Count Nouns, Mass Nouns, Plurality and Measure Phrases

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1 Introduction

- Main Issues: This talk is an introduction to a large research program about how plurality, count nouns, mass nouns and measure words (both classifiers and measure nouns) are semantically represented in natural language. This project also relates to my investigations into whether category features can be assigned a consistent semantic interpretation.
- Specific Issues:

1. The interpretation of plural marking in English and Armenian:
   (a) Does it actually mark the generation of groups as suggested by Link (1983), Lasersohn (1995), and Chierchia (1998) among others?
   (b) Is plural marking meaningless with respect to the generation of groups (as suggested by Sauerland, 2003; Sauerland, Anderssen, & Yatsushiro, 2005; Borer, 2005; and Krifka, 1995)?
2. The contrast between count nouns and mass nouns in English.
   (a) Is there a principled difference between the denotations of the two types of nouns? See Link (1983, 1998).
   (b) Can mass nouns and count nouns have the same type of denotation, and if so, how do we account for the fact that mass nouns cannot combine with numerals? See, Bunt (1979, 1985), Gillon (1992, 1999), and Chierchia (1998).

2 The Interpretation of Plural

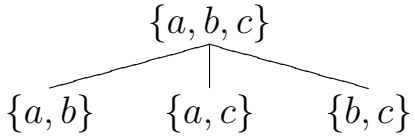
2.1 Background

- Traditional treatment of the plural morpheme hypothesizes that it creates pluralities from a set of singularities. The plural denotation only contains pluralities.

- **Example:** Link (1983) proposed that the plural morpheme should be interpreted as a function that forms a set of pluralities from a set of singularities. A definition of a function similar to Link's is given in (4). A similar denotation is given by Chierchia (1998).[1]

(1) a. $[\![PLURAL]\!] = PL$
b. $PL(X) = \{Y : (Y \subseteq X)\ \&\ (Y \neq \emptyset)\ \&\ (|Y| \geq 2)\}$

- The groups in the denotation of the plural are ordered with respect to the subgroup (or subset) relation. Given a singular denotation of $\{a, b, c\}$, the plural function would derive the following groups and the following ordering of groups (see 2).

(2)


2.2 Challenges

- Sauerland, (2003), Sauerland, Anderssen & Yatsushiro (2005), and Spector (2003) present some well-known problems with the traditional treatment of plurality. In many downward entailing environments, plural denotations seem to include the singular groups/sets as well as the plural groups.

(3) a. If you have children, please raise your hand.
b. Everyone who has children, please raise your hand.
c. Do you have children?

- In response to (3a) and (3b), one would raise their hand if they had only one child. Similarly one would respond "yes" to (3c) even if they only had one child. In these contexts, the plural *children* does not seem to mean "two or more children" as the traditional treatment would expect, rather it means one or more children.

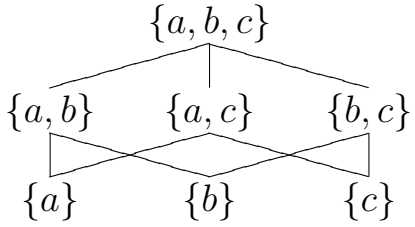
- Sauerland and Spector suggest that these downward entailing contexts reveal the true meaning of plurality: plurals include singular atoms in their denotation. One might revise the traditional treatment in the following way to account for these facts. (cf. Spector, 2003)

(4) a. $[\![PLURAL]\!] = PL$
b. $PL(X) = \{Y : (Y \subseteq X)\ \&\ (Y \neq \emptyset)\}$

- Given the set $\{a, b, c\}$, the revised plural function would generate the following groups and the following ordering among the groups.

[1] Note I have simplified this function slightly for exposition purposes and I have changed the symbols.

(5)



- According to Sauerland, the "plural" aspect of the meaning is derived through **competition** between singular and plural marking. (See Spector, 2003, and Sauerland, 2003)
  - * Generally, since the singular nouns are more restrictive than plural (according to a Sauerland-type theory), sentences with singular nouns are **stronger** than sentences with plural nouns.

