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## From event semantics to force dynamics

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# Seminar 1: From event semantics to force dynamics

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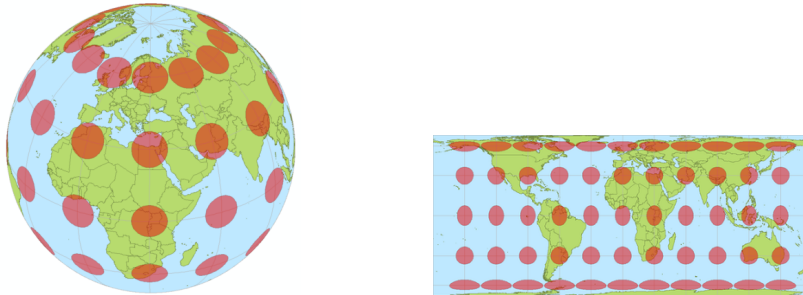
Seoul National University Linguistics Department  
19 October 2021

## 1 Starting point

- (1) Davidson 1967
- a. John buttered the toast with a knife, in the kitchen, at midnight.
  - b. with-a-knife(*e*), in-the-kitchen(*e*), at-midnight(*e*)

What's the matter with event arguments?

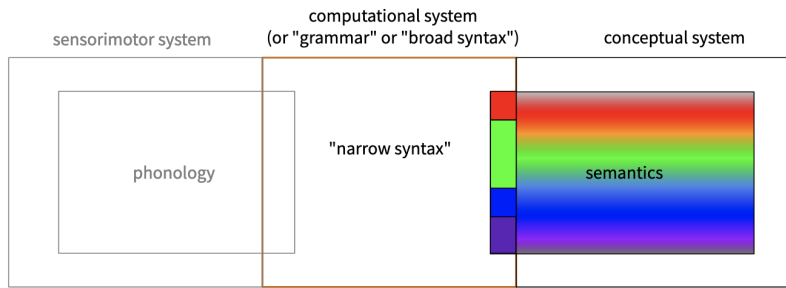
### 1.1 A map is not the territory



“A map is *not* the territory it represents [...]” - Korzybski 1933

What does such distortion look like for us?

- Primarily, too much complexity at the mapping between grammatically-visible objects (features/types/syntactic structures/...) and concepts
- (Note: “map”  $\neq$  “mapping”)



The X-Y interface is the shared information between X and Y.

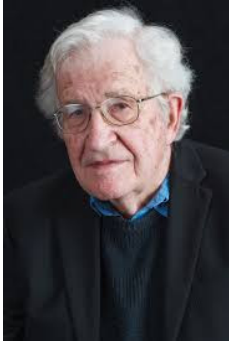
Tension: Should the denotations we write down be simple or complex?

(2) Parsons 1990

- a. *Agatha is crossing the street.*
- b.  $\exists t: [t < \text{now} \ \& \ (\exists e) [\text{crossing}(e) \ \& \ \text{Subject}(e, \text{Agatha}) \ \& \ \text{Object}(e, \text{the street})]]$

(3) Landman 1992

1. For every event  $e'$  in  $w$  such that  $e$  is a stage of  $e'$ ,  $\langle e', w \rangle \in C(e, w)$
  2. If the maximal event  $e_m$  such that  $\langle e_m, w \rangle \in C(e, w)$  stops in  $w$ , then look at the closest world  $w'$  where  $e_m$  does not stop.
    - (a) If  $w'$  is not a reasonable world with respect to  $\langle e, w \rangle$ , the continuation branch stops.
    - (b) If  $w'$  is a reasonable world with respect to  $\langle e, w \rangle$ , then  $\langle e_m, w' \rangle \in C(e, w)$ .
  3. For every event  $e''$  in  $w'$  such that  $e_m$  is a stage of  $e''$ ,  $\langle e'', w' \rangle \in C(e, w)$
  4. If the maximal event  $e_{m'}$  such that  $\langle e_{m'}, w' \rangle \in C(e, w)$  stops in  $w'$ , then look at the closest world  $w''$  where  $e_{m'}$  does not stop.
    - (a) If  $w''$  is not a reasonable world with respect to  $\langle e, w \rangle$ , the continuation branch stops.
    - (b) If  $w''$  is a reasonable world with respect to  $\langle e, w \rangle$ , then  $\langle e_{m'}, w'' \rangle \in C(e, w)$ .
- etc.



**Minimalism:** “Other systems of the mind/brain have to be able to access expressions generated by the faculty of language, to “read” them and use them as “instructions” for thought and action... Language is an optimal solution to legibility conditions.”  
 –Chomsky 1998:8-9

⇒ Our theory of grammar and its interaction with concepts should be as simple as possible

⇒ Simple denotations



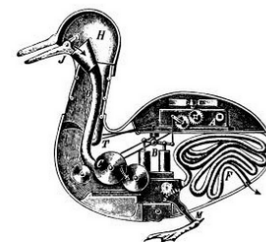
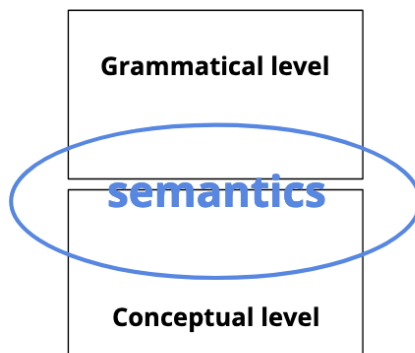
**Hume’s definition of definition:**  
 “[T]he chief obstacle ... to our improvement in the ... metaphysical sciences is the obscurity of the ideas, and ambiguity of the terms.”  
 –*Enquiry Concerning Human Understanding* 7.1.2/61

⇒ Concepts should be broken down into combinations of more well-understood concepts

⇒ Complex denotations

- (4) Resolving the tension: two levels of representation (a simpler grammatical “map” and a more complex conceptual “territory”)

**Grammar sees: a simple (formal) object**



*Canard Digérateur*, Jacques de Vaucanson, 1735

**Conceptual level sees: all the messy detail**

Good practices

- Taking morphology and syntax *extremely* seriously
- Using good denotational hygiene

## 1.2 Back to event arguments

So what *is* the matter with event arguments?

