Quantifiers from Space

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Overview

1. Jasper is allowed to invite **up to 10** friends to his party
2. I finished the half marathon in **under 3** hours
3. We are expecting **around 500** guests

- Cue from Cognitive Linguistics:

  "Most of our fundamental concepts are organized in terms of one or more spatialization metaphors" *Lakoff & Johnson 1980, p.17*

- Denotational semantics can make sense of spatial metaphor in quantification

Plan

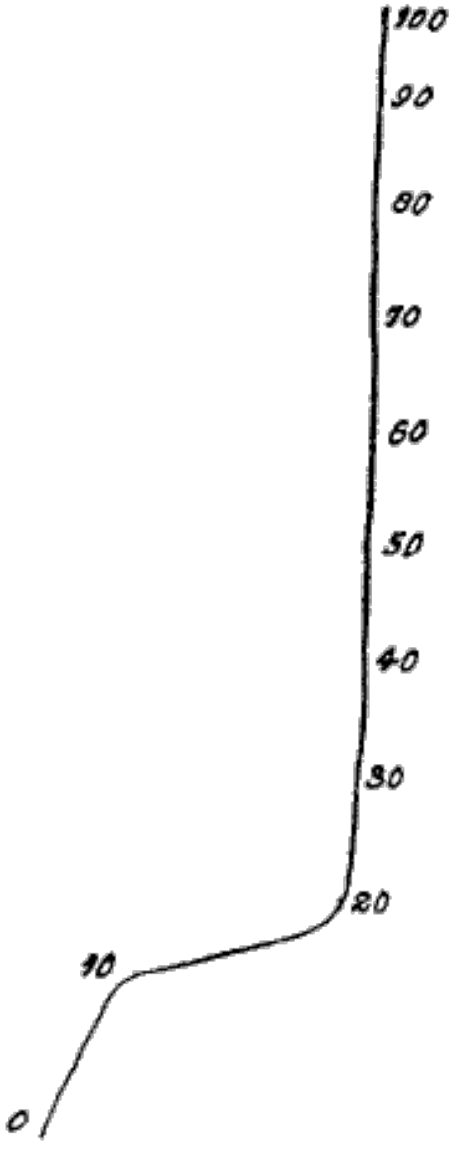
The Bigger Picture —	Numbers and Space
Zooming in —	Spatial Prepositions and Numerals
Zooming in —	Boundaries on Quantities
Zooming in —	Quantities and Paths
The Bigger Picture —	Conclusion

Numbers and Space

Various clues that Space is cognitively related with Quantity

- Conceptualisation/Perception of numbers
- Spatial interference with reasoning about numbers
- Conceptual metaphors for quantities

Number forms



From: Francis Galton 1880,

Visualised Numbers,

Nature **21** Number forms: The common tendency to visualise numbers in a particular visuo-spatial configuration

'*this peculiarity consist in the sudden and automatic appearance of a vivid and invariable "Form" in the mental field of view, whenever a numeral is thought of, and in which each numeral has its own definite place.*' (Galton 1881, p.88)

The number form of 'T.M.'

"The representation I carry in my mind of the numerical series is quite distinct to me, so much so that I cannot think of any number but I at once see it (as it were) in its peculiar place in the diagram." (T.M.)

The SNARC

- Spatial-Numerical Association of Response Codes
  (Deheane et al. 1993)
- Task: decide whether a given number (0-9) is odd or even
- Response rule 1: left button $\rightarrow$ odd, right button $\rightarrow$ even
- Response rule 2: left button $\rightarrow$ even, right button $\rightarrow$ odd
- 3 quicker responses with rule 1
- 7 quicker responses with rule 2

Spatial Metaphor

- Lakoff & Johnson 1980: MORE IS UP; LESS IS DOWN
- the metaphor of quantity as a pile of stuff
  - my income *rose*
  - the number of errors he made is *low*
  - he is *under*age
  - turn the heat *down*

Modified Numerals

- Many modified numerals have the syntactic make-up of a spatial preposition
  - over 60 guests
  - under 20 acres
  - between 10 and 30 students
  - up to 5 years in prison

Modified Numerals

- Modified numerals are syntactically and semantically diverse

  cf. Krifka 1999, Hackl 2000, Corver & Zwarts 2005, Takahashi 2006, Geurts & Nouwen 2007, Solt 2007, Nouwen 2008

comparative: less than 30

superlative: at most 30

coordination: 30 or fewer

prepositional: under 30

other: almost 30, only 30, minimally 30, 30 tops

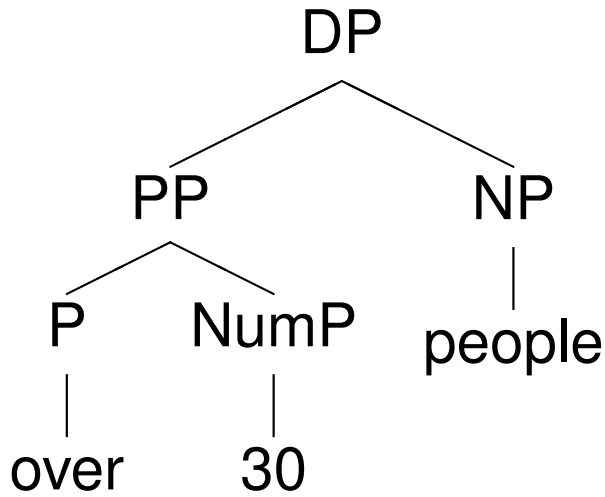
Prepositional Numerals

Corver & Zwarts 2005

- Prepositional Numerals are cross-linguistically common
- Prepositional Numerals vary cross-linguistically w.r.t. the prepositions used
- Exclusively vertically oriented prepositions
- Exclusively locative prepositions

