A unified semantics for number marking, numerals, and nominal structure

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Abstract. This paper develops a semantic account of morphological number in the presence of numerals. In addition to accounting for number on basic nouns like *book* in English, our approach extends to cover data from two seemingly disparate domains: 1) number marking on measure terms like *kilo*, which is determined by the numeral co-occurring with these terms: *one kilo of apples* vs. *two kilos of apples*; and 2) cross-linguistic variation in patterns of number marking: numerals greater than one obligatorily combining with plural-marked nouns (e.g., English), all numerals obligatorily combining with singular (unmarked) nouns (e.g., Turkish, Hungarian), and numerals optionally combining with either singular or plural nouns (e.g., Western Armenian). Building off the presuppositional approach to morphological number in Sauerland (2003), we show that all of the data considered receive an account once we assume variation in the selection of the measure relevant to the one-ness presupposition of the morphological singular form.

Keywords: number marking, numerals, measure phrases, Turkish, Western Armenian.

1. Introduction

Speakers of number marking languages decide between singular and plural forms of nouns as they embed them in larger linguistic contexts: *book* is felt to mean something different from *books*, and the choice between these forms is regular and well defined. If I am talking about a single book, I use the singular form of the noun; when I am talking about more than one book, I use the plural. While intuitively appealing, this characterization of grammatical number in terms of one vs. more than one faces problems (see the discussion in Sauerland (2003) and Sauerland et al. (2005), as well as in Section 2 below). Still, it gives us a point from which to begin investigating the topic at hand: the impact numerals have on the choice of grammatical number.

In English, the numeral *one* requires that the noun it appears with bear singular morphology, thus *one book* and not *one books*. For numerals greater than one, plural morphology is required: *two books* and not *two book*. We can describe this pattern using our characterization of grammatical number above: with *one*, I am talking about a single thing, and so I require the singular form; with greater numerals, I am talking about more than one thing, thus the plural form must be used. The problem lies in explaining how these facts arise: what aspect of the linguistic form is responsible for the choice of grammatical number, and at what level of grammar does it operate?

Suppose that the determination of grammatical number is a wholly syntactic process determined by features of modificational elements that then agree with features on modified nouns. Such a system would posit a SINGULAR feature on the numeral *one* and a PLURAL feature on all other numerals. When composing with a noun, the number feature of the numeral would value the number feature of the noun and determine its morphological form. Note that this feature distribution –

one+SINGULAR; not-one+PLURAL – captures the facts of English, but the system being considered admits a great deal of variation beyond the English pattern. Without stipulations on the distribution of these features, a numeral could possess any feature and so we should expect to find languages with unintuitive – and unattested – patterns of number marking. For example, how would we block a language from attributing the PLURAL feature to *one* and the SINGULAR feature to all other numerals? In other words, how do we rule out languages in which nouns agree with *one* in the plural and numerals other than *one* in the singular? The problem with such a syntactic/featural approach is that grammatical number bears only an indirect relationship to the meaning of the elements indexed with it and so we lack a principled way of constraining the patterns that can be generated.

In this paper, we develop a semantic account of grammatical number in the presence of numerals that attributes the distinction between singular and plural forms to an interaction between the meaning of numerals and the semantics of the nominal elements they modify. In developing this system, we consider data from two types of nouns: the basic type, as exemplified by *book*, and measure terms such as *kilo*. By augmenting the data to be covered to include measure terms, we highlight the breadth required by the semantic mechanism that modulates grammatical number. We then expand the coverage of the system beyond English, seeing what it takes to account for different patterns of number marking such as those found in Turkish and Western Armenian (Bale et al., 2011a). What results is a program centered around a designated functional projection, #P, from which morphological number features originate (cf. Sauerland (2003), a.o.). The head of #P, either SG or PL, is an operator that establishes conditions on the denotation of the resulting nominal: SG checks for singularity of the predicate, and PL applies when singularity is not satisfied. We show how variation in the way that singularity is checked captures the cross-linguistic diversity in patterns of number marking that we consider. This variation also accounts for number marking within the second domain of nominals, measure terms. Before we begin to develop this system, however, we must consider in more detail the assumptions at its foundation, together with the data to be explained. This is the topic of the next section.

