\[ \text{time } t \]
Event Calculus II: The Basic Operations – Non-monotonic Inference

(3) \([\text{Johann baute das Haus}]_e [\text{zwei Jahre lang}]_p\)

‘John built the house for two years’

- Event Calculus employs non-monotonic logic
- Default inferences can be canceled (imperfective paradox)

▷ Subtractive coercion
Given a predicate like

\[ build(x, y, t) \]

there are two possibilities to construct terms (van Lambalgen & Hamm 2005):

1. event types: John’s building of the house

   \[ e_{build}(j, h) \text{ is constructed from } \exists t. build(j, h, t) \]

2. time dependent properties: John’s building the house

   \[ p_{build}(j, h) = \{ t | build(j, h, t) \} \]

   \[ \text{HoldsAt}(p_{build}(j, h), s) \text{ means that } s \in \{ t | build(j, h, t) \} \]
Abstract type shift

(4) Johann nieste fünf Minuten lang.
   ‘John sneezed for five minutes.’

(5) John dived through the pool for two hours

The adverbial for two weeks requires an activity. Therefore the semelfactive and the accomplishment have to be transformed into an iterative process. This is achieved via the canonical map, i.e. imperfect nominalization (c.f. Hamm & van Lambalgen 2003):

\[ e \rightarrow \text{Happens}[e, \hat{t}] = p \]

\[(p: \text{the set of time intervals filled by event tokens of type } e)\]
(6) Peter durchtauchte das Becken den ganzen Vormittag. Peter through-dived the pool the whole morning.

There are two possible derivations:

- Subtractive coercion: one diving event lasting the whole morning
- Abstract type shift: a series of diving events

- Event representation contains a process, therefore subtractive coercion is predicted to be the first choice
- Is this example more difficult to process than abstract type shift of semelfactives?
Perfective aspect perspectivizes an event as a complete whole

Hierarchical planning allows to take a complex event and define a new event atom

e.g. build a house:

\[ \text{Happens}(e_{\text{build}}(h), t), \text{ i.e. the perfective accomplishment, is defined by the following conditions:} \]

- there is a building activity which
- culminates in a finish event at \( t \)
- with the finished house coming into existence at \( t \)

Perfective accomplishments cannot undergo subtractive coercion

They can, however, be lexically reanalyzed as perfective activities

- only a single condition: there is a building activity
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Outline

1. Additive Coercion: Smooth Update of the Event Representation
2. Abstract Type Shift: Differences in Coercion Costs
3. Subtractive Coercion: Crosslinguistic Differences
4. Open Questions and Conclusions
Additive Coercion

Operator Based Accounts: Reject and Recompute

"Coercion operators are only inserted when they are triggered by a mismatch. [...] The interpretation in terms of coercion is fully compositional, but the value of the hidden operator is dependent on linguistic context and world knowledge.” (De Swart, 2003, p. 8)

Event Calculus: Smooth Update

Additive coercion consists in elaborating a scenario. The coercing stimulus adds an eventuality that has to be substituted with a concrete event from discourse context or world knowledge.
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Reject-and-Recompute vs. Smooth-Update

The mountaineer reached the top for three hours ... The mountaineer reached the top in three hours ...

Reject-and-Recompute

- ERPs indicate two processes
  - Mismatch detection
  - Insert coercion operator
- Early on, aspectual mismatch and coercion elicit the same effects

Smooth-Update

- ERPs indicate only one process
  - Update the model with a preparatory process
- Mismatch and coercion elicit qualitatively different ERP effects
Additive Coercion

An ERP Study on Additive Coercion – the Design

- **Adverbial**: mismatch vs. coercion vs. control

- **Critical segment**: participle (*entdeckt*)

- Apart from the first word physically identical stimuli

- Processing differences must be due to semantic context

Oliver Bott (Tübingen)
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ERP Study *Additive Coercion* - Methods

- Sentences presented word by word (800 ms per word)
- *Did the sentence make sense?* judgment after each trial (time limit 4s)
- 120 experimental items in three conditions + 180 distractor sentences
- Latin square design
- 24 participants

- EEG continuously recorded using a standard montage with 29 scalp electrodes
- Referenced to linked mastoids
- Only artefact free trials
ERP Study *Additive Coercion* – EEG recordings
Additive Coercion – Judgments

- Mism. < coerc. < contr.
- Coercion accepted in more than 75%.
- No differences in answer time.
- Subjects computed coerced meanings during reading.

