Sign language semantics, Day 3: Plurality and dependency (verbs)

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Section 1

Overview: plurality and dependency

Different kinds of plurality in natural language

(1) I saw zebras.

(2) The boys read one book each.

(3) John coughed again and again.

(4) All the dogs licked the same cat.

(5) Each dog licked a different cat.

Plurality and dependency

(4) All the dogs licked the same cat.

- 'external reading': compares another individual in context.
- 'internal reading': compares dogs to *each other*.

- Only a single cat, but a plurality of lickings.
- The internal reading of *same* is **licensed** by the presence of a plural elsewhere in the sentence.

(6) * Fido licked the same cat.
(on internal reading)

Cross-linguistic, cross-categorial dependency

- The internal reading of *same* is an instance of a much larger pattern of **dependency** cross-linguistically.
- **Nouns:** inflection on a DP may indicate that a plurality of individuals are distributed across another plurality.

(7) **Kaqchikel Mayan** (Henderson 2014)

a. Xeqatij ox-ox wäy.
we-eat three-three tortilla
'We each ate three tortillas.'

b. * Xe'inchäp ox-ox wäy.
I-handle three-three tortilla
Desired reading: 'I took (groups of) three tortillas.'

Cross-linguistic, cross-categorial dependency

- **Verbs:** inflection on a verb may indicate that a plurality of events is distributed in some way.

(8) **Chechen** (Wood 2007 via Cabredo Hofherr & Laca 2012)

a. Bombanash lilxira.
bomb.PL explode.PLR.WP
'The bombs exploded.'

b. # Bomba lilxira.
bomb.SG explode.PLR.WP
'The bomb exploded again and again.'

- Distribution across participants is licensed by a plurality elsewhere in the sentence.

Theoretical questions:

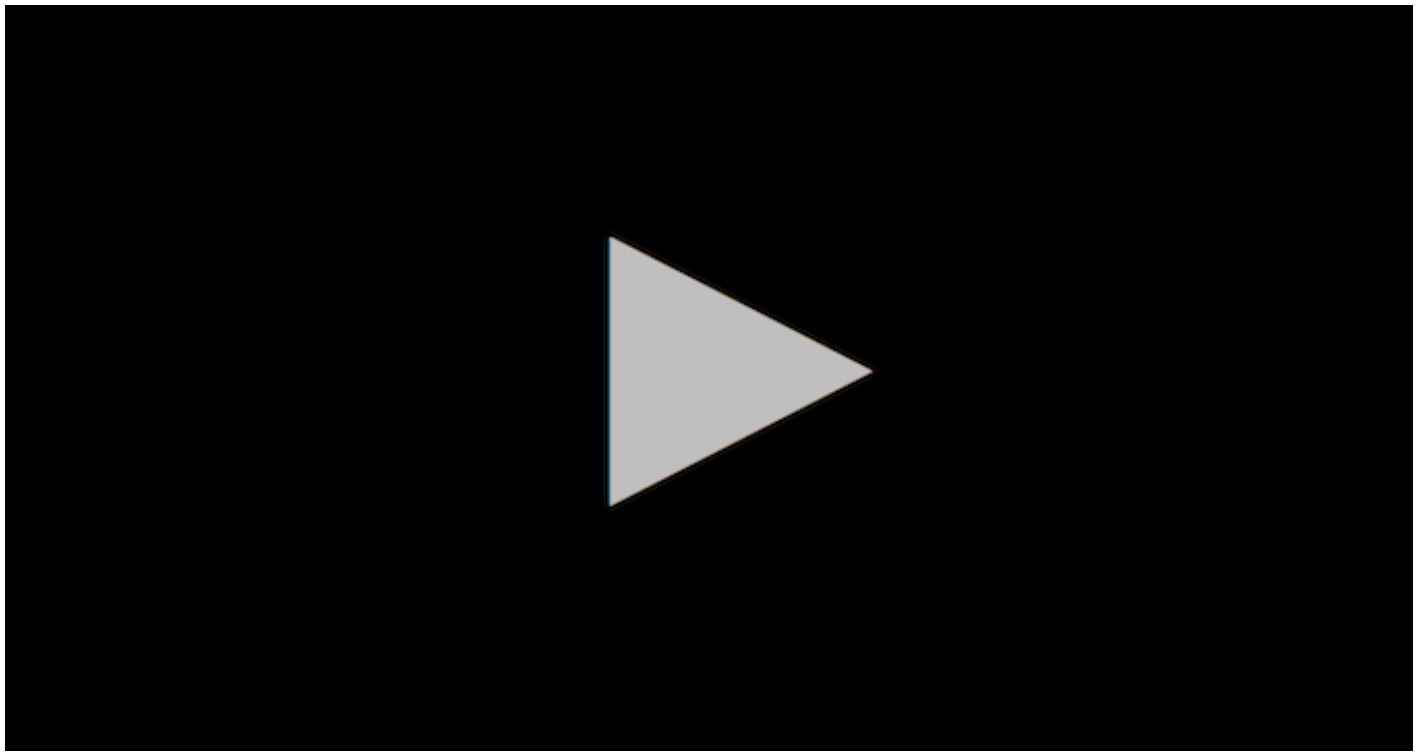
- What is the semantic contribution of these dependent forms?
- What is the link between a dependent term and its licensor?

Plurality in sign language!

- Sign languages (ASL, LSF, ...) make a very intuitive, morphological natural class out of these constructions.
  - Semantic objects corresponding with nominal plurality are arranged in space in the horizontal plane.
  - Semantic objects corresponding to verbal plurality (i.e. multiple events) involve a repeated motion.
- The use of space and iconicity in sign language shed new light on theoretical questions.

Verbal plurality

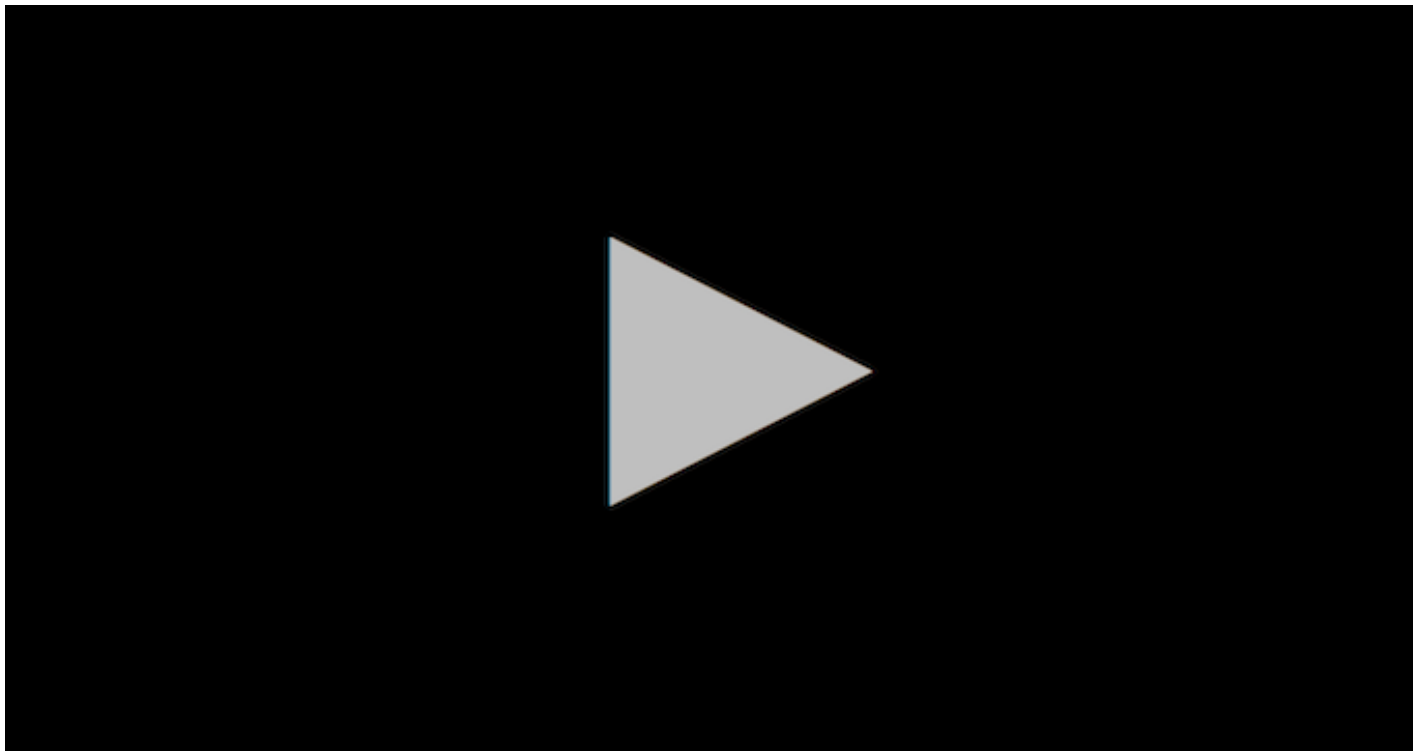
- Example 1 (French Sign Language):



(9) OFTEN ONE PERSON FORGET-rep ONE WORD.
'One person repeatedly forgot a word.'

