Cardinality in counting & measurement: evidence for two systems in Bangla*

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1. Overview

In Bangla, cardinality expressions with numerals and *many* appear in two forms: with and without the particles –*Ta* and –*gulo* (classically considered numeral classifiers).

In this paper we explore the interpretational effects of this alternation, observing that the absence of these morphemes yields a cardinality expression that **cannot be counted with precision.**

Analysis:

- We develop an approach to the syntax and semantics of container/measure pseudopartitives ("two bottles of wine"), and extend it to simple cardinality expressions such as *many boys*.

- We propose that properties underlying this ambiguity explain the interpretational and distributional differences between cardinality expressions with–*Ta/-gulo* and those without.

Organization of the talk:

Section 2: an empirical observation about Bangla
Section 3: overview of theoretical proposal
Section 4: how the proposal explains the Bangla data
Section 5: conceptual support from findings in the cognitive sciences, and empirical support from Bangla

2. The data

The equivalent to *many* in Bangla is *Onek;* similar to measure phrases, bare *Onek* has a cross-categorial distribution:

(1) ami Onek meye-ke nemontonno korechhi.
I Onek girl-acc invite did
'I invited a lot of girls.'

(2) ami Onek lOmba.
I Onek tall
'I am very tall.'

(3) ajke Onek briSTi hoyechhe.
today Onek rain happened
'It rained a lot.'

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Nominal *Onek* can also combine with *-gulo* (with count nouns) or *–Ta* (mass nouns). Numerals are (usually) accompanied by *–Ta.*[1]

(4) ami Onek(-Ta) pauMruTi kheyechhi.
I Onek(-Ta) bread ate
'I ate a lot of bread.'

(5) ami Onek(-gulo) apel kheyechhi.
I Onek(-gulo) apple ate
'I ate a lot of apples.'

(6) ami tin-Te apel kheyechhi.
I three-Ta apple ate
'I ate three apples.'

Absent these morphemes, cardinality constructions are allowed but have a peculiar characteristic: they necessarily denote quantities that cannot be precisely counted.

For example, *-Ta* can be omitted with large, round numbers, but is mandatory with large precise numbers:

(7) a. michhil-e 100/300/5000 chhele eSechhilo.
rally-loc 100/300/5000 boy came
'100/300/5000 boys came to the rally.'

b. ? michhil-e 100/300/5000-Ta chhele eSechhilo.
rally-loc 100/300/5000-Ta boy came
'100/300/5000 boys came to the rally.'

(8) a. *108/249/5001 chhele
b. 108/249/5001-Ta chhele

Small numbers usually require *–Ta,* unless they can be marked as approximations using *–Ek,* in which case *–Ta* is omitted.

(9) char-*(Te) chhele
four-*(Ta) boy
'four boys'

[1] For the purposes of this paper we treat *–gulo* and *–Ta* as a natural class, leaving as an open question how the two morphemes differ from one another (including why *–Ta* occurs with numerals and *–gulo* with 'a lot'). Dayal (in press) adopts Ionin & Matushansky (2006)'s theory of numerals as modifiers that combine with a set of atomic individuals, and suggests that *–Ta* has the dual role of (a) mapping a kind-denoting noun into a set of object-level individuals, and (b) sifting out its atomic parts for cardinality measurement. This proposal, however, is at odds with the observation that omission of *–Ta* has semantic consequences but crucially, leaves the expression grammatically intact.

(10) goTa char-Ek chhele
whole four-approx boy
'around four boys'

Similar patterns are observed in for time adverbials: measure units like "four days/weeks/hours": also can appear with the approximation marker *–moto* when *–Ta* is omitted, but not otherwise.

(11) a. ami tomar jonno char-{din/SOptaho/maS}-mOto Opekkha-korechhi.
I you for four-{day/week/month}-approx wait-did
'I have waited for you for around two days/weeks/months.'

b. *ami tomar jonno char-Te {din/SOptaho/maS}-mOto Opekkha-korechhi.
I you for four-Ta {day/week/month}-approx wait-did

Onek and *Onek-gulo* also differ on these terms. When *–gulo* is omitted, the quantity cannot be specified for any exact cardinality (rendering the follow-ups below infelicitous); the cardinality is understood to be high in absolute terms, with individuals unavailable for exact enumeration.