Copley & Harley 2015, 2020 ms.: They're not the best map for the territory, not because they're arguments but because they're *atomic*, and because they're *events*. (What's the commonsense notion of an event? Maybe "change"; see Lombard 1979.)

- Hard to represent **interaction** between events
- Hard to represent **(a)telicity**
- Both of these  $\Rightarrow$  **overly complex mapping** to morphosyntax

We'll see that force arguments seem to give us a better "map" to the event-semantic "territory" than event arguments do. Do they give us a better mapping to morphosyntax as well?

## 2 About forces

### 2.1 What is a force?

- Intuitively, a force is an input of energy
- It has an origin, a direction, and magnitude  $\Rightarrow$  vector representation
- It has a *Ceteris paribus* condition for its result ( $\approx$  normality/stereotypicality/closed-world/efficacy)
- We can define abstract forces based on concrete forces

Things the concept of force easily captures:

- Interaction or lack thereof (*ceteris paribus*/defeasibility/normality/stereotypicality/closed world/efficacy)
- Entrained (cotemporal) results

In thinking of forces, we need to distinguish change and energy. Change is not energy (see Croft 2012, 2015), but change and energy are closely related (Bohnmeyer & Swift 2006); change cannot happen without energy. But look at how the word "dynamic" is used...

(5) *dynamic* as 'characterized by change':

- a. Bohnmeyer & Swift 2006: "we propose the basic meaning of dynamicity is change"
- b. Beavers 2008: dynamic predicates are those that "involve some "change" or potential change in one participant"
- c. Fábregas & Marín 2014: "dynamicity" refers to "(abstract) movement in some quality space"

d. Maienborn 2007: definition of “dynamic predicates” excludes predicates such *sleep* and *stay*

(6) *dynamic* as ‘characterized by energy’:

- a. Comrie 1976: “With a dynamic situation, ... the situation will only continue if it is continually subject to a new input of energy”
- b. Smith 1991: “The bounded nature of events can be derived by their dynamicity. Events require a constant input of energy.”
- c. Bach 1986: ‘dynamic’ predicates are *sit, lie, etc.*
- d. Beavers 2011: “I assume that change can only be encoded in dynamic predicates. But which dynamic predicates involve changes ...?”

## 2.2 Forces are needed

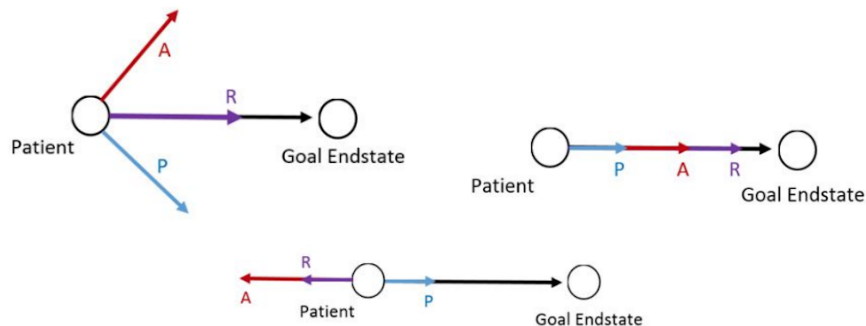
(7) Talmy (1972, ..., 2000)

- a. The ball was rolling along the green.
- b. The ball kept rolling along the green.

(8) Copley & Harley 2015: *keep* + SC hard to do with event arguments

- a. Mary kept her door open.
- b. *keep open* = cause to stay open
- c. *stay open* ≠ *be open* (complexity, difference in Aktionsart)
- d. *stay open* ≠ *cause to be open*
- e. Solution: *stay open*: there is a force whose entrained (cotemporal) result is the door being open

(9) CAUSE, ENABLE, PREVENT (Wolff & Song 2003, Wolff 2007)



## 2.3 Forces come for free

- Hume: Causally-derived regularities can be perceived but causal relations themselves cannot be, they come from the mind

- Wolff & Shepard (2013): Temporal gaps, direction influence causal impression  $\Rightarrow$  representation of causation must include time and direction  $\Rightarrow$  must not be mere regularities
- Robles-De-La-Torre & Hayward (2001): force perception competes favorably with other kinds of perception
- Runeson & Frykholm 1981, 1983: Force-dynamic information can be recovered from information about kinematics alone, difficult to ignore or obscure

### 3 A brief history of forces in semantics

Force dynamics in cognitive linguistics: Talmy 1973, 1976, 1981, 1988, 2000...; Shibatani 1973,... Croft 1990, 1991, 1998, 2012...; Langacker 1991..., Gärdenfors 2004, 2005, 2007...

#### 3.1 Three components of Talmy's theory

##### 3.1.1 Main organizing principle: Force opposition

- All force-dynamic meanings expressed in language necessarily involve an opposition between two forces that are in opposing directions
- Each of these two forces is related to one of two entities (expressed or accommodated):
- The Agonist (usually the agent) is 'singled out for focal attention'
- The Antagonist is considered only insofar as it impacts the Agonist
- Does the Agonist's force overpower the Antagonist's force, or vice versa?

(10) The ball kept rolling.

- (11) a. ... because of the stiff wind.  
b. ... despite the stiff grass.

*because of* and *despite* each both introduce an entity and indicate which entity has the stronger force.