Verbal plurality

- Example 2 (French Sign Language):



(10) MY FRIENDS IX-arc ARRIVE-alt.
'My friends each arrived.'

Plan

Today: verbal plurality
Tomorrow: nominal plurality

Verbal plurality

(Joint work with Valentina Aristodemo)

Section 2

Background: events and plurality

Events

- We will be assuming a semantic ontology that includes **events**.
- Events are minimal parts of the world.
  - E.g. there is an event in which John kisses Bill—no other information about the world is included in this event.
- Verbs denote sets of events.

Events – motivation

(11) The boy pushed the dog with a bone.

- Reading 1: ⟦dog⟧ ∩ ⟦with a bone⟧
  - both of these are sets of individuals
- Reading 2: ⟦pushed the dog⟧ ∩ ⟦with a bone⟧

Events – motivation

(12) The boy pushed the dog with a bone.

- Reading 1: $[\![\text{dog}]\!] \cap [\![\text{with a bone}]\!]$
  - both of these are sets of individuals
- Reading 2: $[\![\text{pushed the dog}]\!] \cap [\![\text{with a bone}]\!]$
  - = the set of individuals who pushed the dog
    $\cap$ the set of individuals with a bone?

...no...

Events – motivation

(13) The boy pushed the dog with a bone.

- Reading 1: ⟦dog⟧ ∩ ⟦with a bone⟧
  - both of these are sets of individuals
- Reading 2: ⟦pushed the dog⟧ ∩ ⟦with a bone⟧
  - = the set of individuals who pushed the dog ∩ the set of individuals with a bone?

  ...no...
  - = the set of individuals who pushed the dog ∩ the set of individuals who used a bone as a tool?

  ...still not right; need to tether the pushing and the bone...

Events – motivation

Better:

- Reading 2: $[\![\text{pushed the dog}]\!] \cap [\![\text{with a bone}]\!]$
  = the set of *events* in which the dog was pushed
  $\cap$ the set of *events* in which the bone was used as a tool

As we will see, very useful for plurality, too!

The logical form of a sentence in event semantics

(14) The boy pushed the dog with the bone

$$\exists e[[\![\text{push}]\!](e) \wedge \text{agent}(e) = \iota[\![\text{boy}]\!] \wedge \text{patient}(e) = \iota[\![\text{dog}]\!] \wedge \text{instrument}(e) = \iota[\![\text{bone}]\!]]$$

'There is a pushing event of which the boy is the agent, the dog is the patient, and the bone is the instrument.'

Plurality

- We will assume that both individuals and events show mereological structure.

$$\boxed{\textbf{mereology} = \text{the study of } \textit{parthood}}$$

- '$\preceq$' defines a partial order; $x \preceq y$ means that x is part of y.
  - E.g. Ann is part of the plurality containing Ann, Ben, and Cat.

- *Summation:*
  $x \oplus y$ is the smallest object z such that $x \preceq z$ and $y \preceq z$.
  - *Note:* if x and y are type α, $x \oplus y$ is also type α.

The star operator

- The star-operator, written *, returns the algebraic closure of a set with respect to sum formation.

(15) $^*P = \{x | \exists P' \subseteq P[x = \bigoplus P']\}$
'$^*P$ is the set of all objects that can be made by summing non-empty subsets of P.'

- Example:

$$P = \{a, b, c\}$$
$$^*P = \{a, b, c, a \oplus b, a \oplus c, b \oplus c, a \oplus b \oplus c\}$$

Plural nouns

- The meaning of the plural suffix /-s/ is just the star operator.

(16) There is a boy in the room.

$$[\![\text{boy}]\!] = \{a, b, c\}$$

(17) There are boys in the room.

$$[\![\text{boys}]\!] = {}^*[\![\text{boy}]\!] = \{a, b, c, a \oplus b, a \oplus c, b \oplus c, a \oplus b \oplus c\}$$

- '*the*' takes the unique maximal salient plurality in a set

(18) $[\![\text{the boys}]\!] = a \oplus b \oplus c$

Inherently pluralized verbs

- **Observation**: on cumulative readings, (unmarked) verbs can denote plural events.

  (19) The boys left.

  (20) Two girls invited three boys.

- Assumption: lexical predicates are inherently pluralized with the star operator. (Krifka 1992 and Kratzer 2008)
  - *Arrive* denotes the set of all singular or plural arriving events.

Distributive readings

- Additionally, there are **distributivity operators**, relatives of the star operators, that may pluralize a predicate at other points in the derivation.

  (21) The boys each read one book.

- $[\![\text{read 1 book}]\!] = \lambda e[\text{read}'(e) \wedge \text{pat}(e) \in \textit{book} \wedge |\text{pat}(e)| = 1]$
- Assume '*each*' $\approx$ the star operator
- What's the meaning of $[\![\text{each read one book}]\!]$?

Section 3

Pluractionality

Pluractionality

- In many languages of the world, verbs show "pluractional" inflection, often created by reduplication.
- These contribute the notion that the sentence in some way describes **a 'multitude' of events**.
  - An event happened again and again
  - Many things happened at the same time