    (6) a. a boy jumped.
    b. Boys jumped.

    In the competition story, a speaker should prefer to use the **stronger** sentence if it is appropriate to use that sentence. Use of the weaker sentence implies that it would have been inappropriate to use the **stronger** sentence.
  - * As is well-known from implicatures, downward entailing contexts neutralize such competitions.
  - * Note, this proposal predicts that plural nouns that have no singular counterpart should be able to quantify over singularities. Indeed, this prediction is borne out. Pluralia tantum words such as *scissors* and *pants* denote individuals in all contexts. For example, one can use *those scissors* and *those pants* to refer to singular objects.

2.3 Further Challenges

- Not only can one challenge the idea that plural denotations do not contain singulars, it is also possible to challenge the whole idea that groups are generated from a set of singularities. In other words, there is evidence that plural denotations are not formed from a set of singularities by the application of some operator.
- THREE PROBLEMS (to be reviewed and then solved):
  1. The Problem of too many pounds.
  2. The paradox of grams.
  3. Plural agreement for numbers less than one.

- **PSEUDO-PARTITIVES and MEASURE NOUNS**
  - The nature of these problems stems from measure nouns such as *pounds* and *grams* in pseudo-partitive constructions like *pounds of potato* and *grams of apples*.[2]

[2]The term pseudo-partitives comes from Selkirk, 1977.

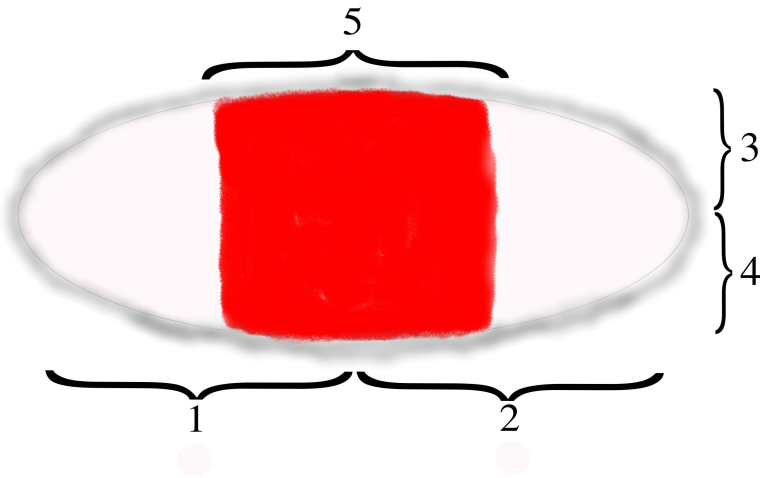


Figure 1: A graphical representation of the two pound lump of mashed potato sitting on the table. The vertical strip in the center represents the spilt food dye. The bracket represent the different places pointed to in the order indicated by the numbering.

  - Note I assume that the plural marking on measure nouns is no different from the plural marking on other nouns. In this way, my approach to measure nouns has a different emphasis than Schwarzschild (2002), where plural marking remains unanalyzed.

- THE PROBLEMS DISAPPEAR when...

  1. all nouns (without plural marking) are treated as inherently plural;
  2. the plural morpheme is treated as an identity function;
  3. numerals and the singular morpheme are treated as restrictors that shrink the denotation of the nominal they modify.

2.4 Three Problems

2.4.1 The Problem of Too Many Pounds

- There are many different ways in which a substance can be measured and furthermore singular NPs seem to be able to make reference to different types of measurements.

- **Example**: Consider a context where there is a two pound lump of mashed potato sitting in a bowl. For argument's sake, suppose that some grey food dye was spilled, staining the center of the lump of potato. (see figure 1)

- In this scenario, the following sentences can be truthfully uttered.