Problematic to insist on opposition in all cases (Jackendoff 1990, Wolff & Song 2003):

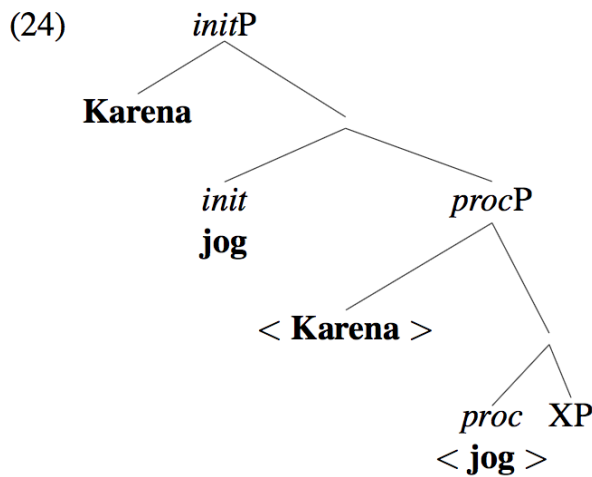
(12) Smoothing the earth helped the logs roll down the slope

##### 3.1.2 Two temporal relations: the force is applied before the result, or during the result

- **Launching:** Talmy's "onset causation" (Michotte's (1946) "lancement", Shibatani's (1973) "ballistic causation"): e.g. *The stirring rod's breaking let the particles settle*
- **Entrainment:** Talmy's "extended causation" (Michotte's "entraînement", Shibatani's (1973) "controlled causation"): e.g. *The wind kept the ball rolling*

Compare to the formal tradition: Launching but no entrainment

- (13) Pustejovsky 1995  
 Mary ran to the store: [*cause*(*act*(*m*), *become*(*at*(*m*, *the-store*) BY run)]
- (14) Higginbotham 2000  
 John saddled the horse:  $\exists e \exists e'$  [*agent*(John,*e*) & *saddled*(the horse,*e'*) & (*e*,*e'*) is a telic pair]
- (15) Ramchand 2008  
 Mary opened the door: *Subject*(Mary,  $e_1$ ) &  
 a.  $[[v]] = \lambda P \lambda x \lambda e \exists e_1, e_2 [P(e_2) \& v(e_1) \& \text{State}(e_1) \& e = e_1 \rightarrow e_2 \& \text{Subject}(x, e_1)]$   
 b.  $[[V]] = \lambda P \lambda x \lambda e \exists e_1, e_2 [P(e_2) \& V(e_1) \& \text{Process}(e_1) \& e = (e_1 \rightarrow e_2) \& \text{Subject}(x, e_1)]$



### 3.1.3 Intrapersonal forces: a way to understand exertion

Physical force manifestations of animate entities are understood to arise (in part at least) from their minds, rather than their physical properties alone

Psyche split in two, one part that is “repose-oriented” and another that is “goal-oriented”

*try*: Physical Agonist force is a result of exertion of the Agonist

## 3.2 Modality with forces: Talmy and Sweetser

- (16) The ball can't sail out of the ballpark with the new dome in place.



Bouletic/deontic *may/ must*

- “[W]anting . . . seems to be conceived in terms of a kind of psychological “pressure”, “pushing”, toward the realization of some act or state”; “psychosocial force”
- Content of desire = direction, relative authority/ability = relative magnitudes
- *may*: Agonist desires p, non-impingement by a potentially stronger Antagonist force
- *must*: no or no particular desire for p on the part of the Agonist, stronger Antagonist force for p

Epistemic (Sweetser 1994, 1990)

- Modals are “semantically ambiguous between our sociophysical understanding of force and some mapping of that understanding onto the domain of reasoning”
- “Epistemic forces” cause a train of reasoning leading to a conclusion

(17) *Mary must be at home*: The strongest “epistemic force” points to Mary’s being home

Portner (2009) critique:

- 1. Not really a theory
- 2. Where is intensionality?
- 3. Don’t they just reduce to logical relations?

My answers to the critique:

- 1. ok
- 2. Intensionality should come from *ceteris paribus* property of forces; may also however need difference between e.g., desires and actions
- 3. Logical relations *are* on this view essentially epistemic relations between propositions—the problem is in using them for *root* modality, not epistemic modality.

### 3.3 Causal chains: Croft and others

Croft (1991 et seq.) extended usefulness of force dynamics as an organizing principle for argument structure.

- Criteria for agent and patient roles can be causal, e.g. Dowty 1991, but change need not be implicated (Levin & Rappaport Hovav 1995): *Dash hit the table*. Force dynamics solves the problem - agents are energy sources and patients are recipients of the energy
- Causal chains represented in structure: agents higher, patients lower, instruments in between
- Direct/indirect distinction is important to language but is not represented if causation is only about dependencies (e.g. Lewis 1973)

## 3.4 Forces in formal theories

### 3.4.1 Can there be forces in formal theories?

Cog lx: meaning “cannot be reduced to an objective characterization of the situation described: equally important . . . is how the conceptualizer chooses to *construe* the situation and portray it for expressive purposes” (Langacker 1990) We must though stay “in touch with reality” (Johnson 1987; note similarity to map-territory question!)

Frege, Lewis, etc.: meaning is based on membership in a set and is about the world itself; propositional, digital, objective, so it’s fruitless to try to understand meaning in terms of psychological and sociological phenomena or subjective ideas.

Are forces ok with the formal perspective?

- No reason formal theories can’t talk about conceptual structures instead of the world (Hamm et. al 2006)
- Three ways to represent “analogue” forces formally: break it down into minimal parts (e.g. Zwarts & Winter 2000 vectors), make reference to them through basic relations such as ATTACH and SUPPORT (Zwarts 2010), or represent a simplified/abstract version of them (Copley & Harley 2015, 2020 ms)

### 3.4.2 The syntax-semantics interface

In cognitive lx, little interest in relating semantics to a formal, autonomous syntactic structure.

“Syntax is required only for the most subtle aspects of communication—pragmatic and semantic features are more fundamental for communication.” (Gärdenfors 2014)

In generative approaches, the mapping between semantics and syntax is of intense interest. Is this a problem for formal forces?

No: cognitive structures as starting point from which to construct possible or plausible meanings, with work still to be done at the interface. Also, forces should simplify the interface!

### 3.4.3 Intensionality: possibilities and causation

Forces seem to have outcomes built into them (their direction). But these outcomes are not always realized.

Thus to formally represent forces we need some sort of caused (small) possibilia.