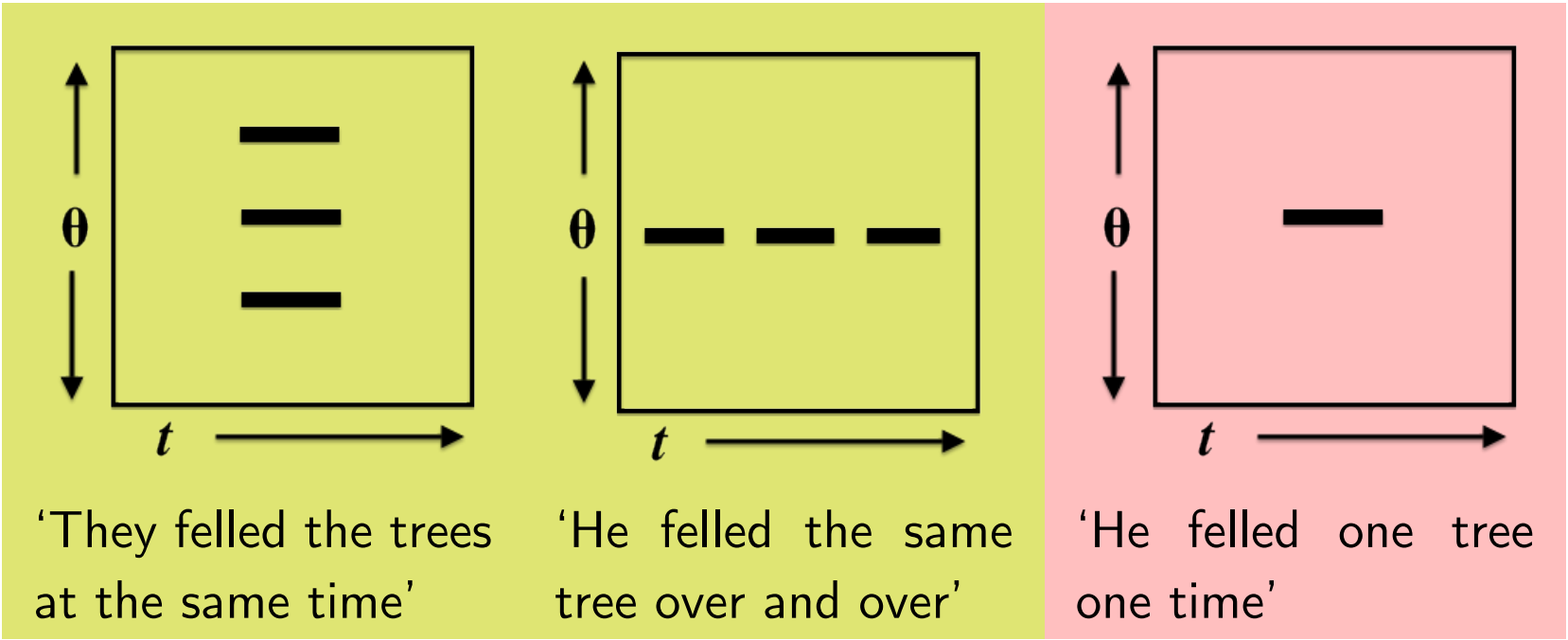
Pluractionality along many dimensions

- Upriver Halkomelem (Thompson 2009):

(22) **yáleq'** -et -es te theqát (cf. yáq'-et)
fell.pl -tr. -3S det. tree

- True if ...
  - **a.** He felled the trees. (all in one blow, or one after the other)
  - **b.** He felled the same (magic) tree over and over.
  - **c.** They felled the tree.
  - **d.** They felled the trees.
- False if ...
  - **e.** He felled the tree (once).

Pluractionality along many dimensions



'They felled the trees at the same time'

'He felled the same tree over and over'

'He felled one tree one time'

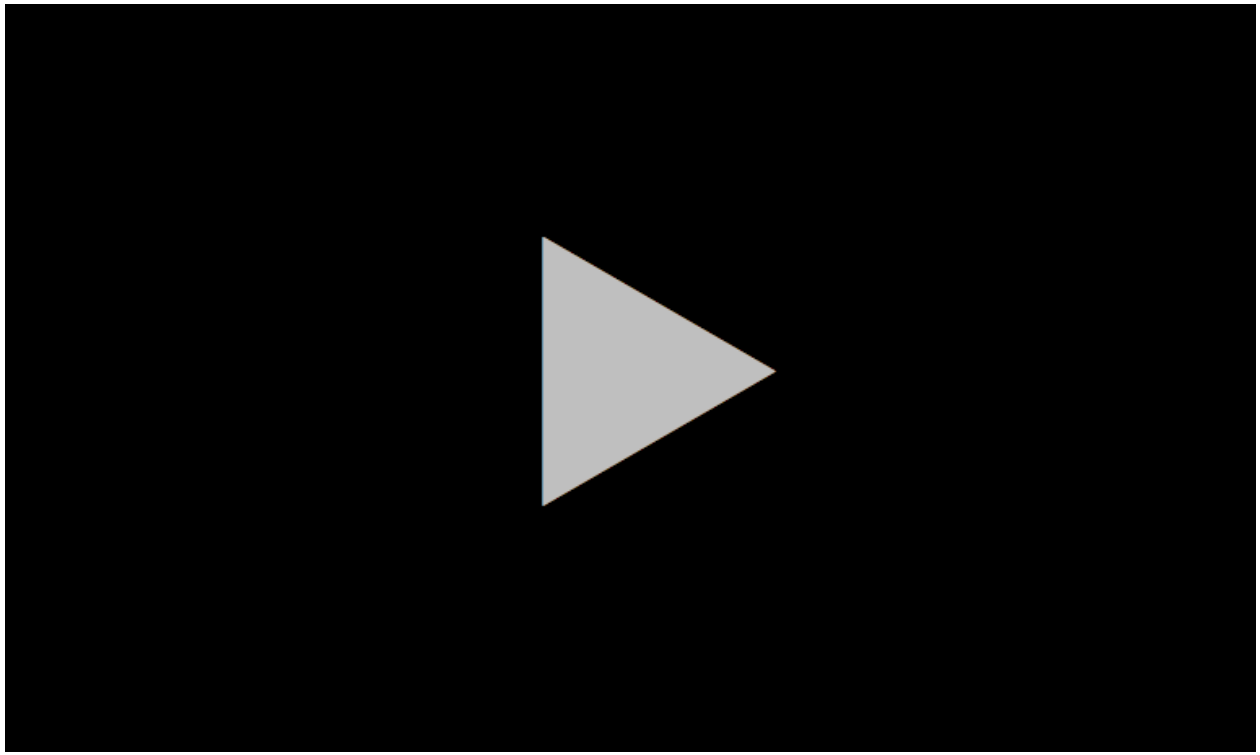
- Pluractional means: "you have more than one line."

Pluractionality in French Sign Language

- In LSF, too, verbs may be modified with reduplication to indicate pluractionality.
- There are at least two different morphemes that appear across a wide range of verbs.
  - /-rep/ is full repetition of the exact same motion of the verb
  - /-alt/ is alternating repetition of the two hands
- Examples:
  - FORGET
  - ARRIVE
  - GIVE
  - LEAVE
  - SPIT
  - TAKE

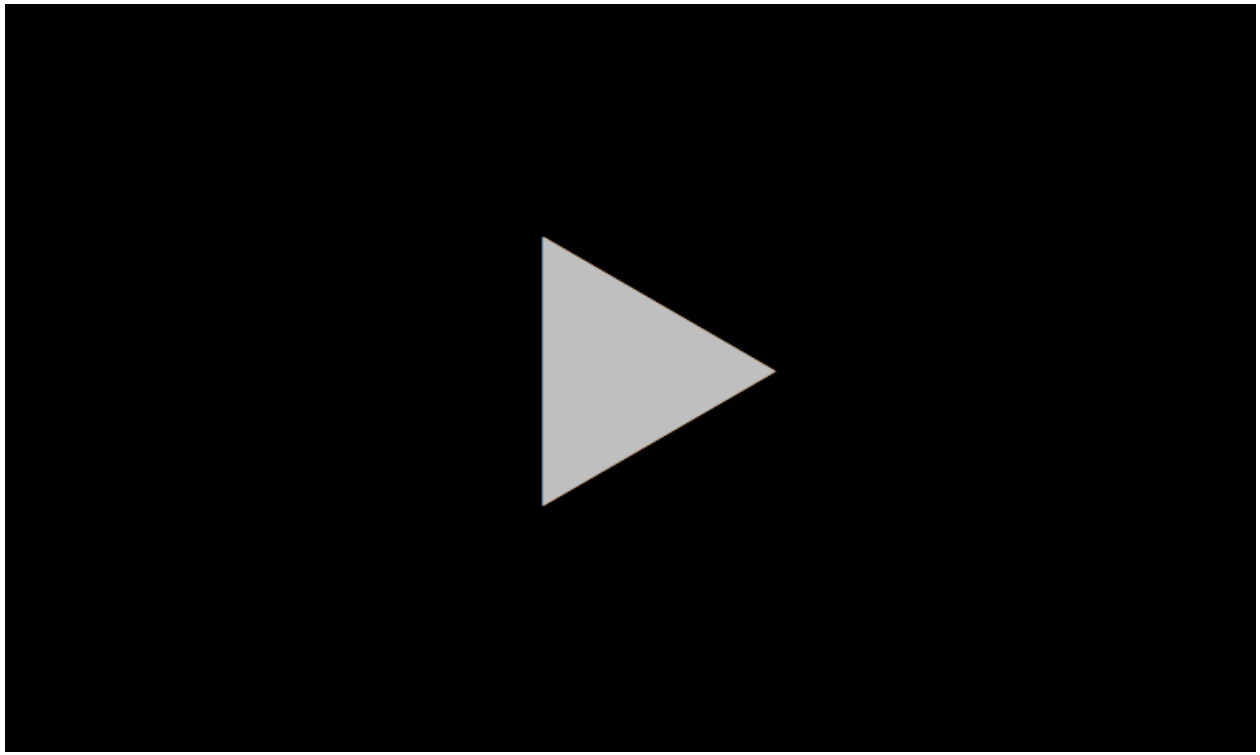
Pluractionality in French Sign Language

LSF: GIVE (singular), GIVE-rep, GIVE-alt



Pluractionality in French Sign Language

LSF: FORGET (singular), FORGET-rep, FORGET-alt



Pluractionality in French Sign Language

- What is the difference in meaning?
- Roughly:
  - FORGET-rep = forget again and again
  - FORGET-alt = forget many things
    OR
    many people forget
- Exactly the same dimensions of pluractionality as earlier; /-alt/ and /-rep/ carve up the space of pluractional meanings.

