Turning context into meaning

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➔ *indicating*

➔ *demonstrating*

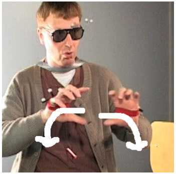
'Can you jump over this spout?'

'then the house is like this'

Outline

The gesture event

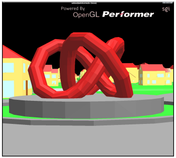
Why demonstrations? (Image sources: SaGA/Lücking 2013)



‘die Skulptur die hat ’n BETONsockel’

‘the sculpture it has a concrete base’

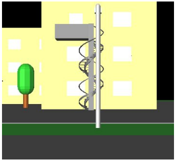
➔ good continuation

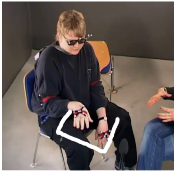


‘Ich glaube das sollen TREPPEN sein’

‘I think that should be staircases’

➔ hyponym

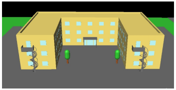




‘dann ist das Haus halt so’

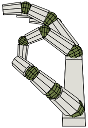
‘then the house is like this’

➔ complete demonstration



Why grammar?

- *Semantic well-formedness*
  - A: *The square
  - B: The circle



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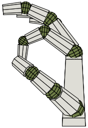
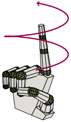
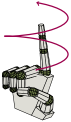


- *Temporal/structural well-formedness*
  - C: I think that should be staircases



  - D: *I think that should be staircases



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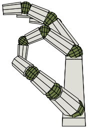

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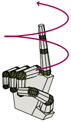

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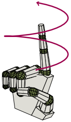

- '*mixed syntax*' (Slama-Cazacu 1976)

  He is a bit [*rotating index finger on front of temple*]

1. How is a gesture capable of
   - indicating linguistically unexpressed properties?
   - invoking hyponymic meanings of affiliated expressions?
   - providing complete demonstrations?
2. And how to integrate it into grammar?

‘Ich glaube das sollen Treppen sein’

I think those should be stairs

How many events are involved in the spiral gesture?

e:	circular upward movement
e':	quick circular upward movement
e'':	carrying tracking marker

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Granularity of event theories (Engelberg 2000)

Approaches

- Quine (1960): too coarse-grained
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'each individual event has three unique constituents: a substance (the "consitutitve object" of an event), a property it exemplifies (the "consitutive property" or "generic event") and a time.'

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'[...] generic events seem to be just those properties whose possession by an object bestows upon it a causal power or potency, or whose possession by an object indicates its being subjected to such powers.'

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Quickness can have different causal relations than mere movement.

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Lombard (1998:290)

‘an event, *e*, and an event, *e*′, are the same event if and only if *e* and *e*′ are simultaneous movements by the same object through the same portions of the same quality spaces.’

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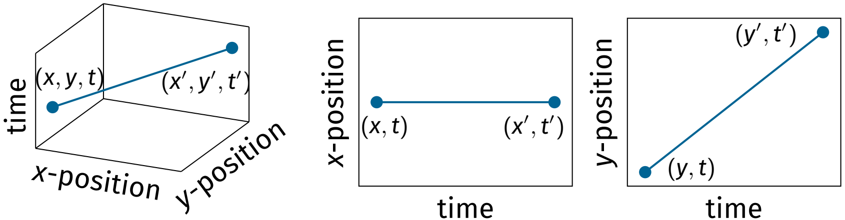
e:	circular upward movement
	quick circular upward movement
e″:	carrying tracking marker

- Implicitly, the spiral upwards movement is treated as one single movement.
- But why not decompose it into two events?
  - e': circular movement;
  - e'': upward movement.
- (Lombard (1986)) has no decisive answer to the general question of what dimension(s) exactly span the quality space.



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- Rotation and translation **Carriers** are the basis for the vector model.

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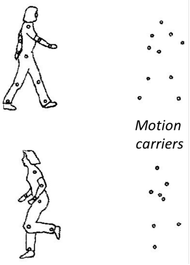
Input Carrier



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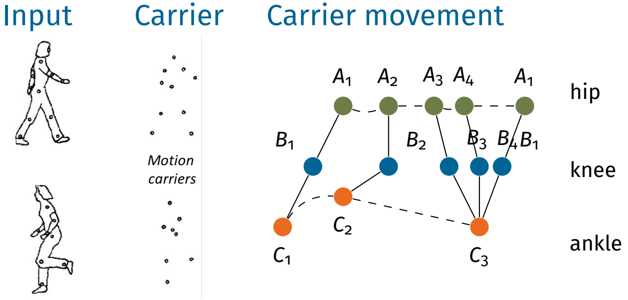
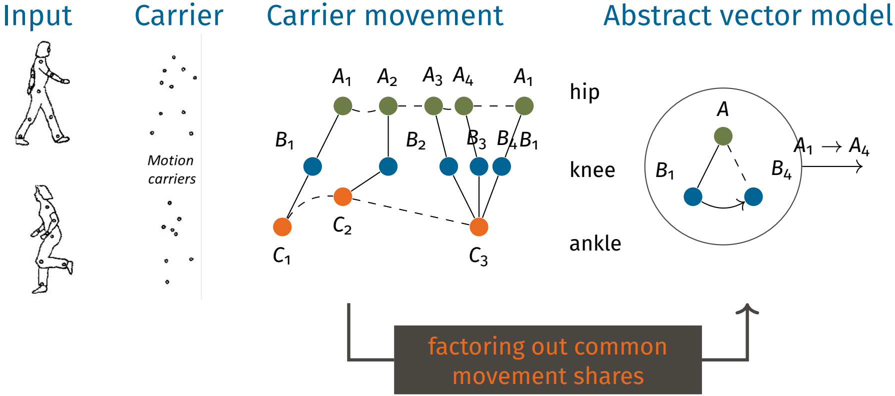
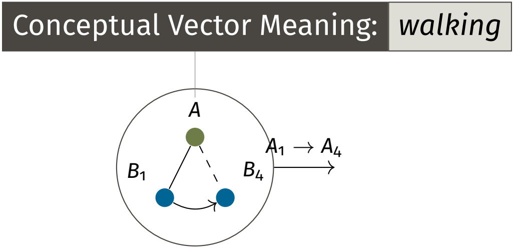


Vector analysis of biological motion (Johansson 1973)

- Motion perception can be captured by means of a **vector model**.
- Rotation and translation **Carriers** are the basis for the vector model.



Gesture as vector model exemplifiers



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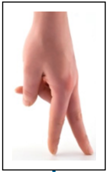
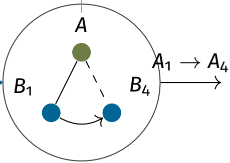
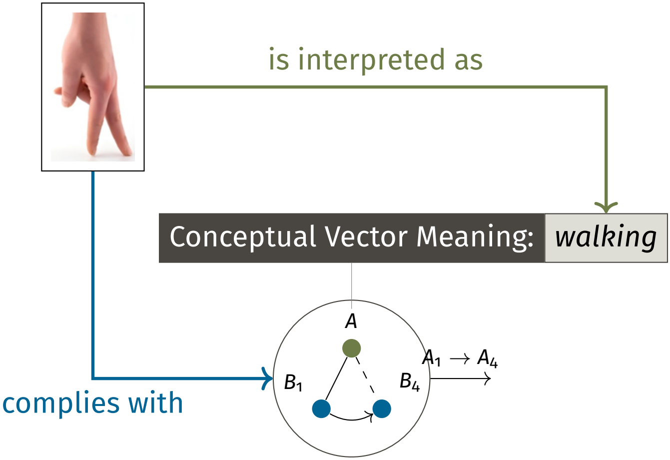


Conceptual Vector Meaning: *walking*

complies with



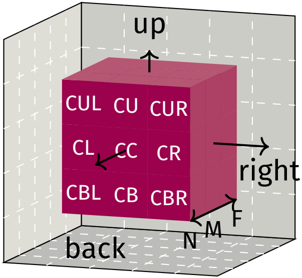

is interpreted as
Conceptual Vector Meaning: *walking*
A
$A_1 \to A_4$
B_1
B_4
complies with

Gesture vectorisation

hand = right
hs = claw
carrier = [boh = none
plm = none
wrst = MR>MB>ML
move = line>line>line]
sync = [sloc = CBR-F
eloc = CBR-N
stime = 2:32
etime = 2:33]
rel = none

- Annotation format:
  - handedness (right, left)
  - handshape (modified ASL lexicon)
  - movement carrier (back-of-hand, palm or wrist; path of movement)
  - synchronized info (temporal, local)
  - relation to other hand
- The values of the features are of type *AP* (*annotation predicate*), e.g. [hs : *AP*]

start and end locations of gesture movements are given in terms of three-dimensional **gesture space** (adapted from McNeill 1992)



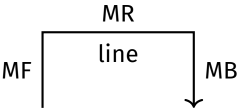
CBL:	center below left
CL:	center left
CUL:	center upper left
CB	center below
CC:	center center
...	...
N:	near
M:	middle
F:	far

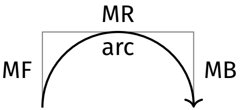
Movements: lines vs. arcs

- A movement is captured in terms of a direction seen from the speaker (e.g. *move forward* (MF)) and
- a concatenation type which distinguishes straight (“line”) from roundish (“arc”) trajectories.
- Complex movements are built by combinations of directions (‘>’).

