

On the underspecification of measurement

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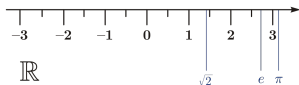


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- 1-to-1 correspondence:

$$\llbracket tall \rrbracket = \lambda d \lambda x. \mu_{HEIGHT} \succeq d$$

- lexical item \leftrightarrow dimension \leftrightarrow scale \leftrightarrow measure function
- Scales isomorphic to (segments of) real number line:



- Dense and totally ordered
- Variation in endpoint
 - Closed: $[0,1]$
 - Open: $(0,\infty)$
 - Lower closed: $[0,\infty)$
 - etc.

- Measurement in language is inherently underspecified.
- Scale structure is variable.
- Comparing seemingly unrelated cases gives clues to how this variation and underspecification is constrained.



- 1 Varieties of underspecification
- 2 A less idealized picture
- 3 Constraining Underspecification
 - Dimension
 - Mappings
 - Scale structure
 - A final case study
- 4 Concluding remarks

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#1: Underspecification of dimension

- (1) The trip to Tübingen is **longer** than the trip to Konstanz.
 - Distance
 - Duration

- (2) London is **larger** than New York.
 - Area 😊
 - Population 😞



#1: Underspecification of dimension

(3) How **much** ...

... rice did you buy?	weight
... rice does the recipe call for?	volume
... beer did you drink?	volume
... land do they own?	area
... money did you spend?	monetary value
... did you sleep?	duration
... do you go to the movies?	frequency
... do you like beer?	intensity
... taller is Mabel?	scalar extent
... etc.	



#2: Underspecification of scale boundedness

- (4) The glasses are completely / ?very **dry**. upper closed
 This region of the country is ?completely / very **dry**. upper open
- (5) The gas tank is completely / ?very **full**. upper closed
 The train is completely / very **full**. distinct readings
- (6) The soup **cooled** in 20 minutes. telic
 The soup **cooled** for 20 minutes atelic

(Kennedy and McNally, 2005; Kennedy and Levin, 2008)



#3: Cardinal / proportional ambiguities

- (7) **Few** cooks applied.
- small # of cooks applied cardinal
 - small % of cooks applied proportional
 - small % of applicants were cooks reverse proportional
- (8) **More** residents of Ithaca than New York City know their neighbors.
- # of residents 😞
 - % of residents 😊
- (9) My manuscript has **more** typos than yours does.
- total # of typos
 - # typos / page

(Partee, 1989; Herburger, 1997; Solt, 2018b; Bale and Schwarz, 2020)



#4: Underspecification of orderings



- (10) A: The Picasso is more **beautiful** than the Miró.
 B: No, the Miró is more **beautiful** !
- (11) A: Your shirt is **dirtier** than my shirt.
 B: No, yours is **dirtier**!
- (12) The chocolate cake is **heavier** than the carrot cake.

(Kennedy, 2013; McNally and Stojanovic, 2017; Solt, 2018a)



#5: Underspecification of scale structure

- (13) a. **Most** Americans have broadband internet access.
b. **More than half** of Americans have broadband internet access.
- (14) a. **Most** pastel hues have a calming effect.
b. ??**More than half** of pastel hues have a calming effect.
 - *More than half* requires possibility of precise counting.
 - *Most* does not.

▷ 'Cardinality' can be tracked by scales that differ in their structure.

(Solt, 2016)



#5: Underspecification of scale structure

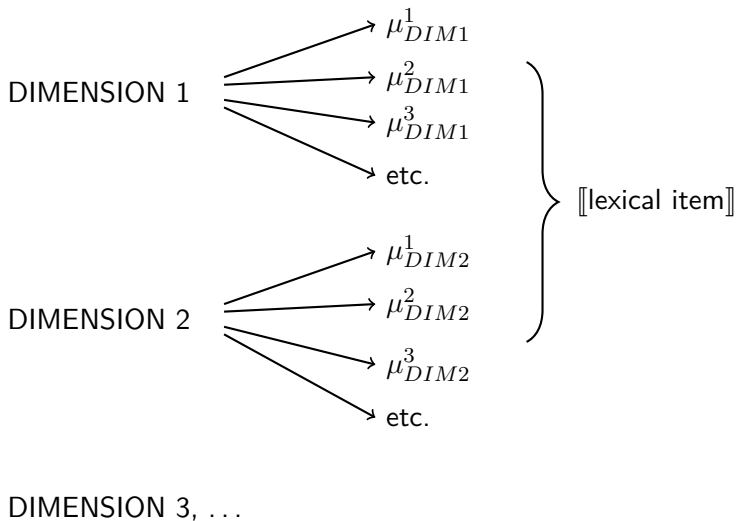
- (16) I think **??25%** / **#a quarter** / **.25** / **#1 in 4** is a small number.
- (17) Let's disperse **25%** / **a quarter** / **#.25** / **1 in 4** of the donations.
- (18) Her odds of winning are **25%** / **#a quarter** / **#.25** / **1 in 4**.
- (19) The probability of winning is **25%** / **#a quarter** / **.25** / **1 in 4**.
- ▷ Even *odds* and *proportions* seem to reference distinct scales!