2. Theoretical background: #P

Following Sauerland (2003) (see also Sauerland et al., 2005), we assume that the locus of number features is the designated functional head which we term #. Morphological number marking comes about as a result of syntactic agreement with #. In this system morphological number is never directly interpreted; the determination of semantic number is a separate but related process.

We find (minimally) two variants of the # heads: SG and PL.[1] Unlike Sauerland, we assume that # occurs as the sister to a nominal projection and serves as an identity map on the property denoted by the nominal with which it composes. This move allows for the account of measure terms developed in Section 4. Still, a major contribution of Sauerland's work is the demonstration that SG, and not PL, is semantically marked (see Sauerland et al. (2005) for a discussion of the facts that lead to this conclusion). SG carries with it a numerical presupposition for one-ness of the property with which

[1] Additional # heads are likely needed to account for dual, trial, paucal, etc., values of grammatical number.

it composes, (1-a); PL carries no such presupposition, (1-b).[2] For now, assume that the measure μ relevant to the one-ness presuppotion of SG is basic cardinality: $\mu(x) = |x|$. The choice between SG and PL is mediated by Heim's (1991) principle of Maximize Presupposition, which ensures that SG is used whenever its one-ness presupposition is met.

(1) a. $[\![\text{SG}]\!] = \lambda P: \forall x \in P[\ \mu(x) = 1\ ].\ P$
b. $[\![\text{PL}]\!] = \lambda P.\ P$

At this point we must draw a clear distinction between morphological number, expressed by ø and *–s* in English and determined by the functional number heads SG and PL, and semantic number. Assume three books: *a*, *b*, and *c*. In its basic form, semantically singular *book* denotes a set of atoms, (2-a). The star operator * (Link, 1983) closes the semantically singular property under sum formation and produces the plural property, (2-b).[3]

(2) a. $[\![\text{book}]\!] = \{a, b, c\}$
b. $[\![\text{*book}]\!] = \{a, b, c, a+b, a+c, b+c, a+b+c\}$

Suppose nouns always express grammatical number, that is, they always appear in the presence of #. The semantically singular property in (2-a) may compose with SG: every member of [[book]] is atomic and thus has cardinality 1. The semantically plural property in (2-b) does not satisfy the one-ness presupposition of SG in (1-a) because there are elements of [[*book]] with cardinality greater than 1. Without any presupposition, PL may compose with either of the properties in (2). What blocks PL's combination with semantically singular properties, and thus accounts for why morphologically plural *books* is not used to refer exclusively to book atoms, is the principle of Maximize Presupposition (Heim, 1991): because SG contains stronger presuppositions – PL contains none at all – with semantically singular properties we must use SG. It is only when SG's presupposition is not satisfied, i.e., when we have a semantically plural property, that PL is used. In this way, morphological number corresponds directly to semantic number: the only licit combinations are SG with semantically singular properties and PL with semantically plural properties.

Next, consider how numerals fit into this program of number marking. Suppose that cardinal numerals are restrictive modifiers: they compose with predicates and restrict their denotation to those elements with the appropriate cardinality.[4]

[2]Note that here we depart from Sauerland in assuming that # composes with predicates and not with individuals.

[3] We construe semantic plurality as closure under sum, and not closure under sum less the atoms, in order to account for the behavior of plurals in downward entailing environments. There, plurals may be used to refer to singularities. For example, if I ask if John has children, it would be infelicitous to answer no when he has only one child. For a fuller discussion of these data, see Sauerland et al. (2005).