![Bar graph showing percentage of "yes, makes sense" judgments for mismatch, coercion, and control conditions.](image-url)
Additive Coercion – ERPs 500-900 ms Post Stimulus

- Mismatch elicits a P600
- Coercion leads to a sustained anterior negativity
- But no P600
- Increased working memory demands in coercion
- But no rejection
Additive Coercion – Mismatch Effect

Mismatch elicits a P600
Additive Coercion – Coercion Effect

Coercion leads to a working memory LAN only
Additive Coercion – A replication

In cooperation with Matthias Schlesewsky (Mainz):

- Same materials
- More participants ($N = 30$)
- Faster presentation rate: 300ms per word + 200ms inter stimulus interval
Replication: coercion leads to a LAN
Replication: mismatch leads to P600
Additive Coercion – Discussion

- Semantic interpretation breakdown in aspectual mismatch indexed by P600
- Coercion elicits only a working memory LAN
- Update of the situation model with an inferred preparatory process
- The study provides evidence for a smooth update:

Smooth-Update Hypothesis

The already computed representation is modified without rejecting it first.
Additive Coercion – Discussion

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Further Evidence – Context Effects in Self-Paced Reading

- Sentences without context: coercion slows down RT
- Supportive context: coercion effect disappears

telic context:
For half a year now, John has been swimming two kilometers every morning. When he started, it took him almost one hour but he is becoming faster by the day.

target with *in*-adverbial:
Heute schwamm er in nur dreißig Minuten.
(Today he swam in only thirty minutes).

target with *for*-adverbial:
Heute schwamm er ganze dreißig Minuten.
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Abstract Type Shift

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Abstract Type Shift

Same Operator – Same Difficulty?

Iterative semelfactive:

(1) John nieste vier Stunden lang.
John sneezed for four hours.

Iterative accomplishment:

(2) John durchtauchte das Becken vier Stunden lang.
John dived through the pool for four hours.
Iterative Semelfactives vs. Accomplishments: Operator Based Accounts

Local mismatch:

```
for VP_{no \ act.}
```

Insert an iterative operator:

```
for repeat VP_{no \ act.}
```

▸ (1) and (2) are predicted to be equally difficult
Iterative Semelfactives in EC

The boy sneezed

- $\text{Happens}(\text{sneeze}, t) \land t < \text{now}$

for four hours

- $\text{Happens}(\text{stop}_p, t) \land \text{HoldsAt}(\text{time}_p(4h), t) \rightarrow \text{For}(p, 4h)$

There is no process $p$ available in the scenario

- Abstract type shift:
  $\text{Happens}(\text{sneeze}, t) \rightsquigarrow \text{HoldsAt}[\text{Happens}(\text{sneeze}, \hat{t})]$  
- $p$ can now be instantiated by $[\text{Happens}(\text{sneeze}, \hat{t})]$  
- ”Pure” abstract type shift
Iterative Accomplishments in EC

(2) The boy dived through the pool ...
(2) The boy dived through the pool the whole morning.

Implausible situation, recomputation required
(2) The boy dived through the pool the whole morning.

An alternative computation has to be chosen:
Iterative Readings in EC

Semelfactives:
1. Abstract type shift

Accomplishments:
1. Subtractive coercion
2. Revision of implausible reading
3. Abstract type shift

Iterative accomplishments should be harder to process than iterative semelfactives

Comparing them with subtractive coercion and iterative semelfactives reveals underlying processes
Abstract Type Shift

Reading Time Study – Semelfactives

iter  Fünf Minuten lang|nieste|der Junge|ziemlich|laut,...
      For five minutes|sneezed|the boy|rather|loudly,...
      For five minutes the boy sneezed rather loudly,...

singl  Vor fünf Minuten|nieste|der Junge|ziemlich|laut,...
      Five minutes ago|sneezed|the boy|rather|loudly,...
      Five minutes ago the boy sneezed rather loudly,...

...|dann|verließ|er|das Klassenzimmer.
...|then|left|he|the classroom.