/alt/: distribution over participants

- /-alt/ entails that subevents have different participants.
- Thus, needs to be licensed by a plural in an argument position.

(23) GROUP PEOPLE BOOK GIVE-1-alt. **pl. agent**
'A group of people gave me books.'

(24) ONE PERSON FORGET-alt SEVERAL WORDS. **pl. theme**
'One person forgot several words.'

- Although (23)-(24) are compatible with events spread over time, distribution over time alone is not sufficient for /-alt/.

(25) * (OFTEN) ONE PERSON FORGET-alt ONE WORD.
Intended: 'One person (often) forgot one word.'

/rep/: distribution over time

- In contrast, /-rep/ entails distribution over time.

(26) OFTEN ONE PERSON FORGET-rep ONE WORD.
'One person often forgot one word.'

(27) MIRKO BOOK a-GIVE-1-rep.
'Mirko gave me a book repeatedly.'

- Distribution over time, even with a plural argument.

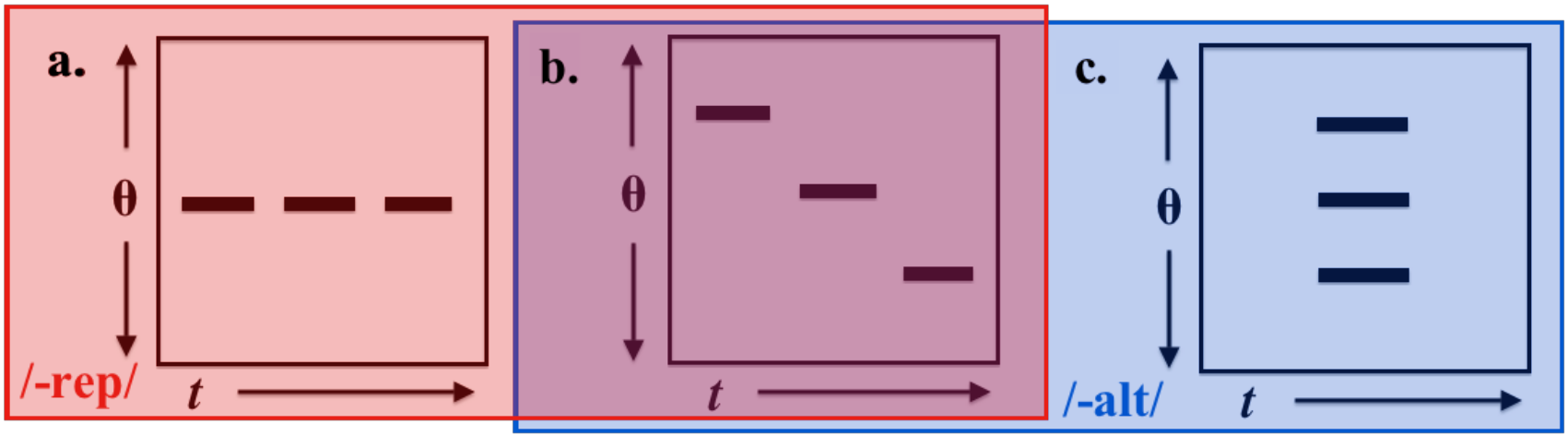
(28) MY FRIENDS CL:plural FORGOT-rep BRING CAMERA
'My friends repeatedly forgot to bring a camera.'

a. ✓ several times; each time, all forgot

b. * a single time; all forgot

/-rep/ vs. /-alt/

	/-rep/	/-alt/
a. distribution over only time	✓	*
b. distribution over only participants	✓	✓
c. distribution over participants and time	*	✓



Question: how is plurality introduced?

(29) a. Every three seconds, John coughed once.

b. John coughed repeatedly for several minutes.

- Intuitively different.
- Let me anticipate, and suggest that the analytic difference is the following:
  - '*every three seconds*' is a pluralizing operator (like *)
  - '*repeatedly*' is a filter, leaving only non-atomic events
- How can we test empirically?

Question: how is plurality introduced?

An empirical difference:

(30) a. John read one book every week.
✓many books ✓one book

b. John read one book repeatedly.
*many books ✓one book

(31) a. Every three seconds, John ate one strawberry.

b. # John ate one strawberry repeatedly.

Making indefinites dependent

- Why is this? Suppose:
  - $e_1 \vdash$Alice read *The Left Hand of Darkness* Monday
  - $e_2 \vdash$Alice read *American Gods* Monday
  - $e_3 \vdash$Alice read *Catch-22* Monday
  - $e_4 \vdash$Alice read *Catch-22* Tuesday
  - $e_5 \vdash$Alice read *Catch-22* Wednesday

- $[\![\text{read one book}]\!] =$
  $\lambda e.[\![\text{read}]\!](e) \wedge \mathbf{theme}(e) \in \mathit{book} \wedge |\mathbf{theme}(e)| = 1$

- $[\![\text{read one book}]\!] =$
  $\{ \qquad \}$

Making indefinites dependent

- Why is this? Suppose:
  - $e_1 \vdash$Alice read *The Left Hand of Darkness* Monday
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- $[\![\text{read one book}]\!] =$
  $\lambda e.[\![\text{read}]\!](e) \wedge \mathbf{theme}(e) \in \mathit{book} \wedge |\mathbf{theme}(e)| = 1$

- $[\![\text{read one book}]\!] =$
  $\{e_1, e_2, e_3, e_4, e_5, e_3 \oplus e_4, e_3 \oplus e_5, e_4 \oplus e_5, e_3 \oplus e_4 \oplus e_5\}$

Making indefinites dependent

- Why is this? Suppose:
  - $e_1 \vdash$ Alice read *The Left Hand of Darkness* Monday
  - $e_2 \vdash$ Alice read *American Gods* Monday
  - $e_3 \vdash$ Alice read *Catch-22* Monday
  - $e_4 \vdash$ Alice read *Catch-22* Tuesday
  - $e_5 \vdash$ Alice read *Catch-22* Wednesday

- $[\![\text{read one book}]\!] =$
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- $[\![\text{read one book}]\!] =$
  $\{e_1, e_2, e_3, e_4, e_5, e_3 \oplus e_4, e_3 \oplus e_5, e_4 \oplus e_5, e_3 \oplus e_4 \oplus e_5\}$

- $[\![\text{read one book repeatedly}]\!] =$
  $\{ \qquad \}$

Making indefinites dependent

- Why is this? Suppose:
  - $e_1 \vdash$Alice read *The Left Hand of Darkness* Monday
  - $e_2 \vdash$Alice read *American Gods* Monday
  - $e_3 \vdash$Alice read *Catch-22* Monday
  - $e_4 \vdash$Alice read *Catch-22* Tuesday
  - $e_5 \vdash$Alice read *Catch-22* Wednesday

- $[\![\text{read one book}]\!] =$
  $\lambda e.[\![\text{read}]\!](e) \wedge \mathbf{theme}(e) \in \mathit{book} \wedge |\mathbf{theme}(e)| = 1$

- $[\![\text{read one book}]\!] =$
  $\{e_1, e_2, e_3, e_4, e_5, e_3 \oplus e_4, e_3 \oplus e_5, e_4 \oplus e_5, e_3 \oplus e_4 \oplus e_5\}$

- $[\![\text{read one book repeatedly}]\!] =$
  $\{\qquad\qquad e_3 \oplus e_4, e_3 \oplus e_5, e_4 \oplus e_5, e_3 \oplus e_4 \oplus e_5\}$

Question: how is plurality introduced?