[wrst = MR>MB>ML
move = **line>line>line**]

[wrst = MR>MB>ML
move = **arc>arc>arc**]

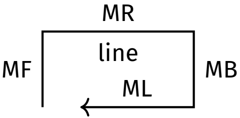




- Movements are underspecified with regard to the lengths of the movement parts.
- Closed and open paths are discriminated in terms of the *sync*-feature.

wrst	= MF>MR>MB>ML
move	= line>line>line>line
sloc	= CC-M
eloc≠sloc	= CR-M

wrst	= MF>MR>MB>ML
move	= line>line>line>line
sloc	= CC-M
eloc=sloc	= CC-M



Alternative representation: Gesture strings

- Based on 'String Theory of Events' (Fernando 2007, Cooper 2012).
- The gesture annotation using '>' is equivalent to a 'string event' notation using '$\frown$', using '$\frown_{line}$' and '$\frown_{arc}$' as line and arc variants.
- $$e = \begin{bmatrix} \text{wrst = MF} \\ \text{sync} = \begin{bmatrix} \text{sloc = p1} \\ \text{eloc = p2} \end{bmatrix} \end{bmatrix} \frown_{line} \begin{bmatrix} \text{wrst = MR} \\ \text{sync} = \begin{bmatrix} \text{sloc = p3 = p2} \\ \text{eloc = p4} \end{bmatrix} \end{bmatrix}$$
  $$\frown_{line} \begin{bmatrix} \text{wrst = MB} \\ \text{sync} = \begin{bmatrix} \text{sloc = p5 = p4} \\ \text{eloc = p6} \end{bmatrix} \end{bmatrix} \frown_{line} \begin{bmatrix} \text{wrst = ML} \\ \text{sync} = \begin{bmatrix} \text{sloc = p7 = p7} \\ \text{eloc = p8 = p1} \end{bmatrix} \end{bmatrix}$$

Vector types

- Gesture annotations are mapped onto vector sequence representations **p** form spatial vector semantics (Zwarts 2003): $\mathbf{p} : [0,1] \mapsto \mathbf{V}$.
- Format:
  - **Type**: axis, place, outline, … (Zwarts 2005)
  - **Path**: description of contour (Zwarts 2003)
  - **Shapes**: shape constraint (cf. Weisgerber 2006)
- $Vec =_{\text{def}} \begin{bmatrix} \text{vt} : \text{Vtype} \\ \text{pt} : \text{Vpath} \\ \text{sh} : \text{multiset(Vshape)} \end{bmatrix}$
- Rule-based translation from gesture event to vector type: π_v and π_d.

Configuration	=	Vector π_v	→	Constraints π_d
Handshape $\in$ {C, 5, B, O, Y}	=	$\{\mathbf{u}\}$	→	volume
{MF, MR, MB, ML}	=	$\mathbf{u}$	→	translational
$\emptyset$	=	–	→	–
MF>MR + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MR>MB + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MB>ML + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MF>ML + arc	=	$\mathbf{u} \circ \mathbf{v}$	→	quadrant
MF>MR + arc	=	$\mathbf{u} \circ \mathbf{v}$	→	quadrant
...	=	...	→	...
MF + ... + MB	=	$\mathbf{u}, \mathbf{u}^{-1}$	→	inverse
ML + ... + MR	=	$\mathbf{u}, \mathbf{u}^{-1}$	→	inverse
sloc = eloc	=	$\mathbf{u}(0) = \mathbf{v}(1)$	→	closed
sloc $\neq$ eloc	=	$\mathbf{u}(0) \neq \mathbf{v}(1)$	→	open
lh.sloc = rh.sloc +	=	$\mathbf{u}(0) = \mathbf{v}(0)$		
lh.eloc = rh.eloc [two-handed]	=	$\mathbf{w}(1) = \mathbf{x}(1)$	→	closed
quadrant + quadrant + invers				semicircle
semicircle + semicircle + closed				circle
orthogonal + orthogonal + invers + open				rectangular
orthogonal + orthogonal + invers + closed				rectangle
...				...

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Handshape $\in$ {C, 5, B, O, Y}	=	$\{\mathbf{u}\}$	→	volume
{MF, MR, MB, ML}	=	$\mathbf{u}$	→	translational
$\emptyset$	=	–	→	–
MF>MR + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MR>MB + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MB>ML + line	=	$\mathbf{u} \perp \mathbf{v}$	→	orthogonal
MF>ML + arc	=	$\mathbf{u} \circ \mathbf{v}$	→	quadrant
MF>MR + arc	=	$\mathbf{u} \circ \mathbf{v}$	→	quadrant
...	=	...	→	...
MF + ... + MB	=	$\mathbf{u}, \mathbf{u}^{-1}$	→	inverse
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quadrant + quadrant + invers				semicircle
semicircle + semicircle + closed				circle
orthogonal + orthogonal + invers + open				rectangular
orthogonal + orthogonal + invers + closed				rectangle
...				...

- $$\pi_v\left(\begin{bmatrix} \text{wrst} = \text{MR>MB>ML} \\ \text{move} = \text{line>line>line} \\ \text{sync} = \begin{bmatrix} \text{sloc} = \text{p1} \\ \text{eloc} = \text{p2} \neq \text{p1} \end{bmatrix} \end{bmatrix}\right) = \begin{bmatrix} \text{pt1} : \begin{bmatrix} \mathbf{u} \perp \mathbf{v} \perp \mathbf{w} \\ \mathbf{u}(0) \neq \mathbf{w}(1) \end{bmatrix} \end{bmatrix}$$
- $$\pi_d\left(\begin{bmatrix} \text{pt1} : \begin{bmatrix} \mathbf{u} \perp \mathbf{v} \perp \mathbf{w} \\ \mathbf{u}(0) \neq \mathbf{w}(1) \end{bmatrix} \end{bmatrix}\right) = \begin{bmatrix} \text{sh} : \left\{ \text{rectangular, open} \right\} \end{bmatrix}$$

(results of π_v and π_d are often lumped together in the following)

Perceptual contents

- The intensions of some predicates have a **Conceptual Vector Meaning (CVM)**, representing their perceptual impression in terms of **vector sequences** (Lücking 2013).
- $[\![\text{U-shaped}]\!] =$

$$\left[\begin{array}{l} \text{bg} = \left[\text{x} : \text{Ind}\right] \\ \text{f} \;\; = \lambda r : \text{bg} \,.\, \left(\left[\begin{array}{l} \text{c}_\text{u} : \text{U-shaped}(r.\text{x}) \\ \text{cvm} = \left[\begin{array}{l} \text{vt} : \text{axis-path}(r.\text{x}, \text{pt}) \\ \text{pt} : \left[\begin{array}{l} \mathbf{u} \perp \mathbf{v} \perp \mathbf{w} \\ \mathbf{u}(0) \neq \mathbf{w}(1) \end{array}\right] \\ \text{sh} : \left\{\text{rectangular, open}\right\} \end{array}\right] : \mathit{Vec} \\ \text{c}_\text{shape} : \text{shape}(r.\text{x}, \text{cvm}) \end{array}\right]\right) \end{array}\right]$$

Simple Update Model (Larsson 2015):

- 'Standard update' **C-upc** (informal):

  if information state s_t is compatible with $[\![e]\!].bg$, then update to $s_{t+1} = s_t + [\![e]\!].bg$

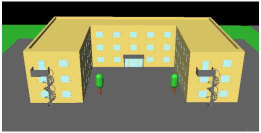
- Gestures are part of the (list-valued) display situation (dp) of the utterance of an expression at a given state s_t.
- 'Gesture update' **C-upc** (informal):

  if a gesture occurs at s_t, it updates $[\![e]\!].cvm$ in s_{t+1} and adds a **perceptual linking constraint 'cvm=dp'**.

