Scalarity and additivity in natural language: (I) scales and degrees

Linmin Zhang (NYU Shanghai)
zhanglinmin@gmail.com

ESSLLI 2024
Day 1, July 29th, 2024

Slides are available on lingbuzz:
https://lingbuzz.net/lingbuzz/008297

Overview: Relevant empirical phenomena

- Language phenomena that involve **scales / gradability**:

(1) A small elephant is larger than a large rabbit.

(2) He is very handsome.

(3) She runs fast.

(4) She runs as fast as I do.

(5) The train arrived before the scheduled time.

(6) Maybe she will come. It's very likely that she will come.

(7) How tall is Lucy?

(8) How short is Bill?

(9) How many kids does an elephant have?

(10) How many more kids does he have than you expected?

(See e.g., Lassiter 2017 for a scalarity-based view on modality)

Overview: Relevant empirical phenomena

- Language phenomena that involve **additivity or increments**:

(11) Lucy came. Mary also came.

(12) Lucy came. Mary came, too.

(13) A girl, Junko, met another girl, Hanako.

(14) It was raining and raining and raining.

(15) I read the book again.

(16) I ate two bars of chocolate. Then I ate a bit more.

Overview: Relevant empirical phenomena

- Language phenomena that involve **both scalarity and (anti)-additivity**:

(17) Even Mary came.
 ⇝ This sentence says something about people other than Mary.
 ⇝ There is an ordering among Mary and other people.

(18) Only Mary came.
 ⇝ This sentence says something about people other than Mary.
 ⇝ There is an ordering among Mary and other people.

Overview: Research questions

- Conceptually,
  - What are scales?
    What are their formal properties?
    What operators do they support?
  - What is additivity?
- Empirically,
  - How does an additivity-based perspective improve our understanding of scalarity-related phenomena?
  - How does a scalarity-based perspective improve our understanding of additivity-related phenomena?

Overview: Take-home messages of the course

- Scalarity and additivity are highly related and should be studied together.
  - QUD provides a unified perspective on scalarity and additivity.
- There is a large family of cross-linguistic phenomena worth further investigation.
  - To account for cross-linguistic variation, we need to consider parameters both at the language level and at a more fine-grained construction level.

Overview: Course arrangements

- Day 1: Basics of scales and degrees; how they are relevant to natural language
  - What are scales? What are their formal properties? What operators do they support?
- Day 2 and Day 3: Comparatives and *-er*/*more*
  - How an additivity-based perspective improve our understanding of scalarity-related phenomena?
  - What is additivity?
- Day 4 and Day 5: *Even* and its cross-linguistic siblings
  - How a scalarity-based perspective improve our understanding of additivity-related phenomena?

ESSLLI workshop related to this course

- Incremental constructions within and across languages:
  see http://www.carla-umbach.de/ESSLLI2024/ for details and updates

Schedule

Monday 29. July	11:00	Yael Greenberg & Carla Umbach	Introduction
	11:15	Guillaume Thomas	Cross-linguistic variation in the expression of incrementality and related functions
	12:00	Ang Li (zoom)	Alternative comparison in underspecified degree operators
Tuesday 30. July	11:00	Yael Greenberg	Contextual constraints on incrementals: Some more pieces of the puzzle
	11:45	Linmin Zhang & Florence Zhang	Comparative morphemes are additive particles: English *-er/more* vs. Chinese *geng*
Wednesday 31. July	11:00	Osamu Sawada	Scale structures of numerical additive particles in Japanese: Their interaction with eventuality and intensionality
	11:45		Poster session
Thursday 1.Aug	11:00	Katja Jasinskaja	Discourse time is real
	11:45	Carla Umbach	The temporal trait of German incremental *noch*
Friday 2. Aug	11:00	Sigrid Beck	Event-related readings of universals
	11:45	Yael Greenberg & Carla Umbach	Wrap up: what we have learned about incrementals and where to go

Posters

Agnes Bi: Mandarin additive particles yě vs. hái

My Thi Ha: A comparison of incremental interactions and parallel patterns in Cantonese and Vietnamese

Chungmin Lee: Incrementality and even-like particles in Korean

Today

- Day 1: Basics of scales and degrees; how they are relevant to natural language
  - What are scales? What are their formal properties? What operators do they support?
- Day 2 and Day 3: Comparatives and *-er*/*more*
  - How an additivity-based perspective improve our understanding of scalarity-related phenomena?
  - What is additivity?
- Day 4 and Day 5: *Even* and its cross-linguistic siblings
  - How a scalarity-based perspective improve our understanding of additivity-related phenomena?

Outline

SCIENCE

Vol. 103, No. 2684 Friday, June 7, 1946

On the Theory of Scales of Measurement

S. S. Stevens

Director, Psycho-Acoustic Laboratory, Harvard University

FOR SEVEN YEARS A COMMITTEE of the British Association for the Advancement of Science debated the problem of measurement. Appointed in 1932 to represent Section A (Mathematical and Physical Sciences) and Section J (Psychology), the committee was instructed to consider and report upon the possibility of "quantitative estimates of sensory events"—meaning simply: Is it possible to measure human sensation? Deliberation led only to disagreement, mainly about what is meant by the term measurement. An interim report in 1938 found one member complaining that his colleagues "came out by that same door as they went in," and in order to have another try at agreement, the committee begged to be continued for another year.

