Talking about Quantity and Number

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1 Introduction

We will survey a range of linguistic constructions that relate to quantity and number in different languages. These phenomena include

- in the **nominal** domain:
  - grammatical number and the singular-plural distinction
  - the count-mass distinction
  - numerals and quantifiers
  - measure constructions and pseudopartitives
- in the **verbal** domain:
  - distributivity and atomicity
  - the atelic-telic distinction
  - transfer of properties from the object to the verb
  - plural and iterative interpretations of verbs

We will also briefly survey numeral systems and approximate interpretations of number words.

2 Grammatical Number

2.1 Basic observations

Number distinctions interface with core grammatical distinctions,
i.e. cannot be left un-expressed (cf. Corbett 2000 for survey).

- Pronouns: *he/she/it* vs.*they*: Extremely frequent
- Nouns: *apple / apples*: Frequent
- Verbs (Iteratives) (*he coughed and coughed*): Relatively frequent
- Verbal agreement: *he is asleep. / they are asleep*: Quite frequent
  Adjectival agreement: *der rote Apfel / die rote-n Äpfel*: Somewhat rare

In this, number is similar to other cognitive categories that interface with language:

- Time of utterance: Tense   Completion: Aspect
- Sortal distinctions: Gender   Speaker role: Person
- Space: Deictic distinctions   Movement: To / from origo point
- Size: Diminutives, Augmentatives   Shape: Classifiers

Observation:

- Number enters grammar more frequently than Tense, Aspect, Gender
- Only Person definitely more frequent than number

2.2 Lack of grammatical number

Pirahã (Mura, Brazil; Everett 2009):

No grammatical number distinction, even with pronouns:

(1)   1st person: *ti*,
2nd person: *gí*
3rd person: *hi*

(2)   *ti gí* 1st + 2nd person inclusive
gí hi 2nd + 3rd person inclusive

(3)   combination with *xaítiso* 'other',
misanalysed as number marker by Sheldon 1988

2.3 Exuberance of grammatical number

Daakie (Oceanic; Vanuatu)

Pronouns:

Person	Singular	Dual	Paucal	Plural
1	ngyo	komoo	kidyee	kemem
1+2		adoo	adyee	et
2	ngyak	kamoo	kamdyee	kimim
3	ngye	koloo	kilyee	ngyee

Possessives:

Person	Sing.	Dual	Paucal	Plural
1	s-ok	s-umoo	s-ememdyee	s-emem
1+2		s-adoo	s-adyee	s-at
2	s-am	s-amoo	s-amdyee	s-amim
3	s-an	s-aloo	s-ayee	s-aa

(4) *Kiyee kiye-m   van lon s-adyee   vale*
   3PC   3PC-REAL go   to   3PC-POSS land
   'They went to their land.'

(5) *vanten kiye   vanten koloo   vanten kiyee   vanten ngyee*
   'the man'   'both men'   'the small group of men'   'the large group of men'

◆ Singular: single entities, compatible with multiple non-animates
◆ Dual: two persons or objects, address and reference to a single respected person
◆ Paucal: small group of persons (subitizing?), group of persons one identifies with;
◆ Plural: more than about five persons, multiple entities

Lexical number in verbs: *idi* 'take one or two objects', *sógó* 'take more than one object'

2.4 Grammatical number and number learning

Evidence for bootstrapping of number learning by grammatical number:

- ◆ English / Russian (Singular / Plural)
  vs. Japanese / Chinese (no firmly established plural):
  Li et al. 2003, Sarnecka et al. 2007
- ◆ English (Singular / Plural)
  vs. Slovenian, Saudi Arabic (Singular / Dual / Plural):
  cf. Almoammer, … Barner 2013

2.5 Generic, Singulative, Portion, Distributive

Bayso (Cushitic, Ethiopia; Corbett & Hayward 1987)

(6) Generic/Unit: *lubán* 'lion'   Singulative: *lubán-titi* 'a lion'
                                        Paucal: *lubán-jaa* 'a few lions'
                                        Pural: *luban-jool* 'lions'

Welsh (Celtic, Great Britain)

(7) Singular: *afal* 'apple'   Plural: *afal-au*
     Collective: *adar* 'birds'   Singulative: *adar-yn* 'a bird'
                 brics 'bricks'   *brick-sen* 'a brick'

Dagaare (Gur, Ghana)

(8) Singular: *bíé* 'a child'   Plural *bíí-ri* 'children'   Distrib. *bie-εε*
     Collective: *bìè* 'seeds'   Singulative: *bí-rì* 'a seed'   Distrib. *bí-εε*
     Sing.mass: *muɔ* 'grass'   Portion: *muɔ-ruu* 'blade of grass' Distrib. *muɔ-εε*
     Sing.mass   *kùó* 'water'   Distrib. *kùó-εε*

Distributive: spatially scattered exemplars

MK

2.6 Augmentation systems

Classical analysis of person markers of Ilocano (Austronesian, Philippines):

(9)

	Singular	Dual	Plural
1st person	-ko	-ta (inclusive)	-tayo (inclusive)
			-mi (exclusive)
2nd person	-mo		-yo
3rd person	-na		-da

Reanalysis by Thomas (1955):

(10)

	Minimal (Restricted)	Non-minimal (Augmented)
[+ Speaker – Addressee]	-ko	-mi
[+ Speaker +Addressee]	-ta	-tayo
[– Speaker + Addressee]	-mo	-yo
[– Speaker – Addressee]	-na	-da