But wait, doesn’t causation have to be represented with counterfactuals and possible worlds?

No.

Copley & Wolff 2014:

- Dependency theories of causation - causation is defined in terms of dependencies between (occurrences of) events. Includes logical, counterfactual, probability.
- Production theories of causation - take causal concepts such as force and transmission of energy to be basic, defines causation in terms of these

⇒ Causation can be represented EITHER with e.g. counterfactuals, OR with force dynamics; both are powerful enough, and only one is needed

### 3.5 Formal force theories

	data	force arguments	event arguments	categories
Zwarts 2010, Goldschmidt & Zwarts 2016	force verbs and prepositions	are vectors (Zwarts & Winter 2000)	are associated with paths along which forces are exerted in time	syntax-semantics interface, vector-oriented
Pross & Rossdeutscher 2015	conative alternation, other force verbs and prepositions	are atomic, introduced by force head within PP	are atomic, introduced by v head, interpreted as exertions of forces	syntax-semantics interface, vector-oriented
van Lambalgen & Hamm 2005	event structure, viewpoint aspect	are functions from times to truth values ("fluents"), but the <i>Trajectory</i> predicate is closer to a force vector	are atomic; eventualities are ordered quadruples that include events and fluents	calculus that derives only and all the occurring events given starting conditions, <i>ceteris paribus</i> -oriented
Copley & Harley 2015, 2018	event structure, viewpoint aspect	are functions from situations to situations	are replaced by force or situation arguments	syntax-semantics interface, <i>ceteris paribus</i> -oriented

#### 3.5.1 Zwarts 2010 and Goldschmidt & Zwarts 2016

- *on*, Dutch *op* (support), *aan* (attachment/hanging)
- *attached to/\*from*, *hanging \*to/from*
- *push/pull*, *squeeze/stretch*: a different vector direction from Talmy's!
- *hit*
- *hard*, *softly*

- (18) a. Maria schlägt auf den Nagel  
 Maria hits on the nail  
 'Maria hits the nail.'
- b. Maria schlägt den Nagel in die Wand  
 Maria hits the nail into the wall  
 'Maria hits the nail into the wall.'

**Forces** are located vectors that have (i) an origin, (ii) a magnitude, and (iii) a direction

A **path** is a continuous function from a time interval to the set of located force vectors. Roughly speaking, it is a sequence of positions at which forces (possibly zero) are exerted.

For any **event**  $e$ ,  $\text{PATH}(e)$  is the path that corresponds to  $e$ , if defined.

An **agent** is the exiter of the force, a **patient** is the recipient of the force, an **instrument** is the part of the agent in forceful contact with the patient.

For any event  $e$  with  $\text{PATH}(e)$ , there is a participant  $\text{THEME}(e)$  that occupies subsequent positions of  $\text{PATH}(e)$  during the running time of  $e$ .

$\text{CAUSE}(e_1, e_2)$ : if  $\text{PATH}(e_1, t_i) + \text{TENDENCY}(e_1(t_i))$  is collinear with  $\text{PATH}(e_2)$  while  $\text{TENDENCY}(e_1)(t_i)$  is not

- (19) a. Maria schlägt auf den Nagel  
 Maria hits on the nail  
 ‘Maria hits the nail.’  
 b. Maria schlägt den Nagel in die Wand  
 Maria hits the nail into the wall  
 ‘Maria hits the nail into the wall.’
- (20) a.  $\exists e . \exists p [ \text{PATH}(e) = p \ \& \ \text{AUF}(p, \text{den-nagel}) \ \& \ \text{SCHLAGEN}(e) \ \& \ \text{AGENT}(e) = \text{Maria} ]$   
 b.  $\exists e \exists e_1 \exists e_2 \exists p [ e = e_1 + e_2 \ \& \ \text{CAUSE}(e_1, e_2) \ \& \ \text{SCHLAGEN}(e_1) \ \& \ \text{PATIENT}(e_1) = \text{THEME}(e_2) = \text{den-nagel} \ \& \ \text{PATH}(e_2) = p \ \& \ \text{IN}(p, \text{die wand}) \ \& \ \text{AGENT}(e_1) = \text{Maria} ]$

### 3.5.2 Roßdeutscher & Pross 2015

- (21) a. Peter zieht an der Rübe  
 Peter pulls at the carrot  
 ‘Peter pulls at the carrot.’  
 b. Peter zieht die Rübe aus der Erde  
 Peter pulls the carrot out the soil  
 ‘Peter pulls the carrot out of the soil.’

Events are to V what forces are to P, or: V conceptualizes events and P conceptualizes forces.

- (22) a. verb phrase: VoiceP and vP  
 b. prepositional phrase: pP (Svenonius 2003) and forceP
- v introduces events:  $e$
  - *force* introduces forces:  $f$
  - a force  $f$  is conceptualized as that force  $f$  of which  $e$  is an exertion:  $vP + \text{force-denoting pP} \rightarrow e \text{ EXERT } f$
  - an “exertion” in this sense is best thought of as a notation of the idea that the event is the

conduit through which the initiator is connected to the force

- (23) a. Peter zieht an der Rübe  
Peter pulls at the carrot  
'Peter pulls at the carrot.'  
b. Peter zieht die Rübe aus der Erde  
Peter pulls the carrot out the soil  
'Peter pulls the carrot out of the soil.'
- (24) a. Peter is the initiator of an event which is an exertion of a pulling force located on the carrot.  
b. Peter is the initiator of an event which is an exertion of a pulling force, where the carrot is the force recipient, and the goal of the pulling force is a region located out of the soil.

### 3.5.3 Van Lambalgen & Hamm 2005

- There are forces (and events)
- Two kinds of causation
- Closed-world hypothesis
- Next event
- "Commonsense inertia"
- But: basic typological difference is governed by duration

- (25) An eventuality is a structure  $(f_1, f_2, e, f_3)$ , where
- $f_1$  is a fluent which represents an activity, something which exerts a force
  - $f_2$  is a parametrized fluent, representing a parametrized object or state, which is driven by the force  $f_1$
  - $e$  is the culminating event, representing a canonical goal
  - $f_3$  is a fluent which represents the state of having achieved the goal

Not viable given the widespread selectional distinctions between dynamic and non-dynamic verbs: progressive aspects, adverbials, choice of modal base depending on dynamicity of the complement  
...