For its final report (1940) the committee chose a common bone for its contentions, directing its arguments at a concrete example of a sensory scale. This was the Sone scale of loudness (S. S. Stevens and

by the formal (mathematical) properties of the scales. Furthermore—and this is of great concern to several of the sciences—the statistical manipulations that can legitimately be applied to empirical data depend upon the type of scale against which the data are ordered.

A Classification of Scales of Measurement

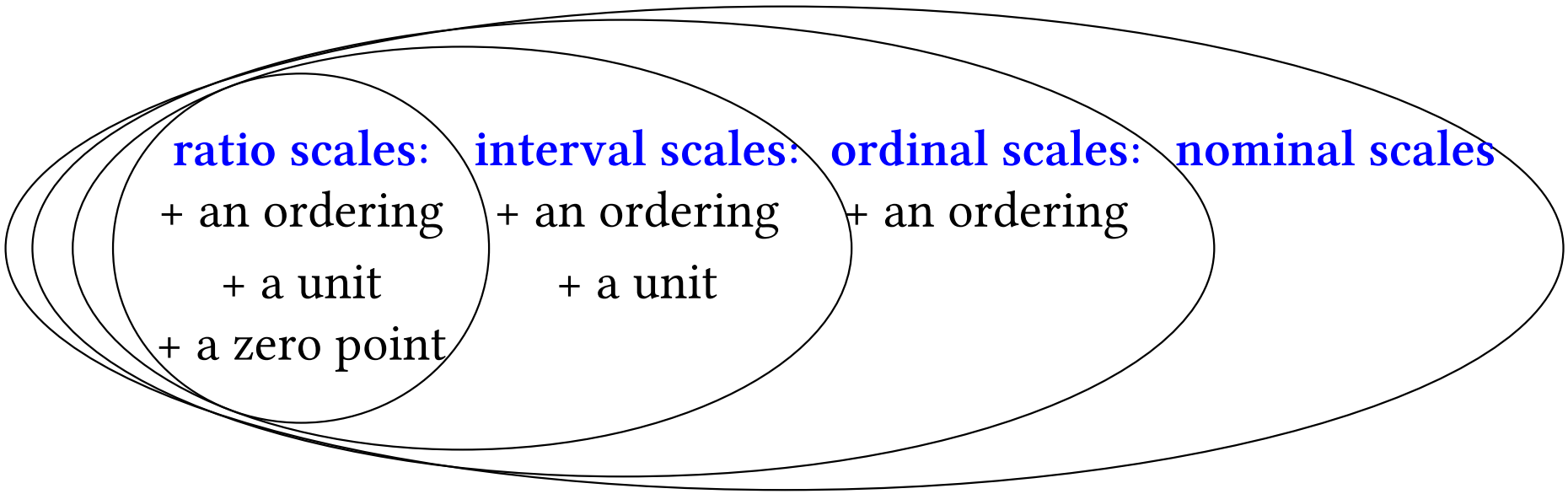
Paraphrasing N. R. Campbell (Final Report, p. 340), we may say that measurement, in the broadest sense, is defined as the assignment of numerals to objects or events according to rules. The fact that numerals can be assigned under different rules leads to different kinds of scales and different kinds of measurement. The problem then becomes that of making explicit (a) the various rules for the assignment of numerals, (b) the mathematical properties (or group structure) of the resulting scales, and (c) the statistical operations applicable to measurements made with each type of scale.

Stevens (1946): What is measurement?

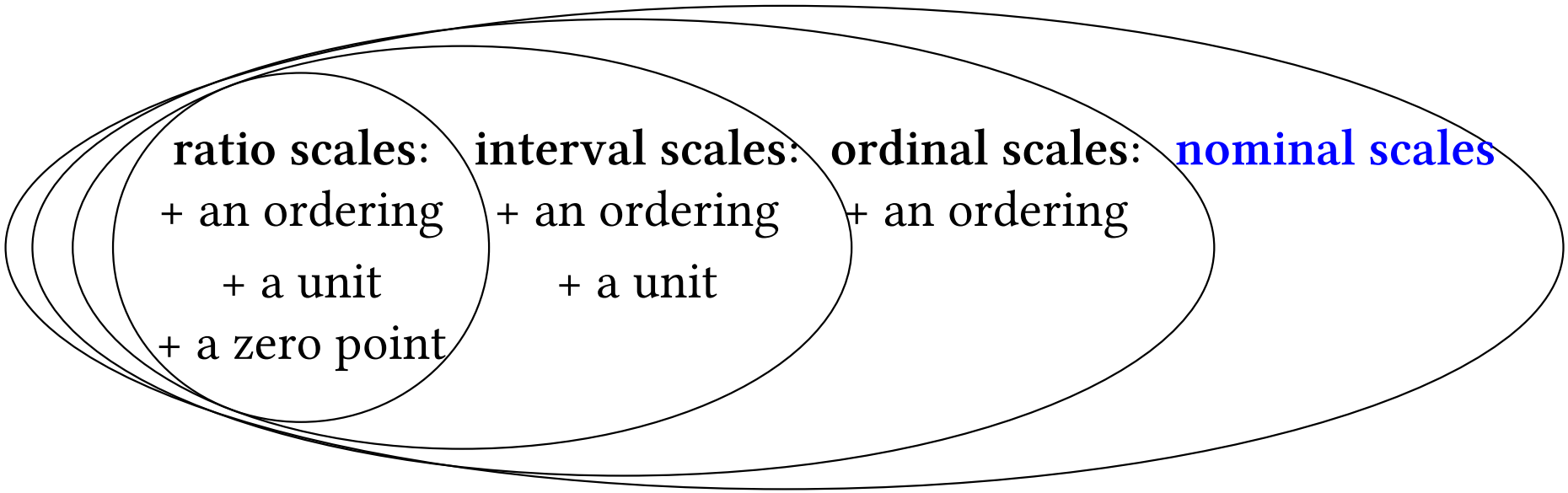
A Classification of Scales of Measurement