Context: After seeing an UFO landing on a desert, an eyewitness reports to the reporters.

(12) Eyewitness: spaceship theke Onek alien namlo.
Spaceship from Onek alien descended
'Many aliens descended from the spaceship.'

Reporter: # Thik kOto-(gulo)?
actual how-many
'How many, specifically?'

Eyewitness: #Thik dOS-Ta/dOS-hajar-Ta
actually 10/10000-Ta
'In fact, there were 10/10000 of them.'

When *–gulo* is included, cardinality can be specified precisely; it is understood to be high relative to the NP denotation, but not high in absolute terms – similar to proportional *many*.

(13) Eyewitness: spaceship theke Onek-gulo alien namlo.
Spaceship from Onek-gulo alien descended
'Many aliens descended from the spaceship.'

Reporter: Thik kOto-gulo?
actual how-many
'How many, specifically?'

Eyewitness: Thik dOS-Ta/?dOS-hajar-Ta
actually 10/?10000-cla
'In fact, there were 10/?10000 of them.'

Question: What does it mean to have *cardinality* expressions where *counting is impossible*?
- Implications for cardinality measurement in general?
- Implications for the distribution and meaning of *–Ta/-gulo*-marked expressions?

3. Towards a solution

3.1. Measuring vs. counting at the syntax-semantics interface

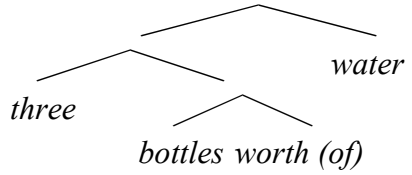
To explain this pattern, we draw on the syntax and semantics of pseudopartitive constructions, in particular the well-known *container / measure* ambiguity shown in (14)-(15). (Selkirk 1977, Doetjes 1997, Chierchia 1998, Landman 2004, Rothstein 2009).

(14) John drank three bottles of water. (MEASURE)
(15) John broke three bottles of water. (CONTAINER)

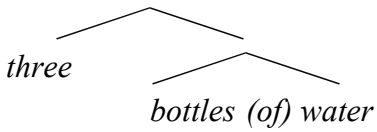
In (14), *bottle* is interpreted as an abstract measure (*bottlesworth, bottleful*); the water may be in a non-bottle container (for example, several cups). (15) entails that there are three actual bottles, each containing wine.

The two constructions are compatible with different predicates, and are usually associated with different syntactic structures (Rothstein 2009): one where *water* functions as a head noun, and another where *bottles* is the head noun.

(16) Measure reading:



(17) Container/counting reading:



The exact semantic correlates of this syntactic ambiguity remain a relatively open question:

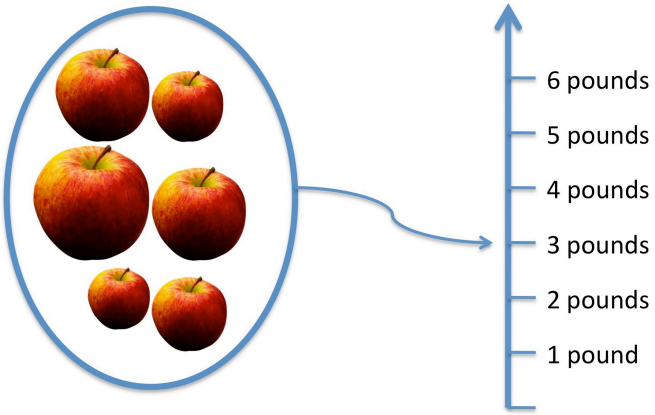
- Brasoveanu (2009): proposes a degree-to-individual polysemic shift for words like *pound*
- Rett (to appear): proposes an individual-to-degree polysemic shift for words like *bottle*
- Landman (2004): proposes that *bottle* has separate relational (container of a substance) and measure meanings (also adopted by Rothstein 2009, Li & Rothstein 2011)

3.2. A conceptual approach to measure/container ambiguities

We propose that measure/container ambiguities correspond to fundamentally different cognitive operations, as follows:

In the *quantity measurement* or "measure reading" of pseudopartitives, an object with part-whole structure is mapped to a value on a scale, as shown in (18)c.