So-called Minimal-Augmented systems, cf. Cysouw 2011

2.7 Occurrence of nominal plurality

World Atlas of Language Structures (Data: M. Haspelmath), feature 34A

○	No nominal plural
○	Only human nouns, optional
●	Only human nouns, obligatory
○	All nouns, always optional
○	All nouns, optional in inanimates
●	All nouns, always obligatory
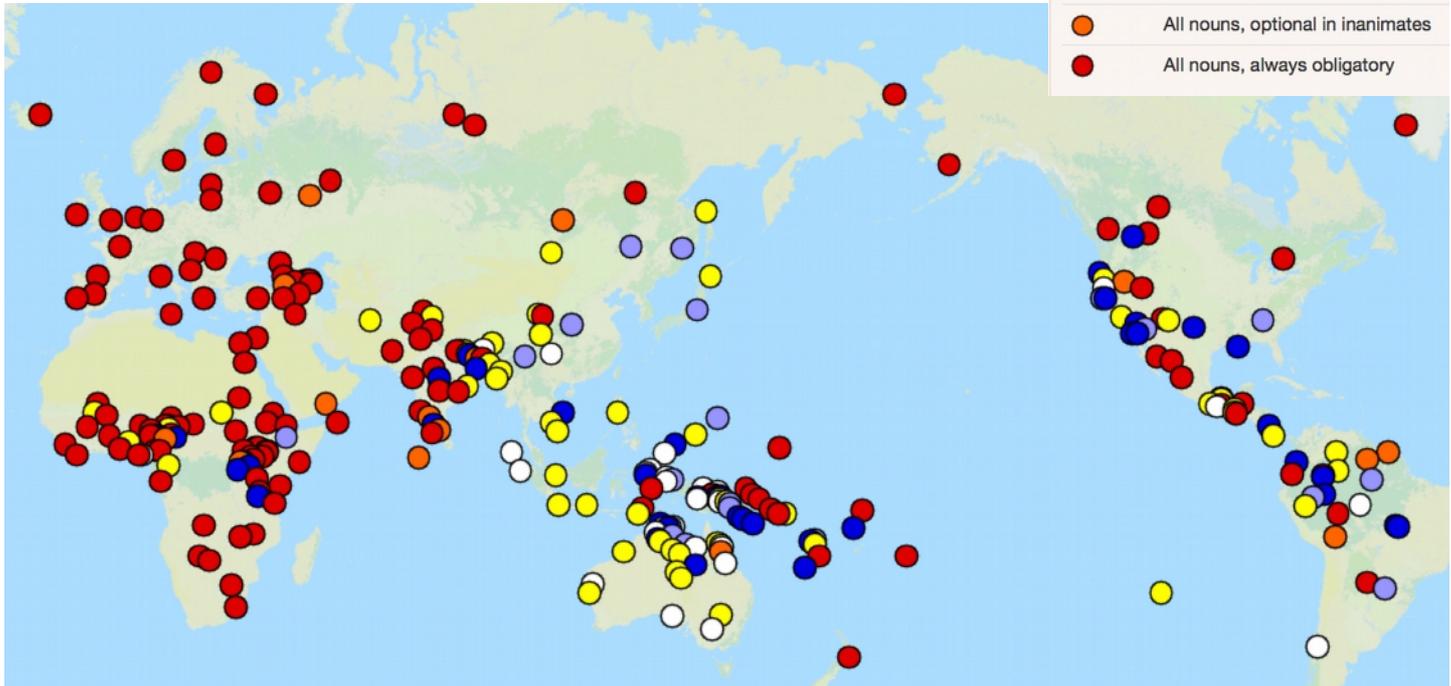
3 Mass / Count distinction

Cf. Doetjes 2012 for overview.

3.1 Syntactic properties of Mass/Count distinction

Formation of morphological forms:

(11) Plural forms in English: *apple / apple-s*, but: *gold / *gold-s*

(12) Plural or singulative forms in Welsh (similarly in Dagaare):
afal / afal-au 'apple/s', *ader-yn / adar* 'bird/s' but: *llefrith* 'milk', only one form

Combination with numerals:

(13) With agreeing plural in English:
*one apple, *one gold, two apple-s, *two gold(s)*

(14) Without agreeing plural in Turkish:
bir elma 'one apple', *iki elma* 'two apples', *elmalar* 'apples', **iki elmalar*

Combination with certain quantifiers:

(15) *each apple, *each gold, (*) much apple, much gold*

Bare singular nouns as full noun phrases:

(16) *There was gold / (*) apples on the table.*

3.2 Semantic properties of the mass/count distinction?

Apparent semantic arbitrariness of the mass/count distinction:

(17) *leaf, leaves*: Count, *foliage*: Mass
      German *Laub*: Mass
      hair: Mass, French *cheveux*: Count.

Possible shifts between classes:

(18) a. *There was chicken all over the floor.*   (Universal grinder)
      b. *We ordered three beers.*   (Universal packager)

Hypotheses:

◆ Mass / Count is semantically arbitrary (Chierchia 2010)
◆ Mass / Count just depends on syntactic context (Borer 2005)

Arguments against arbitrariness

◆ Substances are universally mass,
   small grain items more likely mass (cf. rice vs. beans)
◆ Grinder / packager: Coercion, e.g. to meat of animal; not always possible
◆ Arbitrariness would constitute a learnability problem

3.3 Semantic correlations of the mass/count distinction

Smith-Stark 1974: Animacy scale

(19) inanimate < animate < human < rational < kin < addressee < speaker
    no sg/pl distinction   sg/pl distinction

Grimm 2012: Scale of Individuation

(20) liquids/substances < granular aggregates < collective aggr. < individual entities

Relation to coding strategies in English, Welsh, Dagaare:

Language	liquids/ substances	granular aggregates	collective aggregates	individual entities
Dagaare	0	0/Singulative (–*ruu*)	0/Singular (–*ri*)	0/Plural (–*ri*)
Welsh	0	0/Singulative (–*yn*)		0/Plural (–*od*)
English	0		0/Plural (–*s*)	

Wierzbicka (1988), Middleton e.a. (2004): Types of interaction

(21) Berries: Sg vs. Mass in Polish (plucking vs. selling)

3.4 Special interpretations of plurals

In some languages, mass nouns can be pluralized, but with a special meaning e.g. Greek (Tsoulas 2006, Kouneli 2015):

(22) *I   baniera ine gemati   **nera***
   the bathtub is   full   water.acc.**pl**
   'There is water all over the bathtub's surface.'

(23) *I   baniera ine gemati   **nero***
   the bathtub is   full   water.acc.**sg**
   'The bathtub is full of water.'