Paraphrasing N. R. Campbell (Final Report, p. 340), we may say that measurement, in the broadest sense, is defined as the assignment of numerals to objects or events according to rules. The fact that numerals can be assigned under different rules leads to different kinds of scales and different kinds of measurement. The problem then becomes that of making explicit (a) the various rules for the assignment of numerals, (b) the mathematical properties (or group structure) of the resulting scales, and (c) the statistical operations applicable to measurements made with each type of scale.

Stevens (1946): there are 4 levels of measurement and scales



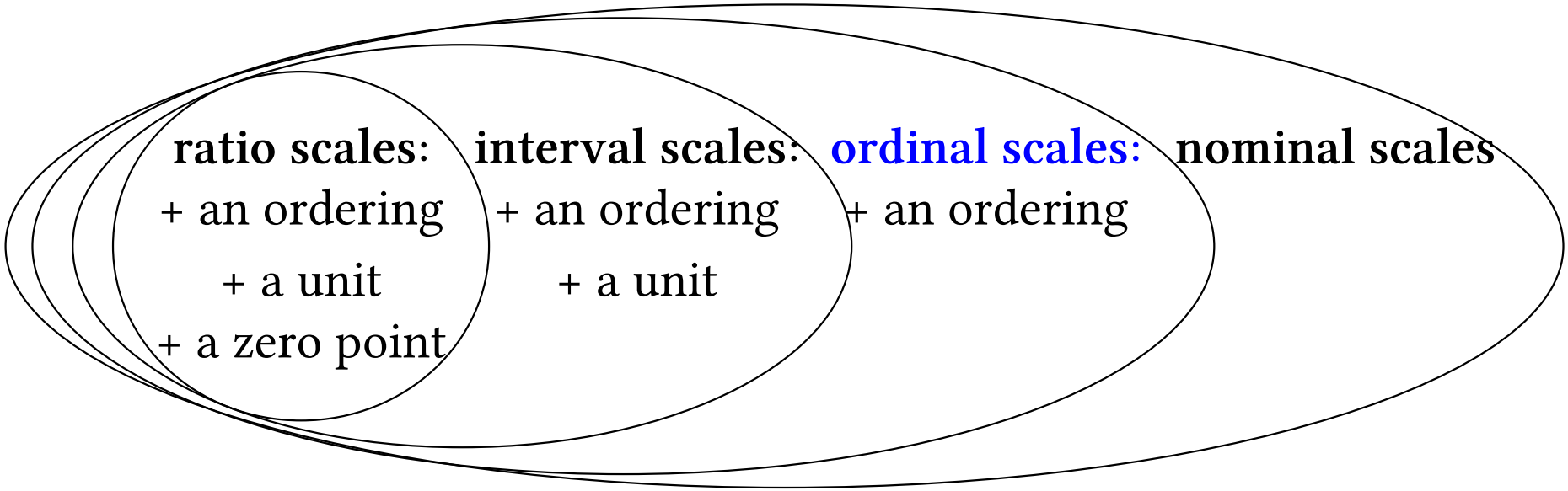
Nominal scales



(19) The postal code of my school is 200124.
The postal code of my home is 200062.

- Here '200124' and '200062' are distinct values, but there is no ordering between them.