Demonstration

'dann ist das Haus halt so'

'then the house is like this'



Annotation:

$$\begin{bmatrix} \text{wrst = MR>MB>ML} \\ \text{move = line>line>line} \\ \text{sync} = \begin{bmatrix} \text{sloc} = \text{p1} \\ \text{eloc} = \text{p2} \neq \text{p1} \end{bmatrix} \end{bmatrix}$$

Vector representation:

$$\begin{bmatrix} \text{pt1} : \begin{bmatrix} \mathbf{u} \perp \mathbf{v} \perp \mathbf{w} \\ \mathbf{u}(0) \neq \mathbf{w}(1) \end{bmatrix} \\ \text{sh} : \{\text{rectangular, open}\} \end{bmatrix}$$

PROCESSING *HOUSE*

- Lexical entry: ⟦house⟧ =

$$\begin{bmatrix} \text{bg} = \begin{bmatrix} \text{x} : \text{Ind} \end{bmatrix} \\ \text{f} \quad = \lambda r : \text{bg} \,.\, \left(\begin{bmatrix} \text{c}_{\text{hs}} : \text{house}\,(r.\text{x}) \\ \text{cvm} : \mathit{Vec} \\ \text{c}_{\text{shape}} : \text{shape}(r.\text{x}, \text{cvm}) \end{bmatrix} \right) \end{bmatrix}$$

- Information state after processing the noun:

$$s_{t+1} = \begin{bmatrix} \text{x} & : \text{Ind} \\ \text{c}_{\text{hs}} & : \text{house}\,(\text{x}) \\ \text{cvm} & : \mathit{Vec} \\ \text{c}_{\text{shape}} & : \text{shape}(\text{x}, \text{cvm}) \end{bmatrix}$$

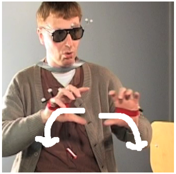
Adding gesture

- Gesture updates cvm of s_{t+2} and introduces additional predicate *U-shaped* via perceptual linking:

$$s_{t+2} = \begin{bmatrix} \mathrm{x} & : & \mathit{Ind} \\ \mathrm{c_{hs}} & : & \mathrm{house\ (x)} \\ \mathrm{cvm{=}dp} & : & \mathit{Vec} \\ \mathrm{c_{shape}} & : & \mathrm{shape(x, cvm)} \\ \mathrm{dp} & = & \begin{bmatrix} \mathrm{pt} : \begin{bmatrix} \mathbf{u} \perp \mathbf{v} \perp \mathbf{w} \\ \mathbf{u}(0) \neq \mathbf{w}(1) \end{bmatrix} \\ \mathrm{sh} : \left\{ \mathrm{rectangular, open} \right\} \end{bmatrix} : \mathit{Vec} \\ \mathrm{c_u} & : & \mathrm{U\text{-}shaped(x)} \end{bmatrix}$$

- $\approx$ ‘U-shaped house’

MODIFIER + *GOOD CONTINUATION*



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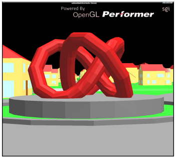
‘the sculpture it has a concrete base’



$$
\begin{bmatrix}
\text{hands = both} \\
\text{rh} = \begin{bmatrix}
\text{hand} & = \text{right} \\
\text{hs} & = \text{C} \\
\text{carrier} & = \begin{bmatrix} \text{wrst = MR>MF} \\ \text{move = arc} \end{bmatrix} \\
\text{sync} & = \begin{bmatrix} \text{sloc=lh.sync.sloc = CC-N} \\ \text{eloc = CR-M} \end{bmatrix}
\end{bmatrix} \\
\text{lh} = \begin{bmatrix}
\text{hand} & = \text{left} \\
\text{hs} & = \text{C} \\
\text{carrier} & = \begin{bmatrix} \text{wrst = ML>MF} \\ \text{move = arc} \end{bmatrix} \\
\text{sync} & = \begin{bmatrix} \text{sloc = CC-N} \\ \text{eloc = CL-M} \end{bmatrix}
\end{bmatrix} \\
\text{rel = axissymmetric}
\end{bmatrix}
$$

$$
\begin{bmatrix}
\text{pt1lh} = \begin{bmatrix} \{\mathbf{u} \circ \mathbf{v}\} \\ \mathbf{u}(0) \neq \mathbf{v}(1) \end{bmatrix} \\
\text{pt1rh} = \begin{bmatrix} \{\mathbf{w} \circ \mathbf{x}\} \\ \mathbf{w}(0) \neq \mathbf{x}(1) \end{bmatrix} \\
\text{comb} = \begin{bmatrix}
\text{pt} = \begin{bmatrix} \mathbf{u}(0) = \mathbf{w}(0) \\ \mathbf{v}(1) \neq \mathbf{x}(1) \\ \mathbf{a} \circ \mathbf{b} \circ \mathbf{c} \\ \mathbf{a}(0) \neq \mathbf{c}(1) \end{bmatrix} \\
\text{sh} = \{\text{semicircle, volume, open}\}
\end{bmatrix}
\end{bmatrix}
$$

Good continuation

GoCont can be formulated as a constraint over *types* of input and output display situations:

$$
\textit{GoCont} =_{\text{def}} \lambda r : \left[\begin{array}{lll}
\text{ap1} & = \text{open} : \textit{AP} & \\
\text{cc} & = \widehat{\textit{line}} \vee \widehat{\textit{arc}} : \text{Vpath} & \\
\text{dp}_{\text{in}} & : \left[\begin{array}{l} \text{sh} : \text{set(AP)} \\ \text{pt} : \text{Vpath} \\ \text{vt} : \text{Vtype} \end{array}\right] & \\
\text{c}_{\text{memb}} & : \text{member(ap1, dp}_{\text{in}}\text{.sh)} & \\
\text{c}_{\text{conc}} & : \textbf{member(cc, dp}_{\textbf{in}}\textbf{.pt)} & \\
\text{cvm} & : \emptyset &
\end{array}\right] . \left(T = \left[\begin{array}{ll}
\text{svec} & : \text{Vpath} \\
\text{c}_{\text{cond}} & : \text{init(svec, } r\text{.pt)} \\
\textbf{spt=svec}^{-1} & : \text{Vpath} \\
\text{dp}_{\text{out}} & : \left[\begin{array}{l} \text{pt} = \left[\begin{array}{l} r.\text{dp}_{\text{in}}.\text{pt } \boldsymbol{r}\textbf{.cc spt} \\ \boldsymbol{r}\textbf{.dp}_{\textbf{in}}\textbf{.pt(0) = spt(1)} \end{array}\right] \\ \text{vt} = r.\text{dp}_{\text{in}}.\text{vt} : \text{Vtype} \end{array}\right]
\end{array}\right] \right) . \pi_d(T)
$$

- Idea: if shape is open, get the concatenation type ($\widehat{\textit{line}}$ or $\widehat{\textit{arc}}$) and suffix it at the output
- Add a new vector that is inverse to the start of the input vector (where 'init' is taken from (Cooper ms)) such that the new output path is closed

Applying *GoCont*

Applying (the two-handed extension of) *GoCont* to the incomplete gesture gives rise to a voluminous circle, that is, a **cylinder**:

$$
\mathit{GoCont}\left(\begin{bmatrix} \mathrm{dp_{in}} = \begin{bmatrix} \mathrm{pt1lh} = \begin{bmatrix} \{\mathbf{u}\circ\mathbf{v}\} \\ \mathbf{u}(0)\neq\mathbf{v}(1) \end{bmatrix} \\ \mathrm{pt1rh} = \begin{bmatrix} \{\mathbf{w}\circ\mathbf{x}\} \\ \mathbf{w}(0)\neq\mathbf{x}(1) \end{bmatrix} \\ \mathrm{comb} = \begin{bmatrix} \mathrm{pt} = \begin{bmatrix} \mathbf{u}(0)=\mathbf{w}(0) \\ \mathbf{v}(1)\neq\mathbf{x}(1) \\ \mathbf{a}\circ\mathbf{b}\circ\mathbf{c} \\ \mathbf{a}(0)\neq\mathbf{c}(1) \end{bmatrix} \\ \mathrm{sh} = \{\text{semicircle}, \text{volume}, \text{open}\} \end{bmatrix} \end{bmatrix} \end{bmatrix}\right) \rightarrow \begin{bmatrix} \mathrm{dp_{out}} = \begin{bmatrix} \mathrm{pt1lh} = \begin{bmatrix} \{\mathbf{u}\circ\mathbf{v}\circ\mathbf{y}\} \\ \mathbf{u}(0)\neq\mathbf{y}(1) \end{bmatrix} \\ \mathrm{pt1rh} = \begin{bmatrix} \{\mathbf{w}\circ\mathbf{x}\circ\mathbf{z}\} \\ \mathbf{w}(0)\neq\mathbf{z}(1)=\mathbf{y}(1) \end{bmatrix} \\ \mathrm{comb} = \begin{bmatrix} \mathrm{pt} = \begin{bmatrix} \mathbf{u}(0)=\mathbf{w}(0) \\ \mathbf{y}(1)=\mathbf{z}(1) \\ \mathbf{a}\circ\mathbf{b}\circ\mathbf{c}\circ\mathbf{d}\circ\mathbf{e} \\ \mathbf{a}(0)=\mathbf{e}(1) \end{bmatrix} \\ \mathrm{sh} = \{\textbf{circle}, \textbf{volume}, \textbf{closed}\} \end{bmatrix} \end{bmatrix} \end{bmatrix}
$$