[4]For discussion of numerals as modifiers, see Link (1987), Verkuyl (1993), Carpenter (1995), Landman (2003),

(3) a. $[\![\text{one}]\!]_{\langle et,et\rangle} = \lambda P \lambda x.\ P(x) \wedge |x| = 1$
b. $[\![\text{two}]\!]_{\langle et,et\rangle} = \lambda P \lambda x.\ P(x) \wedge |x| = 2$

Recall our assumptions regarding morphological and semantic number; we repeat the semantics for the # heads in (4), and the semantics of plurality in (5). Assume further that numerals are intermediate between the noun and the # projection: # $>$ *numeral* $>$ NP.[5]

(4) #'s semantics:
a. $[\![\text{SG}]\!] = \lambda P: \forall x \in P[\ \mu(x) = 1\ ].\ P$
b. $[\![\text{PL}]\!] = \lambda P.\ P$

(5) Semantic number:
a. $[\![\text{book}]\!] = \{a, b, c\}$
b. $[\![\text{*book}]\!] = \{a,b,c,a+b,a+c,b+c,a+b+c\}$

The numeral *one* may compose with either a semantically singular or a semantically plural property; in either case the resulting denotation is a set of atoms that satisfies the one-ness presupposition of SG. Because the presupposition of SG is satisfied once *one* composes, Maximize Presupposition rules out the choice of PL, (6-c,d), and thus rules out *one books*. If we want to rule out the composition of a semantically plural property with singular morphology as in (6-b), we may appeal to a principle of economy, whereby the strings with and without * compete: because (6-a) and (6-b) are denotationally equivalent, and because (6-b) is more complex (it contains *), (6-b) is uneconomical and cannot occur.

(6) *One* + SG
a. ✓ $[\![\text{SG one book}]\!] = \{a, b, c\}$
b. ✗ $[\![\text{SG one *book}]\!] = \{a, b, c\}$, but *failure of economy principle*[6]
c. ✗ $[\![\text{PL one book}]\!]$ = *failure to apply Maximize Presupposition*
d. ✗ $[\![\text{PL one *book}]\!]$ = *failure to apply Maximize Presupposition*

The numeral *two* with its restrictive semantics in (3-b) requires that the property with which it composes be semantically plural. When *two* composes with a semantically singular property it looks among a set of atoms for individuals with the appropriate cardinality and finds none; the result is the empty set. We must say, then, that necessarily denoting the empty set as in (7-b,d) is somehow deviant and thus ruled out.[7] With semantically plural properties *two* readily composes and restricts the nominal's denotation to those individuals with cardinality 2. The one-ness presupposition of SG fails on such a denotation because it is not the case that all members number 1, (7-c). Because the presupposition of SG fails, we must use PL instead, thus *two books*.

among others.

[5]We address the motivation behind this structural assumption once we extend our account to measure terms in Section 4.

[6]From Sauerland (2003): "Do not use the plural if the resulting meaning is identical to the meaning of the singular in the present context."

[7]Such a move should be familiar from recent work on the ungrammaticality that results from logical triviality (Gajewski, 2002).

(7) *Two* + PL

a. ✓ ⟦PL two *book⟧ = {a+b, a+c, b+c}
b. ✗ ⟦PL two book⟧ = Ø
c. ✗ ⟦SG two *book⟧ = *presupposition failure*
d. ✗ ⟦SG two book⟧ = Ø

At this point we appear to have an account of number marking in the presence of numerals for basic count nouns like *book* in English. Our task now is to extend the coverage of this account. We first consider two different systems of number marking from Turkish and Western Armenian. We then return to English and explore the semantics of measure terms like *kilo* which, to all intents and purposes, behave as nouns, yet do not appear to refer in the way that a noun like *book* does. Without clear referents to check the atomicity of, we must assess what it means to be semantically singular for these nouns.

3. Shortcomings of the present account

3.1. Cross-linguistic variation

Languages vary with respect to their patterns of number marking in the presence of numerals (Bale et al., 2011a). So far we have considered one type of language, exemplified by English, in which the numeral *one* requires singular-marked nouns, and all other numerals require plural-marked nouns. Here we consider data from two other types of languages. In the first, all numerals obligatorily combine with singular-marked nouns (‘one book’, ‘two book’; e.g., Turkish); in the second, numerals optionally combine with either singular- or plural-marked nouns (‘one/two book(s)’; e.g., Western Armenian). We will see that our system for number marking as it stands cannot account for either of these patterns.