Plural mass nouns can have special interpretations. Kouneli 2015 reports that the plural very strongly implicates that the bathtub is not full of water, while the singular sentence "can be true either when the bathtub contains water or when there is water scattered on the bathtub's surface, with the former reading being the salient one."

In Nez Perce (Penutian, USA): mass nouns referring to quantities (Deal 2013):

(24) a. *k'uyc heecu*   b. *yi-yos-yi-yos mayx*
       nine   wood   PL-blue   sand
       'nine pieces of wood'   'quantities of blue sand' (lit.: 'blue sands')

Similar for Yudja (Tupi, Brazil) (Lima 2012)

4 Formal semantic theories

4.1 Sum individuals and plural

(Cf. review article of Champollion & Krifka, to appear. ling.auf.net/lingbuzz/002099).

To formally represent the meaning of grammatical number and related phenomena, semantics use lattice-like algebraic structures provided by **mereology.** Complete boolean algebras with the bottom element removed.

The small circles here stand for the children Tom, Dick, and Harry, our *atomic individuals*.

The large circles are *sums*: formal objects that represent pluralities of children.

The binary *sum operation,* ⊕, is taken to be associative, commutative, and idempotent.

The lines indicate the *parthood relation* ≤, a partial order (reflexive, transitive, and antisymmetric).

Fundamental assumption in mereology: any nonempty set of things of the same sort (e.g. individuals, events) has one and exactly one sum. The sum operation coincides with the notion of *least upper bound.*
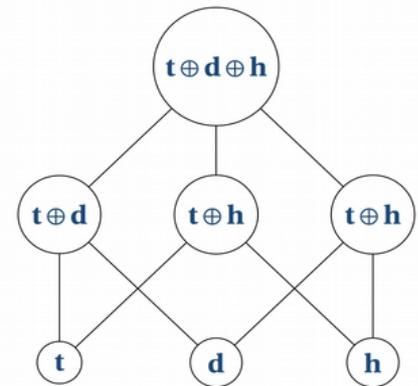
4.2 Formal Theories of Mass / Count distinction

Various proposals for the mass / count distinction

◆ Count nouns: mereology with atoms,
Mass nouns: atomless mereology
Numerals count atoms,
Plurals: individuals with ≥2 atoms
(Link 1983, Chierchia 2008)
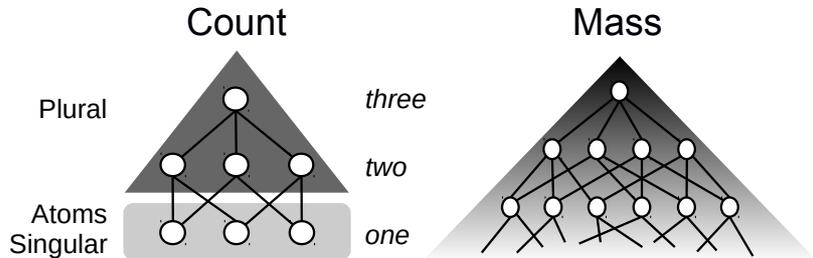
◆ Count nouns: clear, relevant atoms
Mass nouns: atoms too small, irrelevant

rice

◆ Count nouns: precise, non-overlapping atoms
Mass nouns: vague, overlapping atoms

apple, apples

ratatouille

- "Object mass nouns" like *silverware, luggage, furniture, jewelry, mail* involve reference to inherently individuable and countable entities
- as opposed to "substance mass nouns" like *mud, space, water*

(Who has more silverware?) *(Who has more shoes?)* *(Who has more toothpaste?)*
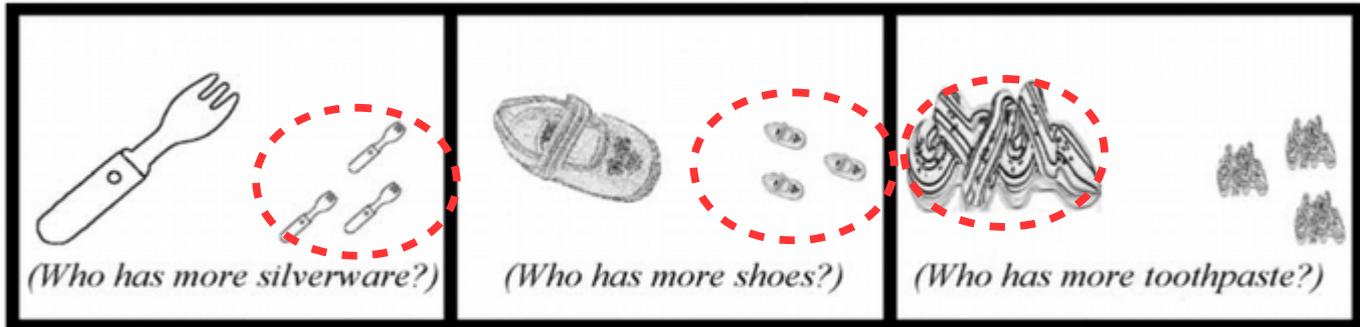
Linguistic evidence: Quantity judgments (Barner and Snedeker 2005)

4.3 Meaning of plural

Assumption: Plural denotes sums of ≥2 entities (Link 1983, Chierchia 2008). But:

(25) A: *Do you have children?* – B: *Yes, one. /* #*No, just one*.

Hence: Plural includes atomic entities:

(26) ⟦*child*⟧ = {x | x is a child}
⟦*children*⟧ = {x | x is a plurality of one or more children}

Scalar implicature in case of assertions:

(27) *I have children.* Meaning: 'I have one or more children'
Not said: *I have a child*, Meaning: 'I have one child.'
Implicated: 'I have two or more children.'

Plural

Singular

Plural as semantically unmarked – but morphologically marked.

Meaning of plural may be restricted to ≥2 entities in other languages, e.g. Indonesian:

(28) *Sudah punya anak /* # *anak-anak?*
have   you   child / children
'Do you have children?'

