LINGUISTIC WAYS AND BENEFITS OF BEING VAGUE

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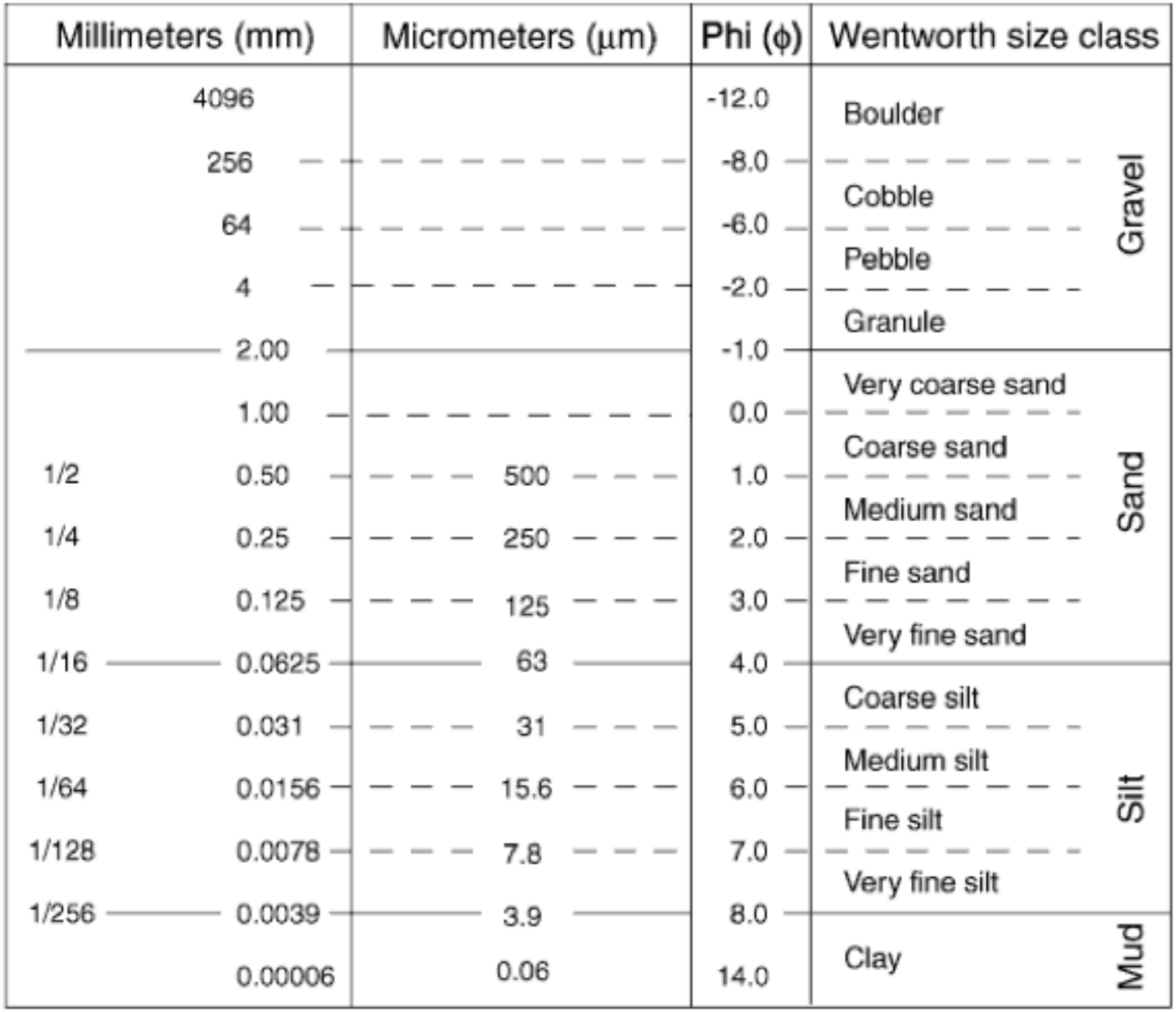
Z A S

Vagueness – the traditional view

- Predicates in natural language are typically vague; it can be undetermined whether they apply to x or not.
  - Verbs: *walk, run, sprint*
  - Adjectives: *red, orange, yellow*
  - Nouns: *silt, sand, gravel, pebbles*
- Vagueness creates problems:
  - Sorites problem (problem of the heap): Unclear categorical borders
  - Potential for misunderstandings

- Vagueness is bad and has to be fixed in regimented languages in analytic philosophy and in science.


Millimeters (mm)
Micrometers (μm)
Phi (ϕ)
Wentworth size class
4096
256
64
4
2.00
1.00
1/2
0.50
1/4
0.25
1/8
0.125
1/16
0.0625
1/32
0.031
1/64
0.0156
1/128
0.0078
1/256
0.0039
0.00006
500
250
125
63
31
15.6
7.8
3.9
0.06
-12.0
-8.0
-6.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
14.0
Boulder
Cobble
Pebble
Granule
Very coarse sand
Coarse sand
Medium sand
Fine sand
Very fine sand
Coarse silt
Medium silt
Fine silt
Very fine silt
Clay
Gravel
Sand
Silt
Mud

Our message:

- Vague terms have a precise core meaning
- Even precise terms have an approximate interpretation
- Vague and approximate interpretations
  can be investigated experimentally
- Vagueness is a good thing for communication
- Vagueness is difficult to eliminate
  from the application of law and medical diagnosis
- Some results of this:
  Collaborative project
  Vagueness, Approximation, Granularity
  (ZAS Berlin; U Amsterdam, Lund, Zagreb; 2008-2011)

VAGUE PREDICATES AND THEIR PRECISE CORE

Vague predicates – traditional view

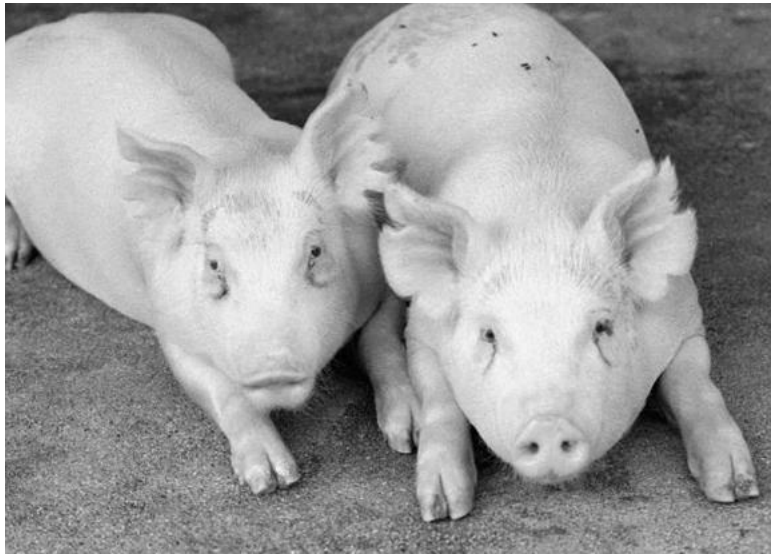
- Example: Pairs of gradable adjectives (antonyms),
  - e.g. *short* and *tall* (for persons)
- Related to a scale (of heights):

- Truth-value gap for persons that are neither *short* nor *tall*:

- Alternatively, they assign fuzzy truth values:

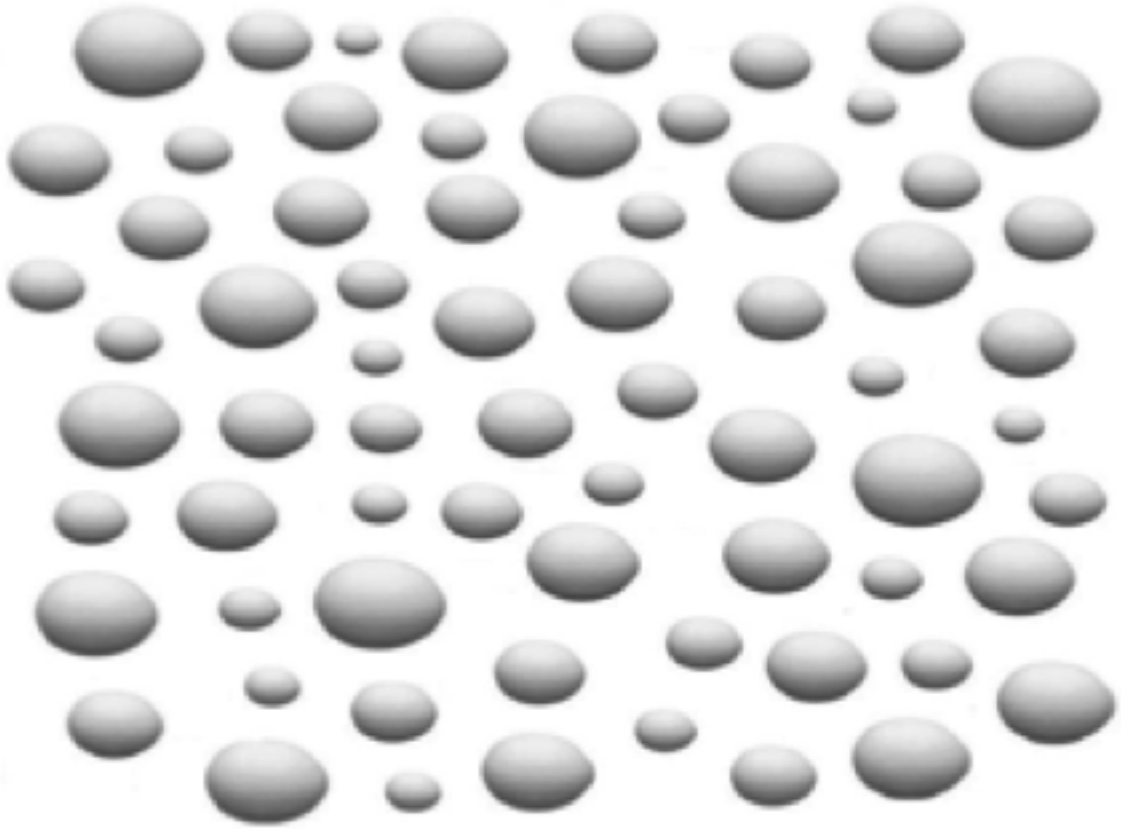
Vague predicates: precise core

- Vague predicates have a precise meaning, dependent on a parameter:
  - *tall*: size(x) ≥ Standard,
  - *short*: size(x) ≤ Standard
- The standard can be set in order to make maximal use of terms in communication.
- Cf. Kyburg & Morreau (2000):
  - Farmer: *Which pig do you want?*
  - Butcher: *I want the big one.*



Vague predicate: precise core

- Pragmatic rule:
  Fix the “standard” parameter in such a way as to make the predicate maximally useful in communication!
- In other situations this might be more difficult:



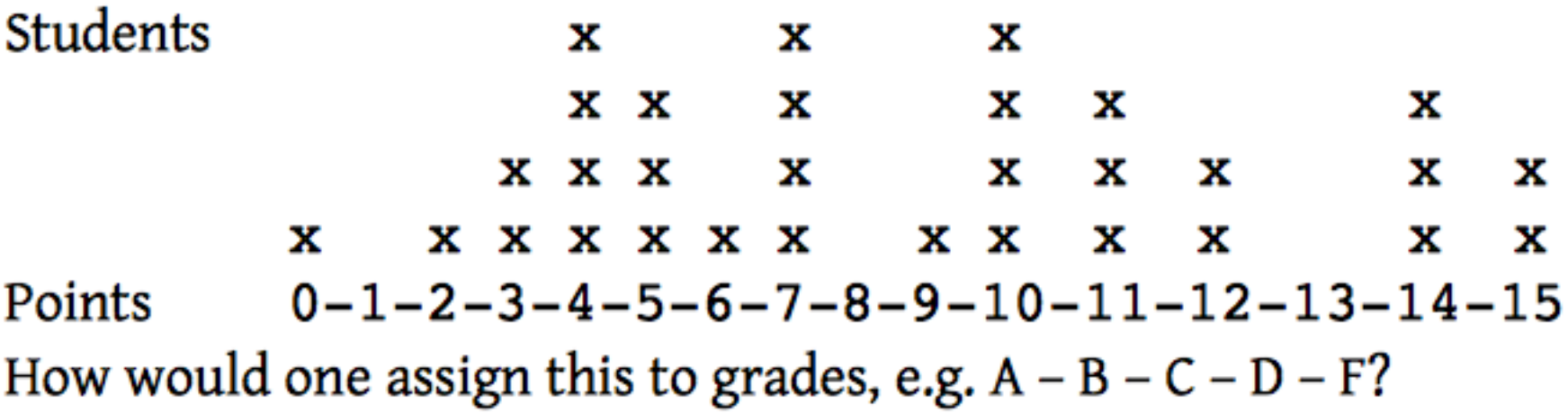
- *Collect the big eggs!*

Vague predicate: precise core

- Requirements for fixing the standard:
  - Standard should be greater than the average, or median, but
  - this might be difficult to detemine, so
  - estimate the average, or median, and increase the value for the standard, in order not to be misunderstood.
- This is sufficient for
  - *Give me a big egg!*
- But other things come into play in:
  - Customer: *I want to buy all your big eggs. How many do you have?*
  - Tax collector: *The king wants all your big eggs. How many do you have?*
- Underlying conception:
  - Lewis (1970), delineations;
  - Williamson (1994), epistemic theory

Vague predicates: precise core

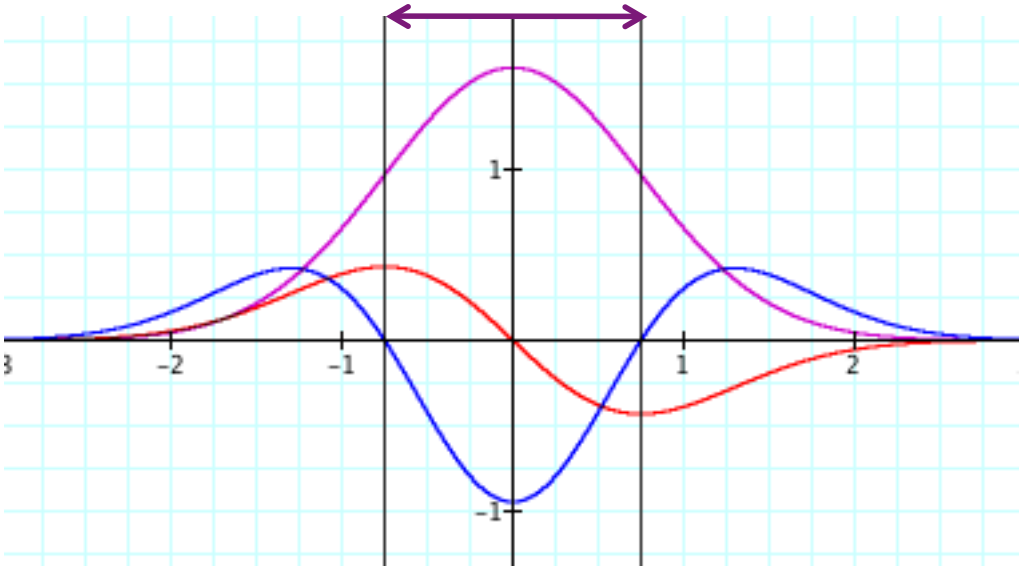
- Another way of fixing standards:
  Use gaps to minimize borderline cases.



How would one assign this to grades, e.g. A – B – C – D – F?

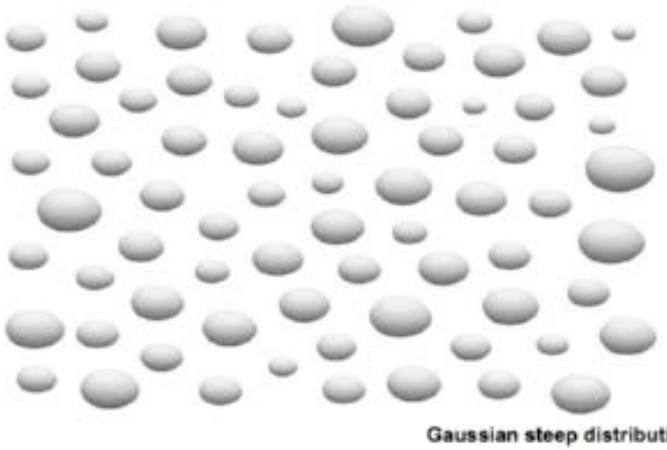
Vague predicates: precise core

- Minimizing borderline case and normal distribution: the cognitive relevance of standard deviations.
  - normal distribution (purple, exaggerated by factor 3), first derivative (red), second derivative (blue) standard deviation (purple)