- Materials similar to Brennan & Pylkkänen (2008)
Reading Time Study – Accomplishments

l-for  Der Arbeiter belud die Karre zwanzig Jahre lang, ...  
The worker loaded the cart for twenty years...  
For twenty years the worker loaded the cart.  
... dann ging er in Rente.  
... then he went into retirement.

s-in  Der Arbeiter belud die Karre in zwanzig Minuten, ...  
In twenty minutes the worker loaded the cart...  
... dann ging er in die Pause.  
... then he went into the break.

s-for  Der Arbeiter belud die Karre zwanzig Minuten lang, ...  
For twenty minutes the worker loaded the cart...

l-in  Der Arbeiter belud die Karre in zwanzig Jahren,  
In twenty years the worker loaded the cart...
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l-in Der Arbeiter belud die Karre in zwanzig Jahren,
In twenty years the worker loaded the cart...
Methods

- Self-paced reading with moving window presentation
- After each trial: Did the sentence make sense?
- Experiment *Semelfactives*
  - 20 items
  - Iterative event vs. single event
  - Critical segment: verb (+ subject)
- Experiment *Accomplishments*
  - 40 items: *long-for* vs. *short-for*, *short-in* (control), *long-in* (mismatch)
  - Critical segment: adverbials (controlled for length)

- 40 participants
- Latin square design
- 80 fillers
Pretests

Experimental conditions received the expected interpretations:

**Semelfactives**
- unmodified: single event ($> 90\%$)
- *control (ago adv.)*: single event ($> 90\%$)
- *iterative coercion*: iterative interpretation ($> 90\%$)

**Accomplishments**
- unmodified: single, complete event ($> 90\%$)
- *control (short in adv.)*: single, complete event ($\approx 80\%$)
- *short for*: incomplete event ($> 80\%$)
- *long for*: iterative interpretation ($\approx 80\%$)
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Experimental conditions received the expected interpretations:

Semelfactives
- unmodified: single event \((> 90\%)\)
- control (ago adv.): single event \((> 90\%)\)
- iterative coercion: iterative interpretation \((> 90\%)\)

Accomplishments
- unmodified: single, complete event \((> 90\%)\)
- control (short in adv.): single, complete event \((\approx 80\%)\)
- short for: incomplete event \((> 80\%)\)
- long for: iterative interpretation \((\approx 80\%)\)
Judgments

- Only mismatch is judged nonsensical
- Iterative accomplishments are somewhat less acceptable

Is there an indication of difficulty?
No difference between coercion and control

Semelfactives are easy to iterate
**Accomplishments – Reading Times**

**Adverbial:**
- **Short-** *for = control**
  - It is easy to reanalyze an accompl. as activity
- **long-** *for = mismatch**
  - Iteration is difficult

**Next segment:**
- Only mismatch is slow
  - Readers have recovered from local incompatibility
Accomplishments – Mean RTs of the Adverbial Region

![Bar chart showing mean reading times (+ 95% CIs) for different conditions: control, subtractive coercion, iterative coercion, and mismatch.](chart.png)
Semelfactives are easy to iterate (in contrast to Brennan & Pylkkänen’s study on iterative semelfactives in English)

Accomplishments are hard

- Coercion costs depend on aspectual class
- EC offers an explanation – more steps required in iterating accomplishments

Comparison with subtractive coercion and abstract type shift of semelfactives suggests that difficulty is due to revising the first, implausible interpretation

A potential concern: habitual reading may be different from iterated process
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Reading Time Studies – Discussion

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Iterative coercion of semelfactives:

Brennan & Pylkkänen (2008)

(3a) Throughout the day the student sneezed . . .
(3b) After twenty minutes the student sneezed . . .

- Self-paced reading and MEG showed coercion costs in (3a)

Bott (2008, 2010)

- Two self-paced reading experiments revealed null effects of iterated semelfactives in German
- Items normed as in Brennan & Pylkkänen (2008)
Abstract Type Shift

An Explanation

Event Calculus

- In both languages: iterative interpretations require abstract type shift
- Same operation as in imperfect nominalizations (e.g. *Peters dauerndes Niesen nervte*/ *Peter’s continuous sneezing was annoying*)
- This operation may differ in how frequently it is used across languages
- Testable hypothesis: imperfect nominalization much more frequent in German than in English
Outline

1. Additive Coercion: Smooth Update of the Event Representation
2. Abstract Type Shift: Differences in Coercion Costs
3. Subtractive Coercion: Crosslinguistic Differences
4. Open Questions and Conclusions
The Interplay of Lexical and Grammatical Aspect

At first sight, the English and German examples (1a/b) and (2a/b) seem to be very similar ((1/2a) requires subtractive coercion):

(1) The architect built the monument
   a) for two years . . .
   b) in two years . . .