For distributive plurals (cf. Scott 2012):
Combination of mereological with topological notions (connected wholes).
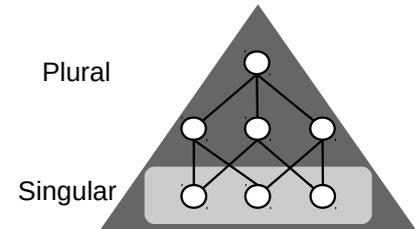
5 Measuring and Counting

5.1 Measure constructions (pseudo-partitives)

Different types of measure constructions:

◆ Container measures (container: count noun):

(29) *three glasses of beer, three baskets of apples*

◆ Abstract measures (usually no plural in German):

(30) *three liters of beer, three pounds of apples*

(31) *drei Liter Bier, drei Pfund / *Pfund-e Äpfel* (but: *drei Elle-n / *Elle Tuch*)

Based on extensive, additive measure function:

◆ If $m(x) = n$ and y is a proper part of x, then $m(y) < m(x)$

◆ $m(x \oplus y) = m(x) + m(y)$, if x, y do not overlap

(32) ⟦*three liters of beer*⟧ = {x | x ∈ ⟦*beer*⟧ & liter(x) = 3}

Not possible with extensive measure functions:

(33) **thirty degrees Celsius of water*
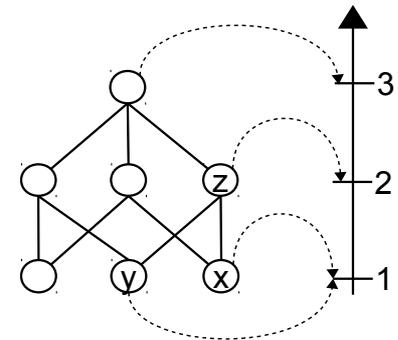
5.2 Classifier construction

Example, English:

(34) *fifty head of cattle*

Predominant in classifier languages, e.g. Mandarin Chinese:

(35) *san   ge   pingguo*
three   CL   apple   'three apples'

Unlike measure nouns, classifiers need not create the unit but can merely name it when it is already provided by the noun (e.g., Cheng & Sybesma 1999).

Krifka (1989): Natural Unit, NU

(36) ⟦*pingguo*⟧ = APPLE, atomic and sum apples, also parts of apples
⟦*ge pingguo*⟧ = function n → {x | x ∈ APPLE ∧ NU(APPLE) = n}
⟦*san ge pingguo*⟧ = {x | x ∈ APPLE & NU(APPLE)(x) = 3}

Syntactic differences measure / classifier also in classifier langauges, hence: classifier languages also have a mass / count distinction.

(37) *san   ba   (de)   mi*
three   handful   LINKER rice 'three handfuls of rice'

5.3 Occurrence of classifer languages

WALS, Data: David Gil, Feature 55A
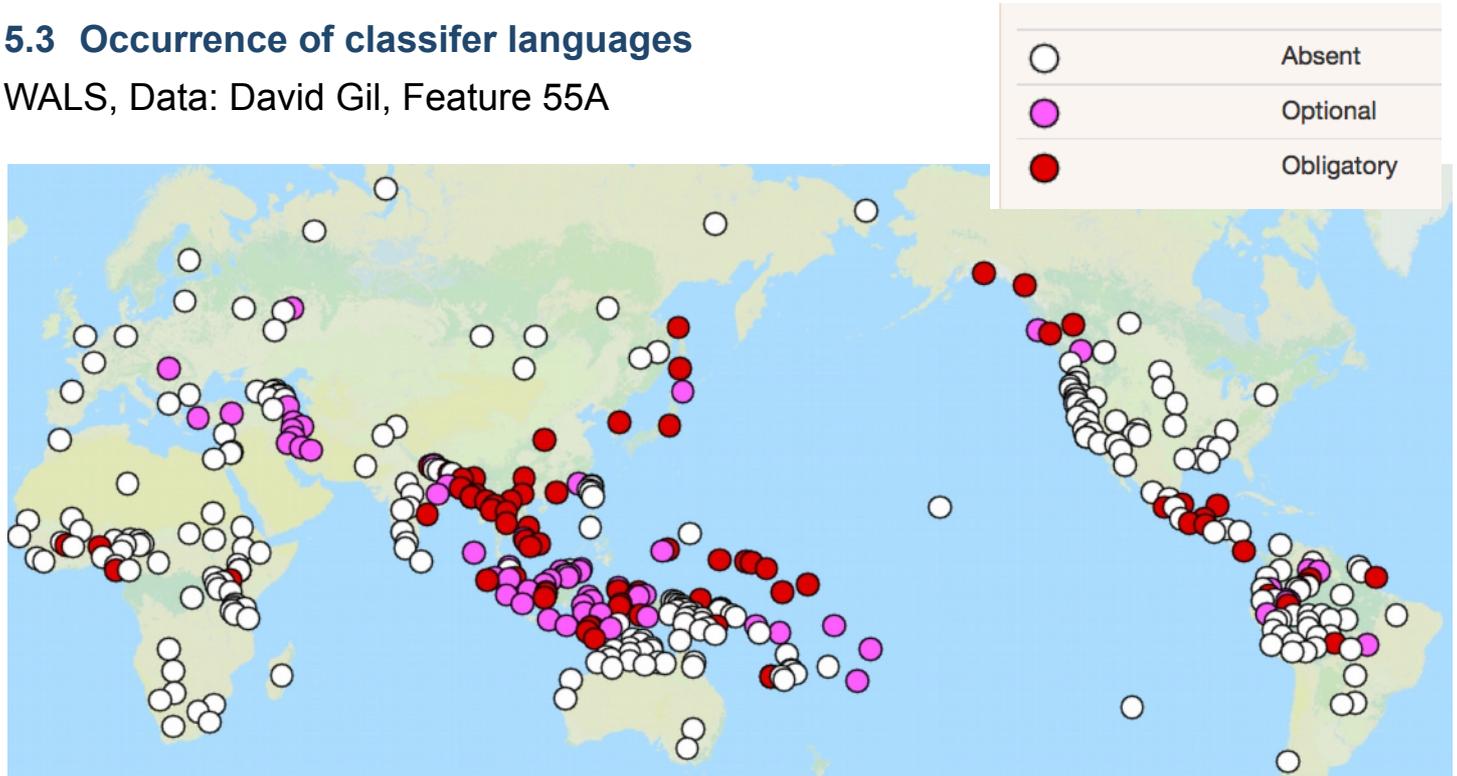
5.4 Count noun construction