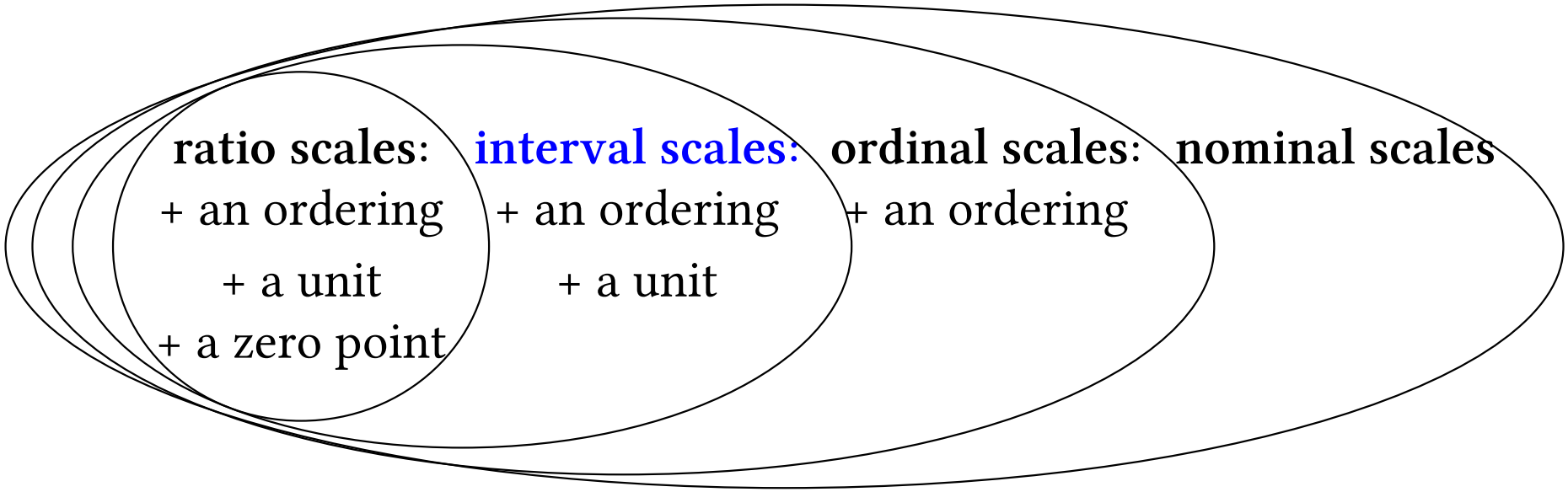
Ordinal scales



(20) I prefer vanilla-flavored ice cream to lavender-flavored ice cream.

- There is an ordering between the preference degrees of 'vanilla-flavored ice cream' vs. 'lavender-flavored ice cream', but the difference between these degrees cannot be measured.

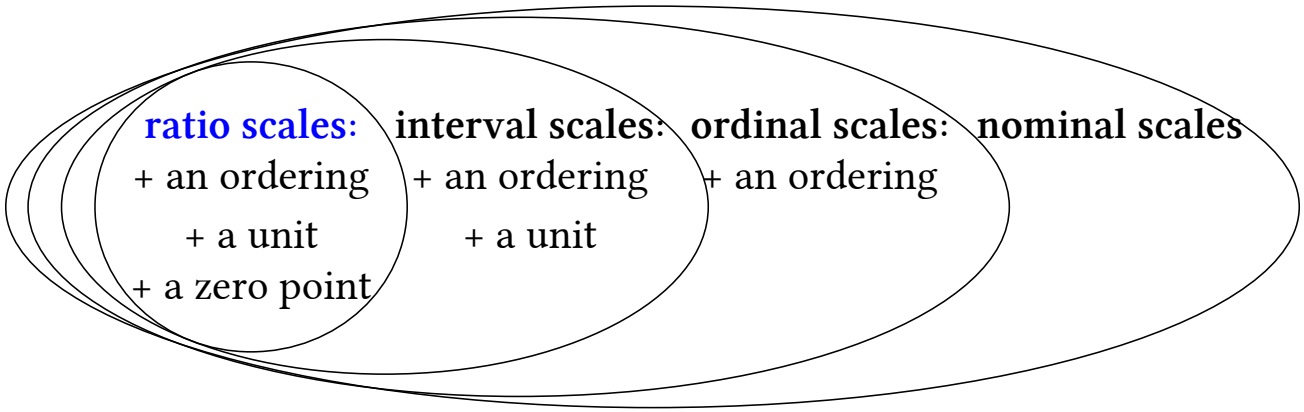
Interval scales



(21) a. Shanghai is (about 12 degrees) hotter than Brussel.
b. I arrived (2 hours) earlier than John did.
c. I am (1 inch) shorter than Lily is.
d. The Olympics 2024 is (5 days) longer than ESSLLI 2024.

- Interval scales support the measurement of the difference between two degrees along a scale.

Ratio scales



(22) ?Shanghai is about 1.5 times as hot as Belgium.

(Context: It's 24 degrees Celsius in Belgium. It's 36 degrees Celsius in Shanghai.)

(23) *I arrived three times as early as John did.

(Context: I arrived at 1 pm, and John arrived at 3 pm.)

(24) The Olympics 2024 is about 6 times as long as that conference.

(The Olympics 2024 is 17 days long, and that conference is 3 days long.)

- A ratio scale has a meaningful zero point, supporting the expression of ratios.

Interim summary

- Measurement means mapping an entity (or an event) to a value along a scale according to rules.
- There are 4 levels of measurement and scales, based on their formal properties.
- Natural language phenomena indicate that human cognition is sensitive to the distinction of these different levels of measurement and scales as well as the formal properties of scales.
  - More works on formal properties / operations of measurement and scales
    - ★ Fox and Hackl (2006): the universal density of measurement in natural language
    - ★ Sassoon (2010): the limited distribution of ratio expressions and measure phrases
    - ★ Wellwood (2019): the structure-preserving of measure functions
    - ★ Coppock (2022): natural language encodes complex operations like division
    - ★ etc.

Outline

Major uses of gradable adjectives

(25) Lucy is tall. **Positive use**

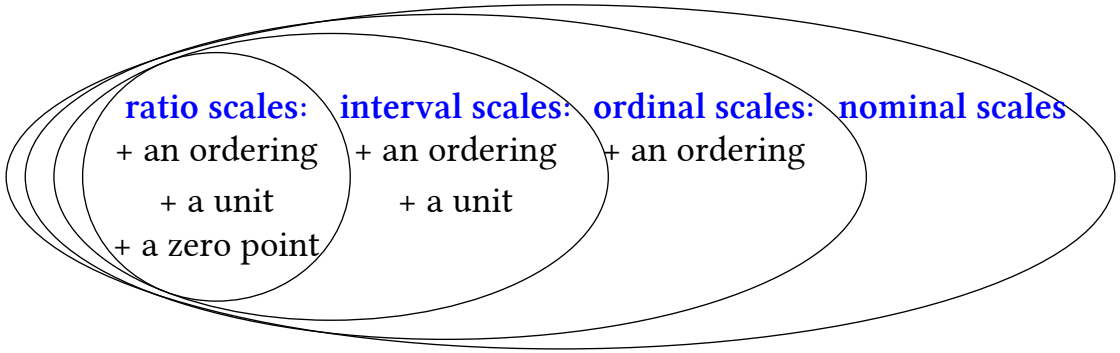
(26) Lucy is 6 feet tall. **Measurement**