(18) a. I put three pounds(worth) of apples in the pie.
b. Syntax: [[three [pounds(worth of)]] [apples]]
c. Meaning:



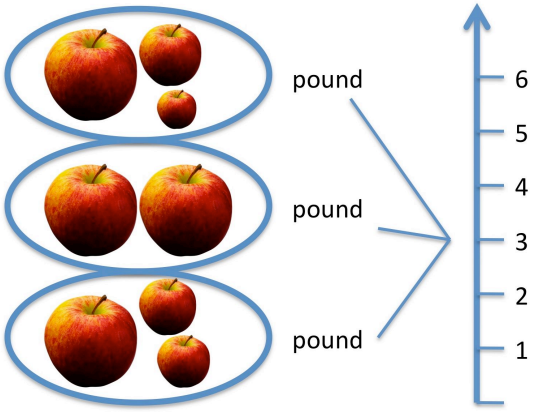
- A scale of quantity is introduced by a measure morpheme such as *–worth*
- The unit noun *pound* partitions that scale into units corresponding to non-overlapping, equal-sized pound units
    - This follows from the fact that *pound* combines first with a quantity measure, *–worth, -ful*
- The numeral *three* specifies the number of partitions
- The plurality *apples* is mapped to a value on that scale

→ Result: a non-cardinality measure: weight of apples in pounds.

Quantity counting or "container" readings of pseudopartitives involve counting partitions over the part-whole structure itself.

(19) a. I stored the three pounds of apples next to each other.
b. Syntax: [three [pounds [of apples]]]

c. Meaning:



- *Pound* partitions the plurality *apples* into non-overlapping, equal-sized units the weight of a pound
    - Again, this follows from the syntax: *pound* combines first with the noun phrase *apples*
- The numeral again specifies the number of partitions

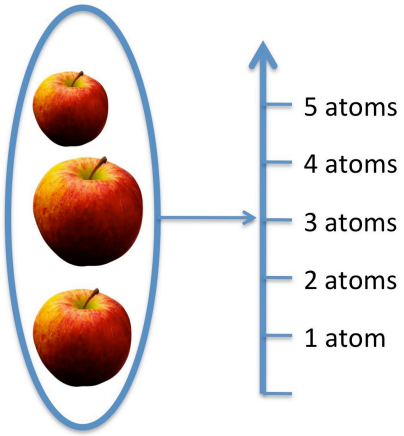
→ The result is a non-cardinality measure (weight) derived through a step of counting units

3.3 Extension to cardinality expressions

Our approach: extend this to cardinality constructions with numerals and *many,* whose syntax, we claim, is similarly ambiguous between *measurement* and *counting* readings (see also Li & Rothstein 2011).

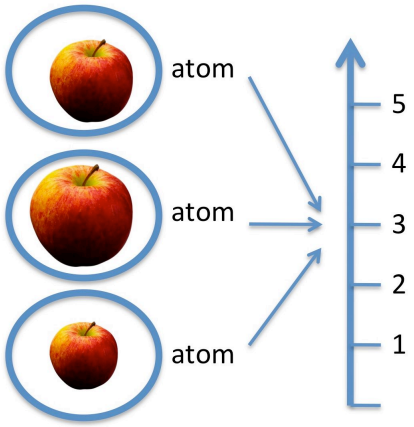
In the *quantity measurement* reading, a dense scale is partitioned into non-overlapping, atom-sized units; the plurality is mapped to a value/interval on that scale via a process of estimation.

(20) a. three (or so) apples (MEASUREMENT)
b. Syntax: [[three [atoms-worth]] apples]
c. Meaning:



In the *cardinality counting* reading, the count syntax first partitions *apples* into units the size of an atomic apple, and then counts them one by one.

(21) a. exactly three apples (COUNTING)
b. Syntax: [three [atoms apples]]
c. Meaning:



Interim summary:

The logical output of "counting" and "measurement" is very similar: in both cases we arrive at a plurality of apples with a value along some dimension (cardinality, weight, etc.)