(Gobeski and Morzycki, 2021)

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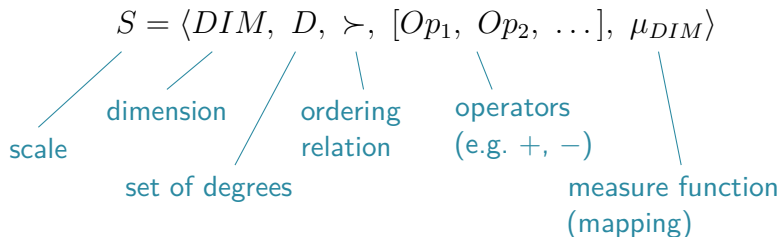


A less idealized picture





Loci of underspecification



Dimension (DIM): *large, much*

Scale structure (D, \succ, Op): *dry, most/more than half, odds/proportions*

Mapping (μ_{DIM}): *more beautiful, many/few*

Questions



What constrains ...

... the full range of dimensions, scale structures and mappings that a lexical item α can associate with?

... which dimension, scale structure and mapping is invoked by a particular occurrence of α ?

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Dimension: conceptual factors

- (20) The suitcase was heavy.
The cake was heavy.
The music was heavy.

- Metaphorical extension: concrete → abstract
(Lakoff and Johnson, 1980)

- (21) The rope is long. spatial
The meeting was long. temporal

- Conceptualization of time in spatial terms (Haspelmath, 1997)

- ▶ Same dimension conceptually (e.g. (21): DIM = EXTENT)?



Dimension: conceptual factors

(22) How **much** ...

... rice did you buy?	weight
... beer did you drink?	volume
... land do they own?	area
... money did you spend?	monetary value
... did you sleep?	duration
... do you go to the movies?	frequency
... do you like football?	intensity
... taller is Mabel?	scalar extent

- ▶ All conceptually specific cases of DIM = AMOUNT?
 - Monotonic (Schwarzschild, 2006)



Dimension: lexical factors

	English	English	German	Italian
Count	many people	a lot	viel	molto
Mass	much wine	a lot	viel	molto
Duration	(not) sleep much	a lot	viel	molto
Frequency	(not) go out much	a lot	viel	molto
Intensity	(not) like football much	a lot	sehr	molto
Adjectival	very tall	very	sehr	molto

(Doetjes, 2008)



Dimension: lexical factors

(23) How much / long / #often did you sleep? duration

(24) How much / #long / often do you go to the movies? frequency

- ▶ **Dimension constrained via interplay of conceptual and lexical factors.**

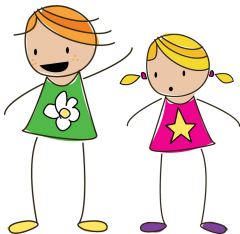
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Mappings: (extra)linguistic factors

- (24) A: Anna is **taller** than Berta.
B: No, Berta is **taller**!

factual



- ▷ Heights can be measured in inches, cm, hands, etc. – but whichever function μ_{HEIGHT} we choose, the relative ordering of two individuals does not change.



Mappings: (extra)linguistic factors

- (25) A: The Picasso is more **beautiful** than the Miró.
 B: No, the Miró is more **beautiful**!

faultless



- (26) A: The soup is **tastier** than the chili.
 B: No, the chili is much **tastier**!

faultless

- ▷ Speakers may use distinct functions μ_{BEAUTY} and μ_{TASTE} , on which order of relevant individuals is reversed.