  (7) a. This pound of potato is partially grey. (pointing to left-half, 1)
  b. That pound of potato is also partially grey. (pointing to right-half, 2)
  c. Furthermore, this other pound of potato is partially grey. (pointing to top, 3)
  d. Also, that other pound of potato is partially grey. (pointing to bottom-half, 4)

e. However, this pound of potato is completely grey. (pointing to center, 5)

- For convenience lets label the different pounds of potato with the numbers 1 through 5. The felicity of the sentences in (7) suggest that all the possible pounds from 1 to 5 are members of the singular denotation.
- **UNDESIRED GROUPS:** if all these different pounds are members of the singular denotation, then the plural function will form lots of different groups. Specifically...

1. Since 1 and 2 are members of the singular denotation, the group $\{1, 2\}$ must be a member of the plural denotation ($\{1, 2\}$ is a subset of $\{1, 2, 3, 4, 5\}$).
2. Since 3 and 4 are members of the singular denotation, the group $\{3, 4\}$ is also a member of the plural denotation ($\{3, 4\}$ is a subset of $\{1, 2, 3, 4, 5\}$).
3. Since 1, 2 and 5 are members of the singular denotation, the group $\{1, 2, 5\}$ is a member of the plural denotation.

Hence one would expect the following (partial) denotations for *pounds of potato*, *two pounds of potato*, and *three pounds of potato*.

(8) a. $[\![\textit{pounds of potato}]\!] = \{..., \{1, 2\}, \{3, 4\}..., \{1, 2, 5\}...\}$
b. $[\![\textit{two pounds of potato}]\!] = \{..., \{1, 2\}, \{3, 4\}...\}$
c. $[\![\textit{three pounds of potato}]\!] = \{..., \{1, 2, 5\}...\}$

THE PROBLEM: The problem with the denotations in (8) is two fold.

1. They predict that it would be possible to point at the two pound lump of potato on the table and talk about and refer to it as *three pounds of potato*
   – there is a group, namely $\{1, 2, 5\}$, that has a cardinality of three.

   In other words, the sentence in (9) should be coherent in the context specified above.

   (9) At least three pounds of potato are on the table.

2. They predict that one can not use the phrase *the two pounds of potato* to refer to the two pound lump of potato on the table.
   – Given the denotation of *two pounds of potato*, the sentence in (10) should be unacceptable. The definite determiner requires there to be a unique two pound group. However, as shown in (8) there is no unique two pound group.[3]

   (10) I poured grey dye on the two pounds of potato.

[3]Amendments could be made to the theories to deal with one of the problems by prohibiting groups that contain two members that material over-lap with one another. This amendment could be made in the plural function itself by specifying that group formation prohibits material over-lap. However, the problem of uniqueness still remains.

2.4.2 The Paradox of Grams

- With the knowledge that two pounds is roughly equivalent to 900 grams, the sentences in (11) have similar truth conditions.

(11) a. I put the two pounds of apples on the table.
b. I put the 900 grams of apples on the table.

- **Problem?**, consider one possible representation of the singular NP *gram of apples*:

(12) $[\![\text{gram of apples}]\!] = \{x : x \in [\![apples]\!] \ \& \ \mu_g(x) = 1\}$

The plural function when applied to (12) would create the plural denotation. However, since no apple weighs only one gram (an apple weighs about 150 grams), this singular denotation would be empty. Thus the plural denotation would be empty, contrary to the evidence given in (11).

- Consider another possible representation of the singular NP *gram of apples*, where $\preceq$ is a *material-part-of* relation:

(13) $[\![\text{gram of apples}]\!] = \{x : x \preceq \iota([\![apples]\!]) \ \& \ \mu_g(x) = 1\}$

The denotation in (13) is not empty. It contains all the apple-stuff that weighs one gram. The measure noun grinds up the apples and then quantifies over the bits.

However, the denotation in (13) predicts that the sentences in (14) should be acceptable and interpretable in a context where an apple weighs more than 150 grams. Yet, the sentences are anomalous.

(14) a. ? Give me 50 grams of apples.
b. ?? Give me one gram of apples.
c. ?? 50 grams of apples are rotten.

The sentences in (14) imply that apples weigh less than 50 grams or less than one gram.

2.4.3 Plurals for Quantities Less than One

- Numbers less than one lead to plural agreement.