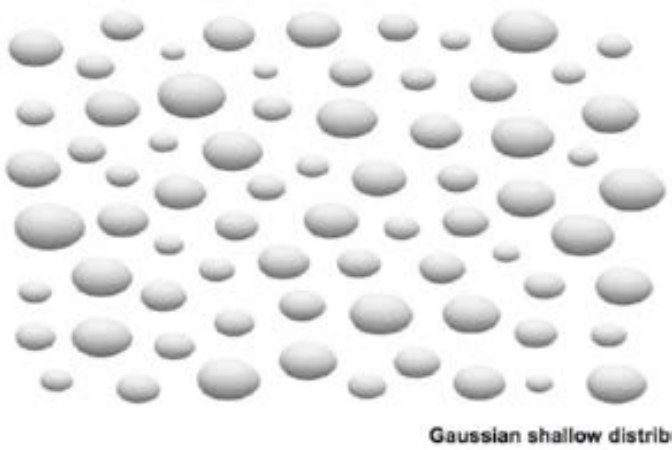


Vage predicates: precise core

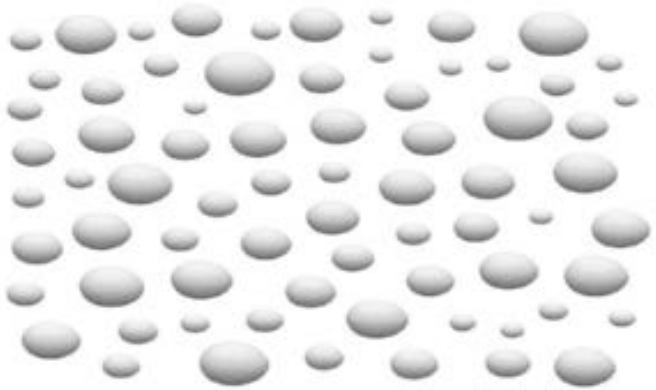
- Influence of distribution on judgements (Solt, Gotzner)