(2) Der Architekt baute das Monument
   a) zwei Jahre lang . . .
   b) in zwei Jahren . . .

In English, (3) is the preferred way to express the meaning of (1a), whereas German has no grammaticalized progressive

(3) The architect was building the monument for two years . . .

How does the aspectual system of a language affect aspectual processing?
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Crosslinguistic Aspectual Variation (CAV) Hypothesis

Only if a language has the grammatical means to express an aspectual distinction, the processor does immediately commit to an aspectual interpretation.
Pragmatic strengthening in English: *The architect built the monument* ➤ perfective

➤ The accomplishment is interpreted as a complete event
➤ Continuation with a *for*-adverbial yields a contradiction
➤ There’s a way out: reinterpretation of the accomplishment as an activity

German: *Der Architekt errichtete das Monument* ➤ underspecified with respect to grammatical aspect

➤ The *for*-adverbial disambiguates towards an imperfective interpretation
➤ No or less cost for subtractive coercion than in English
English:

s-for) The architect built the monument for two years . . .
p-for) The architect was building the monument for two years . . .
s-in) The architect built the monument within two years . . . after the city had finally provided the money for it.

German:

for) Der Architekt errichtete das Monument zwei Jahre lang . . .
in) Der Architekt errichtete das Monument in zwei Jahren . . . in einem Vorort von Paris.
Methods

English:
- Self-paced reading with moving window presentation; sensicality judgment after each sentence
- 30 items in six conditions + 110 fillers
- 30 native English speakers

German:
- Self-paced reading with moving window presentation; sensicality judgment after each sentence
- 20 items in four conditions + 64 fillers
- 32 native German speakers
Both German preterite accomplishments and English simple forms allow for-modification.
Reading Times

**English:**

- Coercion costly in English

**German:**

- No coercion costs in German
The same type of coercion – subtractive coercion – is processed differently in English and German

Support of CAV hypothesis

We need to account for two types of non-monotonic updates of the event representation

1. Cancelation of the culmination in imperfective contexts
2. Revision of the situation type in perfective contexts

(build_{accomplishment} \rightsquigarrow build_{activity})
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### Conclusions

Next Steps

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- ACHIEVEMENT
- ACCOMPLISHMENT
- POINT
- ACTIVITY
- HABITUAL

- perfect: $\rightarrow$ constate
- +activity $\rightarrow$ constate
- progressive: $\rightarrow$ progstate
- iterate

(from Moens & Steedman 1988)

- Systematic comparison of coercion (sub)types in planned ERP research

Oliver Bott (Tübingen)
Conclusions

Semantic P600 Effects (Herten, Kolk & Chwilla 2005)

(1) De vos die op de stroper joeg...
The fox that at the poacher hunted...
The fox that hunted the poacher...

- Sentence becomes implausible at joeg
- This was indexed by a P600

(One) interpretation of the P600

The P600 is a "monitoring component that checks upon the veridicality of ones sentence perception" (p. 241)
Conclusions

Iterated Accomplishments – Underlying Processes

coerc Den ganzen Tag hatte der Junge das Becken durchtaucht...
The whole day had the boy the pool trough-dived...
The whole day, the boy had dived through the pool...

mism In einem Tag hatte der Junge das Becken durchtaucht...
In one day had the boy the pool trough-dived

contr In einer Minute hatte der Junge das Becken durchtaucht...
In one minute had the boy the pool trough-dived

If our model of aspectual analysis is correct, we expect *reprocessing* in the coercion condition.

Given the Herten, Kolk & Chwilla (2005) study, this should be reflected by a P600 effect in the coercion condition.
Conclusions

Additive Coercion vs. Abstract Type Shift: Predictions

Additive coercion:
- Preparatory process has to be inferred and to be added to the situation model
- No mismatch, smooth update
- Enhanced working memory demands
  - only working memory LAN

Abstract type shift:
- Accomplishments: revision of an implausible model leads to a shift event $\rightsquigarrow$ process
  - Reprocessing
- Semelfactives: immediate shift event $\rightsquigarrow$ process
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We have demonstrated that EC allows us

- to differentiate among (cognitively) distinct coercion types
- model the processes in aspectual coercion (e.g. elaborating a scenario)
- connect the expected cognitive processes to ERP research and neurolinguistic models
Thank you very much for your attention!