Turkish possesses a morphological distinction between singular and plural nouns, as evidenced in (8); the morpheme *-lar* indexes plurality.[8]

(8) a. çocuk
boy

b. çocuk-lar
boy-pl

In the presence of a numeral, *-lar* is prohibited. In other words, nouns in Turkish are obligatorily singular, at least morphologically so, when they occur with numerals.

(9) a. iki çocuk
two boy(sg)
‘two boys’

b. *iki çocuk-lar
two boy-pl

[8] All cross-linguistic data in this subsection come from Bale et al. (2011a).

We find an more complex pattern of number marking in Western Armenian. Like Turkish and English, Western Armenian possesses productive plural morphology: the morpheme *-ner* indexes plurality.

(10) a. degha
boy

b. degha-ner
boy-pl

Western Armenian's pattern of number marking in the presence of numerals represents a hybrid of the English and Turkish systems: nouns either may appear as morphologically singular in the presence of a numeral greater than one, as in Turkish, or they may appear as morphologically plural, as in English.[9]

(11) a. yergu degha
two boy(sg)
'two boys'

b. yergu degha-ner
two boy-pl
'two boys'

Assuming the system of number marking that we developed in the previous section for English, we predict neither the Turkish facts in (9) nor the Western Armenian facts in (11). The problem is that we have aligned semantic and morphological number so that the morphologically singular nouns are semantically singular, and we have assumed a restrictive semantics for numerals in which numerals greater than one require semantic plurality. What we need is a way to allow singular-marked nominals to receive a plural interpretation, i.e., to be semantically plural. Our approach will be to reevaluate the numerical presupposition we have attributed to the # head SG so that it may also compose with semantically plural nouns in the presence of a numeral. Before doing so, however, we must consider additional data for which our system of number marking must account.

3.2. Measure terms

So far we have been considering number marking on what we will term BASIC nouns like *book* and *boy*. These nouns may be viewed as one-place predicates, denoting sets of individuals holding the relevant property. We defined semantic number for these predicates in terms of the cardinality of the members of their denotations: if a predicate refers to a set of atoms, it is semantically singular; if the predicate is closed under sum-formation, it is semantically plural. But what happens when we have nouns that do not refer to individuals, atomic or otherwise, that still behave regularly with respect to number marking? Of interest are the italicized words in (12).

[9]This description of morphological number in Western Armenian from Bale et al. (2011a) is likely an idealization; see Sigler (1996) for a fuller discussion of the facts. Keeping in mind that much more work remains to be done on the nuanced interpretations of these nominals, our goal will be to leave open the option of our approach accounting for the Western Armenian system as it is presented in Bale et al. (2011a).

(12) a. That meat weighs two *kilos*.
b. I ate two *kilos* of meat.

We must first convince ourselves that measure terms like *kilo* are nouns, or at least nominal to the extent that they should be handled by the same system of number marking that determines the morphology of *book* vs. *books*. To begin, measure terms display regular singular/plural morphology: *kilo* vs. *kilos*. Further, they are free to combine with numerals and when they do they behave as expected: *one kilo* vs. *two kilos*. Like basic nouns, measure terms constitute an open class: a nonce word may be substituted for a measure term and still we can conclude that the intended meaning involves a quantity or extent identified by the nonce word. Finally, measure terms are subject to quantifier restrictions: *many kilos* but not *much kilos*.

Assuming that we take these facts as evidence that measure terms are nouns, what do we make of the semantics of singular vs. plural for them? We started with the schema relating morphological and semantic number in (13), but it isn't clear how this schema could apply to measure terms.

(13) a. atoms $\Rightarrow$ SG
b. sums of atoms $\Rightarrow$ PL

The problem is that measure terms do not appear to refer in the way that *boy* does. What kind of atoms are kilos, meters, degrees, etc.? What would it mean to close these supposed atoms under sum formation? We thus take as our starting point the idea that measure terms are nouns which do not refer to individuals.