Prepositional Numerals are PPs

Corver & Zwarts 2005



- Intimite link between Spatial P and the Number word
- The Spatial relation involves the number, not the NP/DP

- between 10 and 30 acres
- *10 and 30 acres

Interim Summary

- The story so far:

  Cognitive Psychology: number processing involves spatial processing

  Cognitive Linguistics: quantity expression involves spatial metaphor

  Formal Linguistics: modified numerals sometimes behave as true spatial PPs
- Limited Conclusion: both the expression of spatial relations and of quantity relations involve **linear order**
- Are the spatial aspects of quantifiers limited to linearity?

The Landscape of Modified Numerals

Jasper found MOD 30 *marbles.*

$\sim$ the number of marbles found by Jasper Δ 30

MOD	Δ
more than, at least, minimally, over	$>$ and $\geq$
less than, at most, maximally, up to, under	$<$ and $\leq$
$\emptyset$, exactly	$=$
around, almost, nearly	approximate
from . . . to, between . . . and	non-monotone

Boundaries

- Naive intuition: there are only three kinds of bounds
  - upper bounds
  - lower bounds
  - double bounds
- Claim: this is wrong
- Boundaries are not necessarily absolute

Boundaries

- Leading example: *at most* versus *less than*
  Geurts & Nouwen 2007, Nouwen 2008
  1. A triangle has more than 2 sides — truism
  2. A triangle has at least 3 sides — false/weird
- Superlatives express modal attitudes toward scales
- Superlatives express boundaries relative to what the speaker considers possible
- Next: directional prepositions can not only express positions on a linear scale, but also **paths** that are being traversed

Directional Ps

- Corver & Zwarts 2005 suggest that directionality plays no role in prepositional numerals

1. The bird flew **over** the bridge	directional
2. The blanket is draped **over** the chair	locative
3. There were **over** 300 guests	locative only

Directional Numerals

- I claim there are directional numerals
  1. Jasper is allowed to invite **up to 10** friends to his party
  2. The talks vary in length **from 10 to 20** minutes
- Notice the following:
  3. ??Jasper invited **up to 10** friends to his party.
     (Seven, to be precise)
  4. ??The length of my talk is **from 10 to 20** minutes.
     (Eighteen, to be precise)
- Versus:
  5. Jasper invited **under 10** friends to his party.
     (7 to be precise)
  6. The length of my talk is **between 10 and 20** minutes.
     (18 to be precise)

The case of *up to*

- *Up to* is exclusively directional
  1. ??Jasper is standing up to here.
  2. Jasper ran up to the edge of the lake.
- In many languages the end-point directional preposition (*up to*) corresponds to the end-point durative adverb (*until*)

Dutch	tot
German	bis (zu)
Hebrew	’ad

- In other words: the same mechanism is responsible for spatial, temporal and quantity end-point marking

Directional semantics for *up to*

A up to X

There exists a path P leading ending in X such that every subpath of P is such that A

Jasper ran up to the edge of the lake

There exists a path leading to the edge of the lake such that Jasper ran all its subpaths

??Jasper is standing up to here

#There exists a path leading to here such that Jasper is standing all its subpaths

Directional Semantics for *up to*

[Dutch:] Jasper worked up to midnight

There exists a path leading to midnight such that Jasper worked (during) all its subpaths

[Dutch:] Jasper arrived up to midnight

#There exists a path leading to midnight such that Jasper arrived (during) all its subpaths

Up to and numerals

- Degree-based semantics for cardinalities
  (Hackl 2000, Takahashi 2006, Solt 2007, Geurts & Nouwen 2007)
- Degrees as intervals
  (Cresswell 1976, Kennedy 2001, Meier 2003)

??Jasper invited up to 10 friends

There exists a path P leading up to 10 such that every subpath P′ of P is such that Jasper invited P′ friends
#Jasper invited 10 friends **and** *he invited 9 friends* **and** *he invited 8 friends* **and** *. . .*

Up to and numerals

Jasper is allowed to invite up to 10 friends

Jasper is allowed to invite 10 friends **and** *he is allowed to invite 9 friends* **and** *he is allowed to invite 8 friends* **and***. . .*

??Jasper needs to invite up to 10 friends

#Jasper needs to invite 10 friends **and** *he needs to invite 9 friends* **and** *he needs to invite 8 friends* **and***. . .*

Saved version: the speaker considers it possible that Jasper needs to invite n friends, for values for n up to 10

Conclusions

- The spatial basis for quantity expression is well-established
- I've added to this:
  - The distinction between locative and directional prepositions is obvious in prepositional numeral quantifiers as well
  - Prepositional numerals are PPs

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