Update of all resources

$$
s_{t+1} = \left[\begin{array}{lll}
\text{x} & : & \text{Ind} \\
\text{dp} & = & \mathit{GoCont}\left(\left[\begin{array}{l} \text{pt} = \left\{\mathbf{a} \circ \mathbf{b} \circ \mathbf{c}\right\} \\ \text{sh} = \left\{\text{semicircle, volume, open}\right\} \end{array}\right]\right) \\
 & & \rightarrow \left[\begin{array}{l} \text{vt} = \text{shape-path(x, cvm)} \\ \text{pt} = \left[\begin{array}{l} \left\{\mathbf{a} \circ \mathbf{b} \circ \mathbf{c} \circ \mathbf{d} \circ \mathbf{e}\right\} \\ \mathbf{a}(0) = \mathbf{e}(1) \end{array}\right] : \mathit{Vec} \\ \text{sh} = \left\{\text{circle, volume, closed}\right\} \end{array}\right] \\
\text{cvm=dp} & : & \mathit{Vec} \\
\text{c}_{\text{cb}} & : & \text{concrete-base(x)} \\
\text{c}_{\text{cy}} & : & \text{cylinder(x)} \\
\text{c}_{\text{shape}} & : & \text{shape(x, cvm)}
\end{array}\right]
$$

Pointing and deferred reference

Ways of demonstrating (Clark 1996)

➔ *demonstrating*

➔ *indicating*

'then the house is like this'

'Can you jump over this spout?'

Exophoric (deictic, perceptual) (Kaplan 1989)

This painting [*nodding towards a canvas*] is by Chagall.

Exophoric (deictic, perceptual) (Kaplan 1989)

This painting [*nodding towards a canvas*] is by Chagall.

Endophoric (anaphoric, cataphoric) (King 2001)

Städel has a new painting$_i$. *This painting*$_i$ is by Chagall.

Exophoric (deictic, perceptual) (Kaplan 1989)

This painting [*nodding towards a canvas*] is by Chagall.

Endophoric (anaphoric, cataphoric) (King 2001)

Städel has a new painting$_i$. *This painting*$_i$ is by Chagall.

Deferred reference (Quine 1968, Nunberg 1993)

This painter [*nodding towards a canvas*] is the most expensive one.

- Configuration: $[_{\text{DemNP}}[[\text{that } i]R]\text{NP}]$
  - *i*: contextually given index, $g(i)$.
  - *R*: salient relation (eventually bridging between $g(i)$ and $[\![\text{NP}]\!]$, defaults to identity).
  - The relation variable *R* can be *bound*, capturing endophoric uses.

- Configuration: $[_{\text{DemNP}}[[\text{that } i]R]\text{NP}]$
  - i: contextually given index, $g(i)$.
  - R: salient relation (eventually bridging between $g(i)$ and $[\![\text{NP}]\!]$, defaults to identity).
  - The relation variable R can be *bound*, capturing endophoric uses.
- **Problems:**
  - **No index** in case of endophoric uses.
  - **Directly referential** assignment $g(i)$ is too simplistic.
  - No representation of **demonstration act**.

Clarification Potential (Purver & Ginzburg 2004; Lücking 2018)

- The *reprise content* of exophoric DemNPs is *restricted to the index*.

(1) A. This[] painting is by Chagall.

B. This[] painting?
⇝ *The object over there?*
⇝ **??** *What do you mean "painting"?*
⇝ **??** *Which one?*

A. Right, this painting. / No, the one to the left.
?? Well, maybe it's a drawing.

No Index for Endophorics

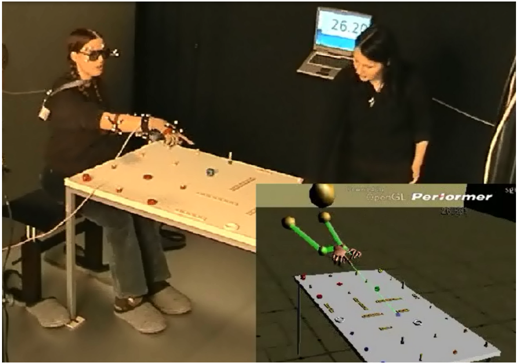
- Only unspecific clarification,
  no index available.

(2) A. I saw a painting$_j$ yesterday.
This painting$_j$ was shocking.

B. This painting?
⇝ **??** *The object over there?*
⇝ **??** *What do you mean "painting"?*
⇝ *Which one?*

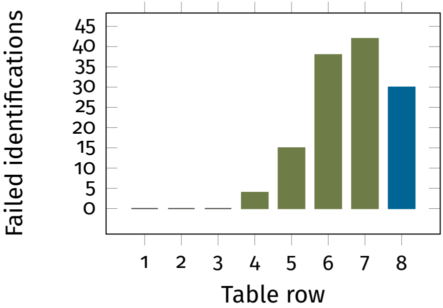
A. The painting I saw yesterday / I just mentioned.
?? This one.
?? Yes/No.

Direct Reference? (Lücking, Pfeiffer & Rieser 2015)



- *Experimental pragmatics* study.
- *Tracking of pointer*: simulate and 'measure' pointing.

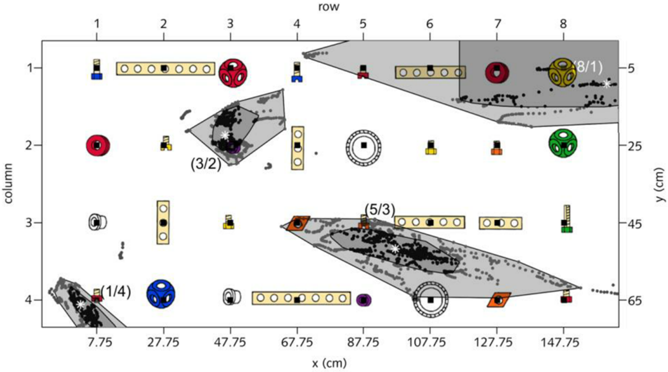
IDENTIFICATION FAILURES (LÜCKING, PFEIFFER & RIESER 2015)

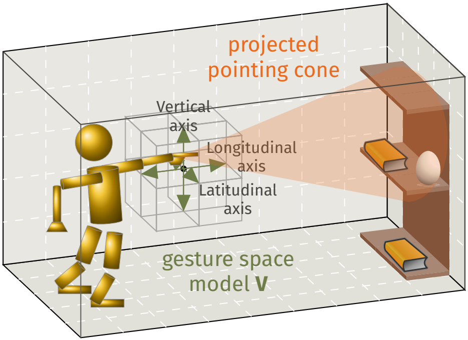


- For the addressee, the identifying force of pointings ceases in distal area.
- Note: decrease in row 8 due to ‘gestural hyperbole’.

- Even in proximal area pointings do not hit their targets.

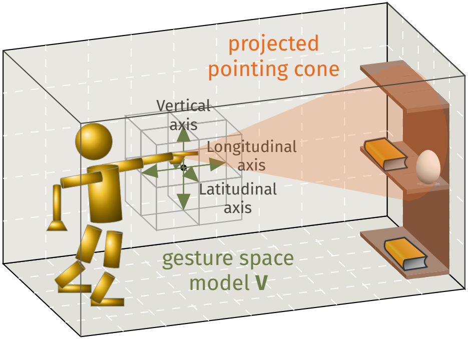
→ Demonstrative reference rests on a *pre-semantic pragmatic inference*.





Spatial Semantics:

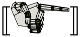
Demonstrations *constrain situation variables.*

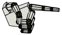


Spatial Semantics:

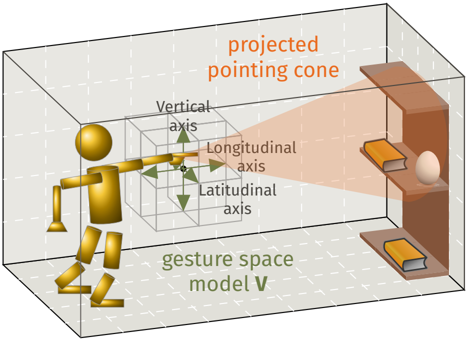
Demonstrations *constrain situation variables.*

- Pointing's *character* at u:

  $[\![$  $]\!]^u = \lambda s.\ \text{region}(s) \cap \text{cone}($  $)(u) \mapsto \text{relmax}$

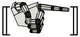
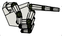
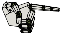
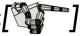
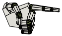
  In short:  $(s) \mapsto \text{max}_i$

Spatial Semantics (Lücking still not published...)