(15) a. I bought 0.725 grams of saffron.
b. I paid a dollar fifty for the 0.725 grams of saffron sitting on the table.
c. This recipe calls for 0.75 kilograms of chicken.

- Note, this fact led Krifka (1995) to remark that "the selection of singular or plural forms seems to be a purely syntactic matter."

2.5 One Solution

- **Nature of the problem**
  - In creating pluralities from a set of singularities, the plural operator creates **undesired/unattested** groups. (Groups that are two big in the problem of *too many pound* and groups that are too small in the problem of *the paradox of grams*.)
  - In creating pluralities from a set of singularities, one does not create entities that are less than one unit.
- **Nature of the solution**: Eliminate the pluralizing function!
  - Interpret the underlying noun, prior to singular or plural marking, as inherently plural (the denotation would contain groups as well as singularities).
  - Interpret the plural morpheme as an identity function.
  - Interpret the singular morpheme as a function that restricts the noun to singularities.
- Eliminating the pluralizing function solves all three problems.

2.5.1 Details of the solution

- One possible tact would be to have a degree variable serving as the argument to some measure function in the noun and also to have this variable explicitly bound by an abstraction operator (a lambda-operator). See Krifka (1995) for such a proposal.
- I will not take this tact here. (Such a tact would require hidden operators in order to have the nouns combine with determiners such as *the* and adjectives such as *blue*. Such hidden operators create difficulties, especially given phrases like *two blue cats*.)
- **THE SOLUTION:** All nouns have a hidden variable that serves as an argument to some measure function. This variable is existentially bound. To manipulate this variable, I will exploit some of the properties of **Dynamic Predicate Logic (DPL)**. (Thanks to Chierchia for suggesting this possibility to me.)
- **Main Aspect of DPL to Exploit**: Due to the way in which DPL treats existential quantifiers and conjunction (as functions from variable assignments to variable assignments), the formula schema in (16a) is truth-functionally equivalent to the schema in (16b).

(16) a. $[(\exists n \Phi) \& \Psi]$
b. $\exists n (\Phi \& \Psi)$

- In effect, the existential quantifier seems to be able to bind a variable outside of its syntactic scope when it appears as the first member of a conjunct. (This is a crude and inaccurate way of describing the system, however it does get the point across.)

1. **Interpretation of the Root Noun**: Given DPL's treatment of existential quantification, consider the following possible interpretation for *pound of potato*. (I will assume that ⟦ *potato* ⟧ denotes all the mass of *stuff* that counts as potato.)

   (17) ⟦ *pound of potato* ⟧ $= \lambda x\, \exists n(x \in [\![potato]\!] \;\&\; \mu_{lbs}(x) = n)$,
   where μ_{lbs} is a function from entities to the measurement of those entities in terms of pounds.

   For simplicity I will treat the noun *pound* as forming a constituent with *of potato*. Number morphology will combine with this entire phrase. (Note, nothing crucial depends on this treatment.)

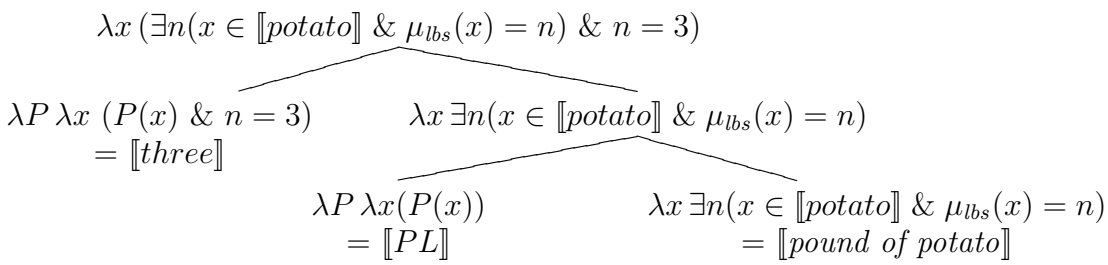
2. **Interpretation of the Plural Morpheme (PL)**: The plural morpheme will simply pass-up the value of the root noun.