(27) How tall is Lucy? **Degree question**

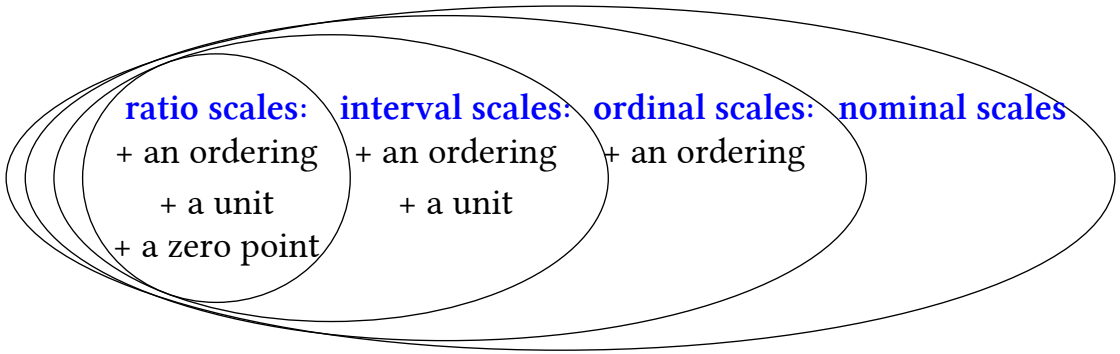
(28) Lucy is taller than Mary (is). **Comparative**

(29) Lucy is as tall as Mary (is). **Equative**

- What kind of scales are assumed in these uses?
  What is the ontological assumption of the degrees involved?
  - Equatives
  - Measurement use
  - Comparatives



Equatives (and the use of *same* and *different*)



- Comparison-related expressions that address whether there are differences
  - The size of the difference is never addressed
- What kind of scales are needed in equatives? Potential hypotheses:
  - ~~Hypothesis 1: interval scales~~ ruled out: no need to measure differences
  - Hypothesis 2: ordinal scales?
  - Hypothesis 3: nominal scales? (see e.g., Anderson and Morzycki 2015)
- Is ordering a necessary element in equatives?

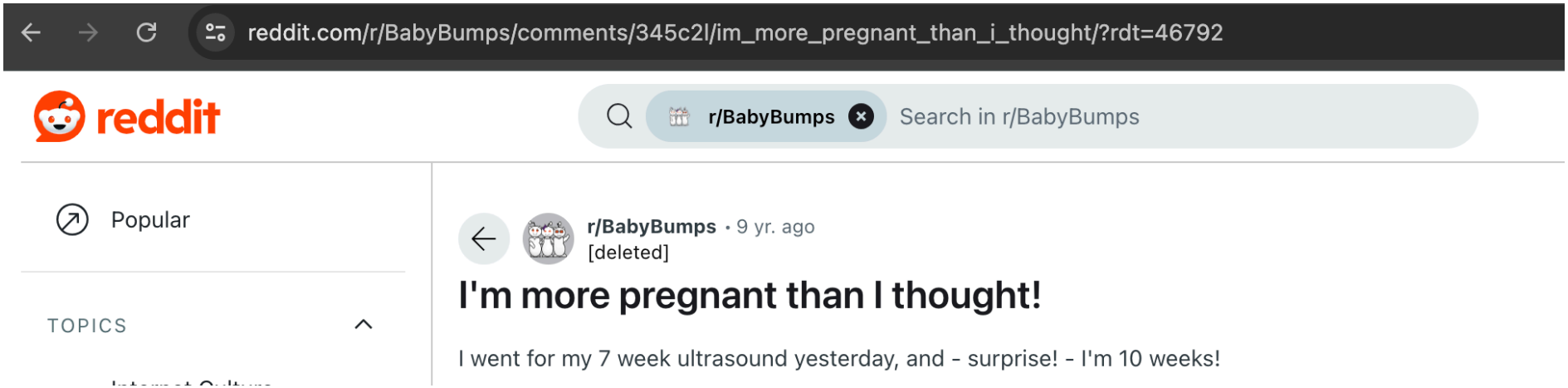
Equatives: Is ordering a necessary element?

- Gradable vs. non-gradable adjectives:
  - Gradable adjectives can have comparative forms and be modified by intensifiers like *very*, while non-gradable adjectives cannot
    - ★ Coercion can be possible under specific context, especially with regard to prototypicality (Rett 2014)

(30)
a. This number is larger than that number. — *large*: gradable
b. ?This number is odder than that number. — *odd*: non-gradable
c. ?3 is primer than 2. — *prime*: non-gradable

(31)
a. This number is very large. — *long*: gradable
b. ?This number is very odd. — *blue*: non-gradable
c. ?3 is a very prime number. — *prime*: non-gradable

Coercion example



Equatives: Is ordering a necessary element?