WIthout a referring semantics for measure terms we immediately face a problem in handling these nouns within our system of number marking. Recall our semantics for the # heads, (4), where the one-ness presupposition of singular morphology depends on the cardinality of the members of the relevant property. Without atoms to count, the one-ness presupposition of SG is meaningless in the context of measure terms. Moreover, what matters to the number morphology of these terms is not cardinality, but rather the measure specified by the term itself: the choice between *one kilo* and *two kilos* does not depend on how many atomic individuals weigh the relevant amount.

4. Proposed analysis

In what follows we revise our system of number marking in the presence of numerals from Section 2 above so that it may handle both measure terms and the observed cross-linguistic variation. We start by motivating numerals as referring expressions, and forming cardinal numerals on the basis of the functional element CARD (Zabbal, 2005). Next, we align the semantics of measure terms with CARD and revise our assumptions concerning the measure relevant to the one-ness presupposition of SG. Finally, we locate the parameter determining cross-linguistic variation in the

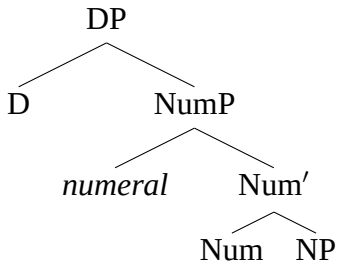
selection of the measure relevant to the one-ness presupposition of SG.

4.1. Numeral semantics

We started with minimal assumptions about numerals: they are property modifiers, type $\langle et, et\rangle$, and they occupy a position intermediate between # and NP. Now we fill in the details of these assumptions.

First, concerning their structure, assume that numerals occupy the specifier of a functional projection NumP (Selkirk 1977; Hurford 1987; Gawron 2002; a.o.), and that NumP is intermediate between NP and DP (Ritter, 1992).

(14)



For their semantics, take numerals to be individual-denoting expressions referring to natural numbers: numerals are of type n. The choice of Num^0 determines the function of the numeral (e.g., cardinal, ordinal, etc.; Zabbal 2005). Cardinal numerals are formed by the operator CARD, which takes a predicate and returns a relation between numbers and individuals (in the spirit of Krifka (1989)).

(15) $[\![\text{CARD}]\!] = \lambda P \lambda n \lambda x.\ P(x) \wedge |x| = n$

(16) $[\![\text{two CARD *boy}]\!] = \lambda x.\ *\text{boy}(x) \wedge |x| = 2$

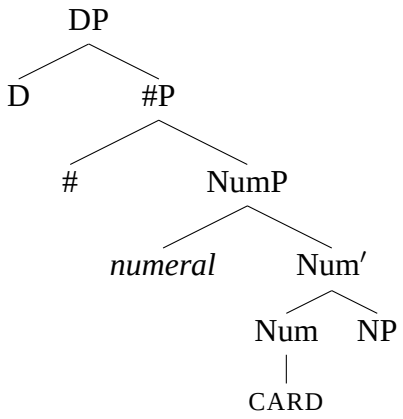
Note that CARD delivers the restrictive semantics for cardinal numerals that we assumed above, and, as before, these semantics ensure that cardinals greater than one must compose with a semantically plural predicate (formed via *) as in (17-b). Were such cardinals to compose with a semantically singular, i.e., atomic predicate, (17-a), the result would be the empty set, (17-c): there are no individuals in the denotation of an atomic predicate with cardinality greater than 1.

(17) Assuming three boys:
- a. ⟦boy⟧ = {a, b, c}
- b. ⟦*boy⟧ = {a, b, c, a+b, a+c, b+c, a+b+c}
- c. ⟦two CARD boy⟧ = Ø
- d. ⟦two CARD *boy⟧ = {a+b, a+c, b+c}

Next, let's preserve the semantics we gave to the # heads, repeated below, and see how these semantics interact with our revised assumptions concerning cardinal numerals.