Count noun constructions

(38) *three apples*

Krifka (1989): Count nouns have built-in reference to natural unit

(39) $\llbracket apple \rrbracket$ = function n → {x | x ∈ APPLE ∧ NU(APPLE) = n}
   $\llbracket three\ apples \rrbracket$ = {x | x ∈ APPLE ∧ NU(APPLE) = 3}

Distinction between Mass Nouns / Count Nouns:

◆ For all count nouns, a natural unit must be defined
◆ There may be nouns that have a natural unit but which is not part of their meaning
   (e.g., *silverware*)
◆ Mass nouns may be endowed with a situation-specific natural unit
   (e.g., *three beers*).

6 Cumulativity, Divisivity, Quantization, Stratification

6.1 Definitions
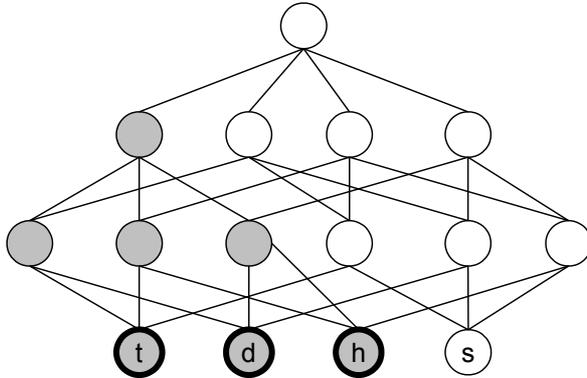
The grey circles form a **cumulative** set
(and also a **divisive** set)
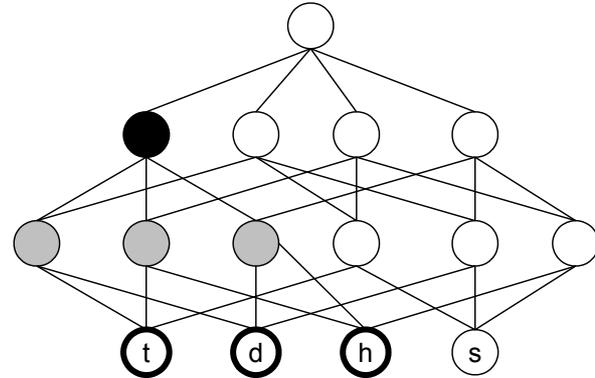
The grey circles form a **quantized** set
(and so do the fat circles t, d, h)

P is **cumulative** if and only if whenever P holds of two things, it also holds of their sum

P is **divisive** if and only whenever P holds of something, it also holds of all of its parts

P is **quantized** if and only if whenever P holds of something, it does not hold of any of its proper parts

6.2 Cumulativity and divisivity

Various authors have identified the properties of mass and plural terms with the notion of **cumulative reference**

◆ if two things are gold then their sum is also gold (see Quine, 1960)
◆ if you add some horses to other horses, you again get some horses (Link, 1983)

Divisive reference has also been proposed to describe mass terms

◆ any part of anything which is gold is also gold (see Cheng, 1973)

This assumption must be qualified, because of the minimal-parts problem:

◆ a hydrogen atom as part of an H_2O molecule does not count as water
◆ a portion of a ratatouille may contain pieces of tomato which do not count as ratatouille

Most semanticists accept that mass nouns do not in general have divisive reference

Stratified reference (Champollion, 2015) generalizes divisive reference by adding two parameters and preventing it from applying below a **threshold ε** on some **dimension**:

◆ anything which is gold is made up of **ε-heavy** parts which are also gold

6.3 Quantization

Singular count nouns are often assumed to be interpreted as **quantized** sets:

(40) S is quantized if and only if the following holds:
 If $x \in S$ and y is a proper part of x, then $y \notin S$

◆ If we consider count nouns as applying to **atoms**, quantization follows vacuously
◆ If not, quantization is often plausible (a proper part of a chair is not a chair).
 But what about *twig, rock,* or *sequence?*
◆ Maybe when the context is fixed, each of these nouns denotes a quantized set in
 that context (see Chierchia, 2010; Rothstein, 2010).

Quantized predicates can also be constructed via **extensive measure functions**:

(41) ⟦*three liters of beer*⟧ = {x | x ∈ BEER ∧ LITER(x) = 3} is quantized,
 as LITER is an extensive measure function.

(42) ⟦*three apples*⟧ = {x | x ∈ APPLE ∧ NU(APPLE)(x) = 3} is quantized,
 as NU(APPLE) is an extensive measure function.

6.4 Maximization

The top entity, t⊕d⊕h, is **maximal** within the set of entities that form this structure.

Definite descriptions are not predicates, but referring expressions (hence not cumulative).

If Tom, Dick, and Harry are the only boys, "*the boys*" and "*the three boys*" refer to this entity.

⟦ *the boys* ⟧ = ⟦ *the three boys* ⟧ = t⊕d⊕h

Suppose that Tom and Dick are good boys, and Harry is bad.

⟦ *the good boys* ⟧ = t⊕d

⟦ *the bad boy* ⟧ = h

The **definite article,** *"the",* picks out the maximal entity within the entities that satisfy the predicate denoted by its complement.