- Gradable vs. non-gradable adjectives:
  - Gradable adjectives often have antonyms that indicate a change of comparison direction

(32) *long* vs. *short*: antonyms

The below 4 sentences are truth-conditionally equivalent:

a. The Danube is longer than The Rhine.
b. The Rhine is shorter than The Danube.
c. The Rhine is less long than The Danube.
d. The Danube is less short than The Rhine. (pragmatically weird)

(33) *red* vs. *non-red*? *blue*? *white*?

a. ?Blood is redder than wine. (maybe fine as a metaphor)
b. ?Wine is more non-red than blood.
c. ?Sky is more non-red than blood.

- In brief, the meaning of gradable adjectives involves a scale with ordering, but the meaning of non-gradable adjectives does not.

Equatives: Is ordering a necessary element?

- The meaning of gradable adjectives involves a scale with ordering, but the meaning of non-gradable adjectives does not.
- Both gradable and non-gradable adjectives can be used in equatives.

(34) Brienne is as tall as Jaime is.

(35) It was as dead as a stone.

(36) Roses are as red as blood.

- $\rightsquigarrow$ Maybe equatives do not necessarily require a scale with ordering.
  - But intuitively, the latter two examples are qualitatively different from the one comparing heights.

(See Zhang 2020, 2023)

Equatives: Is ordering a necessary element?

- Non-metaphorical vs. metaphorical interpretation of equatives:

(37) Brienne is as tall as Jaime is. $\rightsquigarrow \textsc{height}(B) \geq \textsc{height}(J)$

(There is no evaluativity, i.e., the sentence doesn't entail Jaime is tall.)

(38) Brienne is as tall as a mountain is. ?

(There is evaluativity, i.e., the sentence presupposes that mountains are tall.)

- $\rightsquigarrow$ There are different kinds of equatives

(See Zhang 2023)

Equatives: cross-linguistic observations

- Chinese *gēn/hé* (non-metaphorical) vs. Chinese *xiàng* (metaphorical)

(39) a. yányàn { g ēn / hé } míngmíng yī-yàng gāo
Yányàn { with / and } Míngmíng same tall(-er)
'Yányàn is as tall as Míngmíng (is).' **Non-evaluative, non-metaphorical**

b. % yányàn { g ēn / hé } shān yī-yàng gāo
Yányàn { with / and } mountain same tall(-er)
'Yányàn is as tall as a mountain (is).' **World knowledge violation**

(40) a. yányàn xiàng míngmíng yī-yàng gāo
Yányàn similar Míngmíng same tall(-er)
'Yányàn is similar to Míngmíng in being tall.'
Evaluative: $\rightsquigarrow$ Both Yányàn and Míngmíng are tall.

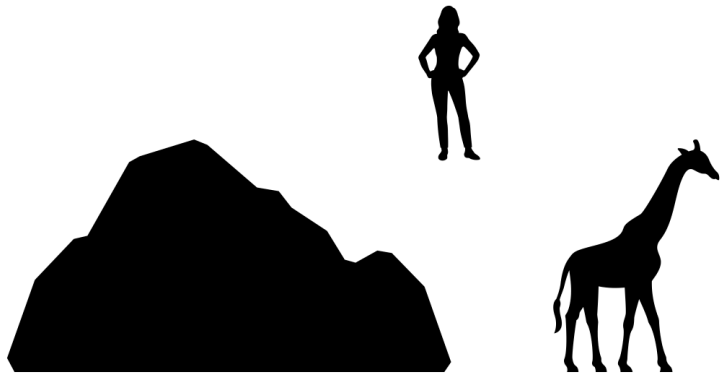
b. yányàn xiàng shān yī-yàng gāo
Yányàn similar mountain same tall(-er)
'Yányàn is as tall as a mountain (is).' **Evaluative, metaphorical**

(See Zhang 2020, 2023)

Equatives: multi-dimensional comparison

- Equatives with a metaphorical meaning express multi-dimensional comparison
  - Not just with respect to a certain, salient property overtly expressed
  - Extra properties of the comparison standard carry over

(41) a. Brienne is as tall as a mountain is.
b. Brienne is as tall as a giraffe is.



(42) a. Roses are as red as blood.
b. Blood is as red as roses.

(See Zhang 2020)

What scales do equatives assume

- Some equatives are based on ordinal scales, i.e., scales with ordering
  $\rightsquigarrow$ Single-dimensional comparison
- Other equatives are based on nominal scales,
  which can support multi-dimensional comparison
  - See also Anderson and Morzycki (2015) ('degrees are kinds') and Moltmann (2009) ('degrees are tropes')

(See Zhang 2020)

Measurement sentences

- Measurement sentences assume ratio scales (i.e., scales with a meaningful, absolute zero point) (Sassoon 2010, Zhang and Ling 2021)

(43) This lecture is 1.5 hours long.
↝ On a scale of temporal length: 0 hours means 'no temporal length'

(44) ?That talk is 20 minutes short.
↝ On a scale of temporal shortness, there is no meaningful zero.

(45) ?Shanghai is 35 degrees Celsius hot.
↝ On a scale of temperature, there is no meaningful absolute zero.
0 degree Celsius does not mean 'no heat'.

(46) ?I arrived at 3 o'clock early.
↝ On a time line, there is no meaningful absolute zero.

Measurement sentences and ratio expressions

(22) ?Shanghai is about 1.5 times as hot as Belgium.
(Context: It's 24 degrees Celsius in Belgium. It's 36 degrees Celsius in Shanghai.)