### 3.6 Copley & Harley 2015

- Basic idea: Dynamic verbs convey that the application of a force results (either by launching or entrainment) in a (perhaps zero) change provided that nothing intervenes
- Reify energy as force functions
- "Flavors" of  $v$  (cf. Folli & Harley 2008)
  
- Dual ontology: grammatical/linguistic/language map vs. conceptual/cognitive territory
- This is familiar: it's  $\llbracket \cdot \rrbracket$ . (Not familiar: using  $\llbracket \cdot \rrbracket$  on variables)

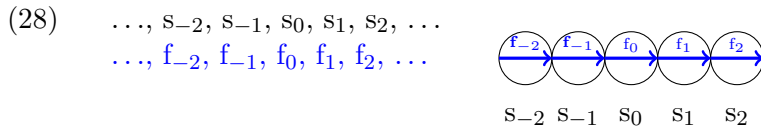
- Forces (inputs of energy) arise in an initial situation
- Forces (inputs of energy) are represented by functions from situations to situations

- (26)  $\langle \llbracket \cdot \rrbracket, U_\sigma, U_\varphi, U_s, U_f, net, init, fin \rangle$  is a causal structure iff:
- $\llbracket \cdot \rrbracket$  is an evaluation function
  - $U_\sigma$  is a non-empty set of conceptual situations
  - $U_\varphi$  is a (possibly empty) set of conceptual forces (representing inputs of energy).
  - $U_s$  is a non-empty set of linguistic situations such that  $\forall s \in U_s, \exists \sigma : \llbracket s \rrbracket = \sigma$
  - $U_f$  is a (possibly empty) set of functions from  $U_s$  to  $U_s$ .
  - $net$  is a partial function from  $U_s$  to  $U_f$  such that  $\forall s \in U_s, \forall f \in U_f : net(s) := f$  iff  $\llbracket f \rrbracket$  is the net force of  $\llbracket s \rrbracket$ .
  - $init(f) :=$  the inverse function of  $net$  (i.e.,  $net(init(f)) = f$ )
  - $fin(f) := f(init(f))$

(27)

language	language-cognition interface	cognition
$f$	— related by evaluation function to —	$\varphi$
		 is the net force of (arises from all the individuals and property attributions in) 
$S$	— related by evaluation function to —	$\sigma$

We define two linked sequences, one of situations and one of force functions:



- (29)
- Let  $f = net(s)$  iff  $\llbracket f \rrbracket$  is the net force of  $\llbracket s \rrbracket$
  - $f_n = net(s_n)$
  - $s_{n+1} = f(s_n)$

- (30)
- $init(f_n) = s_n$
  - $fin(f_n) = s_{n+1}$

Causal sequence, not temporal sequence. Causally-mediated temporal relation: effects do not begin before their causes.

- Stative predicates such as *be in the room*, *know French* are treated as predicates of situations, type  $\langle st \rangle$ .
- Dynamic predicates such as *eat* and *stay* are predicates of forces, type  $\langle ft \rangle$ , aka  $\langle ss, t \rangle$ .
- Active Voice, when present, introduces the Agent/Causer as the (main) SOURCE of the energy constituting the force.

(31)  $\llbracket be - ing \rrbracket = \lambda p f d \lambda s . p(net(s))$

(32) a.  $v_{become} : \lambda p \lambda f . p(init(f)) \ \& \ p(fin(f))$   
 (cf Dowty's (1979) BECOME:  $\neg p(t_1) \ \& \ p(t_2)$ )  
 b.  $v_{occur} = \lambda \pi \lambda f . [\exists f' < fin(f) : \pi(f')]$   
 c.  $v_{appear} : \lambda x \lambda f . x$  is part of  $fin(f)$  (presupposed:  $x$  is not part of  $init(f)$ )  
 d.  $v_{stay} : \lambda p \lambda f . p(fin(f))$  (presupposed:  $p(init(f))$ )

(33) a. heat the soup (a little/to boiling).  
 b.  $\lambda f . \llbracket soup \ hot \rrbracket (init(f)) \ \& \ \llbracket soup \ hot \rrbracket (fin(f))$

(34) a. dance  
 b.  $\lambda f . [\exists f' < fin(f) : \llbracket dance \rrbracket (f')]$

(35) a. write a poem  
 b.  $\lambda f . [\exists x : x$  is part of  $fin(f)$ :  $\llbracket a \ poem \rrbracket (x)]$  (presupposed:  $x$  is not part of  $init(f)$ )

(36) a. stay there  
 b.  $\lambda p \lambda f . \llbracket there \rrbracket (fin(f))$  (presupposed:  $\llbracket there \rrbracket (init(f))$ )

Kagan 2020 (Finnish):

(4) **Matti jäi vanhaksipojaksi<sup>2</sup>.**  
 Matti remained.3SG old.TRAN.boy.TRAN  
 'Matti remained a bachelor.'

(6) **Matti pysyi vanhanapoikana/ \*vanhaksipojaksi.**  
 Matti remained.3SG old.ESS.boy.ESS old.TRAN.boy.TRAN  
 'Matti remained a bachelor.' (based on Fong 2003: (36))

- Both telic and atelic predicates specify a result situation as well as a causing situation.
- The result situation need not be a state, though it can be.
- In the world, there can be an entrained and a launched result, though our description usually picks one of these.
- Given a causing and a result situation, world/lexical knowledge tells us whether the result

situation referred to in the description begins as the causing situation ends (launching), or begins as the causing situation begins, as a “cotemporal result” (entrainment).