   (18) $[\![PL]\!] = \lambda P\, \lambda x(P(x))$

3. **Interpretation of the Singular Morpheme (SG) and Numerals**: The singular morpheme and the numerals simply manipulate/restrict the possible values for the variable n within the root noun.

   (19) a. $[\![two]\!] = \lambda P\, \lambda x(P(x) \;\&\; n = 2)$
   b. $[\![three]\!] = \lambda P\, \lambda x(P(x) \;\&\; n = 3)$
   c. $[\![SG]\!] = \lambda P\, \lambda x(P(x) \;\&\; n = 1)$

4. **Putting things together:** The interpretation of *three pounds of potato*:

   (20)
   

   Equivalence due to DPL

   ⟦ *three pounds of potato* ⟧ IS EQUIVALENT TO $\lambda x\, \exists n(\, (x \in [\![potato]\!] \;\&\; \mu_{lbs}(x) = n) \;\&\; n = 3)$

2.5.2 Solving the Three Problems

1. **The problem of Too Many Pounds - SOLVED!**

   - If there is only a two pound lump of potato on the table, then the topmost member in the denotation of $[\![potato]\!]$ only weighs two pounds. There are no members that weigh three pounds and there is only one member that weighs two pounds.
   - Thus the denotation of ⟦ *two pounds of potato* ⟧ is

     (21) $\lambda x\, (\exists n(x \in [\![potato]\!] \;\&\; \mu_{lbs}(x) = n) \;\&\; n = 2)$.

The characterizing set[4] of this function is the set of entities that are member of the denotation of $[\![potato]\!]$ and weigh two pounds. There is only one such member (the whole lump)! **Hence, the definite determiner *the* can apply to this set and still be defined.**

- $[\![$ *the two pounds of potato* $]\!]$ is the unique potato mass that weighs two pounds. There is no conflict to uniqueness.

2. **The Paradox of Grams - SOLVED!**

- The same type of interpretation is given to *grams of apples* as *pound of potato*, the only difference is in terms of the output of the measure function and the count noun complement.

(22) $[\![$ *grams of apple* $]\!] = \lambda x\, \exists n(x \in [\![apples]\!] \;\&\; \mu_g(x) = n)$

- For now, let's assume that the denotation of $[\![apple]\!]$ is the set of all apples and apple-groups.
- For x to be in the characterizing set of $\lambda x\, \exists n(x \in [\![apples]\!] \;\&\; \mu_g(x) = n)$, it has to be an apple or apple group (that has some weight). Since apples weigh more than 150 grams, there are no entities in this set that weigh under 150 grams.
- If a numeral such as 30 restricts the characterizing set to things that weigh 30 grams, the result will be an empty set. No apple (or apple group) weighs 30 grams.
- If a numeral such as 900 restricts the characterizing set to things that weigh 900 grams, the result will not necessarily be empty. It is possible to have an apple-group that weighs 900 grams.

- **Since groups are not created by the plural morpheme from singulars, there is no need to have a singular denotation in order to have a denotation for *900 grams of apples*.**

3. **Plurals for Quantities Less than One - Explained!**

(a) PART I: Numbers less than one can combine with plural NPs.

- The plural NP *grams of saffron* would have the following interpretation:

(23) $[\![$ *grams of saffron* $]\!] = \lambda x\, \exists n(x \in [\![saffron]\!] \;\&\; \mu_g(x) = n)$

- Since n could be any number, the denotation of *grams of saffron* can contain x's that weigh less than 1.

[4] In DLP, the characterizing set of a function P, can be give as $\{x : P(x)$ is true with respect to the current variable assignment $i\}$. A formula Φ is true with respect to a variable assignment i iff $\exists h : \langle i, h\rangle \in P(x)$.