(23) *I arrived three times as early as John did.
(Context: I arrived at 1 pm, and John arrived at 3 pm.)

(24) The Olympics 2024 is about 6 times as long as that conference.
(The Olympics 2024 is 17 days long, and that conference is 3 days long.)

- These equatives with ratio expressions also assume ratio scales (Sassoon 2010, Zhang and Ling 2021)

(47) Dan is twice as happy as Sam. (Sassoon 2010: (12))
$\rightsquigarrow$ Is there a zero point along a scale of happiness?
$\rightsquigarrow$ Is there a unit along a scale of happiness?

Measurement sentences: cross-linguistic observations

- In Chinese, measurement sentences are expressed like a '*have*' sentence (Zhang 2023, Zhang and Zhang 2024)

(48) a. yányàn yǒu 6 chǐ gāo
Yányàn have 6 foot tall(-er)
Measurement construction: 'Yányàn has 6 feet of height.' ⇝ 'She is 6' tall.'

b. yányàn yǒu 3 pǐ mǎ
Yányàn have 3 CLASSIFER horse
Possession construction: 'Yányàn has 3 horses.'

(49) a. yányàn yǒu duō gāo(er)
Yányàn have many/much/more tall(-er)
Degree q.: 'How much height does Yányàn have?' ⇝ 'How tall is she?'

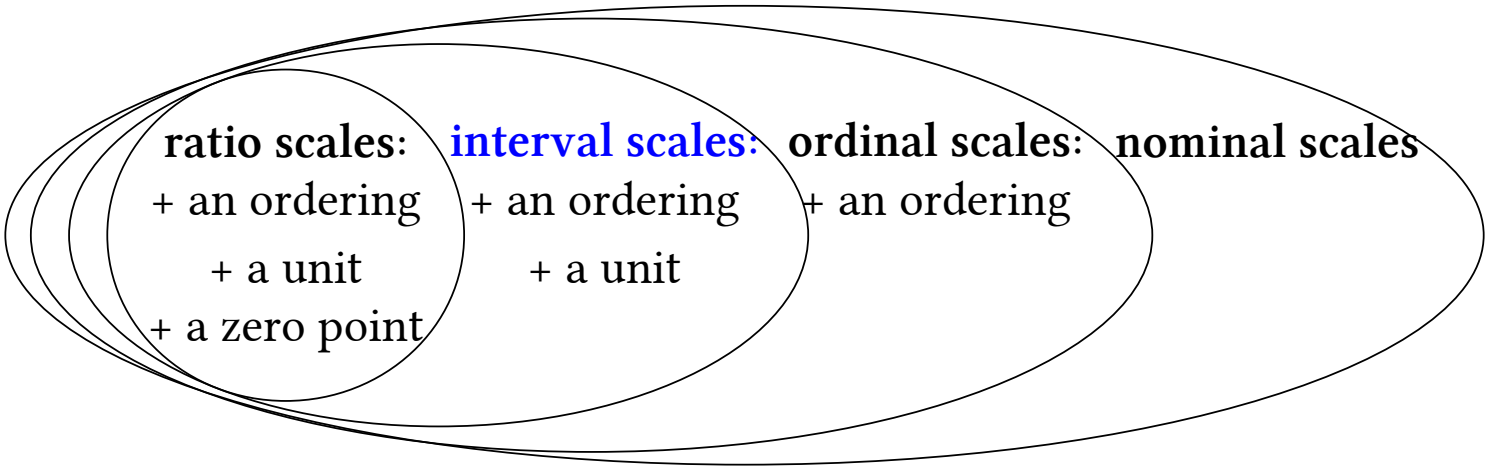
b. yányàn yǒu jǐ chǐ gāo(er)
Yányàn have what-number foot tall(-er)
Degree q.: 'How many feet of height does she have?' ⇝ 'How tall is she?'

c. yányàn yǒu jǐ pǐ mǎ
Yányàn have what-number CLASSIFIER horse
Degree q.: 'How many horses does Yányàn have?'

Comparatives

(21) a. Shanghai is (about 12 degrees) hotter than Brussel.
b. I arrived (2 hours) earlier than John did.
c. I am (1 inch) shorter than Lily is.
d. The Olympics 2024 is (5 days) longer than ESSLLI 2024.

- The measurement of the difference between two degrees along a scale requires a unit $\rightsquigarrow$ an interval scale



(20') I (much / slightly) prefer vanilla-flavored ice cream to lavender-flavored ice cream.

(Is there a measurement of the difference? Is there a unit?)

Equivalence classes: can they capture numerical differentials?

- Equivalence classes: e.g., { 6 feet, Lucy's height, ...} is a set with all items sharing the same value along a scale of height
- Cresswell (1976): Comparatives express the ordering between equivalence classes
- A scale only with ordering but not a unit is insufficient for capturing numerical differentials (see Zhang and Ling 2021):
  - Units like *hours* cannot be derived just from the ordering of equivalence classes like {the scheduled arrival time of a train, 12 o'clock, ...} or {the actual arrival time of a train, 1 o'clock, ...}

(50) She arrived at 10 o'clock, exactly 1 hour earlier than scheduled.