### 3.7 Copley & Harley 2020 ms.

- Same basic idea: Dynamic verbs convey that the application of a force results (either by launching or entrainment) in a (perhaps zero) change provided that nothing intervenes
- Reify energy as force functions, and change as degree intervals on scales
- A single meaning for  $v$

**Degrees and change:** Kennedy & Levin 2007: triples  $\langle S, R, \delta \rangle$  where  $S$  is an (open or closed) set of degrees,  $R$  is an ordering (increasing for ‘positive’ adjectives like warm, decreasing for ‘negative’ adjectives like cool, and  $\delta$  is the dimension of difference)

(37) A typology of scale structures (Kennedy & McNally 2005)

- $\langle D_{(0,1)}, R, \delta \rangle$  (totally) open scale, e.g. *hot/cold*
- $\langle D_{[0,1)}, R, \delta \rangle$  lower closed scale, e.g. *bent/straight*
- $\langle D_{(0,1]}, R, \delta \rangle$  upper closed scale, e.g. *certain/uncertain*
- $\langle D_{[0,1]}, R, \delta \rangle$  (totally) closed scale, e.g. *full/empty*

The idea behind the degree approach is that the predicate makes reference to a scale, and telicity corresponds to the case when satisfaction of the predicate occurs on reaching the maximum endpoint of the scale. Atelicity, on the other hand, corresponds to the case when there is no endpoint specified, and the predicate is satisfied by any minimal amount of change that occurs.

(38) length-en, wid-en, whit-en

Hay, Kennedy, & Levin 1999:  $[\text{INCREASE}(\varphi)(x)(d)(e)] = 1$  iff  $\varphi(x)(\text{SPO}(e)) + d = \varphi(x)(\text{EPO}(e))$

- widen the road in/for an hour
- heat the soup in/for an hour

Kennedy & Levin 2007: “we propose that the adjectival core of a degree achievement is a special kind of derived measure function that measures the degree to which an object changes along a scalar dimension as the result of participating in an event.”

Degree instants/intervals

(40) Measure of impelled difference:

$$\underline{\Delta(p_{sd})(f)} =: \iota d : \underline{[p(\text{init}(f)), p(\text{fin}(f))]}$$

(41) Unified dynamic v:

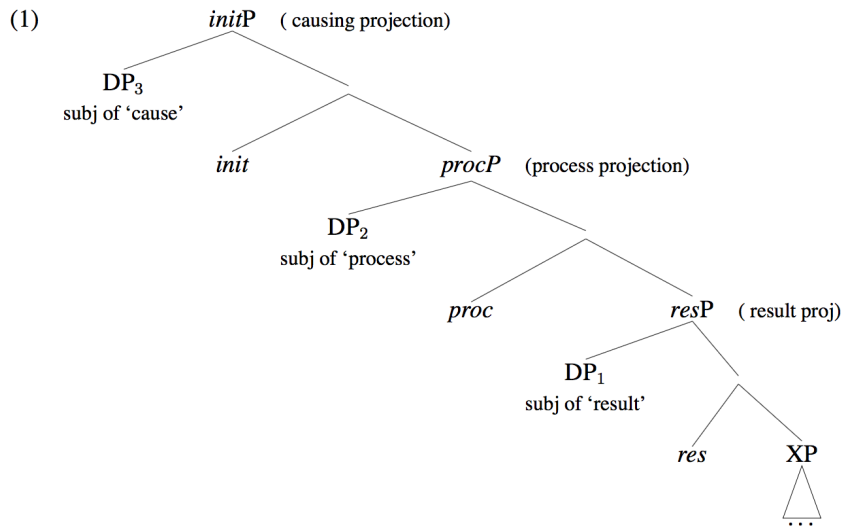
$$\llbracket v \rrbracket = \lambda p_{sd} \lambda f . \underline{\Delta(p)(f)}$$



## 4 A better “map” for a better mapping

- (42)
- a. telic vs. atelic vs. variable telicity  
*climb the mountain* vs. *dance* vs. *eat apples/the apple*
  - b. different paraphrases/flavors  
CAUSE vs. BECOME vs. DO vs. ...
  - c. intuitive causation vs. no intuitive causation  
*heat the soup* vs. *go to the store*
  - d. intuitive degree scale vs. no intuitive degree scale  
*heat the soup, eat the apple, go to the store* vs. *dance the polka*
  - e. delimiting/homomorphic object vs. non-delimiting/non-homomorphic object  
*eat the apple, mow the lawn* vs. *heat the soup, push the cart*
  - f. change vs. no change  
*put* vs. *stay*
- (43) Regarding telicity
- a. Krifka 1998 e.g.: Certain predicates involve a mapping from parts of the event to parts of object; quantized object  $\Rightarrow$  telicity.
  - b. Hay, Kennedy, and Levin 1999, Kennedy & McNally 2005, Kennedy & Levin 2008, e.g.: Certain predicates involve a mapping from parts of the event to degrees on a scale; endpoint  $\Rightarrow$  telicity.
  - c. Filip & Rothstein 2005, Filip 2008, Beavers 2012: Both these mechanisms for telicity are needed.
  - d. Hay, Kennedy, & Levin 1999, Kardos 2012: extent of an object can be seen as a degree scale
- (44) Is there causation in all telic verb phrases?
- a. yes (subevents): Pustejovsky 1999, Higginbotham 2000, Folli 2000, Ramchand 2008...
  - b. no (partial/maximal events): ter Meulen 1985, Bach 1986, Parsons 1990, Filip & Rothstein 2006, Filip 2008...
- (45) Theories of the verbal syntax-semantics interface
- a. Levin and Rappoport Hovav 1998: canonical realization rules for classes of roots (e.g. externally caused change of state: [ [ x ACT ] CAUSE [ BECOME [ y <STATE> ] ] ], that information is mapped to syntax
  - b. Borer 2005: quantity head to get homomorphism facts
  - c. Folli & Harley 2002, 2005: parallel verbal heads (flavors),  $v_{do}$  (needs animate/Agent subject, takes incremental theme complement),  $v_{cause}$  (merely needs Causer, takes state complement)
  - d. Ramchand 2008: serial verbal heads (init, proc, res)
- (46) Folli & Harley 2005
- a. The sea/the groom destroyed the beach.
  - b. #The sea/the groom ate the beach.
  - c. The sea ate away the beach.