Crucially, however, the two syntactic structures map to different cognitive operations:

- In the measuring reading, the individual identity of apple atoms is not directly attended; the atomic structure is used only to form abstract units on a dense scale. The value on this scale must be estimated for the plurality.
    - Such constructions are *approximations* of cardinality, and therefore the syntax associated with this reading is appropriate in situations where the individual atomic elements are not salient or easily countable.
- In the counting reading, the individual apple atoms are directly accessed and a value on a scale of natural numbers is obtained by counting them one by one.
    - Such constructions involve *exact enumeration,* and therefore the syntax associated with the reading is most felicitous in cases where such an operation is plausible (e.g., with lower numbers).
    - Large, round numbers may suggest that the quantity is an approximation and thus are likely to be sub-optimal under this syntax. Thus, though both structures are in principle available, the preference for one over another depends on the meaning.

4. Explaining the Bangla facts

We propose that Bangla *Onek NP and Onek-gulo NP* correspond to **quantity measurement** and **quantity counting** constructions illustrated above

- The countability restriction arises as follows:
    - *Onek-gulo NP* counts the partitions on the plurality one by one.
        - Such an operation is more difficult to perform for an extremely high number of partitions, and thus is less plausible for absolutely high numbers:

(22) Spaceship theke **Onek-gulo** alien namlo. Thik dOS-Ta/**?dOS-hajar-Ta**
Spaceship from **Onek-gulo** alien descended. In fact, 10/**?10000-**Ta
'Many aliens descended from the spaceship. In fact, there were 10/**?10000** of them'

- *Onek NP* maps the plurality to a value on a scale partitioned into *NP*-sized units.
    - This operation corresponds to cardinality estimation, which works very well with numbers that are large in absolute terms (e.g., *1000*) since in such cases it would be difficult to count each atom separately.
    - However, it is infelicitous in a context where exact enumeration is salient.

→ *Does this ambiguity surface in English in a clear way?*

Not that we know of. However, a possible analogue: pseudopartitives are infelicitous when only very few atomic parts are to be measured (Champollion 2010):

(23) a. Context: Bill observes John eat two baked potatoes, each weighing a pound.
b. Bill: ?John ate two pounds of potatoes.

- Bill's utterance is felicitous:
    - (a), If he is unaware of the cardinality of potatoes: Bill has weighed the potato sack before and after John's dinner, without paying attention to (the number of the) potato atoms.
    - (b), If the discourse allows Bill to *ignore* cardinality: when purchasing a meal from a buffet that charges for each dish by the pound, Bill may describe John's meal this way even if he *knows* the cardinality is 2.
- Bill's assertion is not ungrammatical: it is *well-formed* and *literally true*. However, the syntax suggests a set of cognitive operations that are implausible in a context where a precise cardinality is discourse-relevant and highly salient.

- (23) may be bad on *both* of the pseudopartitive readings: low numbers make partitions over atomic potato units especially salient.
    - Measure reading: the plurality should not be directly partitioned at all.
    - Counting reading: the partition over potatoes into pound-units conflicts and competes with a natural partition into atomic potato units.

5. Support for the analysis

5.1. Evidence from cognitive sciences

Perhaps unintuitively, our analysis entails that the grammar allows for cardinality constructions that do not involve counting, and counting operations in non-cardinality expressions (in bold):

	+ CARDINALITY	- CARDINALITY
+ COUNTING	963 apples	**two [pounds of apples]**
- COUNTING	**~1000 apples**	[two pounds] of apples

- - CARDINALITY, + COUNTING: overall a non-cardinality measure (weight in pounds) which involves a step of counting
- + CARDINALITY, - COUNTING: overall a cardinality measurement (number of apples) which is obtained by estimation, rather than counting

It may seem redundant to posit two separable systems for cardinality, but this is actually a relatively uncontroversial assumption in the cognitive sciences (see e.g. Feigenson et al. 2004 for a review).