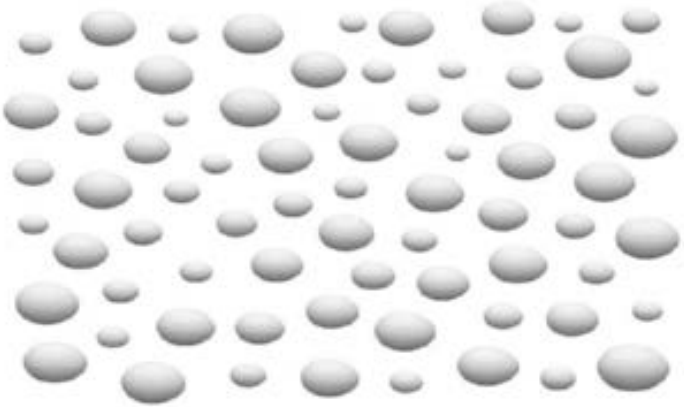
Gaussian steep distribution



Gaussian shallow distribution

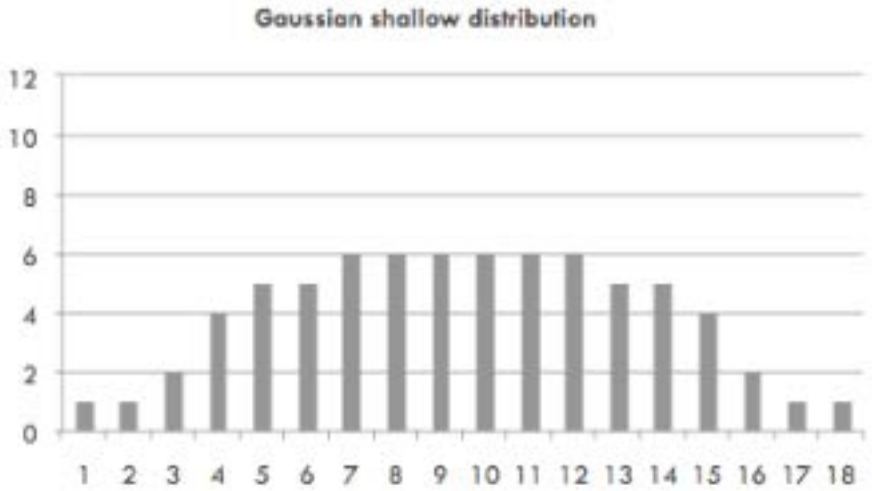


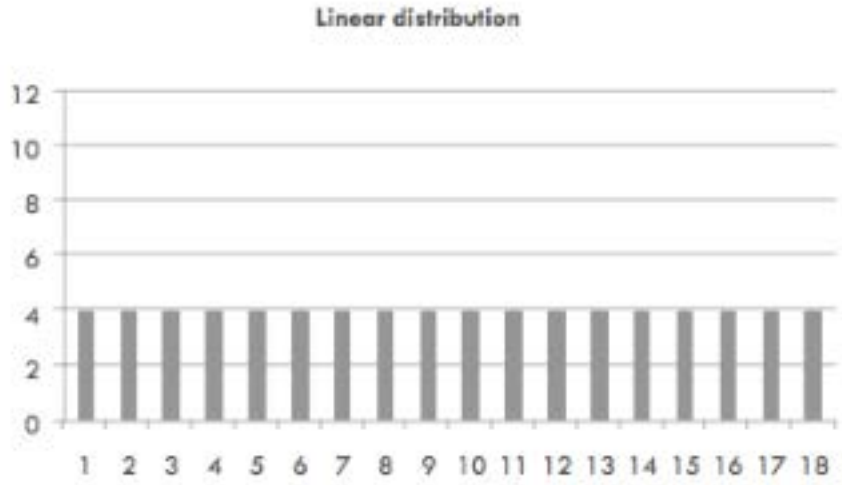
Linear distribution

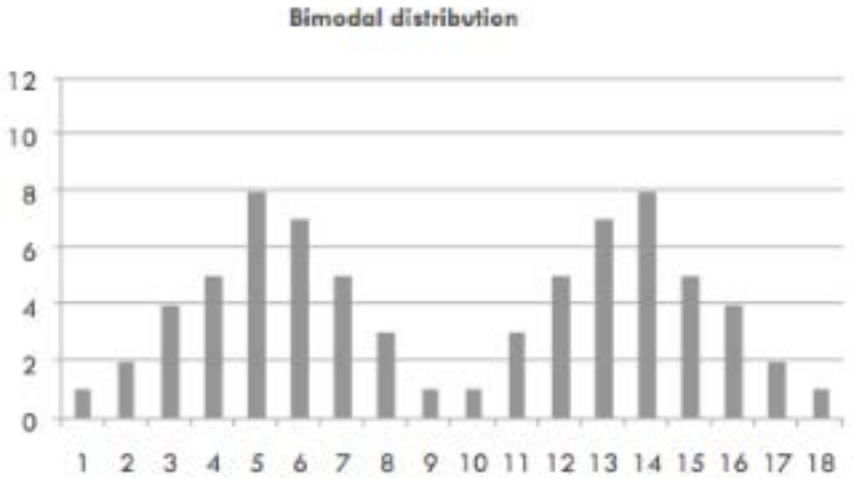


Bimodal distribution

Vague predicates: precise core

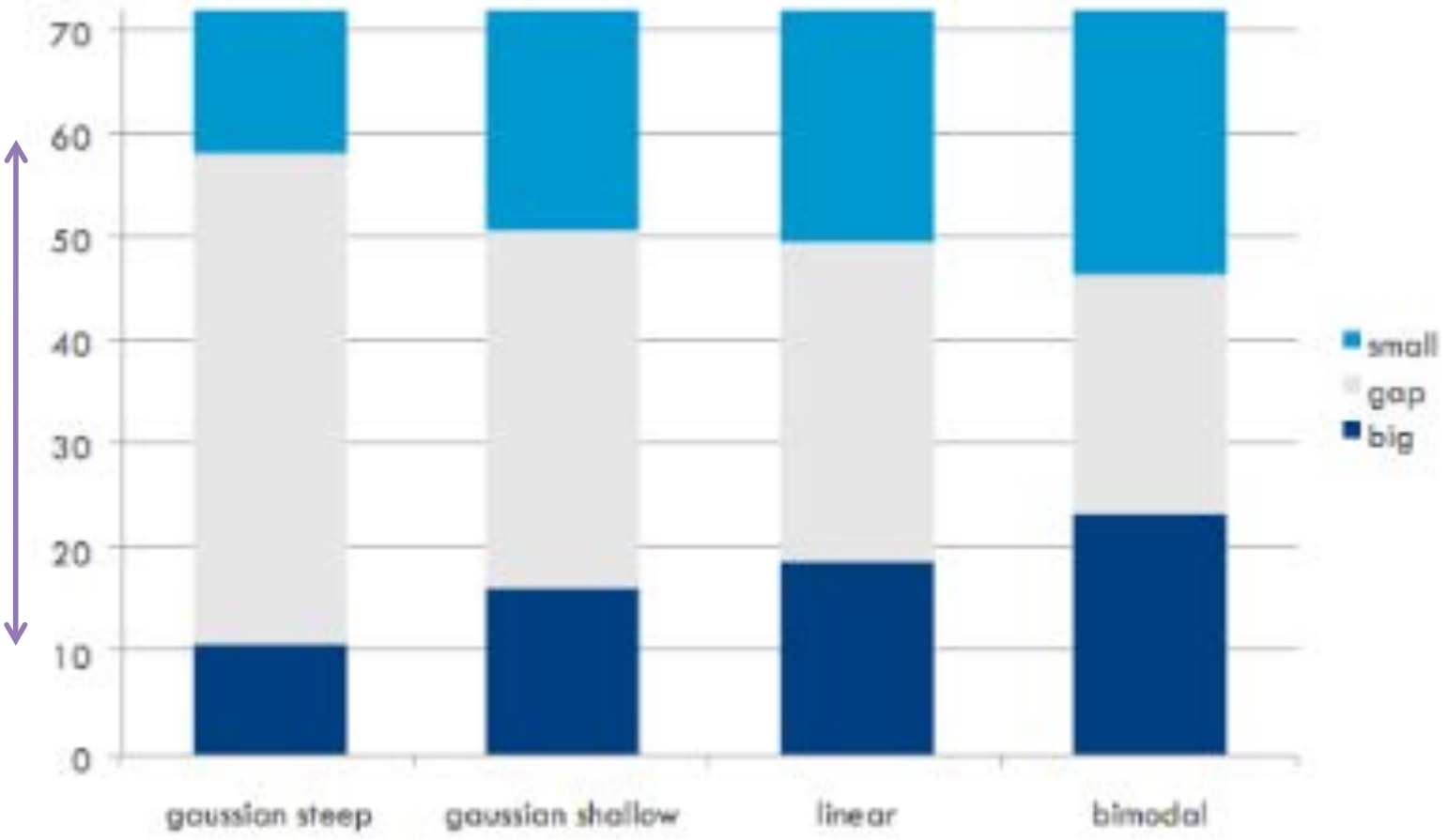






Vague predicates: precise core

standard deviation with normal distribution (68%)



Vage predicates: precise core

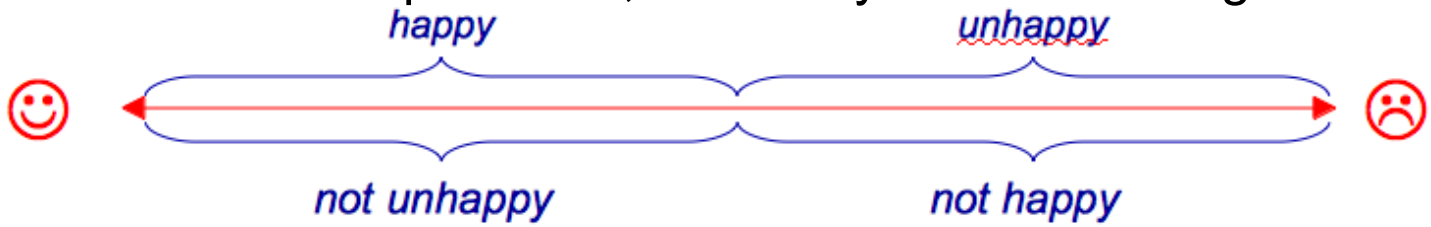
- Talking about the world vs. asking about standards:
  - *This egg is BIG.*
  - A: *I have no idea about the sizes of kiwi eggs.*
    How big can they get?
    B: *Look, THIS is a big kiwi egg.*
    (Barker 2002, “Dynamics of vagueness”)
- Quantifiying over possible states of the world
  vs. quantifying over standards:
  - *If the egg is big, we can use it for making an omelet.*
  - *If this egg is big, then that egg is big, too.*
    (Lewis 1970, “General semantics”, delineations)

Vage predicate: precise core

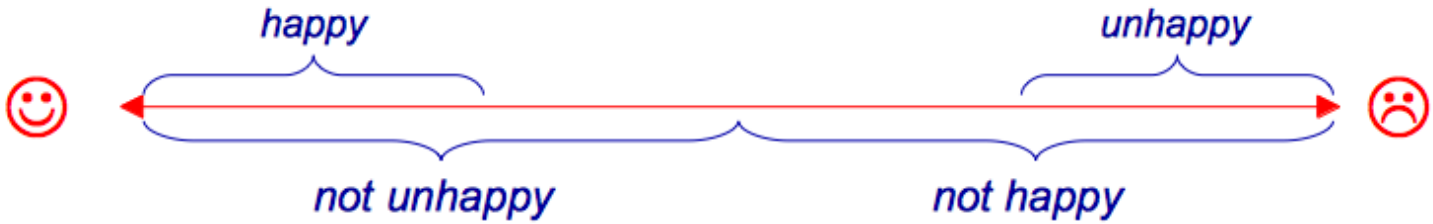
- An application: Negated Antonyms
  - *happy, unhappy, not happy, not unhappy*
  - *likely, unlikely, not likely, not unlikely*
  - *common, uncommon, not common, not uncommon*
  - Cf. Horn (2002), “The logic of double negation”

Vague predicates: precise core

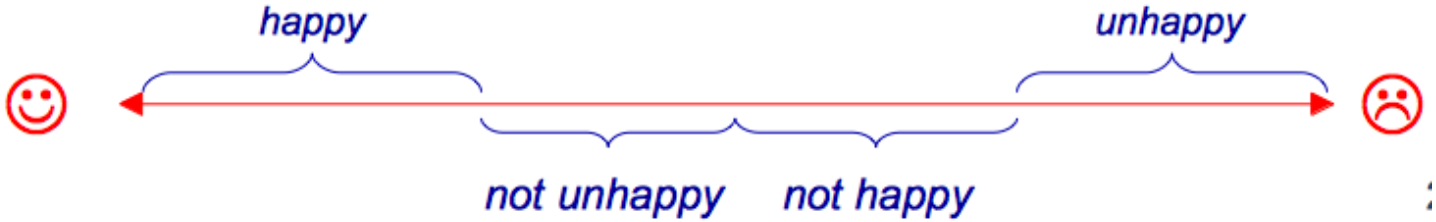
- Interpretation of antonyms and their negation (Krifka 2008)
  - Initial situation: A predicate, its antonym and their negations:



  - Restriction of simpler expressions to clear cases:



Restriction of negated expressions, M implicature (Levinson 2000)



PRECISE TERMS AND THEIR APPROXIMATE INTERPRETATIONS

Precise Terms: Approximate Interpretations

- What could be more precise than a number word?
- But:
  - *There were 50 participants at the Schloss Herrenhausen conference on blurred boundaries.*
  - *There were 47 participants at the Schloss Herrenhausen conference on blurred boundaries.*
- Sometimes, too much precision can be derimental:

Street sign in Kloten,
Switzerland

Protest sign in Great Britain against the introduction of the metric system

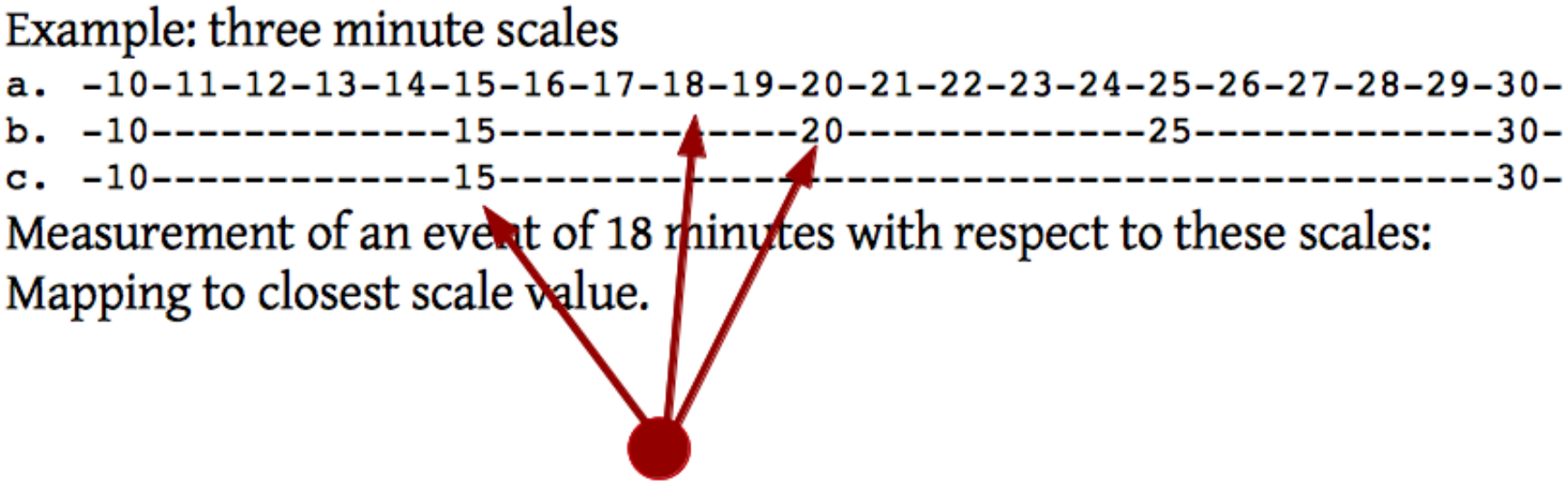
— How old are these bones, Paps?
— Believe it or not, 65,000,0017 years!
— How come?
— Simple math, Son. They told me they were 65,000,000 million years when I visited the museum the first time, and that's now 17 years ago.