Mappings: (extra)linguistic factors

- (27) A: Shirt 1 is **dirtier** than shirt 2.
B: No, shirt 2 is **dirtier**!

potentially faultless



- (28) A: Friedelstr. is **bumpier** than Oranienstr.
B: No, Oranienstr. is **bumpier**!

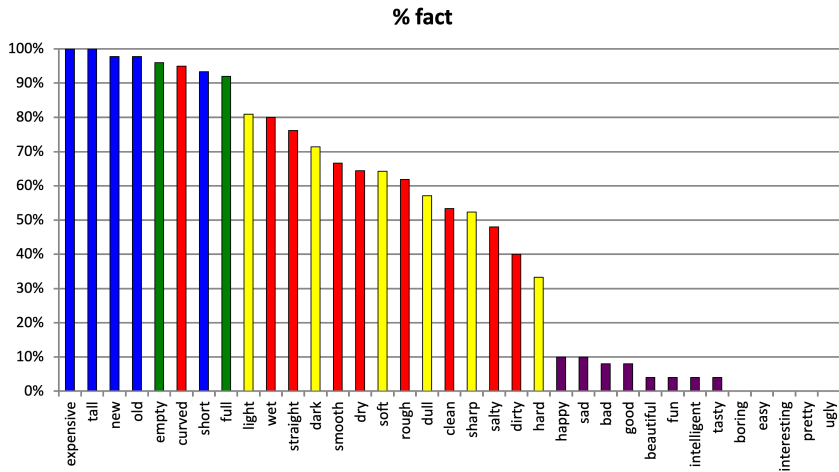
potentially faultless



▶ Again, available measures may reverse relative orders.



Ordering subjectivity experimentally



(Solt, 2018a)

Coordination by stipulation (Kennedy and Willer, 2016)



Interpretation of certain lexical items – but not others – can be fixed by stipulative discourse moves.

- (29) For the purposes of this discussion ...
- a. ... let's count Lee as **vegetarian**, since the only animals he eats are oysters.
 - b. ... let's count these oysters as **expensive**, because they cost \$36 per dozen.
 - c. ?? ... let's count Lee as **fascinating**, since he is an expert on oysters.
 - d. ?? ... let's count these oysters as **tasty**, because of their texture and brine.



Coordination by stipulation

- (30) For the purposes of this discussion ...
- a. ... let's count shirt 1 as **dirtier** than shirt 2, since the spectrophotometer measures it to have more dirt on it.
 - b. ... let's count Friedelstr. as **bumpier** than Oranienstr., because it has more bumps over 15 cm.
 - c. ?? ... let's count the Picasso as more **beautiful** than the Miró, because of its use of color.
 - d. ?? ... let's count the soup as **tastier** than the chili, because of its use of cumin.
- ▷ **Underspecification of measurement of the 'dirty' class a matter of language; that of the 'beautiful'/'tasty' class a matter of extra-linguistic judgements.**



Template for adjective meaning

The lexical meaning of adjectives encodes (at most) a dimension, not a particular measure function or scale:

$$\llbracket \text{Adj} \rrbracket^c = \lambda d \lambda x. \mu_{DIM}^c(x) \succeq d$$



Constraining mappings

dirty: μ lexically constrained:

$$(31) \quad \llbracket \text{dirty} \rrbracket^c = \lambda d \lambda x. \mu_{DIRTINESS}^c(x) \succeq d,$$

$$\text{where } \mu_{DIRTINESS}^c(x) = \frac{\sum_{i=1}^n k_i^c \cdot \mu_{AMOUNT}^c(\text{dirt}_i^c(x))}{\mu_{SIZE}^c(x)}$$

beautiful: μ dependent on a judge:

$$(32) \quad \llbracket \text{beautiful} \rrbracket^{c;j} = \lambda d \lambda x. \mu_{BEAUTY}^{c;j}(x) \succeq d$$

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Scale structure: *Most / more than half*

- (33) a. **Most** Americans have broadband internet access.
b. **More than half** of Americans have broadband internet access.
- (34) a. **Most** pastel hues have a calming effect.
b. ??**More than half** of pastel hues have a calming effect.
- (35) a. Restrictions have been relaxed in **most** counties.
b. Restrictions have been relaxed in **more than half** of counties.
- (36) a. Rain is forecast in **most** parts of the country.
b. ??Rain is forecast in **more than half** of parts of the country.



