A Compositional Constructional Analysis of ‘Hitting’ Verb Argument Realization Patterns and Their Meanings

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‘Hitting’ verbs

• ‘Hitting’ verbs:
  • E.g.: hit, slap, kick, punch, pat, tap, whack, etc.
  • semantically similar
  • exhibit a wide range of similar argument realization patterns
  • different patterns describe different situations
Argument Realization Patterns

1. *She slapped/kicked/punched the box off the table*
   – actor *causes motion of another entity*

2. *She slapped her hand on / kicked her foot against the table*
   – actor *moves body part, contacts another entity*

3. *She slapped him on the back / across the face.*
   – actor *affects person via contact at specific body location*
Road Map

• Argument Structure Constructions
  (Goldberg 1995, 2006)

• Embodied Construction Grammar (ECG)
  (Feldman, Dodge, and Bryant, 2010)

• Analysis:
  – Meaning
  – Verb and A-S Constructions
  – Sentence examples
Argument Structure Constructions

*She slapped the block into the box*

Verb: *Slap*  
<slapper>  <slapped thing>

A-S: Cause Motion

meaning:  
<causer>  <patient/theme>  <landmark>

syntax:  
Subj          DirObj                PrepObj
Argument Structure Constructions

*She slapped the block into the box*

Verb: *Slap*  
A-S: Cause Motion

- meaning: *<causer> <patient/theme>*
- syntax: Subj, DirObj, PrepObj

She slapped the block into the box
Argument Structure Constructions

*She slapped her hand on the block*

Verb: *Slap*  
A-S: MoveBodyPart

meaning:  

syntax:
She slapped him on the arm

Verb: Slap
A-S: PartPossessor

meaning: <causer> <affectedPerson> <bodyPart>
syntax: Subj DirObj PrepObj
Argument Structure Constructions

Need to identify and represent:

– Semantic commonalities that motivate different patterns of integration of verb, A-S construction, and nominal meanings
– Complex meanings that arise from this integration
– Relevant constraints that enable us to distinguish between different patterns
Embodied Construction Grammar

Construction grammar in which embodied semantics are central

Simulation semantics -- understanding a description of an event involves activation of the same/similar neural structure as is active for other experiences of that event
Language Understanding Model

• **Analysis:**
  – Determination of which constructions in a grammar “best-fit” a given utterance
  – Unification of instantiated constructions produces semantic specification (Semspec)

• **Simulation:**
  – Enactment of the situation specified in the Semspec.
  – May allow understander to draw further inferences.
Embodied Construction Grammar

• ECG formalism enables precise, consistent representations of constructions and meanings

• Supports computational implementations:
  – ECG Workbench -- view, write and test grammars
  – Constructional Analyzer (Bryant 2008) – analyzes sentence examples, produces semantic specifications
Meaning

- Represented using schemas
- Consistent with simulation semantics
- Meanings of verb and A-S constructions are represented using some of the same or related schemas
Motor Control Schema

```
schema Process
roles
protagonist
x-net

```

```
schema MotorControl
subcase of Process
roles
  actor: @animate
effector
effort
routine
constraints
  actor ↔ protagonist
  routine ↔ x-net
```
schema MotorControl
  subcase of Process
  roles
    actor: @animate
    effector
    effort
    routine
  constraints
    actor ↔ protagonist
    routine ↔ x-net

schema ForceTransfer
  evokes Contact as c
  roles
    supplier
    recipient
  forceAmount
  constraints
    supplier ↔ c.entity1
    recipient ↔ c.entity2

schema ForceApplication
  subcase of MotorControl
  evokes ForceTransfer as ft
  roles
    actor
    actedUpon
    effector
  constraints
    actor ↔ ft.supplier
    actedUpon ↔ ft.recipient
    effort ↔ ft.forceAmount

  e.g. squeeze, press
schema ForcefulMotionAction

subcase of ForceApplication

evokes SourcePathGoal as spg

roles

actor

actedUpon

effector

constraints

actedUpon ↔ spg.landmark

effector ↔ spg.trajector

schema SourcePathGoal

subcase of TrajectorLandmark

roles

landmark

trajector

source

path

goal

e.g. slap, kick, punch, etc.
CauseEffectAction

schema CauseEffectAction
  subcase of ComplexProcess
  roles
    causalProcess: ForceApplication
    effectProcess: Process
    causer
    affected
  x-net: @causeEffect
  constraints
    process1.actedUpon ↔ affected

schema ForceApplication
  subcase of MotorControl
  evokes ForceTransfer as ft
  roles
    actor
    actedUpon
  constraints
    actor ↔ ft.supplier
    acted Upon ↔ ft.recipient
    effort ↔ ft.forceAmount

schema Process
  roles
    protagonist
  x-net

Many transitive A-S cxns
Cause Motion

e.g. *throwing*, *dragging*

CauseMotion A-S cxn
A given sentence instantiates many constructions

For *She slapped the block into the box*:
- Lexical constructions: *She, slapped, the, block, into, box*
- PastTense cxn
- Phrasal cxns: *the block, into the box*
- Argument Structure Cxn: CauseEffect
- Clause cxn: Declarative
Verb Constructions