Two possibilities:

- /-alt/ and /-rep/ pluralize a singular event
  - i.e., they are equivalent to the star operator.
  - /-alt/ would be similar to English *each*
- They are a cardinality checker on a previously pluralized predicate.

Differences in predictions

(32) a. EVERY-DAY JEAN ONE WORD FORGET.
'Every day, Jean forgot one word.'
✓many words ✓one word

b. JEAN ONE WORD FORGET-rep.
'Jean forgot one word repeatedly.'
*many words ✓one word

(33) a. STUDENT EACH FORGOT ONE WORD.
'Each student forgot one word.'
✓many words ✓one word

b. STUDENT IX-arc FORGOT-alt ONE WORD.
'The students forgot (the same) one word.'
*many words ✓one word

Empirical summary

(34)

	operator	filter
participants	EACH	-alt
time	EVERY-DAY	-rep

Formal definitions

- Formally, we can give a small modification to existing analyses of pluractionals (Lasersohn 1995).

(35) $[\![\text{-alt}]\!] = \lambda V e[V(e) \wedge \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')]]$

'/-alt/ takes a verb denotation V and gives the set of V-ing events that have at least two subparts with different thematic arguments.'

(36) $[\![\text{-rep}]\!] = \lambda V e[V(e) \wedge \exists e', e'' \preceq e[\tau(e') \neq \tau(e'')]]$

'/-rep/ takes a verb denotation V and gives the set of V-ing events that have at least two subparts with different runtimes.'

- $^*V$ gives the algebraic closure of V; $\preceq$ indicates parthood; $\theta(e)$ is a tuple of the participants of an event: $\langle \text{ag}(e), \text{th}(e), ... \rangle$, τ is runtime

Section 4

A compositional puzzle

A puzzle

A compositional puzzle:

- /-alt/ requires a plural argument over which events can vary.
- /-alt/ is licensed by EACH, even though it distributes to atoms.

(37) a. * EACH BOY GATHER.

b. BOY EACH FORGET-alt BRING CAMERA.
'Each boy forgot to bring a camera.'

- This is formally identical to the puzzle of dependent indefinites under distributive quantifiers. (Balusu 2006, Henderson 2014)

A compositional puzzle

More precisely:

(38) EACH INVITE-alt GIRL.
'Each one invited a girl.'

(39) $\exists e.\forall x[\textbf{atom}(x) \rightarrow \exists e'[e' \preceq e \ \wedge \ ^*\text{invite}(e') \ \wedge \ \text{theme}(e') \in \text{girl}' \ \wedge \ \text{agent}(e') = x \ \wedge \ \exists e'', e''' \preceq e'[\theta(e'') \neq \theta(e''')]]]...$

The temporal domain

A similar puzzle in the temporal domain:

(40) EVERY-DAY ONE BOOK JEAN GIVE-1-rep.

a. 'Every day, Jean gave me one book.' *(preferred reading)*

b. 'Every day, Jean gave me one book repeatedly.'

Possible solutions

Two possible solutions.

Option 1:

- No built-in variation condition.
- Dependency marking is the expression of syntactic agreement with a higher operator that introduces pluractionality.
- This operator can be overt or covert.

(Oh 2001, 2005; Kimmelman 2015)

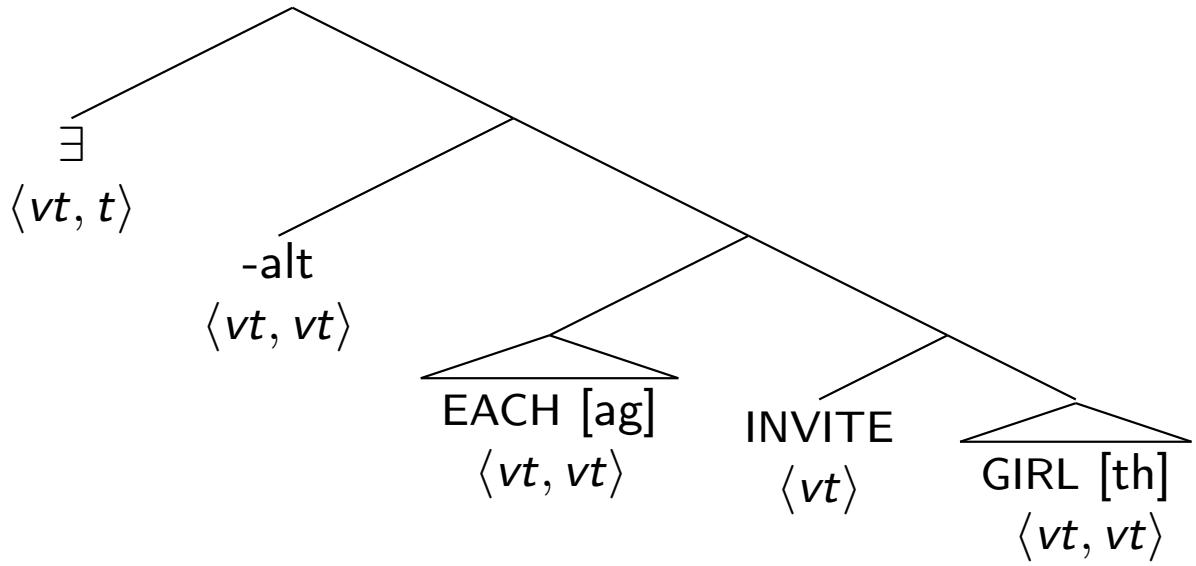
Scopable pluractionality

Option 2:

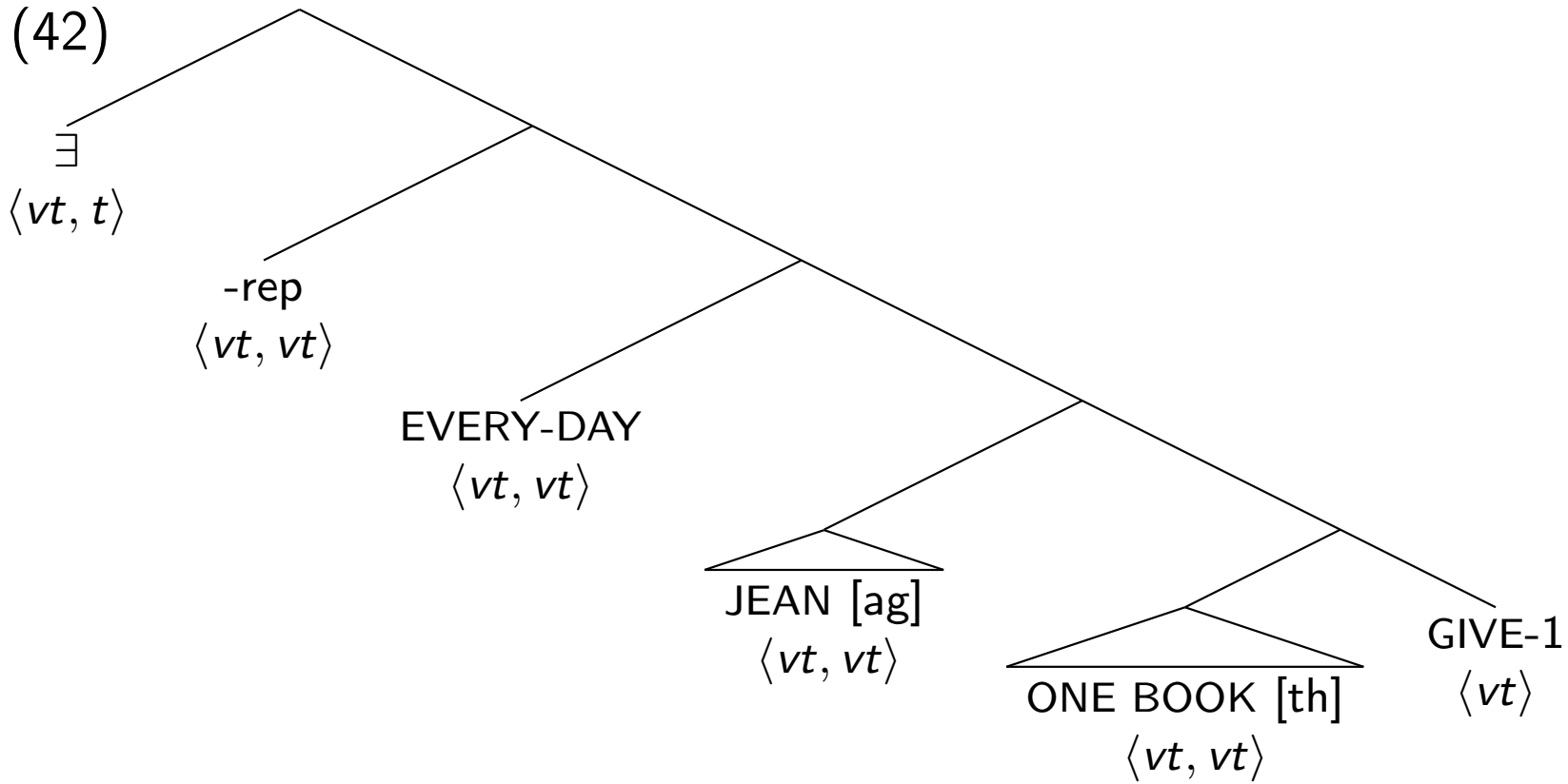
- The distributive quantifier introduces a plurality of events *from a global perspective*.
- The variation condition of /-alt/ is able to escape from the distributive scope of EACH to get access to this global plurality.
  - Henderson 2014: Dynamic plural logic with postsuppositions
  - Kuhn 2015, Ch. 4: DPIL with Quantifier Raising
- The effect is that the plurality condition is evaluated as though attached at a higher node.