(18)
- a. ⟦SG⟧ = λP: $\forall$x$\in$P[μ(x) = 1]. P
- b. ⟦PL⟧ = λP. P

(19)



The # head takes the nominal, NumP, as an argument. We continue to assume that the measure relevant to the one-ness presupposition of SG is cardinality (note that cardinality is the measure supplied by the closest head to #, CARD; more on this below). Number marking in the presence of numerals proceeds as it did above:

(20)
- a. ✓ ⟦SG one CARD book⟧ = {a, b, c}
- b. ✗ ⟦SG one CARD *book⟧ = {a, b, c}, but *failure of economy principle*
- c. ✗ ⟦PL one CARD book⟧ = *failure to apply Maximize Presupposition*
- d. ✗ ⟦PL one CARD *book⟧ = *failure to apply Maximize Presupposition*

(21)
- a. ✓ ⟦PL two CARD *book⟧ = {a+b, a+c, b+c}
- b. ✗ ⟦PL two CARD book⟧ = Ø
- c. ✗ ⟦SG two CARD *book⟧ = *presupposition failure*
- d. ✗ ⟦SG two CARD book⟧ = Ø

We thus maintain our coverage of basic nouns with numerals. Why, then, have we gone to the trouble of revising our assumptions concerning numerals? As we shall see in what follows, viewing numerals as referring expressions that serve as an argument of the functional counting element CARD allows us to account for number marking on measure terms.

4.2. Accounting for measure terms

Before we can attempt to apply our system of number marking to measure terms, we must settle on the semantics of these nouns. To this end, note that measure terms appear to have two distinct uses. In the first, which we call their INTRANSITIVE use, measure terms compose with a numeral and denote a quantity or extent. Intransitive uses of measure phrases typically appear as the internal argument of measure verbs (e.g., *measure*, *weigh*, etc.), as in (22-a). They also appear in predicative *be* constructions, (22-b), as well as modifiers of gradable adjectives, (22-c).

(22) a. John weighs 100 kilos.
b. The temperature is 70 degrees.
c. John is two meters tall.

In (22-a), the measure phrase *100 kilos* specifies the extent of John's weight. Similarly, in (22-c), *two meters* specifies the extent of John's tallness. Intransitive measure terms appear also in equative constructions, (23-a), and in kind-level predication, (23-b).

(23) a. Ten degrees Fahrenheit is less than ten degrees Celsius.
b. Kilos are more widespread than pounds.

Intransitive uses of measure terms contrast with their TRANSITIVE use, where we have an additional nominal that provides the material to be measured. We call this extra nominal the COMPLEMENT of a transitive measure term. The complement can be introduced via partitive, (24), or pseudo-partitive constructions, (25). In what follows we will focus on measure terms in pseudo-partitives.

(24) Partitive:
a. I drank two liters of that wine.
b. I ate two kilos of those apples.

(25) Pseudo-partitive:
a. I drank two liters of wine.
b. I ate two kilos of apples.

In (24) and (25), the measure terms serve to quantize the pluralities denoted by the complement noun: the measure phrase uses the specified extent familiar from intransitive uses to restrict the denotation of the complement noun. For example, in (25-b), *two kilos of apples* returns a subset

of the pluralities denoted by *apples*: those pluralities of apples that measure two kilos. At this point, we must settle on the way in which transitive measure terms, together with the accompanying numeral, quantize the complement noun. We must also be explicit about how intransitive measure terms interact with a numeral to form a predicate of extents along a dimension. Lastly, we must determine the relationship between transitive and intransitive measure terms. Let's work backwards, focusing first on the semantics of measure phrases like *two kilos* and *two kilos of apples*. We can then decide on an appropriate semantics for the measure terms themselves that will yield the desired semantics for measure phrases.

As noted above, measure phrases appear to denote sets of individuals, or properties. For example, the intransitive measure phrase *100 kilos* in (22-a) denotes the property of weighing 100 kilos, a property we then ascribe to John. In (25-b), *two kilos of apples* denotes the property of being a collection of apples that weighs two kilos. Supposing we want our measure phrases to be property-denoting, type $\langle e, t\rangle$, we can conceive of the measure terms as relations between numerals and individuals.

In the intransitive use, a measure term takes a numeral and returns the set of individuals that satisfy the relevant measure to the extent specified by the numeral. In this way, a measure phrase like *100 kilos* will be true of an individual just in case it weighs 100 kilos.

