Reciprocals in Space

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Overview

A theory of reciprocity

Dalrymple et. al. (1997):

- Systematic investigation of the factors underlying the shifts in the truth conditions of reciprocals
- On the basis of the context, a set of candidate meanings is generated
- The meaning of the reciprocal statement is the strongest of these candidate meanings

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An inventory of meanings

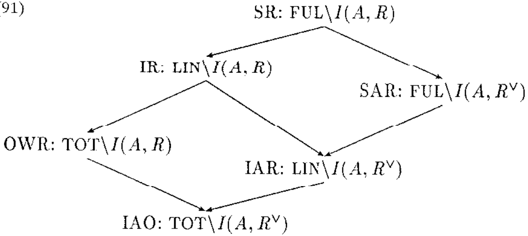
- NP R each other

Given a reciprocal statement containing a relation R, scoping over a domain A:

1. How does R cover A?
   - Each pair in A participates in R directly (FUL)
   - Each pair in A participates in R directly or indirectly (LIN)
   - Each single individual in A participates in R with another individual in A (TOT)
2. Concerning R
   - direction matters (R)
   - direction does not matter ($R^{\vee}$)

Overview of reciprocal meanings

(91)



- Together with SMH this gives the preferred interpretation.

Some examples (that work)

1. House of Common legislators refer to each other indirectly
   - SR is the strongest interpretation; it does not contradict our world knowledge about the relation
2. Five Boston pitchers sat alongside each other
   - the relation ‘sit alongside’ is symmetric
   - therefore, three possible interpretations remain: SR, IR, and IAO
   - people have only two sides, so SR cannot hold
   - IR is the strongest interpretation remaining

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   - people have only two sides, so SR cannot hold
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The problem

1. Those three boxes are stacked on top of each other.
2. # Those three boys are taller than each other.

The problem in Dalrymple et. al.

- Prediction: a reciprocal statement means IAO if all stronger candidates are unsatisfiable
- IAO: $\mathrm{TOT} \backslash \mathrm{I}(\mathrm{A}, \mathrm{R}^{\vee})$
- Each single individual in *A* participates in *R* with another individual in *A* (TOT) (direction does not matter)
- This is a correct prediction for (1)
- But it is incorrect for (2)

Some more examples

- # The two sets outnumber each other
- # My mother and I procreated each other

- # These three people inherited the shop from each other.
- The members of this family have inherited the shop from each other for generations.

- # John and Bill gave each other measles.
- The third-graders gave each other measles.

- The three boxes are stacked on top of each other.
- The two students followed each other into the elevator.
- The two birds are flying above each other.

Generalization:
Only statements containing spatial, temporal and spatiotemporal relations allow for an IAO reading. (Beck (2001))

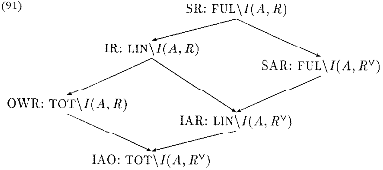
Plan

1. Those three boxes are stacked on top of each other.
2. # Those three boys are taller than each other.

- sketch a method to discern cases like (1) from cases like (2)

Looking at the interpretations again

(91)



Of these interpretations...

- IAO and IAR allow for sentences that are in fact infelicitous
- so, IAO and IAR are too weak
- SAR just arises from the parameterization, and is not to be found in natural language
- so, there is no reason to maintain it

A new schema of interpretations

- We drop IAO, IAR and SAR

$$\mathrm{FUL}\backslash I(A,R)$$
$$\downarrow$$
$$\mathrm{LIN}\backslash I(A,R)$$
$$\downarrow$$
$$\mathrm{TOT}\backslash I(A,R)$$

- i.e. We drop all $R^{\vee}$-interpretations

Spatial reciprocals

- The new setup correctly rules out sentences like ‘the boys are taller than each other’
- However, it wrongly predicts sentences like ‘the three birds are above each other’ to be infelicitous

Vector Space Semantics (Zwarts and Winter (2000))

- object locations - points in the space = vector end-points
- spatial PP - set of located vectors
- $V_w = \{<w,v>: v \in V\}$
- end-point of w is the center of the vector space V_w

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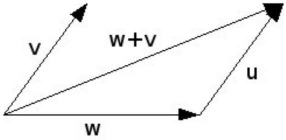
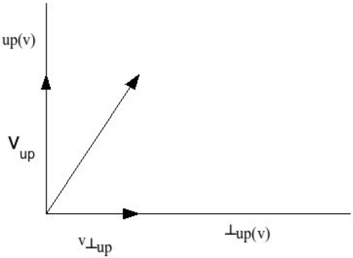


near in Vector Space Semantics

- John is near the box.
- ⟦loc(the box)⟧ - the location of 'the box' in space
- ⟦near⟧ = λA.λv. external(v,A) $\wedge$|v|<r
- ⟦near the box⟧ = λv. external(v, loc(the box)) $\wedge$|v|<r
- ⟦John is near the box⟧ =
  $\forall$p$\in$john $\exists$v [e-point(v)=p $\wedge$ external(v, loc(the box)) $\wedge$|v|<r]