Scopable pluractionality

(41)



Scopable pluractionality



Pluractionality Summary

Interim summary:

- The pattern of pluractional verbs in LSF fits perfectly into a broader typology of pluractionality in spoken languages.
- We established a compositional puzzle, and sketched a solution.

- But wait, there's more...

Section 5

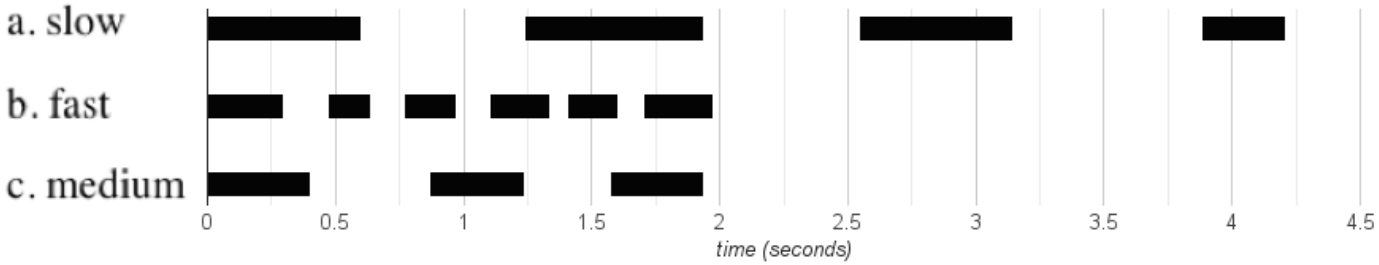
Iconicity

Iconic preservation of rate

Additionally, an iconic mapping...

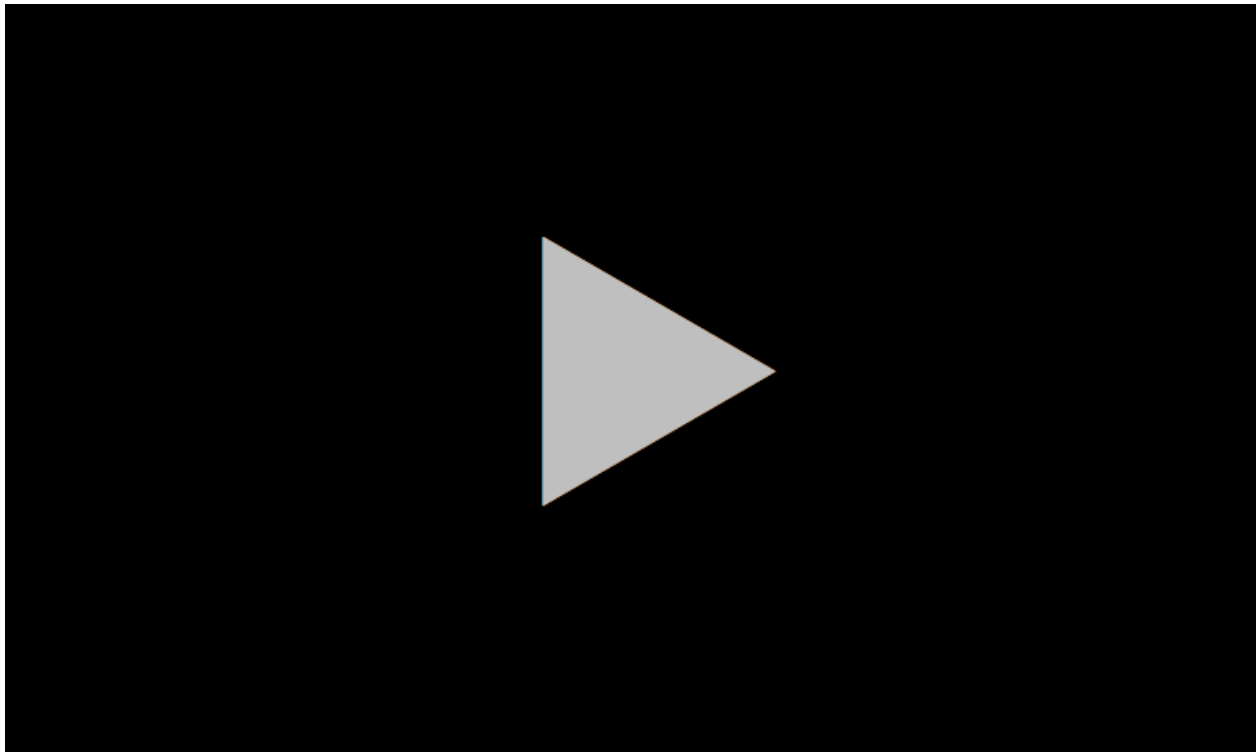
- **Claim:** rate of reduplication is **iconically mapped** to the rate of the event repetition.

(43) a. GIVE-slow b. GIVE-fast c. GIVE-medium



Verb-internal gradience

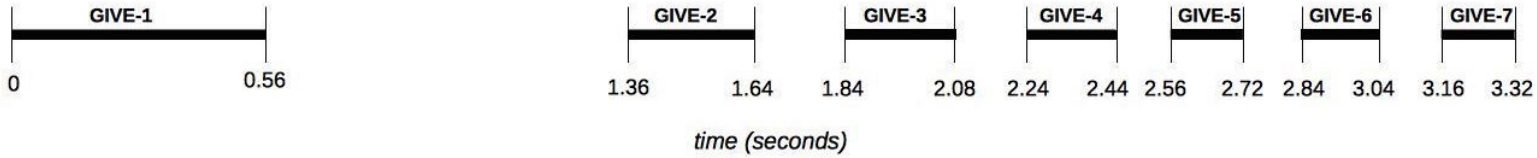
GIVE-rep (accelerating), GIVE-rep (decelerating)



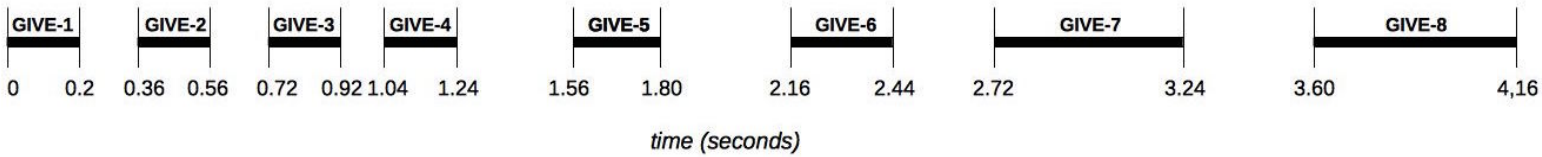
Gradience and iconicity

- Of note, these mappings preserve gradient geometric information about the form of the sign.
  - Cannot be captured by a discrete, combinatorial system alone.