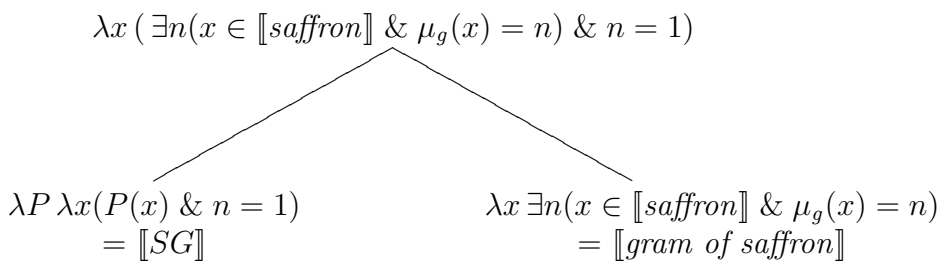
- A numeral such as 0.75, in this system, would restrict the plural denotation to all the entities that weigh 0.75 grams.

- **Hence the characterizing set of** 0.75 ***grams of saffron*** **would contain all the saffron masses that weigh** 0.75 **grams.**

(b) PART II : Singulars cannot combine with numbers less than one.

- The singular NP *gram of saffron* would have the following interpretation.

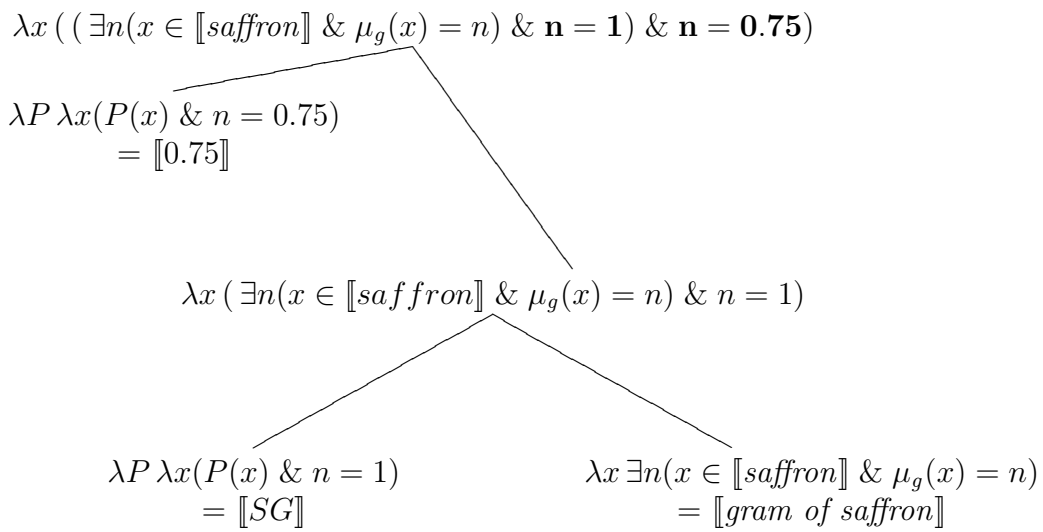
(24)



- The characterizing set of this interpretation would be the set of all masses of saffron that measured exactly one gram. There are no masses that weigh less than one.

- Restricting singular NPs to entities that measure 0.75 would be trivially empty. The function contains a contradiction.

(25)



2.6 Extending the analysis to all nouns

- This analysis can easily be extended to any count noun, such as *dog* for instance. It is possible that such a noun contains two parts:

  1. A basic concept that tell you what counts as a dog or a dog group. Let's label this concept *DOG*.

2. A measure function that measures individuals and groups in terms of their atoms. Let's label this function AT.

- An existentially bound variable n could serve as the output of AT in regular count nouns. Thus *dog* would have the following interpretation...

(26) $[\![\textit{dog}]\!] = \lambda x \, \exists n(DOG(x) \,\&\, AT(x) = n)$

- This noun would combine with numerals and the singular and plural morphemes in exactly the same way as *pound of potato*.

- **Hence, the plural and singular marking on measure nouns is treated the same as the plural and singular marking on regular count nouns!**

3 Revisiting the count/mass distinction

- **Puzzle of Furniture**: There are two properties of mass nouns that are not puzzling in isolation but are puzzling when considered in combination.