Precise terms: Approximate interpretations

- Are number words vague?
  - *one hundred and three*: 103
  - *one hundred:* 90 … 110
- Alternative proposal (Krifka 2008):
  - Number words are precise, but
  - they come with alternatives that form scales, and
  - there are more or less fine-grained scales, where
  - the measure of an entity is represented by the closest number with respect to a given scale, and
  - in many situations, coarse-grained scales are preferred.

Precise terms: approximate interpretaitons

- Example:
  - *We waited fifteen minutes.*
  - *We waited twenty minutes.*
  - *We waited eighteen minutes.*



Precise terms: approximate interpretations

- Principles of scale granularity:
  - multiples of powers of ten in a decimal language
    ten, twenty, thirty…,
    one hundred, two hundred, three hundred…
  - half points of existing scales:
    five, ten, fifteen, twenty, twenty-five…
    ((fifteen minutes)) (thirty minutes) ((fourty-five minutes)) one hour
  - Logarithmic scales
    kilobyte, megabyte, gigabyte, terabyte
    hamlet, village, town, city, (metropolis)
  - Mixture of quasi-logarithmic and half points (cf. Hobbs 2000)
    five minutes, ten minutes, fifteen minutes, thirty minutes, an hour
    45 degrees, 90 degrees, 180 degrees, 360 degrees

Precise terms: approximate interpretations

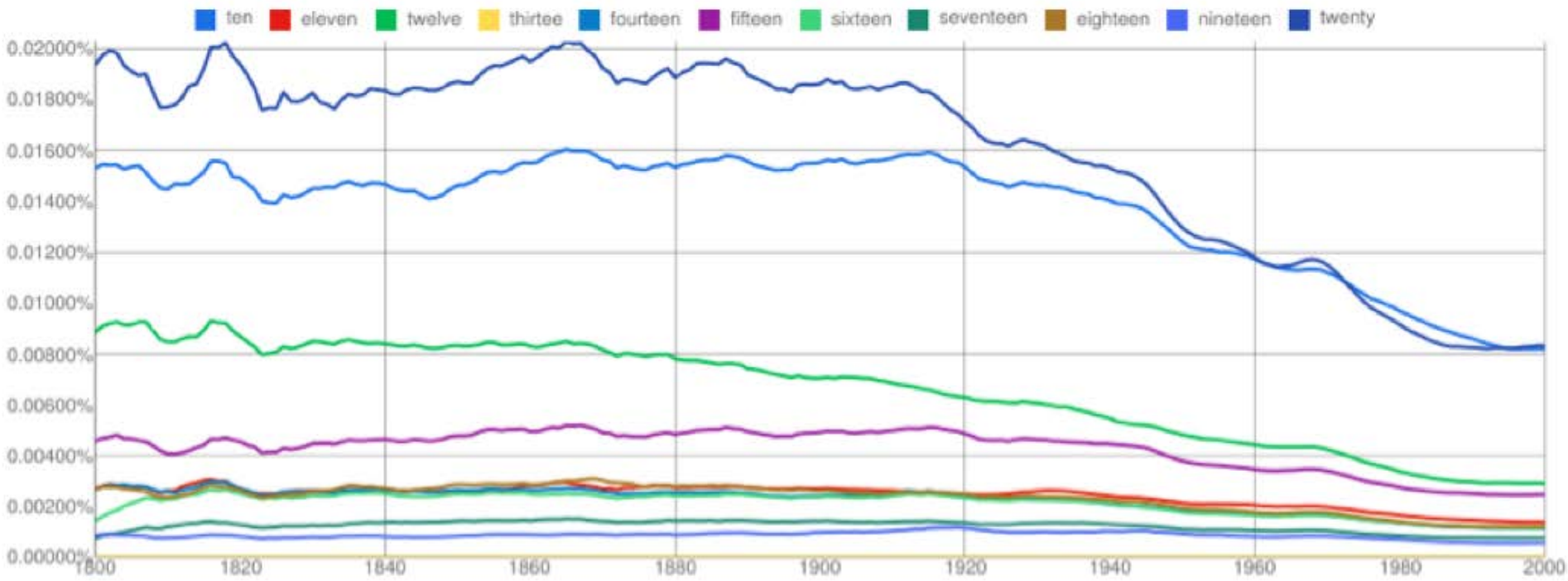
- General pragmatic rule:
  Everything else being equal, interpret a precise term on the coarsest scale possible.
  - *one hundred people* => between roughly 90 and 110 people
  - *ninety-seven people* => 97 people
- But why?
  Is there a general preference for coarse scales?
- Possible reasons:
  - Simplified cognitive representation
  - Simplified reasoning (*the temperature is in the nineties*)
  - Higher chance to say something true (Paul Duhem)

Precise terms: approximate interprations

- But: Preference for coarse scales follows from a game-theoretic view of how we use language in conversation.
  - Example: *There were fifty people in the audience.*
  - A-priori likelihood of number of people:
    … ≈ p(46) ≈ p(47) ≈ p(48) ≈ p(49) ≈ p(50) ≈ p(51) ≈ p(52) ≈ …
  - A-priori likelihood of *there were fifty people in the audience* under coarse-grained and fine-grained interpretation:
    $p([\textit{fifty}]_{coarse}(x)) >> p([\textit{fifty}]_{fine})$
  - General principle to prefer the interpretation with the greatest a-priori likelihood (cf. Parikh 1991)
    - Example:
      Someone gets robbed every ten minutes in Berlin.
      a. ∃x[person(x) ∧ every ten minutes: x gets robbed]
      b. Every ten minutes: ∃x[person(x) ∧ x gets robbed]

Precise terms: approximate interpretation

- Consequences of preference for coarse scales: frequency of words
  - Relative number word frequency in printed English; Google n-grams, 5% of printed English texts from 1800 to present
  - *ten, twenty > fifteen > twelve > eleven, thirteen, sixteen, …*



Precise terms: approximate interpretations

- Influence of the number system:
  - Norwegian: decimal
  - Danish: decimal / vigesimal
  - Basque: decimal
- Frequency of number words on national web sites:

Num-ber	Norwegian		Danish		Basque	
	Numeral	#	Numeral	#	Numeral	#
20	*tjue*	61300	*tyve*	121000		
30	*tretti*	43700	*tredive*	25400	*hogei ta hamar*	892
40	*førti*	**39200**	*fyrre*	**26800**	*berrogei*	**85000**
50	*femti*	**81200**	*halvtreds*	**15500**	*berrogei ta hamar*	**213**
60	*seksti*	**19400**	*tres*	**36400**	*hirurogei*	**34000**
70	*sytti*	10200	*halvfjerds*	581	*hirurogei ta hamar*	69
80	*åtti*	13100	*firs*	3740	*larogei*	9000
90	*nitti*	13500	*halvfems*	540	*larogei ta hamar*	7

How to ensure compliance: Use non-round numbers!

Street sign in Slovakia

IMPRECISION AND CLOCK TIME

Rounding in time telling

Excuse me, can you tell me what time it is?

	Predicted Level	Analog Watch	Digital Watch
5x responses	20%	98%	66%

(van der Henst et al. 2002)

Speaker Uncertainty?

- Do speakers round to limit their commitment?
  - e.g. because they are uncertain their watch is accurate
- Probably. But…

> Seven in ten (71%) of secondary school students plan to attend a four-year college. (Metropolitan Life Survey of the American Teacher 2000) (http://www.mostofus.org/facts/2010/social-norms-facts/)
>
> Three out of four voters in Macoupin County supported the non-binding referendum on whether or not they favor conceal carry in the state. The breakdown was 7,604 (75.49 percent) in favor and 2,469 (24.51 percent) opposed. (http://enquirerdemocrat.com/?p=4320)
>
> More than a quarter of papers were marked A...
>
> ...
>
> According to figures released today...25.9 percent of A-level papers were awarded an A grade.. .(Daily Telegaph 14/8/2008; cited in Williams & Power 2009)

Hearer orientation?