- $\rightsquigarrow$ Numerical differentials represent the measurement of the difference between two values (i.e., two degrees, or two measurements) along an interval scale

Comparatives: cross-linguistic variations

- Li (2015)'s alternative view: starting with the difference between two mass-like objects, and measuring this difference

(51) Context: He read *Anna Karenina* and *The Great Gatsby*, while I read *Anna Karenina*, *The Great Gatsby*, and *Moby Dick*.

a. % wǒ bǐ tā duō dú le { zhè běn shū / Moby Dick}
I BI he many/more read PRF { this CL. book / Moby Dick}
'Compared to what he read, I read something more – { this book / *MD* }.'

b. % tā bǐ wǒ duō dú le { zhè běn shū / Moby Dick }
he BI I few/less read PRF { this CL. book / Moby Dick }
'Compared to what I read, he read something less – { this book / *MD* }.'

Drop the 'interval scale' assumption with Li (2015)'s view?

- Instead of measuring the difference between two measurements along an interval scale, just do the difference between two mass-like items and measure the difference:

(52) Lily read two more books than than I did.
↝ What Lily read minus what I read, and then the difference is measured: 2 books

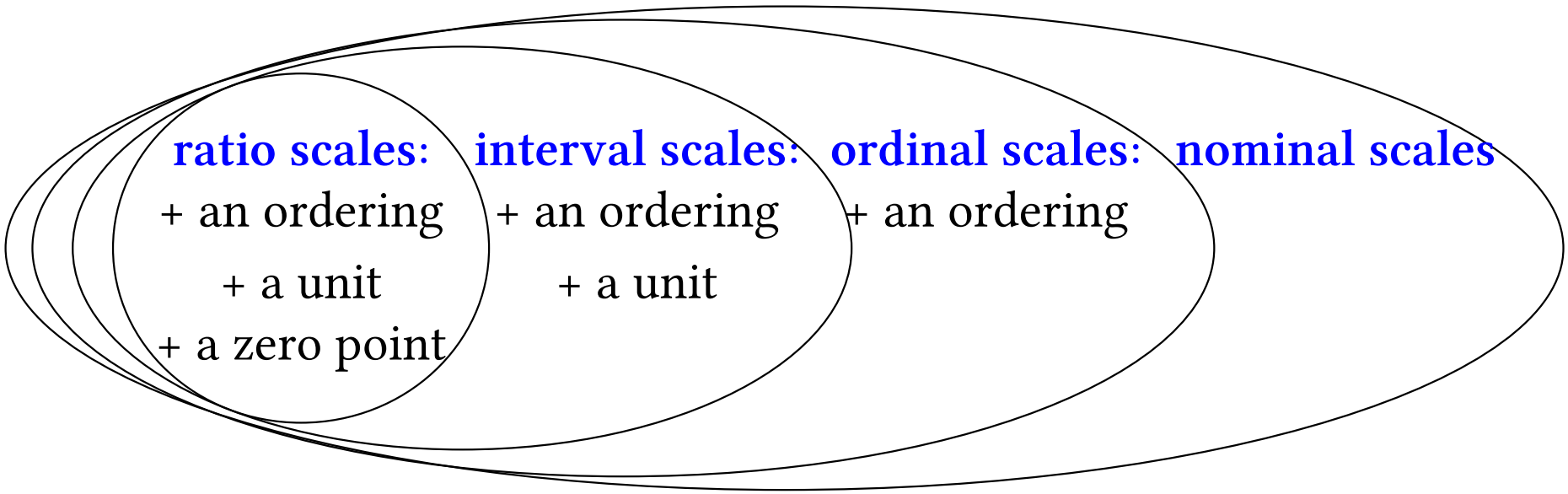
(53) Lily is 1 inch taller than I am.
↝ Lily's height and my height are considered two mass-like items, and the difference is measured: 1 inch

- What scales do measurement sentences assume?
- Another issue:

(54) I arrived 2 hours earlier than John did.
↝ comparing something that represents my earliness and John's earliness? But how about if I was actually late for school, but still two hours earlier than John?

Interim summary

- Ontological assumptions in the uses of gradable adjectives:
  - Equatives: nominal or ordinal scales
  - Measurement sentences: ratio scales
  - Comparatives: interval scales



Outline

Scales and degrees in comparatives

- Measurement means mapping an entity (or an event) to a value along a scale according to rules.
- From now on, we focus on comparatives and use 'scales' to mean interval scales.
- E.g., a scale of height is a totally ordered set of height degrees:

(55) $\{d \mid 5' \leq d \leq 6'\}$
$\rightsquigarrow$ a part of a scale of height / length, including degrees between 5 feet and 6 feet (these two endpoint values are included)

- Degrees are like real numbers
- Most works on comparatives are explicitly or implicitly based on these assumptions: e.g., Seuren (1973), von Stechow (1984), Heim (1985), Kennedy (1999), Schwarzchild and Wilkinson (2002), Zhang and Ling (2021)

Today's take-home messages

- Day 1: Basics of scales and degrees; how they are relevant to natural language
  - What are scales? What are their formal properties? What operators do they support?
- A scale is a set that includes all potential values resulting from a certain way of taking measurement.
- There are 4 levels of scales: nominal scales, ordinal scales, interval scales, and ratio scales.
- Comparatives assume interval scales (i.e., with an ordering and a unit that supports the measurement of differences).

Tomorrow: comparatives and the use of *-er*/*more*

(From *Sapiens: A Graphic History*, Vol.2,
by David Vandermeulen, David Casanave, Yuval Noah Harari, 2021)

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