1. Mass nouns cannot combine with numerals or quantifiers that manipulate number.

(27)
a. * two furniture, two water
b. * several furniture, several water
c. * too many furniture, too many water
d. too much furniture, too much water

2. Some mass nouns seem to be countable. Essentially their denotations are no different from the denotations of count nouns.

(28) **All count nouns allow for a comparison by number, although not all mass nouns.**
a. John has more rocks than Mary. (cf. John has more rock than Mary.)
b. John has more coffees than Mary. (cf. John has more coffee than Mary.)
c. John has more ropes than Mary. (cf. John has more rope than Mary.)
d. John has more chocolates than Mary. (cf. John has more chocolate than Mary.)

(29) **Some mass nouns allow for a comparison by number, just like count nouns.**
a. John has more furniture than Mary. (John has more pieces of furniture.)
b. John has more jewelry than Mary. (John has more items of jewelry.)
c. John has more silverware than Mary. (John has more pieces of silverware.)

- **Semantics of the determiner MORE** (Bale & Barner, 2008): The determiner *more* essentially compares two sets through some kind of measurement. The measurement is underspecified.

  – The sentences,

  1. Mary has more anger than John;
  2. Mary has more gold than John;
  3. Mary has more bus tickets than John,

  ...involve different types of measurements (measurements of emotional intensity, mass, and number of tokens).

  One of these measurements is in terms of the number of atoms/minimal parts. Count nouns all have atoms/minimal parts. Like count nouns, $[\![furniture]\!]$ has atoms although other mass nouns do not.

- **What's Puzzling:** If mass nouns like *furniture* have atoms and number terms like *two* simply involve counting atoms, then why can't *furniture* combine with numerals like *two*.

- **Removing the Puzzle:** Under the current proposal, numerals do not count atoms but simply modify the value of the variable n. If mass nouns do not contain any (existentially) bound variable n that relates to a measure function, then this would explain why numerals cannot combine with mass nouns. (This type of explanation goes back to suggestions by Krifka, 1995, and has recently been revived by Borer, 2005.)

- Note, in the current system, such an explanation would allow for a mass noun to have the exact same kind of denotation as a count noun (namely an atomic denotation), yet the mass noun would not be able to combine with a numeral. As I pointed out above, such mass nouns exist, namely *furniture*, *equipment*, *footwear*, *cutlery*, etc.

- The "hidden variable" analysis of plurality explains how this fake mass nouns are formally different from count nouns but yet have identical types of denotations.

4 Future Directions: Are all plurals the same?

- Having demonstrated the advantages of giving up on Link's plurality operator for English, a natural question arises whether Link's operator should be abandoned more generally.

4.1 Armenian

- Armenian has a plural/singular distinction.

(30) a. shenk-me desar
building-(indef,sg) saw(2,sg)
You saw a building

b. yergu shenk-er desar
two building-(indef, pl) saw(2,sg)
You saw two buildings

- Preliminary data suggests that plurals in Armenian are quite different from English. For example in downward entailing contexts one cannot get quantification over singulars when the noun appears with plural marking.

(31) a. bezdig-ner unis?
child-(indef,pl) have(2,sg)
Do you have (two or more) children?

b. jete bezdig-ner unis, dun kena.
if child-(indef, pl) have(2,sg), home go(2, sg)
If you have (two or more) children, then go home!

c. amen mart vor bezdig-ner uner vodk-i gajne-tsav
all person that child-indef, pl) had foot-(Gen/Dative) stand-up-(perf, past, 3, sg)
Everyone who had (two or more) children stood up

- Furthermore, plural marking on measure nouns is not acceptable.

(32) a. jergu kilo xentsor
two kilo apple

b. * jergu kilo-ner xentsor
two kilo-(indef, pl) apple

- These empirical facts are inconsistent with the interpretation of plurality offered in this paper but are completely consistent with Link's original interpretation of plurality involving the generation of groups from a set of singularities.
- If the plural function can differ cross-linguistically, then the questions arise:
  - **How can such subtle differences be acquired?**
  - **How do these differences relate to the mass/count distinction?**
  - **Differences in plurality predict differences in the interpretation of numerals. Is this difference in the numerals empirically substantiated?**

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