- Less rounding when more precise information hearer-relevant

	Control Condition	Setting Watch
5x responses	96%	60%

(van der Henst et al. 2002)

*…a rounded answer…requires **less processing effort** for the same cognitive benefit* (p. 459)

*Suppose you have an appointment at 3:30 p.m. and it is 3:08. Being told 'It is 3:10' is likely to be optimally relevant: the two-minute departure from the exact time is unlikely to have any consequences, and the rounded answer is **easier to process*** (p 464)

- Rounded answer optimally relevant

Evidence for processing advantage

- Recall of results of addition problems better for round vs. non-round values:

Current assets + noncurrent assets = total assets

	Correct recall
Round (e.g. 11,000):	48%
Non-round (e.g. 11,635):	10%

- Tested on first two digits

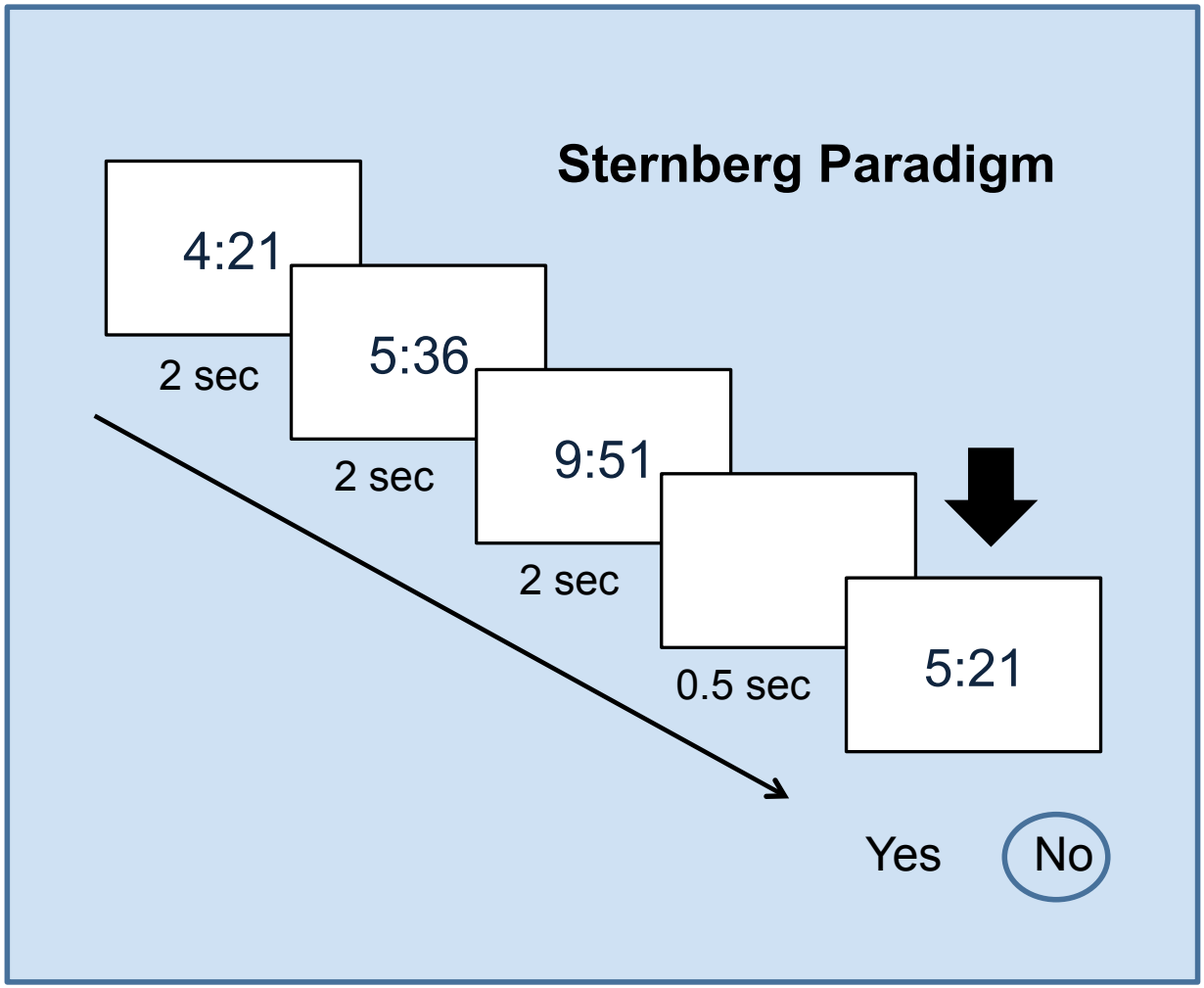
(Mason et al. 1996)

Our Research

- Are ‘rounder’ clock times easier to process?
- What aspects of processing impacted?
- Is advantage due to…
  - Domain general properties of numbers?
    - ‘Round’ ≈ divisible by 10 or 5 (Jansen & Pollmann 2001)
  - Domain specific scale granularity?
    - 3:15 >> 3:10 >> 3:07

Joint work with C. Cummins (Bielefeld) and M. Palmović (Zagreb)
Funded by EURO XPRAG Network