(47) Ramchand 2008



- *initP* introduces the causation event and licenses the external argument ('subject' of cause = INITIATOR)
- *procP* specifies the nature of the change or process and licenses the entity undergoing change or process ('subject' of process = UNDERGOER)
- *resP* gives the 'telos' or 'result state' of the event and licenses the entity that comes to hold the result state ('subject' of result = RESULTEE) .

(10)  $[[\textit{res}]] = \lambda P \lambda x \lambda e [P(e) \ \& \ \textit{res}'(e) \ \& \ \text{State}(e) \ \& \ \text{Subject}(x,e)]$

(11)  $[[\textit{proc}]] = \lambda P \lambda x \lambda e \exists e_1, e_2 [P(e_2) \ \& \ \textit{proc}'(e_1) \ \& \ \text{Process}(e_1) \ \& \ e = (e_1 \rightarrow e_2) \ \& \ \text{Subject}(x,e_1)]$

(12)  $[[\textit{init}]] = \lambda P \lambda x \lambda e \exists e_1, e_2 [P(e_2) \ \& \ \textit{init}'(e_1) \ \& \ \text{State}(e_1) \ \& \ e = e_1 \rightarrow e_2 \ \& \ \text{Subject}(x,e_1)]$

But can we get everything on our wishlist with only one verbal head? Maybe we can, if we reify the right things.

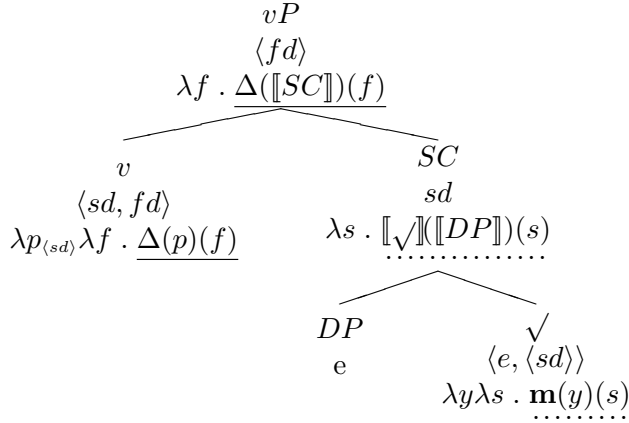


## 4.1 Changes of state

Change-of-state structure:  $[vP v [SC \sqrt{\text{root}} \text{ object}]]$

(48)  $\mathbf{m}(y)(s) =$  the degree  $d$  such that  $y$  has the property  $\mathbf{m}$  in  $s$  to the degree  $d$   
 $\dots\dots\dots$

(49) Change of state predicate (telic or atelic)



(50)  $\llbracket v \rrbracket (\llbracket \text{heat the soup} \rrbracket)$  FA  
 $= \llbracket v \rrbracket (\lambda y \lambda s . \mathbf{hot}(y)(s))(\llbracket \text{the soup} \rrbracket)$  meaning of  $\sqrt{\text{hot}}$   
 $= \llbracket v \rrbracket (\lambda y \lambda s . \mathbf{hot}(\llbracket \text{the soup} \rrbracket)(s))$  FA  
 $= \lambda p_{sd} \lambda f . \Delta(p)(f) (\lambda y \lambda s . \mathbf{hot}(\llbracket \text{the soup} \rrbracket)(s))$  (41)  
 $= \lambda f . \Delta(\mathbf{hot}(\llbracket \text{the soup} \rrbracket)(s))(f)$  FA  
 $= \lambda f . \overline{\iota d : [\mathbf{hot}(\llbracket \text{the soup} \rrbracket)(\text{init}(f)), \mathbf{hot}(\llbracket \text{the soup} \rrbracket)(\text{fin}(f))]}$  (40)

(There is a) degree-interval spanning the degree of the heat of the soup as the force is applied and the degree of the heat of the soup in the resulting situation  $\text{fin}(f)$ .

## 4.2 Incremental themes

(51) Predicate Modification (Heim & Kratzer 1998): If a branching node  $\alpha$  has as its daughters  $\beta$  and  $\gamma$ , and  $\llbracket \beta \rrbracket$  and  $\llbracket \gamma \rrbracket$  are both of type  $\eta, t$  then  $\llbracket \alpha \rrbracket = \lambda x \in D_\eta . \llbracket \beta \rrbracket(x) \ \& \ \llbracket \gamma \rrbracket(x)$ . This formula is of type  $\eta, t$ .

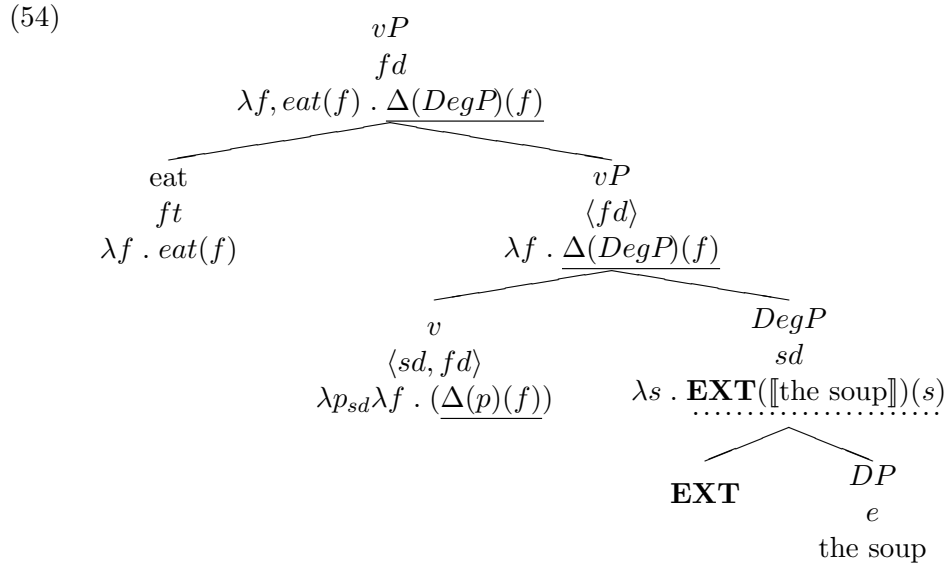
(52) Predicate Restriction (proposed): If a branching node  $\alpha$  has as its daughters  $\beta$  and  $\gamma$ , and  $\llbracket \beta \rrbracket$  is of type  $\eta, t$  and  $\llbracket \gamma \rrbracket$  is of type  $\eta, \theta$  then  $\llbracket \alpha \rrbracket = \lambda x_\eta . \llbracket \beta \rrbracket(x) . \llbracket \gamma \rrbracket(x)$ . This formula is of