That maximal entity must itself satisfy the complement, on pain of failure of reference:

⟦ *the boy* ⟧ = ⟦ *the good boy* ⟧ = ⟦ *the bad boys* ⟧ = ⟦*the two boys*⟧ = <failure>
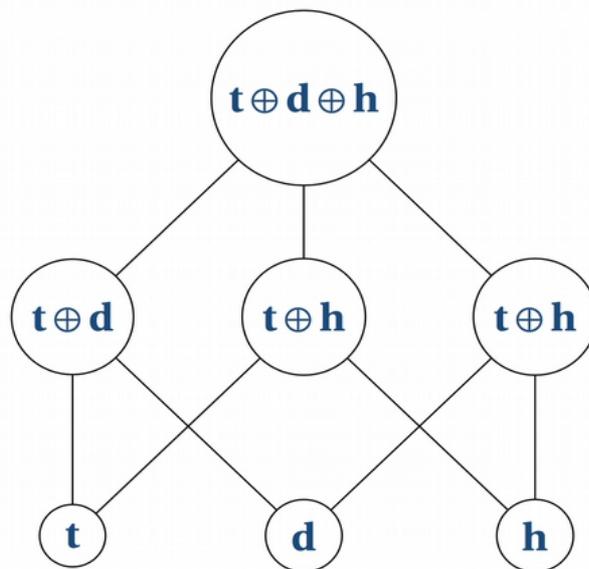
6.5 Cumulativity / quantization and syntax

Basic nominal predicates are cumulative:

(43) [$_{NP}$ *milk*]
     [$_{NP}$ *cattle*]

They can be made quantized with a measure / classifier construction
(cf. Borer 2005 for syntactic projections like #P, number phrases)

(44) [$_{\#P}$ *three* [$_{\#'}$ *liters of* [$_{NP}$ *milk]]*
     [$_{\#P}$ *fifty* [$_{\#'}$ *heads of* [$_{NP}$ *cattle*]]]

Singular count nouns are not basic, but have an argument position for number:

(45) [$_{\#'}$ *apple*⟧
     [$_{\#P}$ *one* [$_{\#'}$ *apple*⟧

Agreement plural in English (not in Turkish)

(46) [$_{\#P}$ *three*$_{+PL}$ [$_{\#'}$ *apple-s*]$_{+PL}$]
     [$_{\#P}$ *one point zero* $_{+PL}$ [$_{\#'}$ *apple-s*]$_{+PL}$]

Semantic plural in English (and Turkish)

(47) [$_{\#P}$ ∅ [$_{Num'}$ *apple-s*]], or [$_{\#P}$ [$_{\#'}$ *apple*] -s]

7 Verbal predicates

7.1 Distributivity and atomicity

Each accesses the atomic part of a sum:

(48) *The boys ate two sausages each*. (= Each boy ate two sausages.)

(49) **John ate two sausages each*.

German:

(50) *Die Jungen aßen jeweils zwei Würstchen*.
     The boys   ate   DIST   two   sausages.
     'The boys ate two sausages each.' / '… on each occasion.'

(51) *Johann aß jeweils zwei Würstchen*.
     Johann   ate DIST   two   sausages.
     'Johann ate two sausages on each occasion.'

German *jeweils* cannot be used as a determiner:

(52) **Jeweils Junge aß   zwei Würstchen.*
     DIST   boy   ate two   sausages.

Generalization (Zimmermann 2002, Champollion 2016): Distributive items that can also be used as determiners can only distribute over individuals, not over occasions.

7.2 Plurality with verbal predicates

Verbs are not pluralized even when adverbials ensure they describe multiple events:

(53) *John cougheds three times, *John wents by repeatedly*

Other languages use overt iterative or pluractional operators in such cases.

The semantic plural on English verbs appears to be silent.

Semelfactives (*John coughed)* all have activity interpretations (*John coughed for 5min)*

Assume event-based semantics (Davidson 1967) with thematic roles (Parsons 1990).

English verbs are **cumulative** (if V applies to two events, V also applies to their sum).

Thematic roles are "pointwise" cumulative (the agent of the sum of two events is the sum of their agents).

Cumulativity of verbs and their roles accounts for inferences about plural individuals:

(54) *John saw Mary.* $\qquad$ $\text{see}(e_1)$ & $\text{ag}(e_1, j)$ & $\text{th}(e_1, m)$

(55) *Bill saw Sue.* $\qquad$ $\text{see}(e_2)$ & $\text{ag}(e_2, b)$ & $\text{th}(e_2, s)$

(56) *John and Bill saw Mary and Sue.* $\text{see}(e_1 \oplus e_2)$ & $\text{ag}(e_1 \oplus e_2, j \oplus b)$ & $\text{th}(e_1 \oplus e_2, m \oplus s)$ $\qquad$ LC

7.3 Atelic-telic opposition

The count-mass and singular-plural opposition is related to the telic-atelic opposition:

◆ **Telic** predicates: *build a house, eat ten apples, run to the store*
(≈ you need to reach a set terminal point in order to have X-ed)

  ○ compatible with *in an hour,* incompatible with *for an hour*

◆ **Atelic** predicates: *walk, sleep, eat apples, run, run towards the store*
(≈ as soon as you start X-ing, you have already X-ed)

  ○ compatible with *for an hour*, incompatible with *in an hour*

Divisive reference has been used to formally capture the notion of atelicity

- any part of any walking event is itself a walking event

Again the minimal-parts problem: some parts may be too small to count as walking

Stratified reference (Champollion, 2015) generalizes divisive reference by adding two parameters and preventing it from applying below a **threshold ε** on some **dimension**:

- any walking event is made up of **ε-brief** parts which are also walking events
- but an eat-ten-apples event will not have this property: it is **quantized**

7.4 Transfer of properties from the nominal to the verbal domain

Some verbs, like *borrow,* are atelic no matter what objects they combine with:

(57) *John borrowed { books / money / three books } for a week.*

For others, like *eat,* quantized objects will lead to quantized (and hence atelic) VPs:

(58) *John ate { apples / applesauce / *three apples } for an hour.*

Object	Object property	VP	VP property
apples	stratified	*eat apples*	stratified
applesauce	stratified	*eat applesauce*	stratified
three apples	quantized	*eat three apples*	quantized
three pounds of apples	quantized	*eat 3 pounds of apples*	quantized

Dowty (1991), Krifka (1998), a.o. explains this transfer of properties:

- *eat* is an **incremental-theme verb:** as you progress through the eating event, you gradually progress through its theme (the object that gets eaten)
- *borrow* is a **holistic-theme verb:** each part of the event involves the whole theme

8 Numeral Systems

Hammarström (2007), for cardinal numerals:
Spoken expressions that denote the exact number of of objects, for an open class of objects in an open class of situations for the whole speech community.