Short-Term Memory



3 granularity levels

Coarse: 15-min

`3:15`

Round

Medium: 5-min

`3:20`

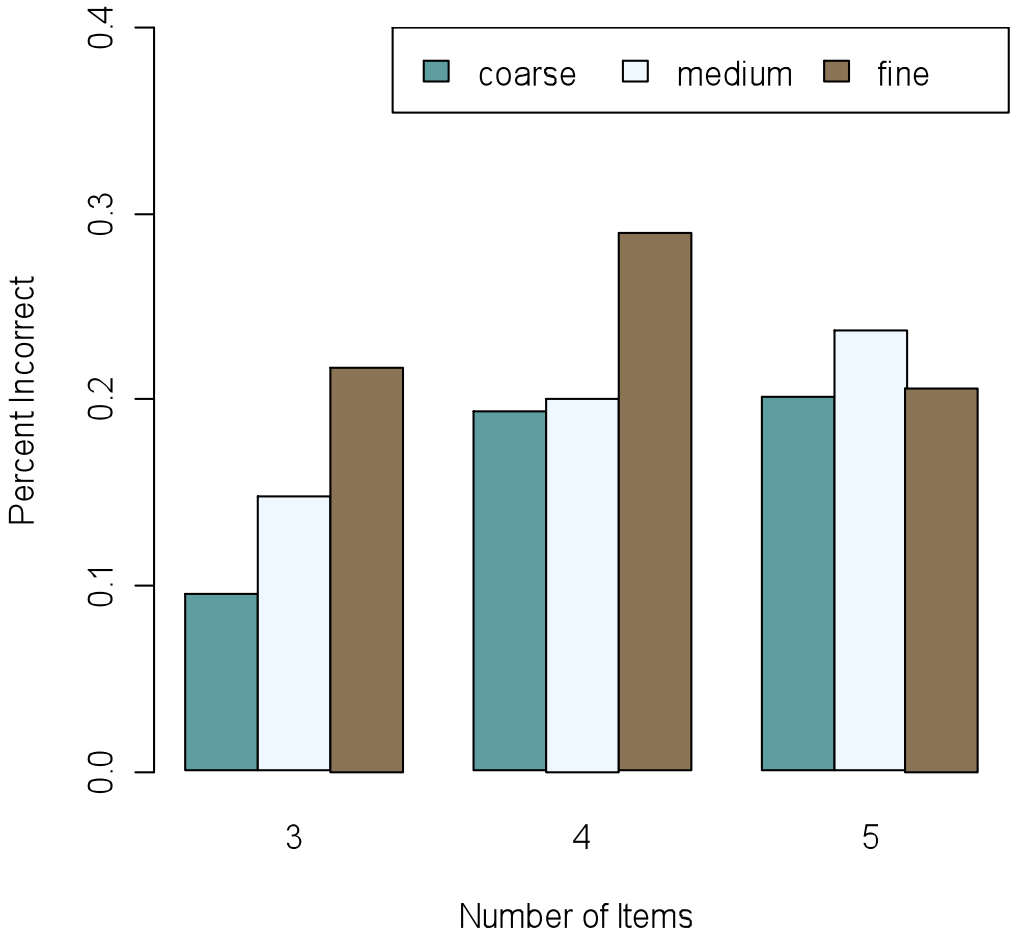
Round

Fine: 1-min

`3:21`

Non-Round

Short-Term Memory

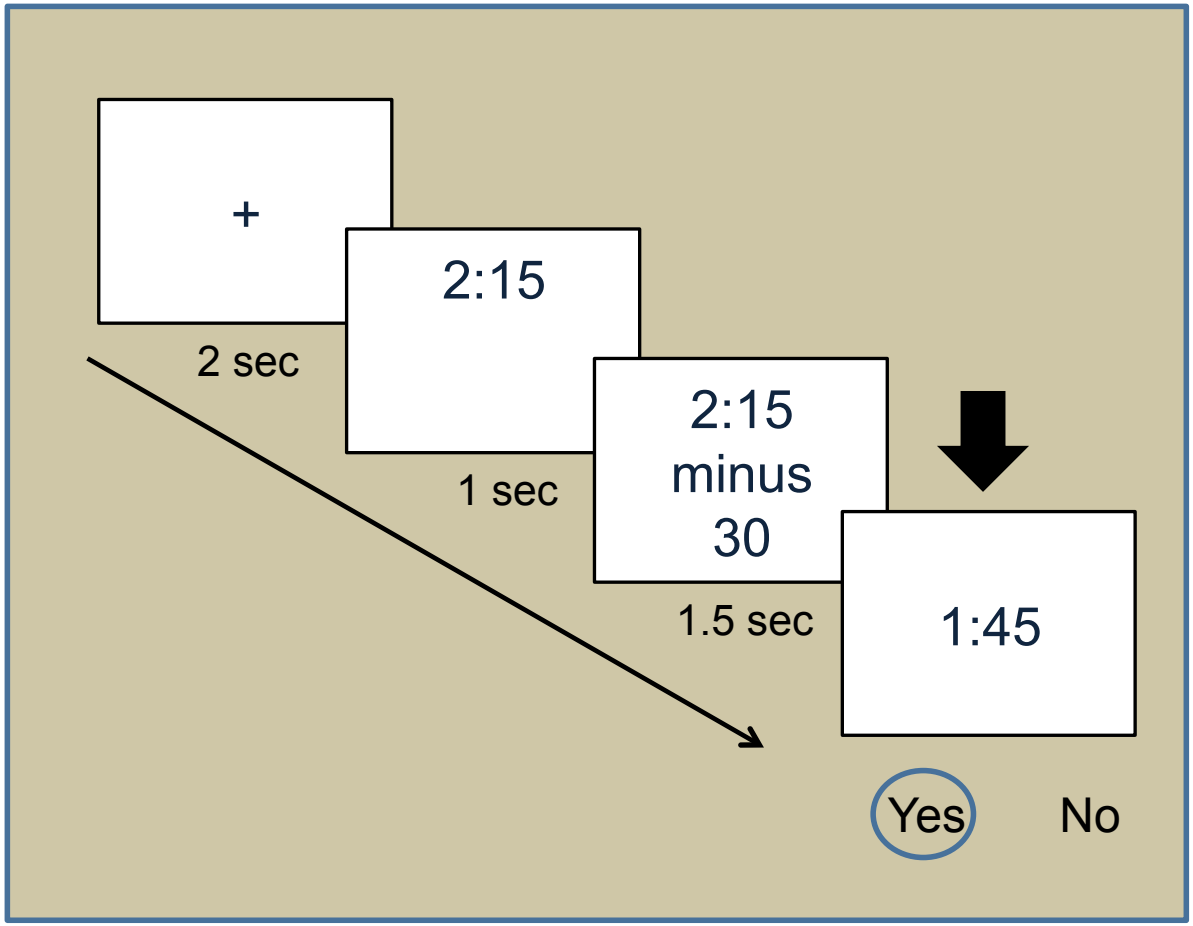


- Significantly greater accuracy:
  - **coarse** vs. **fine** (round vs. non-round)
- No significant difference between
  - **coarse** and **medium** (both round)

Þ Processing advantage

Þ Domain general factors?

Reasoning with Clock Time



- 3 start granularities
  - Coarse (2:15)
  - Medium (2:10)
  - Fine (2:21)
- 3 increment granularities
  - Coarse (:30)
  - Medium (:25)
  - Fine (27)
- Addition/subtraction
- Must be processed as times

Reasoning with Clock Time

Reaction Time

		Increment Granularity		
		Coarse	Medium	Fine
Start Granularity	Coarse	809	945	1222
	Medium	940	970	1259
	Fine	1253	1293	1435

- Significant effect of coarse vs. fine (round/non-round)
- Significant effect of coarse vs. medium (both round)
  - Þ Role of domain-specific granularity levels

Summary

- Research findings are still limited – but suggest that rounding is effective hearer-oriented strategy
- Rounded values are easier to…
  - Remember
  - Reason with
- Implications for communication of numerical information – don’t be too precise!

Don’t be too precise

Postal Facts 2013 (United States Postal Service)

Size and Scope

The Postal Service delivers to more than152 million homes, businesses and Post Office boxes in every state, city, town and borough in this country.

By the Numbers *

65 billion — 2012 revenue, in dollars **160 billion** — number of mailpieces processed **40** — percent of the world’s mail volume handled by the Postal Service **1.8 billion** — dollar amount paid every two weeks in salaries and benefits **522,144**** — number of career employees **108,000**** — number of military veteran career employees **31,272** — number of Postal Service-managed retail offices **212,530** — number of vehicles — one of the largest civilian fleets in the world **1.3 billion** — number of miles driven each year by letter carriers and truck drivers **39.7 million** — number of address changes processed **39** — percent of retail revenue from alternative access channels **423 million** — total number of visits to *usps.com* **67.5 million** — number of inquiries handled by the Postal Service Contact Center **246 million** — dollar amount of online stamp and retail sales at *usps.com* **44.1 million** — number of Click-N-Ship labels printed **483 million** — total revenue, in dollars, from Click-N-Ship label purchases **83.8 million** — number of packages picked up using Free Package Pickup **5.7 million** — number of passport applications accepted **109 million** — number of money orders issued **497 million** — amount in revenue from 2,500 Self-Service Kiosks **…**

Don’t be too precise

Deutsche Post/DHL (http://www.dp-dhl.com/de)

Our strength in numbers:
We do business in more than 220 countries and territories.
We employ about 475,000 employees worldwide, making us one of the top 10 largest employers in the world.
We manage more than 1 million customer contacts per hour.
In 2012, Deutsche Post DHL generated revenues of more than 55 billion euros.

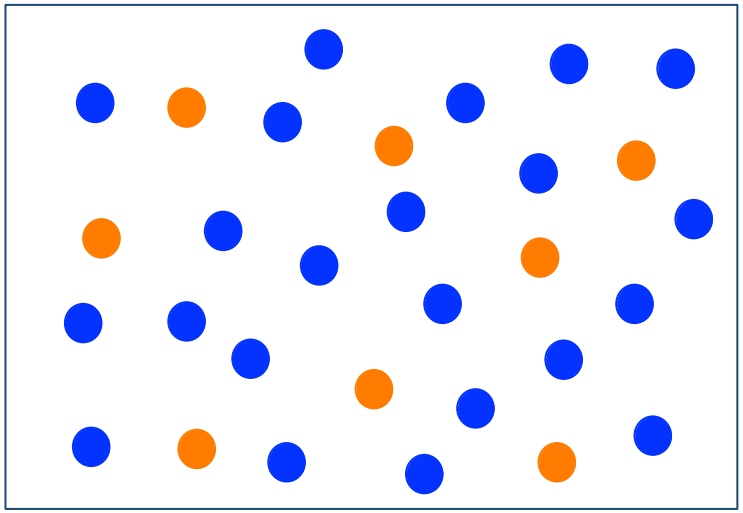
MAIL in figures:
Households: 40 million
Business customers: 3 million
Retail outlet customers: 2 million per working day
Domestic letters: More than 64 million per working day
Domestic parcels: More than 3 million per working day
Packstations: Approx. 2,500
Paketboxes: Approx. 1,000
Mail centres: 82
Parcel centres: 33

MOST AND APPROXIMATE NUMBER

Two superficially equivalent quantifiers

(1) More than half of the dots are blue

(2) Most of the dots are blue



But….

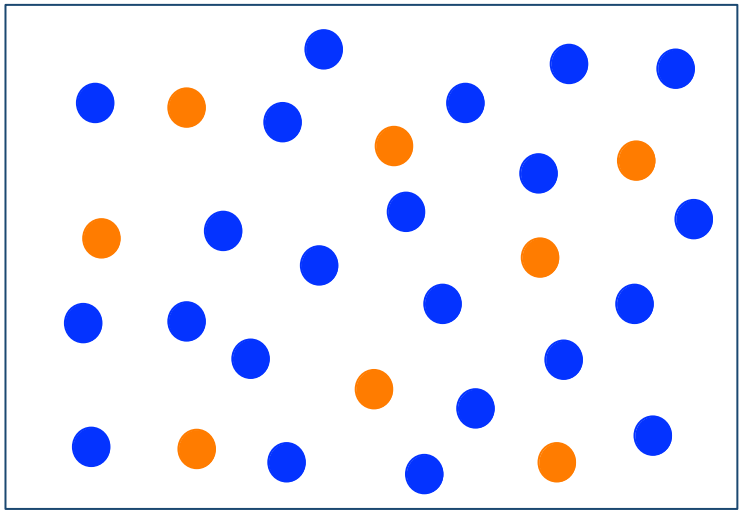
(1) has a precise cutoff (>50%)
(2) has a higher – and vague -- cutoff