**construction** SlapPast  
**subcase of** Slap, PastTense  
**form:** WordForm  
**constraints**  
self.f.orth ← “slapped”  
**meaning:** ForcefulMotionAction  
**constraints**  
effector ← @hand  
self.m.x-net ← @slap

**schema ForcefulMotionAction**  
**subcase of** ForceApplication  
**roles**  
actor: @animate  
actedUpon  
effector  
x-net: @forcefulMotionAction

**Other similar verbs:**  
kick  effector = foot  
punch: effector = fist  
tap: force amount = low  
whack: force amount = high
Ontology

animate sub of entity
animal sub of animate
person sub of animate

bodyPart sub of entity
foot sub of bodyPart
arm sub of bodyPart
leg sub of bodyPart
**CauseMotion A-S cxn**

**construction** ActiveTransCauseMotion2  
**subcase of** ArgumentStructure  
**constructional**  
**constituents**  
  v : Verb // inherited  
  np: NP  
  pp: Path-PP  
**form**  
**constraints**  
  v.f before np.f  
  np.f before pp.f  
**meaning**: CauseMotion  
**evokes** EventDescriptor as ed  
**evokes** ForcefulMotionAction as fma  
**constraints**  
  v.m <-> self.m.causalProcess  
  self.m.affected <-> np.m  
  self.m.causer <-> ed.profiledParticipant  
  self.m.effectProcess.spg <-> pp.m

**schema** CauseMotion  
**subcase of** ComplexProcess  
**roles**  
  causalProcess: ForceApplication  
  effectProcess: MotionAlongAPath  
  causer  
  affected  
  x-net: @causeMotion
Cause Motion A-S construction
e.g. *She slapped the block into the box*

<table>
<thead>
<tr>
<th>CAUSE MOTION 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constituents:</strong> Verb, NP, PP</td>
</tr>
<tr>
<td><strong>Form:</strong> Verb &gt; NP &gt; PP</td>
</tr>
<tr>
<td><strong>A-S cxn meaning:</strong> CauseMotion</td>
</tr>
<tr>
<td><strong>Verb meaning:</strong> ForcefulMotionAction</td>
</tr>
<tr>
<td><strong>Meaning constraints:</strong></td>
</tr>
<tr>
<td>verb meaning = CauseMotion.causalProcess</td>
</tr>
<tr>
<td>profParticipant = causer &lt;-&gt; actor</td>
</tr>
<tr>
<td>NP meaning = affected &lt;-&gt; actedUpon &lt;-&gt; mover &lt;-&gt; trajector</td>
</tr>
<tr>
<td>PP.np meaning = landmark</td>
</tr>
</tbody>
</table>
She slapped the block into the box
She slapped the block into the box
She slapped the block into the box
She slapped the block into the box.
She slapped the block into the box
**EFFECTOR MOTION**

**Constituents:** Verb, NP, PP

**Form:** Verb > NP > PP

**A-S cxn meaning:**

**ForcefulMotionAction**

**Verb meaning:**

**ForcefulMotionAction**

**Meaning Constraints:**

- profParticipant = actor
- NP meaning = effector <-> trajector
- PP.np meaning = actedUpon <-> landmark

*She slapped her hand on the block*
She slapped her hand on the block.
She slapped her hand on the block
She slapped her hand on the block
She slapped him on the hand

**PART POSSESSOR**

**Constituents**: Verb, NP, PP: BodyPartPP (the + BodyPart)

**Form**: Verb > NP > PP

**A-S cxn meaning**: 

- **CauseEffect**

  evokes: **Possession**

**Verb meaning**: 

- **ForcefulMotionAction**

**Meaning Constraints**:

- verb meaning = CauseEffect.causalProcess
- profParticipant = causer <-> actor
- NP meaning = affected <-> actedUpon <-> p.posssessor (@person)
- PP.np meaning = <-> p.possessed (@bodyPart)
She slapped him on the hand.
She slapped him on the hand
She slapped him on the hand
<table>
<thead>
<tr>
<th>A-S Cxn</th>
<th>Subject</th>
<th>Direct Object</th>
<th>PP-Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitive</td>
<td>Causer Actor</td>
<td>Affected ActedUpon</td>
<td>(with Effector)</td>
</tr>
<tr>
<td>CauseMotion</td>
<td>Causer Actor</td>
<td>Affected ActedUpon</td>
<td>Mover Trajector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Landmark</td>
</tr>
<tr>
<td>EffectorMotion</td>
<td>Actor</td>
<td>Effector Trajector</td>
<td>ActedUpon Landmark</td>
</tr>
<tr>
<td>PartPossessor</td>
<td>Causer Actor</td>
<td>Affected ActedUpon</td>
<td>Possessor Possession</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(person)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(body part)</td>
</tr>
</tbody>
</table>
Concluding Remarks

• Important to recognize and represent:
  – Inherent complexity of conceptual structure (and participant roles) utilized by linguistic constructions
  – Importance of inter-related schematic structures for compositional analysis
  – Use of constraints to support best-fit analysis process

• ECG formalism facilitates analysis


SemSpec generated by ECG workbench for analysis of

He cut the bread