Scale structure: *Most / more than half*

- (37) a. **Most** electricity is produced in power plants.
b. **More than half** electricity is produced in power plants.
- (38) a. **Most** sadness diminishes with the passage of time.
b. ??**More than half** of sadness diminishes with the passage of time.



Scales of cardinality and amount

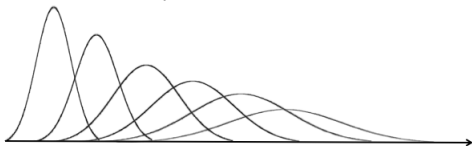
- Ratio



- Ordinal

$A < B < C < D$

- Semi-ordered (cf. ANS; Dehaene et al. 1998)





Lexical semantics

Most As are B:

$$\mu_{DIM}(A \cap B) \succ \mu_{DIM}(A - B)$$

- Ratio ✓
- Ordinal ✓
- Semi-ordered ✓

More than half of As are B:

$$\mu_{DIM}(A \cap B) \succ \mu_{DIM}(A)/2$$

- Ratio ✓
- Ordinal ✗
- Semi-ordered ✗



Effect of scale structure

***most* ✓ / *more than half* ✓**

Americans, states
electricity

exact counting possible
numerical measurement possible

***most* ✓ / *more than half* ✗**

parts of the state
sadness

lack of stable atoms
→ exact counting not possible
numerical measurement not possible

- ▶ **Measurement lexicalized by quantificational expressions may be underspecified wrt. scale structure – but this is constrained by:**
 - **lexical semantics ...**
 - **... in conjunction with properties of measured entities.**

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Ambiguities with *many* / *few*

(39) **Few** cooks applied.

- small # of cooks applied
- small % of cooks applied
- small % of applicants were cooks

cardinal
proportional
reverse proportional

Possible explanations:

- Lexical ambiguity (Partee, 1989; Romero, 2021)
- Variability in standard setting (Solt, 2009; Penka, 2018)
- Syntactic factors (Herburger, 1997)



Proportional readings of *more* (*many+-er*)

Forward:

- (40) More residents of Ithaca than New York know their neighbors.
- Compares % of residents.

Reverse:

- (41) More cooks applied to my program than to your program.
- Compares % of applicants.

Contextual:

- (42) Your manuscript has more typos than my manuscript.
- Compares typos / page.



Underspecified measure functions

many / much: $\mu_{DIM}(\alpha)$

(43) More residents of Ithaca than New York know their neighbors.

- $\mu_{DIM} = |x| / \sqcup ||\llbracket NP \rrbracket||$

(44) More cooks applied to my program than to your program.

- $\mu_{DIM} = |x| / \sqcup ||\llbracket VP \rrbracket||$

(45) Your manuscript has more typos than my manuscript.

- $\mu_{DIM} = |x| / LENGTH$

(Solt, 2018b; Bale and Schwarz, 2020)



Constraining underspecification – lexical factors

Proposed constraints on μ_{DIM} :

- Monotonicity (Schwarzschild, 2006)
- Permutation invariance (Wellwood, 2018)

- (46)
- $|x|$ ✓
 - $|x| / \sqcup |[[NP]]|$ ✓
 - $|x| / \sqcup |[[VP]]|$ ✓
 - $|x| / \text{MEASURE OF RELEVANT UNIT}$ ✓
 - $3 * |x|$ ✗
 - $|x| * |[[NP]]|$ ✗
 - etc.

▷ ‘Rate-based’ measurement cognitively natural?

Constraining underspecification – grammatical factors



(47) **Few** of the cooks applied.

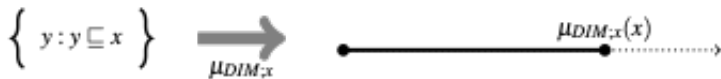
partitive

(48) **Few** cooks here speak Icelandic.

ILP

- Cardinal ✗
- Forward proportional ✓
- Reverse proportional ✗

Solt (2018b): Domain-restricted measure functions



- ▷ How to encode??
- ▷ Connection to *dry*, *full*?

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Concluding remarks

- Measurement in language is inherently underspecified.
- This underspecification is constrained by the interplay of:
 - conceptual factors
 - lexical factors
 - grammatical factors
 - properties of the entities measured
- Many questions remain open!

Thank you!

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