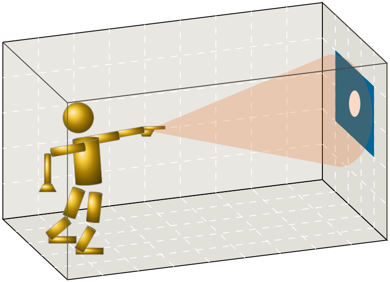
Spatial Semantics:

Demonstrations *constrain situation variables*.

- Pointing's *character* at u:
  $[\![$  $]\!]^u = \lambda s.\ \text{region}(s) \cap \text{cone}($  $)(u) \mapsto \text{relmax}$
  In short:  $(s) \mapsto \text{max}_i$
- *This[*  *] book is great*:
  $\lambda s.\iota x x$ is a book in s' &  $(s') \mapsto \text{max}_i$ is great in s.
  (using Elbourne's (2013) situation semantics system)

Deferred reference

- Deferred ostension (1968) / deferred reference (Nunberg 1993)
- 'This painter is great!'



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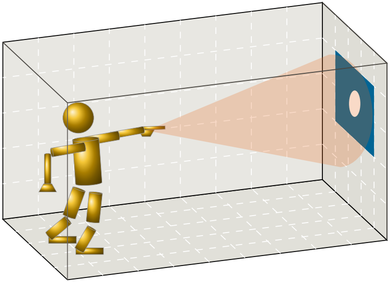
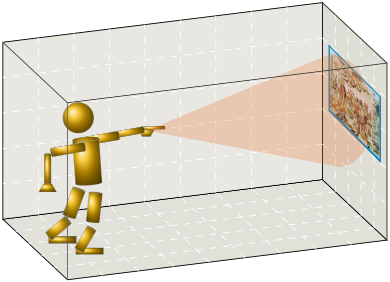


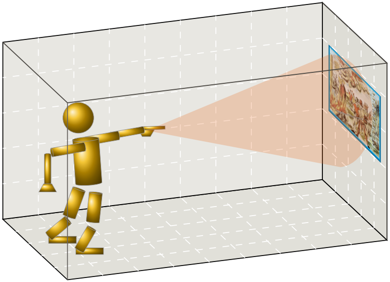
- index $\neq$ referent
- Two stage process:
  1. Identify index
  2. Identify referent by means of a *salient relation*

- ‘This era was a dark one.’
  (Image source: *Wikimedia Commons*, drawing from the Wickiana, a collection of news reports from the 16th century, public domain)



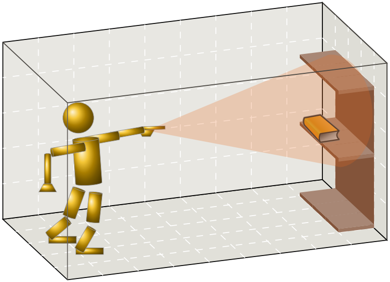
- 'This era was a dark one.'
  (Image source: *Wikimedia Commons*, drawing from the Wickiana, a collection of news reports from the 16th century, public domain)

- Three stage process:
  1. Identify index
  2. Identify intermediate referent (subject)
  3. Identify referent by means of a *salient relation* (historic epoche of subject)



At home with George (Clark 1996)

- George pointing at a copy of Wallace Stegner's novel *Angle of Repose* (*aor*) which lies on a bookshelf (*b*).
- Assumption: $K_{\text{pointing}} \models aor$



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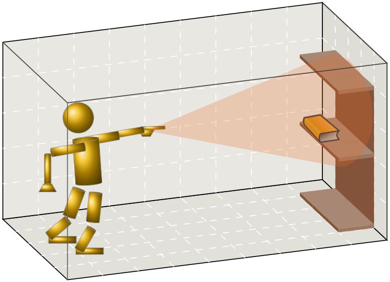


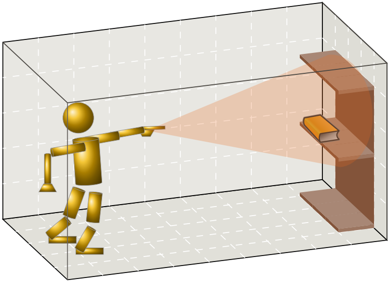
concrete deixis

'That book is mine.'

deferred reference

'That publisher is a good one.'

- George pointing at a copy of Wallace Stegner's novel *Angle of Repose* (*aor*) which lies on a bookshelf (*b*).
- **Assumption:** $K_{\textbf{pointing}} \models \textbf{\textit{aor}}$



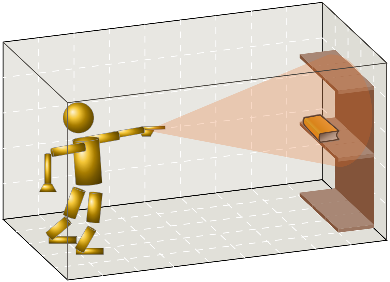
not: concrete deixis

'That shelf is mine.'

not: deferred reference

'That craftsman is a good one.'

- George pointing at a copy of Wallace Stegner's novel *Angle of Repose* (*aor*) which lies on a bookshelf (*b*).
- Assumption: $K_{\text{pointing}} \models aor$



deferred reference

'That shelf is mine.'

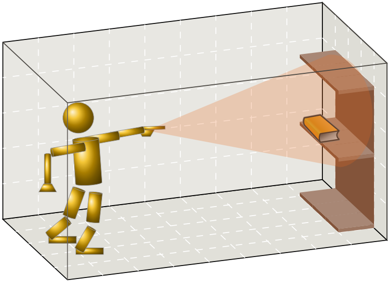
double deferred

'That craftsman is a good one.'

'salient functional relation':

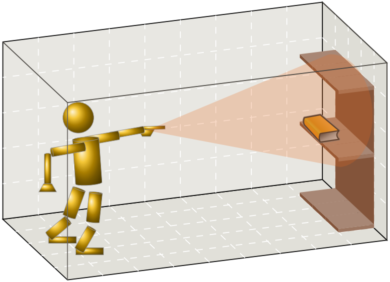
1. factual *lies-on* relation.
2. 1. + *producer* relation.

- George pointing at a copy of Wallace Stegner's novel *Angle of Repose* (*aor*) which lies on a bookshelf (*b*).
- Analogous for $K_{\text{pointing}} \models b$



AT HOME WITH GEORGE (CLARK 1996)

- Contra-intuitive
- Four meanings (two deferrings, two double deferrings) more than necessary: violation of a variant of *Modified Occam's Razor* (Grice 1978): **Do not multiply deferrings beyond necessity!**



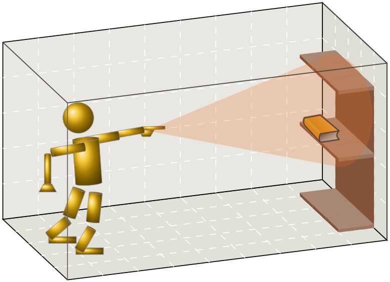
Underlying assumptions

1. A pointing gesture is **referential** in the sense that it picks out an object.
2. A pointing gesture is **autonomous** in the sense that it demonstrates its index independently from accompanying speech (autonomy of demonstrations).
3. The **index need not be the referent**.

1. A pointing gesture is **referential** in the sense that it picks out an object.
2. A pointing gesture is **autonomous** in the sense that it demonstrates its index independently from accompanying speech (autonomy of demonstrations).
3. The **index need not be the referent**.

- Pointing cone studies speak against reference
- Depending on George saying
  - ‘That book’
  - ‘That shelf’

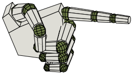
  the index is understood to be the book or the bookshelf, respectively.
- Contradicting the autonomy of demonstration.



New proposal: figure-ground model

this

attentional index



spatial index

‘search space’
(= set of situations, *Ground*)

∋

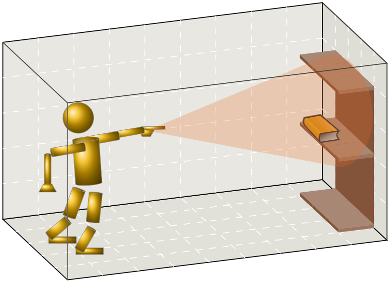
N

(true) description

index
(situational constituent, *Figure*)

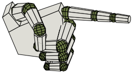
- Depending on George saying
  - ‘That book/publisher’
  - ‘That shelf/craftsman’

  the index is understood to be the book or the bookshelf, respectively.
- Contradicting the true description requirement of Figure-Ground model.