Specialized systems for particular objects (e.g. coconuts), sirtuations (e.g. bride price)

8.1 Attested systems

– No number words above one (Amazonia)
– 1,2,many systems (500-1500 lg): Australia, SE Asia, PNG, S America, N America
– Base 3 systems: (PNG, S America) – rare
– Base 4 systems: N,S America, PNG, Africa
– 5,25 system: Gumatj (Australia)
– 5-10-20 systems: several thousand lg.
– 6-based systems: Frederick Hendrick Island, PNG
– 8-based systems: Pame, Mexico (spaces between fingers)
– 12-based systems (West Africa: Plateau lg., Maledives)
– 15-based system (Huli, PNG)

Hybrid systems with mixed bases:
e.g. – 5,10,20,80: Supyire (Gur, West Africa), 10-20-40-80: Mangareva (Oceanic)

8.2 Numeral bases

WALS (B. Comrie), Feature 131A

Legend:
- Decimal
- Hybrid vigesimal-decimal
- Pure vigesimal
- Other base
- Extended body-part system
- Restricted
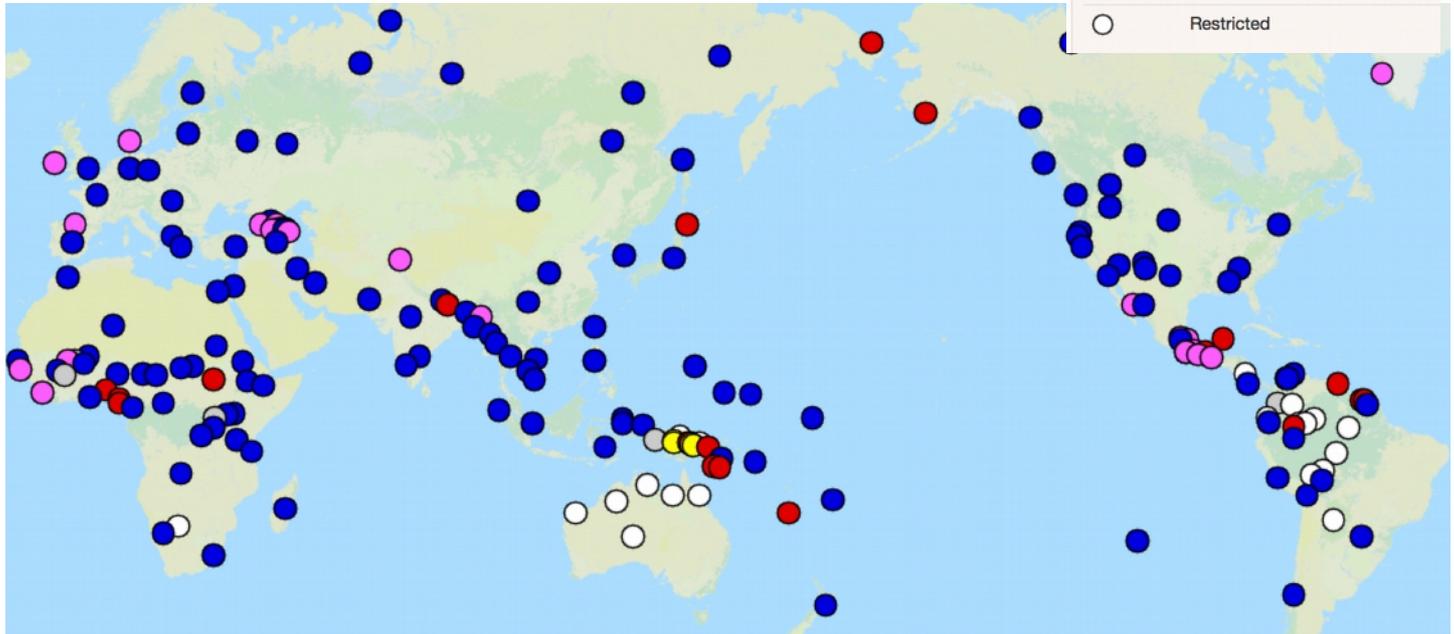
8.3 Word formation of numerals

In unnrestricted numeral systems:

◆ **Recursivity** of language (Chomsky, Hauser, Fitch 2002)
◆ meets **infinity** of numbers

Word formation processes in numeral systems:

◆ Conjunction: *zwei-und-dreißig*
                thirty-two
◆ Subtraction: *duodeviginti* '18' – XVIII
               undeviginti '19' – IXX
◆ Multiplication: *five-hundred*
◆ Derivation: *seven-teen*
              seven-ty
◆ Suppletion: *eleven, twelve*

Accent patterns and modification:

(59) PERSONEN-*auto*   'person car', a sp*e*cial car for pers*on*s

(60) *ZWEI-und-dreißig* (32) – a special type of 30
     ZWEI-hundert (200) – a special type of 100

8.4 Beyond cardinals

Ordinal numbers
– derived from cardinals in spite of learning numbers in counting sequence

(61) *first, second, thirth, four-th, fif-th, …*

Distributive numbers
– often expressed by reduplication

(62) *The ants go marching two-by-two.*

8.5 Precise / approximate interpretations

Street sign in Kloten, Switzerland

Observation: numerals based on multiples of the base
can be interpreted in an approximate way.

(63) *There were fifty people in the audience.* (precise)

(64) *There were fourty-seven people in the audience*. (exactly)

Explanation in terms of granularity of representation (Krifka 2007):

◆ Numeral systems offer different levels of granularity:

(65) Coarse scale: `10 ----- 20 ----- 30 ----- 40 ----- 50 ----- 60 ---- …`

  Middle scale: `…30—35--40--45--50--55--60…`

  Fine scale: `…47-48-49-50-51-52-53-…`

◆ Representation of actual number by the closest scale point:

(66) Let's say that there were 47 people in the audience.