- Acceleration (LSF):



- Deceleration (LSF):

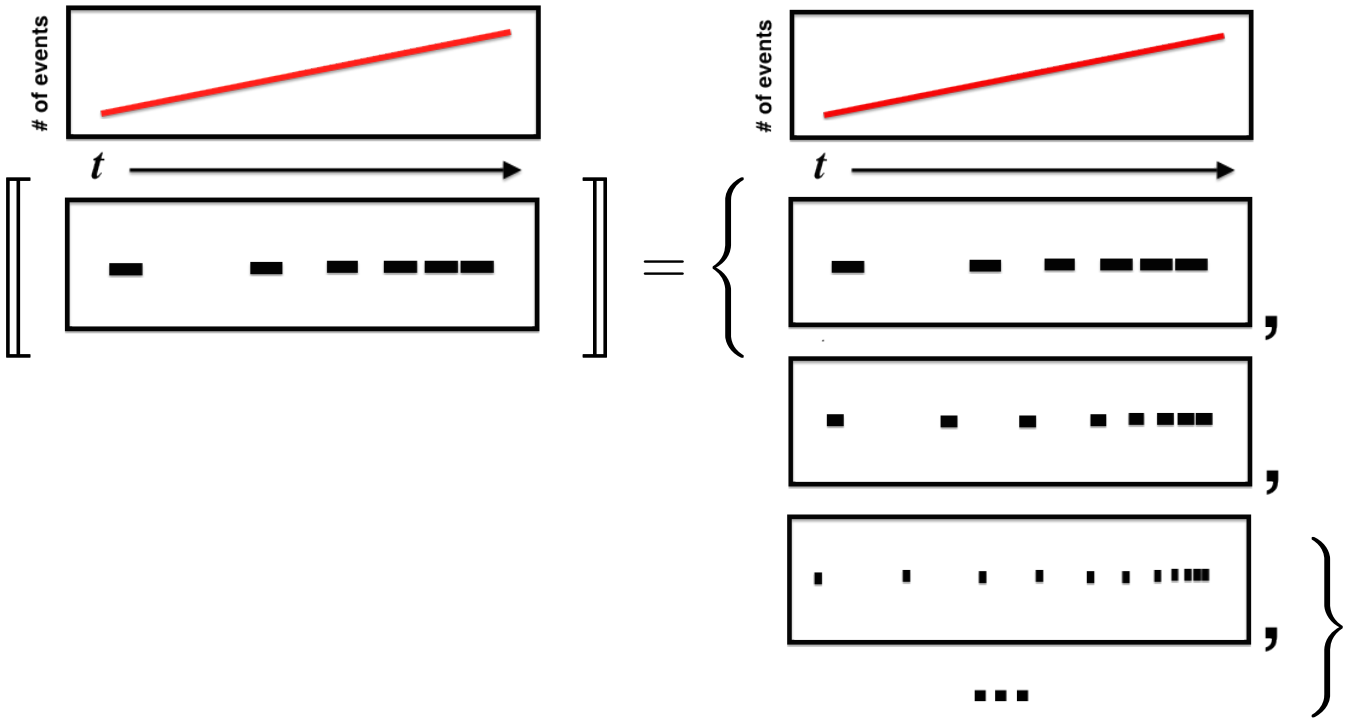


Iconicity: what's (not) preserved

- In fact, it's possible to preserve quite a lot of information:
  - E.g. speeding up, reaching a plateau, then decelerating again
- BUT, notably **not** preserved: the exact number of repetitions.
  - No inference for the "GIVE-rep (accel.)" example that the speaker gave something exactly eight times.
- General finding for sign language: "three means plural."
- General cognitive finding (Carey 2009): relative cardinality judgements is easier than absolute cardinality judgements.

Iconicity: proposal sketch

- **Proposal:** Repetition associated not with a discrete set of points, but with a continuous distribution of events over time.
- The verb is true of any sequence of events which matches the same contour.



Iconicity in the grammar

- Now, notice that what we've just done is associate a verb with a set of plural events — in other words, we have a predicate type $\langle v, t \rangle$ that we can pop into a formal definition.

(44) $[\![\text{-alt}]\!] = \lambda V e[V(e) \wedge \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')] \wedge \mathbf{Icon}^{\Phi}(e)]$

'/-alt/ takes a verb denotation V and gives the set of V-ing events that have at least two subparts with different thematic arguments and that have the temporal distribution shown.'

(45) $[\![\text{-rep}]\!] = \lambda V e[V(e) \wedge \exists e', e'' \preceq e[\tau(e') \neq \tau(e'')] \wedge \mathbf{Icon}^{\Phi}(e)]$

'/-rep/ takes a verb denotation V and gives the set of V-ing events that have at least two subparts with different runtimes and that have the temporal distribution shown.'

- Following Schlenker, Lamberton & Santoro 2012, iconically-defined predicate incorporated directly into the formal system.

Section 6

Scopable iconicity

Proposal sketch

Two components of our proposal:

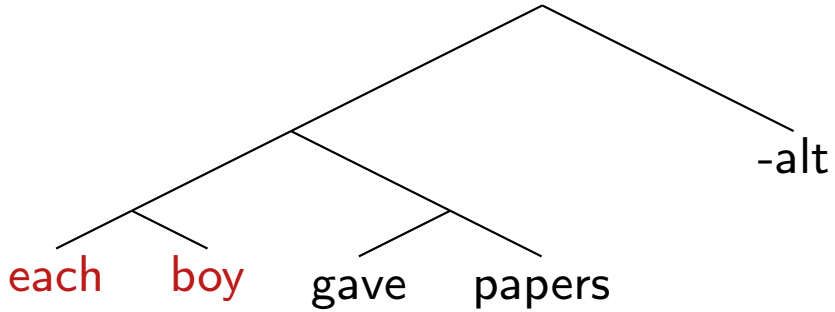
1. A combinatorial morpheme with iconic component:

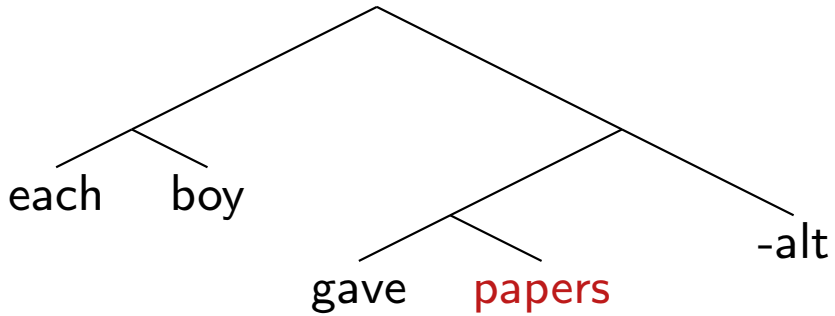
(46) $[\![\text{-alt}]\!] =$
$\lambda V e.\quad \underbrace{V(e) \wedge \exists e', e' < e[\theta(e') \neq \theta(e'')]}_{\text{Logical component}} \quad \wedge \quad \underbrace{\textbf{Icon}^{\Phi}(e)}_{\text{Iconic component}}$