New proposal: figure-ground model, modified

this — attentional index →



→ spatial index →

‘search space’
(= set of situations, *Ground*)

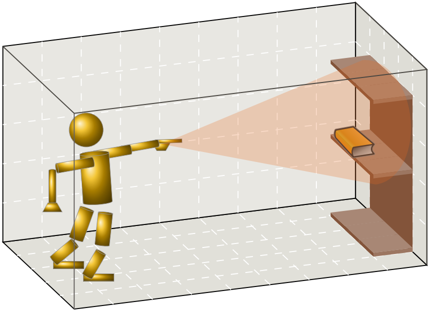
∋

N → (true or metonymic) description →

index
(situational constituent, *Figure*)

Frames (http://framenet.icsi.berkeley.edu)

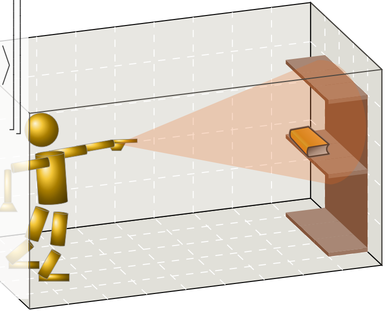
- ‘This author is a genius.’
- Co-determination: s is such that $s \in \mathrm{cone}(\;)$ and s supports *author*(x).
- Making it work with frame knowledge (excerpt):



- 'This author is a genius.'
- Co-determination: *s* is such that $s \in \text{cone}(☞)$ and *s* supports *author*(*x*).
- Making it work with frame knowledge (excerpt):

```
[ cn-lxm
  FORM ⟨book⟩
  SEM [ INDEX  i
        FRAMES ⟨ [ book-fr          [ author-fr    [ genre-fr     [ text-fr
                   LABEL  l0          LABEL  l1  ,   LABEL  l2  ,   LABEL  l3
                   ENTITY i       ,   ENTITY j ]     ENTITY k ]     ENTITY l ] ⟩ ] ]
                   AUTHOR l1
                   GENRE  l2
                   TOPIC  l3 ]

[ cn-lxm
  FORM ⟨author⟩
  SEM [ INDEX  i
        FRAMES ⟨ [ author-fr           [ text-fr
                   LABEL        l0   ,   LABEL  l1
                   ENTITY       m        ENTITY n ] ⟩ ] ]
                   AUTHOR-OF    l1 ]
```



- ‘This author is a genius.’
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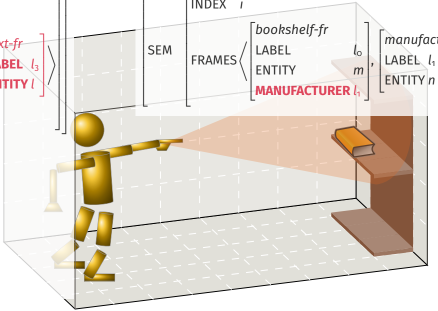
cn-lxm
FORM ⟨book⟩
SEM [INDEX *i*
FRAMES ⟨ [*book-fr* LABEL l_0 ENTITY *i* AUTHOR l_1 GENRE l_2 TOPIC l_3], [*author-fr* LABEL l_1 ENTITY *j*], [*genre-fr* LABEL l_2 ENTITY *k*], [*text-fr* **LABEL** l_3 **ENTITY** *l*] ⟩]

cn-lxm
FORM ⟨**author**⟩
SEM [INDEX *i*
FRAMES ⟨ [*author-fr* LABEL l_0 ENTITY *m* AUTHOR-OF l_1], [*text-fr* **LABEL** l_1 **ENTITY** *n*] ⟩]

cn-lxm
FORM ⟨bookshelf⟩
SEM [INDEX *i*
FRAMES ⟨ [*bookshelf-fr* LABEL l_0 ENTITY *m* **MANUFACTURER** l_1], [*manufact-fr* LABEL l_1 ENTITY *n*] ⟩]



- Let $Fr(\phi)$ be the frame elements of a type ϕ.
- A situation s extendedly exemplifies a type T, $s ::: T$, iff
  - $s : T$, or
  - there is a type T' such that $Fr(T) \cap Fr(T') \neq \emptyset$ and $s : T'$ (indirect classification).

Wrong prediction for anaphoric uses?

Nunberg (2004:271) argues that metonymic uses of demonstratives do not extend to discourse.

Nunberg's example

I can point at Tiger Woods and say (25):

(25) That's what I want to take lessons in.

But this use of the demonstrative doesn't have a parallel in (26):

(26) ?Whenever Mary sees Tiger Woods on TV, she wants to take lessons in that.

Tiger Woods

Example

I can point at Tiger Woods and say
'That's what I want to take lessons in.'

Example

I can point at Tiger Woods and say
‘That’s what I want to take lessons in.’

Scene: Tiger
Woods going
shopping

Example

I can point at Tiger Woods and say
'That's what I want to take lessons in.'

Scene: Tiger Woods going shopping

Scene: Tiger Woods smiling

Example

I can point at Tiger Woods and say
'That's what I want to take lessons in.'

Scene: Tiger Woods going shopping

Scene: Tiger Woods smiling

Scene: Tiger Woods driving a car

What Nunberg probably means:

Example

I can point at Tiger Woods playing golf and say
'That's what I want to take lessons in.'

What Nunberg probably means:

Example

I can point at Tiger Woods playing golf and say
'That's what I want to take lessons in.'

But this perfectly extends to discourse:

(26) Whenever Mary sees Tiger Woods on TV **playing golf**, she wants to take lessons in that.

Example

Can I point at Tiger Woods neutral and say
'That's what I want to take lessons in.' [?]

Example

Can I point at Tiger Woods neutral and say
'That's what I want to take lessons in.' [?]

Upshot

Exophoric reference differs from endophoric reference: the former provides thick particulars while discourse referents are thin particulars.

PLURALS

‘die rechte Kirche die hat zwei spitze Türme’

the church to the right it has to pointed towers

- LF of two pointed towers contributes group variable X and member variable y:
  $\exists X\, [\forall y\, [y \in X \rightarrow tower'(y) \wedge pointed'(y)] \wedge |X| = 2]$
- Gesture interpretation:
  - Each hand/finger represents one of the towers.
  - Neither attaching the gesture to X nor to y captures the desired interpretation.

How to detect denotations? (Lücking, Cooper & Ginzburg u.rev.)

Linguistic theorizing has to come up with all denotations, but only those denotations, that exhibit the property of being *referentially transparent*.

Referential transparency (RT)

The semantic representation of an NP is referentially transparent if

a. it provides antecedents for **pronominal anaphora**
b. it provides the semantic type asked for by a **clarification request**
c. it provides an attachment site for **co-verbal gestures**

- Our proposal: set/ind-based model of quantified noun phrases (QNPs).
- $$NP_{\text{sem}} \mapsto \begin{bmatrix} \text{dgb-params} : \begin{bmatrix} \theta : \mathbb{N} \end{bmatrix} \\ \text{q-params} : \begin{bmatrix} \textit{maxset} & : \textit{Set}(\textit{Ind}) \\ \text{c1} & : \overrightarrow{\textit{Ppty}}(\text{maxset}) \\ \textit{refset} & : \textit{Set}(\textit{Ind}) \\ \textit{compset} & : \textit{Set}(\textit{Ind}) \\ \text{c2} & : \text{partition(refset,compset,maxset)} \end{bmatrix} \\ \text{q-cond} : \textit{Rel}(\text{q-params.refset, q-params.compset}) \vee \textit{Rel}(\text{refset},\theta) \\ \text{q-persp} : \text{refset}=\emptyset \vee \text{refset}\neq \emptyset \vee \text{none} \end{bmatrix}$$
- Every component is referentially transparent, that is, directly relates to clarification requests or pronominal anaphora.

NP_{sem}

$$\left[\begin{array}{lll}\text{dgb-params} & : & \left[\theta : \mathbb{N}\right] \\ \text{q-params} & : & \left[\begin{array}{ll}\text{maxset} & : \mathit{Set}(\mathit{Ind}) \\ \text{c1} & : \overrightarrow{\mathit{Ppty}}(\text{maxset}) \\ \text{refset} & : \mathit{Set}(\mathit{Ind}) \\ \text{compset} & : \mathit{Set}(\mathit{Ind}) \\ \text{c2} & : \text{partition}(\text{refset},\text{compset},\text{maxset})\end{array}\right] \\ \text{q-cond} & : & \mathit{Rel}(\text{q-params.refset, q-params.compset}) \vee \mathit{Rel}(\text{refset},\theta) \\ \text{q-persp} & : & \text{refset}=\emptyset \vee \text{refset} \neq \emptyset \vee \text{none}\end{array}\right]$$

Why individuals and sets?