  Actual event: `47`

  Fine scale: `40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-`
  Middle scale: `40-------------45-------------50-------------55-------`
  Course scale: `40--------------------------50---------------------`

◆ Pragmatic principle: The coarsest scale that contains the scale point is preferred.

Reason for preference of coarsest scale point: Strategic communication (Parikh 1991):

◆ Choose the most likely interpretation!

(67) *Every ten minutes a man gets mugged in New York.*
    i. the same man
    ii. different men ✓

◆ The coarsest scale is compatible with the most possible situations:

(68) Message: *fifty*

```
Fine scale:    40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-
Middle scale:  40-------------45-------------50-------------55-------
Course scale:  40-------------------------------50-------------------------
```

Evidence:

◆ Relative frequency of number words in languages (e.g. Dehaene & Mehler 1992; here; British National Corpus, Hammarström 2004):
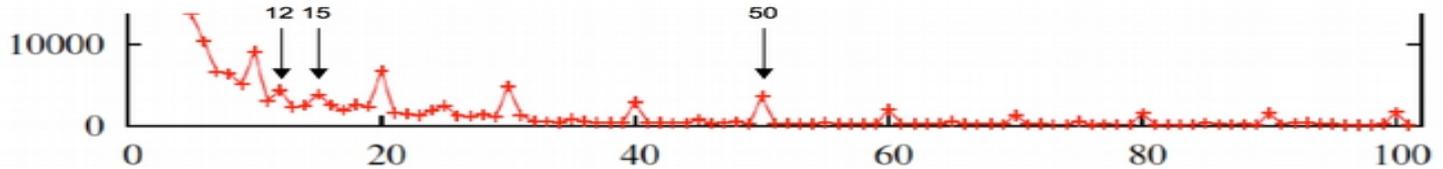
◆ This depends on the language in question (cf. Krifka 2007):

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

◆ Morphological effects; e.g. *five, nine* [ai] but *fifteen, fifty* [i] vs. *nineteen, ninety* [ai]

9 Quantifiers

9.1 What are quantifiers?

Determiners (Det): *all, some, two, no, every, many, few, more than half the*, etc.

Noun phrases (NP): *some poets, all men, no boy, more than half the men*, etc.

Generalized quantifiers (GQ): the interpretations of these NPs,
viewed as sets of properties (Barwise and Cooper 1981)

The notion of a GQ generalizes the standard quantifiers of modern logic, $\forall$ and $\exists$.

We can view the meaning of a NP as a set of properties:

(69) ⟦*something*⟧ = { P : P is a property that holds of something } = { P : $\exists x.P(x)$

⟦*everything*⟧ = { P : P is a property that holds of everything } = { P : $\forall x.P(x)$ }

⟦*most things*⟧ = { P : P is a prop. that holds of most things }   = { P : $|P| > |U - P|$ }

Likewise, we can view the meaning of a Det as a set of pairs of properties:

(70) ⟦*some*⟧ = { ⟨A,B⟩ : $A \cap B$ is nonempty }

⟦*no*⟧   = { ⟨A,B⟩ : $A \cap B$ is empty }

⟦*every*⟧ = { ⟨A,B⟩ : $A \subseteq B$ }

⟦*most*⟧ = { ⟨A,B⟩ : $|A \cap B| > |A - B|$ }

We can analyze numerals as if they were determiners:

(71) ⟦*three*⟧ = { ⟨A,B⟩ : |A ∩ B| ≥ 3 }

But syntactically, they are more like adjectives than like determiners:

(72) *the three apples ~ the green apples*

We can analyze numerals and adjectives in similar terms:

(73) ⟦*green*⟧ = { A : A is a green thing or a sum of green things }

⟦*three*⟧ = { A : A is a sum of three things }

⟦*apples*⟧ = { A : A is a sum of apples }

⟦*green apples*⟧ = ⟦*green*⟧ ∩ ⟦*apples*⟧ = { A : A is a sum of green apples }

⟦*three apples*⟧ = ⟦*three*⟧ ∩ ⟦*apples*⟧ = { A : A is a sum of three apples }

9.2 Proportional quantifiers: most / more than half

Are they equivalent?

(74) *Most Americans have broad-band internet access*.

(75) *More than half of Americans have broad-band internet access*.

Solt (forthc.), Hackl 2009:

- *More than half* is used if the proportion is closer to 50%,
  if the proportion is well-known
- *Most* is used if the proportion is definitely higher than 50%,
  if it is not well-known.

(76) *Most / *More than half of the teens want to fit in*.

Explanation:

- *More than half* requires ratio scale:
  $\#(A \cap B) > \#(A) / 2$
- *Most* requires size comparison between
  $\#(A \cap B) > \#(A - B)$

The cognitive requirements for these two processes
are different, leading to different distributions of *more* and *more than half*.
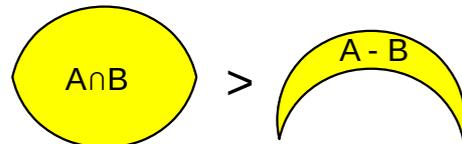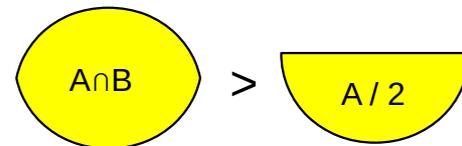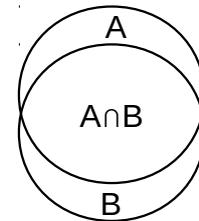
10 Summary

We have surveyed a range of linguistic constructions that relate to quantity and number in different languages. These phenomena include

- in the **nominal** domain:
  - grammatical number and the singular-plural distinction
  - the count-mass distinction
  - numerals and quantifiers
  - measure constructions and pseudopartitives
- in the **verbal** domain:
  - distributivity and atomicity
  - the atelic-telic distinction
  - transfer of properties from the object to the verb
  - plural and iterative interpretations of verbs

We have also briefly surveyed numeral systems and approximate interpretations of number words.

Thank you!

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