A Solution to the Problem of Minimal Parts (Poster Handout)

Ellise Moon, LSA Annual Meeting, January 2025

Some noun phrases can refer to both something and to parts of that thing; this is known as **homogeneity** or **homogeneous reference**. This project presents a new formalization of homogeneous reference which avoids long-standing problems by introducing a distinction in the ways that the parts of something are related to one another.

1   Background

Plural and non-countable nouns have **homogeneous reference** (Bunt 1985) which is defined in terms of **cumulativity** and **divisiveness** (Cheng 1973; Quine 1960).
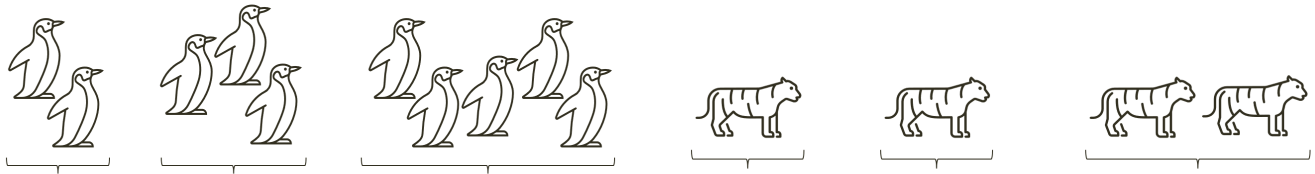
Penguins and *penguins* are *penguins*, but *a tiger* and *a tiger* is not *a tiger*.
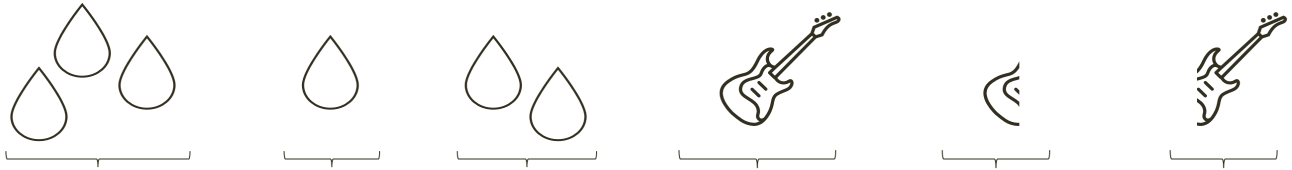
Water divided is *water* and *water*, but *a guitar* is not *a guitar* and *a guitar*.

2   The Problem

This can be formalized as the semantic properties of cumulative and divisive reference to distinguish between singular, plural, and non-countable noun reference.

(1) $\forall P[\textbf{CUM}(P) \leftrightarrow \forall x \forall y[P(x) \wedge P(y) \rightarrow P(x \cup y)]]$

   P has cumulative reference; for any two things that are P, their sum is P.

(2) $\forall P[\textbf{DIV}(P) \leftrightarrow \forall x \forall y[P(x) \wedge y \subseteq x \rightarrow P(y)]]$

   P has divisive reference; any part of P is also P.   Krifka (1989)

As formalized, **divisiveness** predicts that all parts of the thing *water* refers to can also be referred to as *water*. However, not all parts of water can be called *water*, such as hydrogen and oxygen atoms; this is the Problem of Minimal Parts.

3 Previous Proposals

Reference: minimal parts exist in the world but are not a problem for language (Bunt 1985; Gillon 1992; Quine 1960)

 → predicts divisive nouns like *water* will refer to any amount of water, even when the referent is a single H_2O molecule

Vagueness: the point at which reference picks out minimal parts is vague for non-countable nouns (Chierchia 2010, 2017)

 → predicts speakers will never refer to the minimal parts of non-countable nouns

Stratification: divisive reference is "approximate" and only holds above a certain level of granularity (Champollion 2015, 2017)

 → predicts no reference once the referent is smaller than the specified level of granularity

4 Parthood and Leveling

Cumulativity and divisiveness assume unrestricted parthood: multiple apples are a part of *apples* in the same way an apple seed is a part of *apples*. Distinguishing different ways parts compose to form a whole would create a way to restrict divisiveness to only some part-whole relationships, such as a plurality of apples being a part of *apples*, and avoid the Problem of Minimal Parts (Moravcsik 1973).

 A distinction in ways of being a part could be formalized by specifying different ways parts of a thing can compose. For one approach to this, Fine (2010) proposes a number of principles to determine whether two sums are identical, including the principle of **leveling**. Fine's proposal is a metaphysical framework, but these features can be adapted for linguistics.[1]

(3) Leveling: $\sum(\sum(w,x),\sum(y,z)) = \sum(w,x,y,z)$

 The embedding of components is irrelevant to the identity of the whole.   Fine (2010)

Leveling parallels homogeneous reference: *apples* can refer to either the sum of two apples or the sum of those two apples combined with another two apples, but *an apple* cannot refer to a sum of multiple apples or the sum of a few of its apple parts. The individual apples that are the referent of *apples* compose according to the principle of leveling, while the parts that compose *an apple* do not.

 Divisiveness can then be reformulated to only apply to parts which satisfy leveling; any part of *P* which has been composed according to leveling is itself *P*. Given this presupposition about parthood, divisiveness will no longer predict that all parts of what *water* refers to can also be called *water*. **Revising divisiveness in this way avoids the Problem of Minimal Parts while still preserving homogeneous reference.**

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 [1]Another of Fine's principles is absorption, which likely is relevant to the distinction between non-countable and plural nouns; while non-countable and plural nouns both compose according to leveling, but only non-countable nouns also compose according to the principle of absorption, which blocks them from taking plural morphosyntax.

 Absorption: $\sum(x,x,y,y) = \sum(x,y)$

 The repetition of components is irrelevant to the identity of the whole

5 Further Directions

This proposal has a number of implications for theories of countability:

- This way of formalizing homogeneity suggests that language may be highly sensitive to different ways that parts of a thing are related to the whole
- While this proposal focuses on nominal reference, it could extend to divisiveness of atelic predicates (Bach 1986; Krifka 1989)
- Revised divisiveness may also play a role in explaining cross-linguistic variations in nominal countability (Deal 2017)

6 Predictions and Relevant Data

This proposal predicts count nouns can shift between homogeneous (plural) and non-homogeneous (singular) use, but also predicts mass nouns may shift to singular count when their reference is not preserved if composed by leveling (Bunt 1985; Cheng 1973). Examples of this shift can be seen in the following cases, where mass nouns have non-homogeneous reference.

(4) a. The two *arsenics* have a collective charge of plus six, and each *arsenic* has a charge of plus three.
   b. Calcium chloride has two *chlorines* for each *calcium*.
   c. Ice XI is a proton-ordered form of ice I$_h$, where *waters* orient in a repeated manner rather than the more typical random fashion.
   d. The chains can be straight or branched, and they can run to thousands of *sugars* in a single chain.

(5) a. Two *ozones* can combine to form three *oxygens*.
   b. (CH3CH2)4P2O7 molecules contain 8 *carbons*, 20 *hydrogens*, two *phosphoruses*, and seven *oxygens*.
   c. As non-bridging *oxygens* are surrounded with *calciums* this energy is initially decreased until the *calciums* begin to crowd each other.
   d. If we draw lines through the *titaniums*, every fifth one is missing.
   e. Maltose is created by condensation reaction of the two *glucoses*, forming a α-1,4-O-glycosidic linkage.
   f. Since there are fewer methanol molecules close to the bilayer than there are *ethanols* the average area per methanol is larger than the average area per *ethanol*.

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