(3) a. **More than half** of the U.S. population is female ✓
b. **Most** of the U.S. population is female **??**

Two superficially equivalent quantifiers

(1) More than half of the dots are blue

(2) Most of the dots are blue



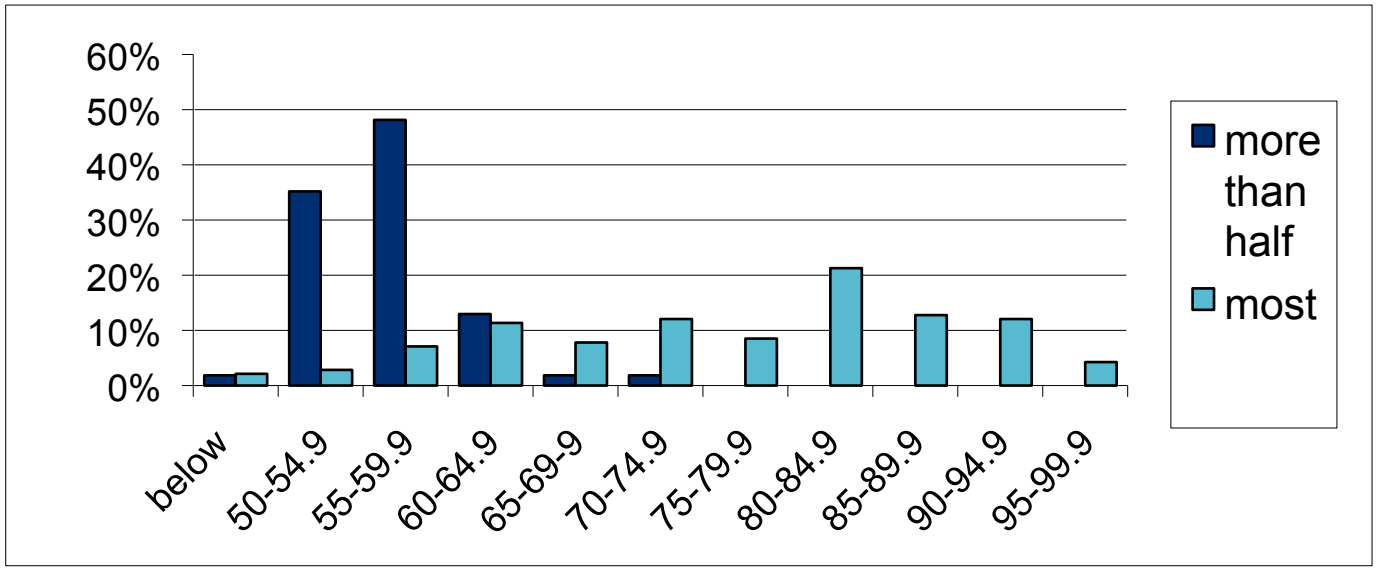
Claim: This pair can tell us something about how vagueness is encoded in language and why it is useful to have expressions of this sort

Corpus findings

- *Most* used for higher proportions than *more than half*

(4) a. **More than half of respondents (55%)** say that making money is more important now than it was five years ago (*Money*, 21(3), p. 72, 1992)

b. The survey showed that **most students (81.5%)** do not use websites for math-related assignments (*Education*, 129(1), pp. 56-79, 2008)



Source: COCA; Davies 2009-

Corpus findings

- *Most* felicitous in contexts where *more than half* isn't

(5) a. But like **most things**, obesity is not spread equally across social classes (*Mens Health*, 23(7), p. 164, 2008)

b. **Most beliefs, worries, and memories** also operate outside awareness (*Science News*, 142(16), 1992)

c. **Most teens** want to fit in with their peers (*CNN YourHealth*, 31/8/2002)

(6) a. ??But like **more than half of things**, obesity is not spread equally across social classes

b. ??**More than half of beliefs, worries, and memories** also operate outside awareness

c. ??**More than half of teens** want to fit in with their peers

- *Most* doesn't rely on precise counting

Logical form and scale structure

- Logical forms superficially equivalent:

  'More than half of the dots are blue' is true iff

  # blue dots > # dots / 2

  'Most of the dots are blue' is true iff

  # blue dots > # non-blue dots

- But place different requirements on scale structure:
  - ***More than half:*** Scale that supports division (ratio level)
  - **Most:** Ordered set of points (ordinal level – or weaker)

Approximate Number System (ANS)

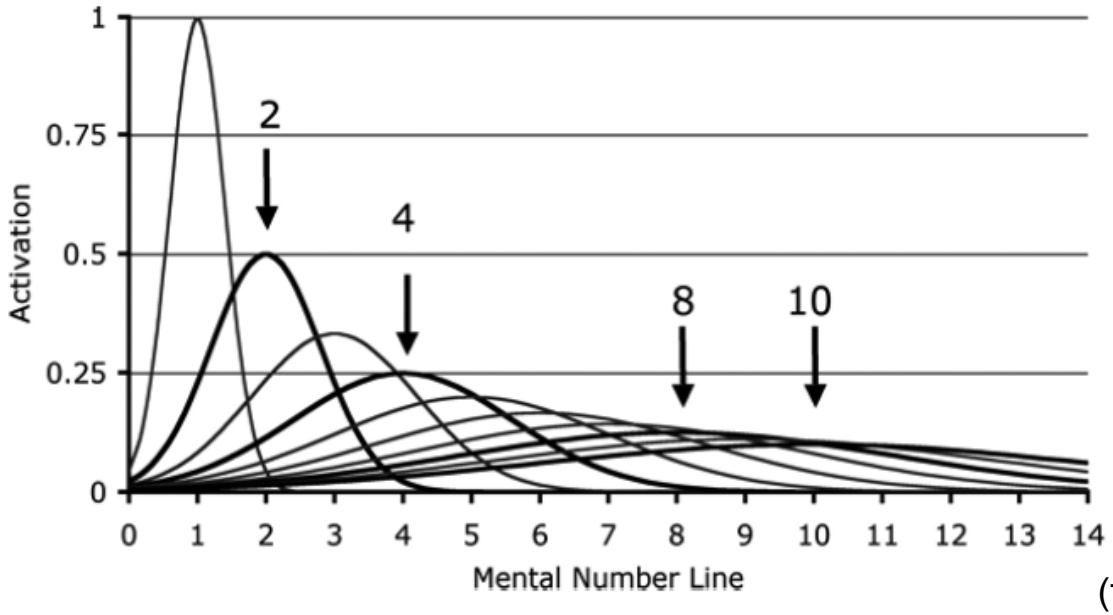
- In addition to the ability to represent/manipulate precise number, humans – and other animals – have a separate **Approximate Number System (ANS)** (cf. research by St. Dehaene).
  - Present in pre-verbal infants, societies lacking complex number systems -- innate
  - Supports comparison of quantities and basic approximate arithmetic (addition/subtraction – but not division)
  - Ratio-dependent operation:
    - 6 vs. 8 equally distinguishable as 30 vs. 40
    - Minimum difference reliably distinguishable (by adults): 7:8
  - Invoked automatically

Which is larger? 5 or 6

2 or 9

Model of the ANS

- Output of ANS represented as analog magnitudes on equivalent of mental number line
- Modeled as Gaussian distributions with increasing spread, where differentiability of two values is a function of the overlap of the corresponding curves



(from Halberda et al. 2009)

Vagueness and Approximate Number

- *Most* is an example of a natural language quantifier whose meaning can be stated w.r.t. a rough, approximate representation of quantity
  - Vagueness as the result
- Such an expression is useful because…
  - Some 'quantities' do not lend themselves to precise counting
  - Evaluation can proceed via our innate and automatically activated approximate numerical capacities
- A potential parallel

  Context: A 99 page book and a 100 page book

  This book is longer than that book

  #*This* book is long compared to that book

Vagueness is a good thing!

- We have seen:
  - The core meanings of natural language terms might be pretty precise
  - But they have parameters that allow for settings that suit the application of terms in particular contexts.
  - By this, the usefulness of language is vastly enriched.
  - The way how parameters are set to maximize the use of terms can be investigated systematically.
- But: Problems with vagueness in law and medical diagnosis
  - Cf. Project *Vernünftiger Umgang mit unscharfen Grenzen*, Geert Keil & Ralf Poscher

Vagueness in law and medical diagnosis

Law:

- Problem: Consistency of application of law
- Role of “unbestimmte Rechtsbegriffe”, e.g. *gute Sitten*
- Slippery slope arguments,
  e.g. *Gewalt* applied to sit-in protests
- precedence cases can point to different directions

Medical iagnosis:

- Symptom combinations → cluster concepts for diagnosis, often unclear
- cf. current discussion about extension of diagnostic notions in the DSM 5 (Diagnostic manual of mental illnesses), Allen Frances.