2. Composition that allows /-rep/ and /-alt/ to take scope.

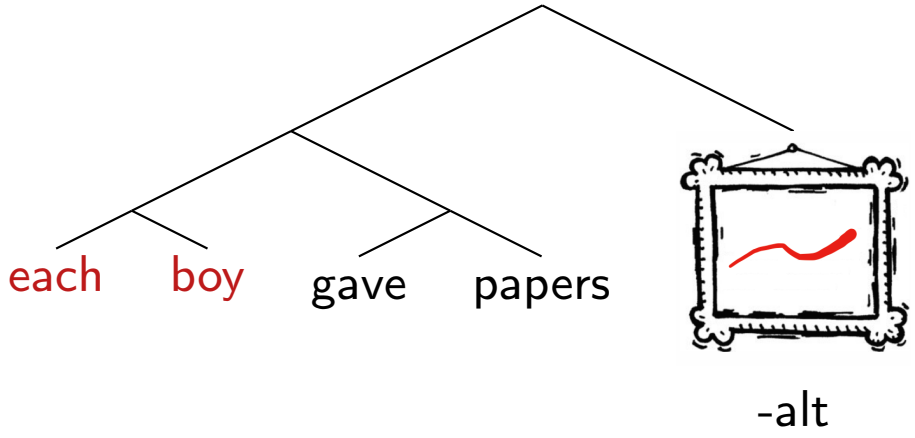
Prediction: 'Scopable iconicity'

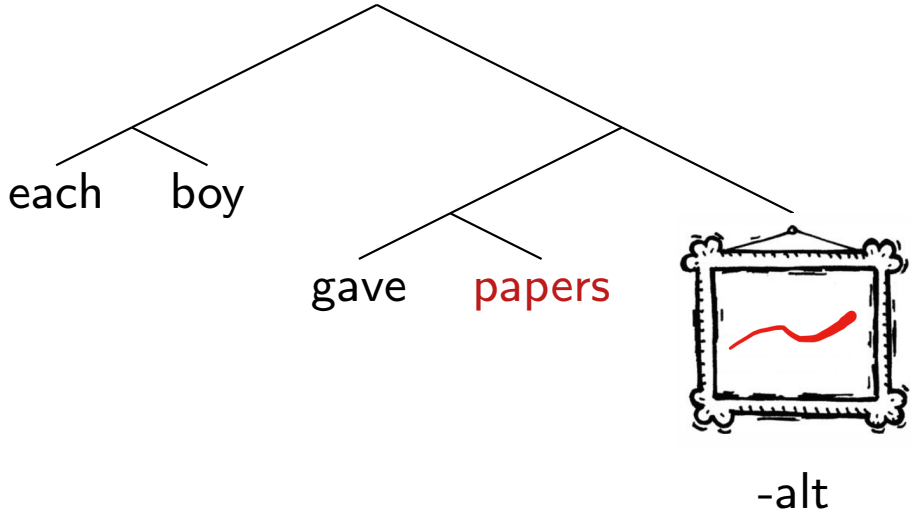
Scopable iconicity





Scopable iconicity



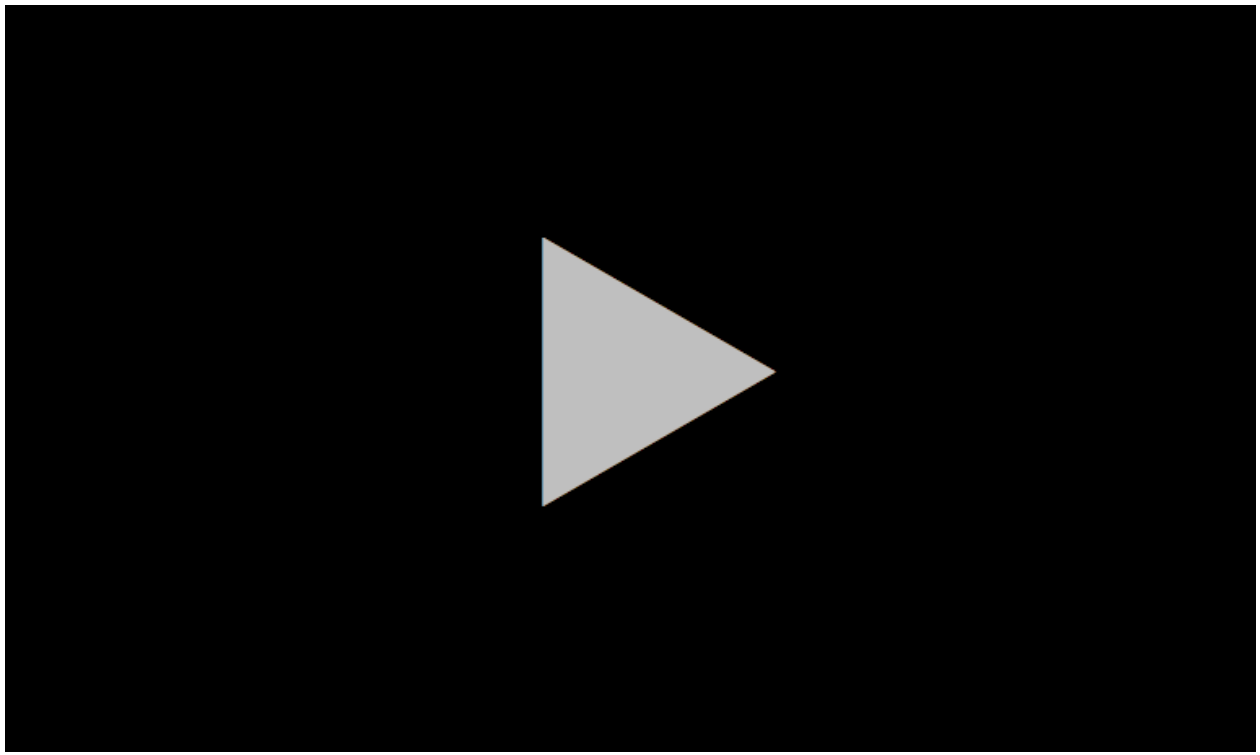


Scopable iconicity

- Consider the case of the overworked secretary:

- A set of slow event sequences may sum up to a plural event that occurs rapidly.
- **Prediction:** The perspective of the iconic component depends on where the pluractional inflection takes scope.

Scopable iconicity



(47) JEREMY OBJECTS VARIOUS a-GAVE-1-alt-decelerating.
NEXT MIRKO VARIOUS OBJECTS b-GAVE-1-alt-decelerating.
SEVERAL c-GAVE-1-alt-decelerating.
EACH-abc abc-GAVE-1-alt-accelerating MORE FULL-UP ALONE.

Section 7

Conclusion

Conclusion

- Here, we focused on two reduplicative verbal forms in LSF.
- First, we showed that the meanings fit in with more general patterns of cross-linguistic pluractionality.
  - Distribution over time vs. distribution over participants
- Then, we argued that the sign language patterns additionally display iconic effects.
  - Critically: in comparative forms, gradient interpretation.
- We proposed a single compositional system, and discussed implications for a recent compositional debate.

Thanks!

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At-issue iconicity

- Iconic meanings may scope under negation.

(48) MIRKO BOOK GIVE-rep-speeding-up NOT. IX BOOK give-rep-slowing-down DOWN.
'Mirko didn't give books at an accelerating rate. He gave books at a decelerating rate.'

- Iconic meanings may scope low in the antecedent of a conditional.

(49) IF MIRKO PAPERS GIVE-rep-speeding-up, IX SECRETARY HAPPY.
'If Mirko gives papers at an accelerating rate, the secretary will be happy.'

At-issue iconicity

- Iconic meanings may scope under distributive operators.

(50) **ASL**
EACH WORKER SECRETARY PAPER GIVE-rep-slow.
BUT, MANY WORKER NUMEROUS, ONE SECRETARY.
SO SECRETARY RECEIVE-alt-fast FAST.
'Each worker gave the secretary papers *at a slow rate*. But there are many workers and one secretary. So the secretary received papers *at a fast rate*.'

Iconicity beyond sign language

(51) That was a loooong meeting.

(52) John coughed and coughed (and coughed).

(53) NBC: "Watch robots fall over again and again and again."

- (In fact, 17 times over the course of one minute.)

http://www.nbcnews.com/watch/nbc-news/watch-robots-fall-over-again-and-again-and-again-460526659963

Iconicity beyond sign language

- Iconicity in a downward entailing environment? (h/t Chris Barker)