(3) a. TERRY: Richard hit **the ball** on the car.
NICK: **What ball**? [$\rightsquigarrow$ *What ball do you mean by 'the ball'?*]
TERRY: **James [last name]'s football. [$\rightarrow$ individual]**

(BNC file KR2, sentences 862, 865–866)

b. RICHARD: No I'll commute **every day**
ANON 6: **Every day?** [$\rightsquigarrow$ *Is it **every** day you'll commute?*]
[$\rightsquigarrow$ *Is it every **day** you'll commute?*]
[$\rightsquigarrow$ *Which days do you mean by **every day**?*]
RICHARD: as if, er **Saturday and Sunday [$\rightarrow$ set]**
ANON 6: And all holidays?
RICHARD: Yeah [pause]

- Accepted answers in terms of **individuals** and **sets**, not sets of sets. (Purver & Ginzburg 2004)
- **Against** type raising involved in generalised quantifer theory.

q-cond

$$\begin{bmatrix} \text{dgb-params} : \begin{bmatrix} \theta : \mathbb{N} \end{bmatrix} \\ \text{q-cond} : \textit{Rel}(\text{q-params.refset, q-params.compset}) \vee \textit{Rel}(\text{refset}, \theta) \end{bmatrix}$$

(4) A: Few students left. B: What do you mean by 'few'?

a. Less than half. ➔ *Rel(refset,compset)*

b. Just two, I think. ➔ *Rel(refset,θ)*

(Note: θ is also required to prevent any *van Benthem problem*.)

maxset / refset

$$\left[\text{q-params} : \begin{bmatrix} \text{maxset} : \mathit{Set}(\mathit{Ind}) \\ \text{refset} : \mathit{Set}(\mathit{Ind}) \end{bmatrix}\right]$$

(5) **Most demonstrators** came to the rally,

a. and **they** raised their placards.
➔ *refset (demonstrators coming to the rally)*

b. but **they all** received an invitation.
➔ *maxset (all demonstrators)*

compset

$\left[\text{q-params} : \left[\text{compset} : \mathit{Set}(\mathit{Ind})\right]\right]$

(6) a. **Few music lovers** admire Reger. **They** prefer Mozart.
➔ *compset (music lovers not admiring Reger)*

b. **Many music lovers** admire Reger. **?** **They** prefer Mozart.

Compset anaphora only available with downward monotone proportional quantifier? (Nouwen 2003)

QUANT. PERSPECTIVE: EXPECTANCY (MOXEY & SANFORD 1986)

q-persp

[q-persp : refset $= \emptyset \vee$ refset $\neq \emptyset \vee$ none]

(7) a. A: Few students passed the exam. *[q-persp : refset $= \emptyset$]*

b. B: Did any? / But someone did?

c. ?B: Did all? / Someone failed?

(8) a. A: Many students passed the exam. *[q-persp : refset $\neq \emptyset$]*

b. ?B: Did any? / But someone did?

c. B: Did all? / Someone failed?

- ‘positive’ QNP: refset $\neq \emptyset$, ‘negative’ QNP: refset $= \emptyset$
- Availability constraint: Compset is available as antecedent just in case [q-persp : refset $= \emptyset$]

- **complex reference objects** (CROs) (Eschenbach et al. 1989): group structures that also make available their members, **pointer objects**.
  - a. A couple was walking by.
  - b. He was wearing glasses, she was wearing a hat.
- pointer objects are introduced for numbers smaller than 3:

$$\begin{bmatrix} \text{phon} & : & \text{/two pointed towers/} \\ \text{q-params} & : & \begin{bmatrix} \text{refset} : \mathit{Set}(\mathit{Ind}) \\ \text{c1} : \overrightarrow{\text{tower}}(\text{refset}) \\ \text{x1} : \mathit{Ind} \\ \text{x2} : \mathit{Ind} \\ \text{i1} : \text{member}(\text{refset},\text{x1}) \\ \text{i2} : \text{member}(\text{refset},\text{x2}) \end{bmatrix} \\ \text{cont} & = & \begin{bmatrix} \text{q-cond} : |\text{q-params.refset} = 2| \end{bmatrix} \; \mathit{Rectype} \end{bmatrix}$$

FÜNF (V2, 6:36)

A: ‘Also dann waren es eigentlich fünf Sachen’—B: ‘Fünf müssen’s sein, ja’
A: Well, then there actually were five things—B Five it has to be, yes

While uttering ‘five’, the speaker shows a five-finger hand, **symbolizing** the cardinal expression.

'wenn du halt diese sechs Fenster hast—eins, zwei, drei, vier, fünf, sechs'
well when you have these six windows—one, two, three, four, five, six

Counting

‘eine Eiswaffel, drei Kugeln’
a cornet, three scoops

The speaker talks about an ice cream stand which is advertised by an oversized artificial cornet filled with three scoops. Each hand makes a single ‘grabbing’ movement, indicating part of the spherical body of two of these scoops.

‘eine Eiswaffel, drei Kugeln’
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→ no CROs are constructed by means of symbolizing, counting or ‘distributing’

- Why a **‘one-two-many’** number system for pointer objects?
- It is remarkable that paying attention to the many aspects of multimodal, face-to-face interaction often has **repercussions to standard semantic theory**.
- Do we need different semantics for **written and spoken** language?

The end

Appendix: Plural types

$\overrightarrow{\text{Plural Types}}$

- If T is type with arity $\langle Ind \rangle$, then $\overrightarrow{T}$ is the corresponding **plural type** with arity $\langle Set(Ind) \rangle$.
- **set type**: $Set(Ind)$, set judgements licensed in virtue of some group constituting property (e.g., perceptual grouping from Gestalt psychology)
- Accordingly, there are different ways of applying $\overrightarrow{T}$ to a witnessing record, namely in terms of teams and meetings.

meeting:
for a record r and a type T, $meeting(r, T) = \{a \underline{\in} r \mid a : T\}$, with $a \underline{\in} r$ iff a is the value of a path in r. Thus, the meeting of r and T is of type $Set(T)$ (i.e., $meeting(r, T) : Set(T)$). A meeting allows to 'extract' the objects of a given type from a record.

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Example

$$r = \begin{bmatrix} l_1 = \text{a} \\ l_2 = \text{b} \\ l_3 = \begin{bmatrix} l_4 = \text{c} \\ l_5 = \text{d} \end{bmatrix} \\ l_6 = \text{e} \end{bmatrix}$$

with a, b, c, d and e being of type Ind.

- $meeting(r, Ind)$ returns the set $\{a, b, c, d, e\}$, being of type $Set(Ind)$.
- $meeting(l_3, Ind) = \{c, d\} : Set(Ind)$.
- $meeting(r, Set(Ind)) = \{\{c, d\}\} : Set(Set(Ind))$

team:
if x is of type *Set*(*Ind*) but behaves like an individual with respect to some type T, then *team*(x) : *Ind*.

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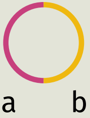
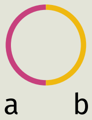
Example



$$r = \begin{bmatrix} x = a \\ y = b \end{bmatrix} : \begin{bmatrix} x : \mathit{Ind} \\ cx : \text{semicircle}(x) \\ y : \mathit{Ind} \\ cy : \text{semicircle}(y) \end{bmatrix}$$

team:
if x is of type $Set(Ind)$ but behaves like an individual with respect to some type T, then $team(\mathrm{x}) : Ind$.

Example

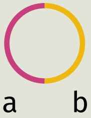


$$\mathrm{r} = \begin{bmatrix} \mathrm{x} = \mathrm{a} \\ \mathrm{y} = \mathrm{b} \end{bmatrix} : \begin{bmatrix} \mathrm{x} : Ind \\ \mathrm{cx} : \mathrm{semicircle(x)} \\ \mathrm{y} : Ind \\ \mathrm{cy} : \mathrm{semicircle(y)} \end{bmatrix}$$

- $meeting(r, Ind) = \{a, b\} : Set(Ind)$

team:
if x is of type *Set*(*Ind*) but behaves like an individual with respect to some type T, then *team*(x) : *Ind*.

Example

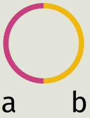


$$r = \begin{bmatrix} x = a \\ y = b \end{bmatrix} : \begin{bmatrix} x : \mathit{Ind} \\ cx : \mathrm{semicircle}(x) \\ y : \mathit{Ind} \\ cy : \mathrm{semicircle}(y) \end{bmatrix}$$

- $\mathit{meeting}(r, \mathit{Ind}) = \{a, b\} : \mathit{Set}(\mathit{Ind})$
- $\mathit{team}(\mathit{meeting}(r, \mathit{Ind})) : \mathit{Ind}$

team:
if x is of type $Set(Ind)$ but behaves like an individual with respect to some type T, then $team(\mathrm{x}) : Ind$.