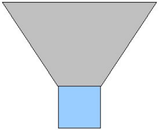
above in Vector Space Semantics

- up(v), $\perp$up(v)
- v = v_{up}+$v_{\perp up}$



A solution

- John is above the box
- $[\![\text{above}]\!] = \lambda A.\lambda v.\text{ext}(v,A) \wedge |v_{up}| > |v_{\perp up}|$



- $[\![\text{John is above the box}]\!] = \forall p \in \text{john}\ \exists v\ [\text{e-point}(v)=p \wedge \text{external}(v,\text{the box}) \wedge |v_{up}| > |v_{\perp up}|]$

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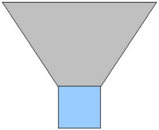

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A solution

- The three birds are above each other.

$$\mathrm{FUL}\backslash I(A,R)$$
$$\downarrow$$
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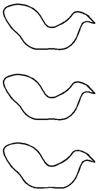
$$\downarrow$$
$$\mathrm{TOT}\backslash I(A,R)$$



- $\mathrm{TOT}\backslash\mathrm{I(A,R)} \Leftrightarrow \mathrm{dom}(\mathrm{R}\cap(\mathrm{A}\times\mathrm{A}))=\mathrm{A}$
- dom({<x,y>: $\forall p \in x \exists v$ [e-point(v)=p $\wedge$ external(v,y) $\wedge$ $v_{up} > v_{\perp up}$]}$\cap$(the three birds$\times$the three birds))=the three birds
- predicted to be false - wrong

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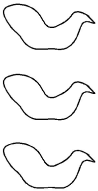

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- $\mathrm{dom}(\{\langle x,y\rangle: \forall p \in x \exists v\ [\text{e-point}(v)=p \wedge \text{external}(v,y) \wedge v_{up} > v_{\perp up}]\}\cap(\text{the three birds}\times\text{the three birds}))=\text{the three birds}$
- predicted to be false - wrong

- . . . but it will be true if we evaluate sentences with reciprocals in a spherical space

A solution

- we assume that nouns and verbs have a situation variable
- $TOT(A,R,s) \Leftrightarrow dom(R \cap (A \times A \times s)) = A$ in s

A solution

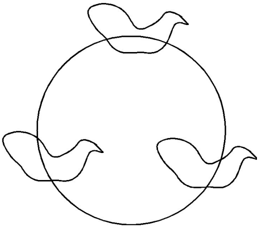
- situations(s) can be projected on a spherical space
- up(s) corresponds to θ (the zenith)
- $\perp$up(s) corresponds to φ (the azimuth)
- the lowest leftmost point in the situation has coordinates (θ, φ)=0, 0
- the highest rightmost point in the situation has coordinates (θ, φ)=2π,2π

above in a spherical space

- $[\![\text{above}]\!] = \lambda A.\lambda v.\text{external}(v,A) \wedge v_{up} > v_{\perp up}$
- situation in a spherical space
- up=θ
- $\perp$up=φ
- $v_{up}=\theta$ between the s-point of v_{up} and end-point of v_{up}
- $v_{\perp up}=\varphi$ between the s-point of $v_{\perp up}$ and end-point of $v_{\perp up}$

above in a spherical space

- The three birds are above each other.



- ∃s dom({<x,y,s>: ∀p∈x∃v [e-point(v)=p ∧ external(v,y) ∧ $v_{up} > v_{\perp up}$] in s}∩(the three birds×the three birds×s)) = the three birds in s

A solution

- # John and Bill gave each other measles.
- ∃s dom({<x,y,s>: x infected y with measles in s]}∩(j+b×j+b×s)) = j+b in s
- ‘giving measles’ does not change in a spherical space!
- sentence correctly predicted as false

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A solution

- # John and Bill are taller than each other.
- $\exists$s dom({<x,y,s>: x's height is bigger than y's height in s]}$\cap$(j+b$\times$j+b$\times$s)) = j+b in s
- I stay smaller than Marieke even if the situation in which we are is mapped on a spherical space!
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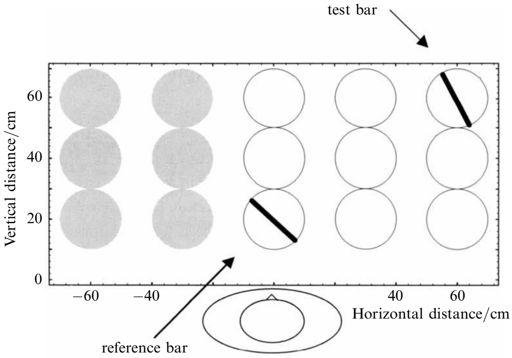
Bend it until it breaks?

- In the model just proposed, reciprocal statements are evaluated in a geometry that is not in accordance with our intuitions
- research in physics and psychology shows that describing the perception of space in purely Euclidean terms is not that straightforward either

The structure of space - as we perceive it

Research in human perception: hypotheses about the geometry of visual and haptic space



Visual and haptic space

The fact that there are stimuli that are perceived differently from their physical existence gives rise to considering visual space as non-Euclidean space. (Buffart and Leeuwenberg, 1978)

Haptic space like visual space is not Euclidean (Kappers and Koenderink, 1996)