Approximate Number System (ANS)

- Human infants and nonhuman animals alike have access to an amodal system for detecting differences in magnitude, based on the ratio between two sets of objects (Weber's Law)
- The number of discrete objects is represented on a continuous scale
- Judgments of numerosity are approximate and subject to error; accuracy of estimation increases with age

Object tracking (OTS) system:

- Small arrays activate a system for tracking numerically distinct individuals by opening a temporary "file" for each one to track them through time and space
- Subjects can determine the exact number of up to 3-4 objects with high precision and speed ("subitizing"); larger numbers can be enumerated with exact counting (or with the ANS)

- This system is neurally distinct from the ANS, and is characterized by sensitivity to attentional manipulations (Hyde & Wood 2011, Burr, Anobile & Turi 2011, Hyde 2011 and others)

5.2 Evidence from Bangla

Properties of –Ta/-gulo

Although the semantics of *–gulo* and *–Ta* remain an open question (see Dayal, in press; Biswas 2012), these morphemes seem to be associated with (i) number marking and (ii) definiteness:

(24) tumi rasta-y gOrto dekhecho?
you road-loc pothole saw
'Did you see (any) pothole on the street?' (bare noun: number-neutral)

(25) tumi rasta-y gOrto-gulo dekhecho?
you road-loc dog-gulo saw
'Did you see the potholes on the street?' (noun-*gulo*: plural, definite)

(26) tumi rasta-y gOrto-Ta dekhecho?
you road-loc pothole-Ta saw
Did you see the pothole on the street?' (noun-*Ta:* singular, definite)

Both of these properties are independently associated with "counting" readings:

(i) Rothstein (2009, 2010): plural morphology forces counting readings in Dutch and English:

(27) Twintig **liter** water **staat** in de kelder (*liter* = measure)
twenty **liter** water **is-SG** in the basement

(28) Twintig **liters** water **staan** in de kelder (*liters* = container)
Twenty **liters** water **are-PL** in the basement

(29) John put two cups of water in the soup. **They were** hot. (*cups* = container)

(ii) It has long been observed that measure phrases are incompatible with strong quantifiers (Jackendoff 1977, Klooster 1972, Higginbotham 1994; Chierchia 1998; de Swart 1998; Schwarzschild 2002); pseudopartitives also tend not to receive a measure interpretation when accompanied by definite articles or demonstratives (Borer 2005).

(30) a. *most feet taller (from Schwarzschild 2002)
b. *most feet of yarn
c. *ran most miles
(31) a. * those three pounds of cheese (from Borer 2005)
b. * the ton of gold

Note that *Onek–gulo,* unlike bare *Onek,* behaves like a strong quantifier, (32). This is likely one reason that it precludes a measure reading.

(32) kichhu chhatro apply korechhilo.
few student apply-did

Onek-*(gulo) chhatro bad-poRe gEchhe.
many-*(gulo) student reject went
Few students applied. Many students were rejected.' (*Onek-gulo* = strong *many*)

Finally, measure pseudopartitives are generally weak-island sensitive: (33) cannot be answered since there are infinite amounts of wine that were not poured into the soup. (34) can be accepted if there is a presupposed and salient set of bottles under discussion.

(33) # How many bottles(worth) of wine did John not pour in the soup?
Measuring predicate, + weak island
(34) How many bottles of wine did not John smash?
Counting predicate, no weak island

The omission of *–Ta/-gulo* yields weak-island sensitivity, again showing that this construction patterns with measures:

(35) # kOto chhatro-ke jOn nemontonno koreni?
how-many student-acc John invite did-neg

(36) kOto-gulo chhatro-ke jOn nemontonno koreni?
how-many-gulo student-acc John invite did-neg
How many students did John not invite?

6. Conclusion

Our observation: in Bangla, cardinality expressions cannot always involve counting.

- The distribution of these expressions suggests that we have dual systems for cardinality, both cognitively and grammatically
    - The 'approximate number system' maps onto the grammar of *quantity measurement*
    - The 'object tracking system' maps onto the grammar of *quantity counting*
    - Because the two systems are engaged in different contexts, pragmatic constraints may affect the felicity of each type of expression
- This proposal builds on and supports several different lines of work:
    - Schwarzschild (2006)'s suggestion that there are parallels between measure phrases (*two pounds*) and quantity expressions with *many* and numerals (see also Nerbonne 1995, Krifka 1989). We explore one possible corollary of this proposal, and describe some of its consequences.

- Li & Rothstein (2011)'s observation that measure readings correspond to approximate quantities. Our approach attempts to derive this generalization in an explanatory way.

- Rett (to appear)'s treatment of degree ambiguity as non-construction-specific, i.e. not limited to pseudopartitives. The data here support her treatment of degree ambiguity as more pervasive than usually thought.

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