type  $\eta, \theta$ .

Predicate Modification can be derived from the special case of Predicate Restriction where  $\theta = t$ , since  $\lambda x . \llbracket \beta \rrbracket(x) \ \& \ \llbracket \gamma \rrbracket(x)$  is truth-conditionally equivalent to  $\lambda x, \llbracket \beta \rrbracket(x) . \llbracket \gamma \rrbracket(x)$ .

(53) **EXT**( $y$ )( $s$ ) = the degree  $d$  such that  $y$  has the extent in  $s$  to the degree  $d$

Incremental theme structure:  $[_{vP} \sqrt{\text{root}} [_{vP} v [_{SC} \mathbf{EXT} \text{ object}]]]$



(55)  $\llbracket \text{eat } v \text{ the soup} \rrbracket$   
 $= \lambda f, eat(f) . \Delta(\llbracket DegP \rrbracket)(f)$  (41), (52), def. EXT  
 $= \lambda f, eat(f) . \Delta(\lambda s . \mathbf{EXT} \llbracket \text{the soup} \rrbracket(s))(f)$  def. EXT  
 $= \lambda f, eat(f) . \iota d : \llbracket \mathbf{EXT} \llbracket \text{the soup} \rrbracket(\text{init}(f)), \mathbf{EXT} \llbracket \text{the soup} \rrbracket(\text{fin}(f)) \rrbracket$  (40)

But how do we distinguish creation vs. consumption? Let's call this difference the "slope", so creation is a positive slope and consumption is a negative slope; including also verbs of maintaining which have zero slope. See also Croft 2010, Verkuyl 2019. Claim: The slope can be recovered from the root meaning (what it means to say "eat(f)") and does not need to be represented in the denotation, so our structure is fine.

- (56) a. Dance = create a dance (entrained, atelic)  
 b. Calve = create a calf (launching, telic)

(57) Flavors of  $v$  for creation and consumption? (not proposed!)

- a.  $\llbracket v_{creation} \rrbracket = \lambda p_{sd} \lambda f, \Delta(p)(f) > 0 . \Delta(p)(f)$   
 b.  $\llbracket v_{consumption} \rrbracket = \lambda p_{sd} \lambda f, \Delta(p)(f) < 0 . \Delta(p)(f)$

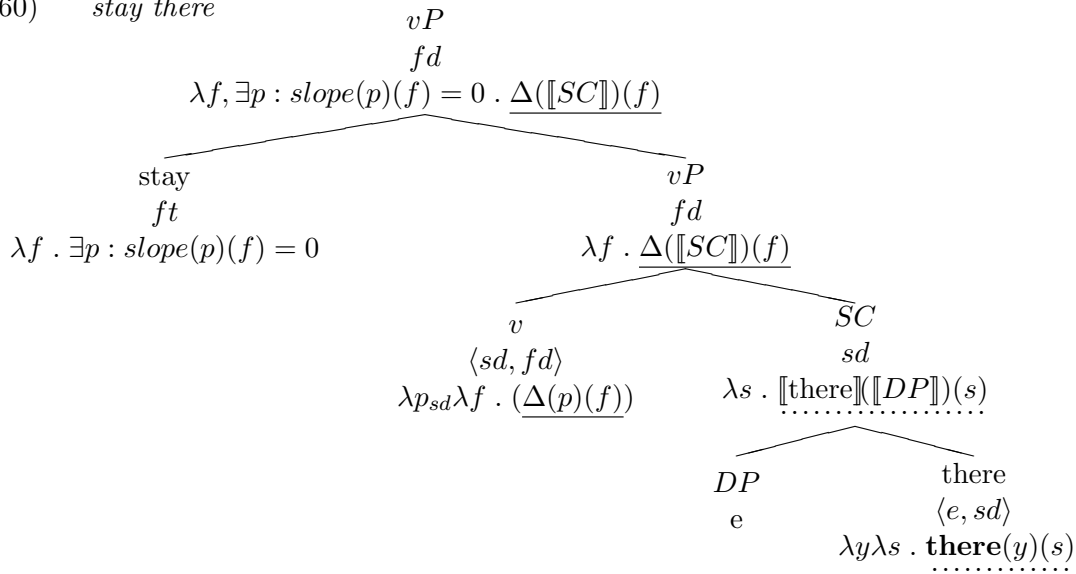
### 4.3 Verbs of maintaining

Change-of-state structure:  $[vP v [SC \sqrt{\text{root}} \text{object}]]$   
 Incremental theme structure:  $[vP \sqrt{\text{root}} [vP v [SC \mathbf{EXT} \text{object}]]]$   
 Change-of-location structure (AT):  $[vP \sqrt{\text{root}} [vP v [SC \text{locatum } AT(\text{location})]]]$

- (58) a. stay hot  
 b. preserve/maintain  
 c. stay in the room

(59) predicate *stay*:  $\lambda f . \exists p : \text{slope}(p)(f) = 0$

(60) *stay there*



## 5 Conclusion

Better “map” (forces and degrees)  $\Rightarrow$  better mapping between morphosyntax and denotations (unified verbal head)