Example



$$\mathrm{r} = \begin{bmatrix} \mathrm{x} = \mathrm{a} \\ \mathrm{y} = \mathrm{b} \end{bmatrix} : \begin{bmatrix} \mathrm{x} : Ind \\ \mathrm{cx} : \mathrm{semicircle(x)} \\ \mathrm{y} : Ind \\ \mathrm{cy} : \mathrm{semicircle(y)} \end{bmatrix}$$

- $meeting(r, Ind) = \{a, b\} : Set(Ind)$
- $team(meeting(r, Ind)) : Ind$
- $\begin{bmatrix} \mathrm{tc}{=}team(meeting(r, Ind)) : Ind \\ \mathrm{cc} : \mathrm{circle(tc)} \end{bmatrix}$

Gathering

- ‘Peter, Paul and Mary gather.’
- $$\left[\begin{array}{ll} \text{s} : & \left[\begin{array}{ll} \text{p} & : \textit{Ind} \\ \text{c1} & : \text{named(p, ‘Peter’)} \\ \text{a} & : \textit{Ind} \\ \text{c2} & : \text{named(a, ‘Paul’)} \\ \text{m} & : \textit{Ind} \\ \text{c3} & : \text{named(m, ‘Mary’)} \end{array}\right] \end{array}\right], \left[\begin{array}{ll} \text{s} & : \textbf{\textit{Set(Ind)}} \\ \text{c4} & : \text{gather(s)} \end{array}\right]$$

  (‘gather’ is a collective predicate)
- $$\left[\begin{array}{ll} \text{s} & : \left[\begin{array}{ll} \text{p} & : \textit{Ind} \\ \text{c1} & : \text{named(p, ‘Peter’)} \\ \text{a} & : \textit{Ind} \\ \text{c2} & : \text{named(a, ‘Paul’)} \\ \text{m} & : \textit{Ind} \\ \text{c3} & : \text{named(m, ‘Mary’)} \end{array}\right] \\ \text{c4} & : \textbf{gather(}\textbf{\textit{meeting}}\textbf{(s, }\textbf{\textit{Ind}}\textbf{))} \end{array}\right]$$

PIANO CARRYING I

Example

$$\begin{bmatrix} x : Set(Ind) \\ c : \overrightarrow{\text{carry-a-piano}}(x) \end{bmatrix}.$$

Witness set: *meeting*(ctxt, *Ind*) = {u, v, w} : *Set*(*Ind*)

- carry-a-piano(l_1), carry-a-piano(l_2) and carry-a-piano(l_3), that is, **fully distributive**; corresponding record:
$$\text{ctxt} = \begin{bmatrix} l_1 = \text{u} \\ l_2 = \text{v} \\ l_3 = \text{w} \end{bmatrix}.$$
- carry-a-piano(*team*(*meeting*(ctxt, *Ind*))) (u, v and w form a team), **outside collective**; corresponding record:
$$\text{ctxt} = \begin{bmatrix} l_1 = \text{u} \\ l_2 = \text{v} \\ l_3 = \text{w} \end{bmatrix}.$$

Piano carrying II

- carry-a-piano(l_1) and carry-a-piano(*team*(*meeting*(l_4, *Ind*))) (v and w form a team), **partition distributive** or **inside collective**; corresponding record:

$$\text{ctxt} = \begin{bmatrix} l_1 = \text{u} \\ l_4 = \begin{bmatrix} l_2 = \text{v} \\ l_3 = \text{w} \end{bmatrix} \end{bmatrix}$$

Polymorphism

- Inside collective focuses on sets, partition distributive focuses on individuals (this is part of what collective distinguishes from distributive).
- However, both allow for teams and hence may coincide.

$$\left.\begin{array}{r} \text{outside collective} \\ \text{inside collective} \approx \text{partition distributive} \end{array}\right\} : \overset{\text{coll}}{\overrightarrow{T}}$$

$$\left.\begin{array}{r} \text{inside collective} \approx \text{partition distributive} \\ \text{fully distributive} \end{array}\right\} : \overset{\text{dist}}{\overrightarrow{T}}$$

- This overlap may offer an explanation for different taxonomies for collectivitiy/distributivity proposed in the literature.

Appendix:
what about scope?

Clarification pattern

(9) a. Every dog chased a cat.
b. Every student speaks two languages

Referential clarification pattern:

(10) a. **Which** cat/languages?
b. The **same** cat/languages or **different** cats/languages?
c. **Which** dog chased the white cat?/**Which** student speaks Hindhi?

Clarification pattern

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c. **Which** dog chased the white cat?/**Which** student speaks Hindhi?

- ➔ functional *Wh*-question and same/different distinction
- ➔ clarified: **assignments** of dogs to cats/students to languages

Functional interpretations

The semantic type of *two languages*:

(11) $$\begin{bmatrix} \text{q-params} : \begin{bmatrix} \text{refset} : \textit{Set}(\textit{Ind}) \\ \text{c} : \overrightarrow{\text{language}}(\text{refset}) \end{bmatrix} \\ \text{q-cond} : |\text{refset}| = 2 \end{bmatrix}$$

is re-interpreted as a **dependent function type**:

(12) $$\text{f} : \begin{bmatrix} \text{x} : \textit{Ind} \end{bmatrix} \mapsto \begin{bmatrix} \text{q-params} : \begin{bmatrix} \text{refset} : \textit{Set}(\textit{Ind}) \\ \text{c} : \overrightarrow{\text{language}}(\text{refset}) \end{bmatrix} \\ \text{q-cond} : |\text{refset}| = 2 \end{bmatrix}$$

The function from (12) depends on some individual x.

Every student speaks two languages

$$
\left[\begin{array}{lll}
\text{phon} & : & \textit{List}(\text{every student speaks two languages}) \\
\text{q-params} & : & \left[\begin{array}{lll}
\text{refset\_s} & : & \textit{Set}(\textit{Ind}) \\
\text{c\_s} & : & \overset{\text{dist}}{\overrightarrow{\text{student}}}(\text{refset\_s}) \\
\text{f} & : & \left[\text{x} : \textit{Ind}\right] \mapsto \left[\begin{array}{lll}
\text{q-params} & : & \left[\begin{array}{lll}
\text{refset} & : & \textit{Set}(\textit{Ind}) \\
\text{c} & : & \overrightarrow{\text{language}}(\text{refset})
\end{array}\right] \\
\text{q-cond} & : & |\text{refset}| = 2
\end{array}\right]
\end{array}\right] \\
\text{cont} & = & \left[\begin{array}{ll}
\text{sit} = \text{s1} : \textit{Rec} & \\
\text{sit-type} = & \left[\begin{array}{lll}
\text{q-cond\_s} & : & |\text{refset\_s}| = |\text{maxset\_s}| \\
\text{nucl} & : & \overset{\text{dist}}{\overrightarrow{\text{speak}}}{}^{1,2}(\text{refset\_s}, \text{f}(\text{refset\_s}).\text{q-params.refset}) \\
\text{anti-nucl} & : & \neg\overset{\text{dist}}{\overrightarrow{\text{speak}}}{}^{1,2}(\text{compset\_s}, \text{f}(\text{compset\_s}).\text{q-params.refset})
\end{array}\right] : \textit{RecType}
\end{array}\right] : \textit{Prop}
\end{array}\right]
$$

Example

The described situation involves a witness set of three students:

(13)
$$\text{ctxt} = \begin{bmatrix} \text{x1} = \text{Tick} \\ \text{x2} = \text{Trick} \\ \text{x3} = \text{Track} \end{bmatrix} : \textit{Rec}$$

Applying the dependent function to ctxt results in the following pair-list reading:

(14)
$$\left[\text{nucl} = \left\{\begin{matrix} \text{speak(ctxt.x1, 2L.q-params.refset),} \\ \text{speak(ctxt.x2, 2L.q-params.refset),} \\ \text{speak(ctxt.x3, 2L.q-params.refset)} \end{matrix}\right\} : \overrightarrow{\text{speak}}^{\text{dist}\,1,2}\text{(refset\_s, f(refset\_s).q-params.refset)}\right]$$

Each student ctxt.x1, ctxt.x2, ctxt.x3 is related to the refset of type '2L' which abbreviates the type of two-languages:

(15)
$$\begin{bmatrix} \text{q-params} : \begin{bmatrix} \text{refset} : \textit{Set}(\textit{Ind}) \\ \text{c} : \overrightarrow{\text{language}}(\text{refset}) \end{bmatrix} \\ \text{q-cond} : |\text{refset}| = 2 \end{bmatrix}$$

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