(26) $[\![\text{kilo}]\!]_{\langle n,\langle e,t\rangle\rangle} = \lambda \text{n} \lambda \text{x}.\ \mu_{kg}(\text{x}) = \text{n}$

In their transitive uses, measure terms take an additional predicate-denoting argument: the complement noun.[10] We may use the semantics for intransitive measure terms in (26) as the basis for the transitive measure term semantics, where the only difference is that the latter takes an additional internal argument supplied by the complement noun.[11]

(27) $[\![\text{kilo}]\!]_{\langle\langle e,t\rangle,\langle n,\langle e,t\rangle\rangle\rangle} = \lambda \text{P} \lambda \text{n} \lambda \text{x}.\ \text{P}(\text{x}) \wedge \mu_{kg}(\text{x}) = \text{n}$

(28) $[\![\text{CARD}]\!] = \lambda \text{P} \lambda \text{n} \lambda \text{x}.\ \text{P}(\text{x}) \wedge |\text{x}| = \text{n}$

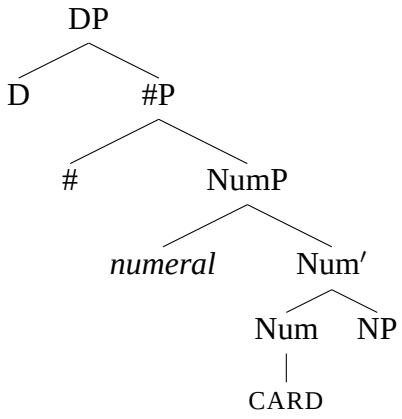
It bears noting that the semantics given here for transitive measure terms results in the same semantic type that we gave to our Num head CARD: $\langle\langle e, t\rangle, \langle n, \langle e, t\rangle\rangle\rangle$. The parallels in structure are obvious: CARD takes a property-denoting argument and then a numeral, forming NumP. A mea-

[10] Complements of transitive measure terms used in pseudo-partitive constructions may only be bare plurals or mass nouns, suggesting that they refer at the kind level. We may therefore want to modify the semantics in (27) so that transitive measure terms take a kind-denoting, and not a predicate-denoting internal argument.

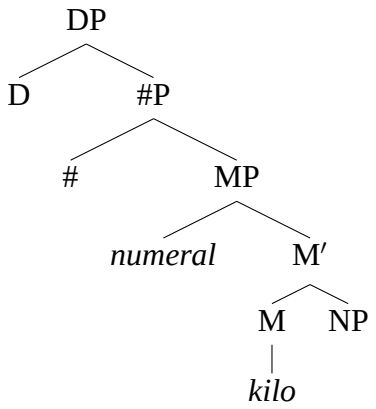
[11] Ongoing work investigates the relationship between transitive and intransitive semantics for measure terms: assuming one use is derived from the other, which use is primary? One possibility is that the intransitive use is derived from the transitive via a process of existential closure over the predicate-denoting argument.

sure term (e.g., *kilo*) takes a property-denoting argument and then a numeral, forming M(easure)P. We illustrate both structures in (29) and (30).

(29)

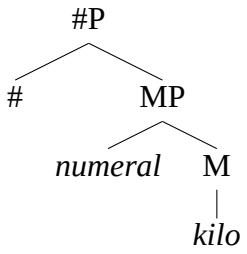


(30)

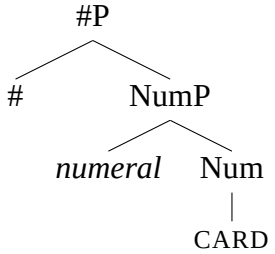


Intransitive measure terms lack an internal argument, and so their structure differs from that of a transitive measure term by the absence of an NP complement as in (31). So far we have noted both structural and semantic similarities between CARD and measure terms; we can pursue the parallel between these elements further by observing that like measure terms, CARD also allows both transitive and intransitive uses. Transitive uses are far more common, and constitute what we consider cardinal numerals (i.e., *three boys*). A candidate structure for an intransitive use of CARD, where a cardinal appears without an NP complement, would be constructions such as *The boys are three* or *Those books number ten*. The structure for an intransitive cardinal appears in (32).

(31)

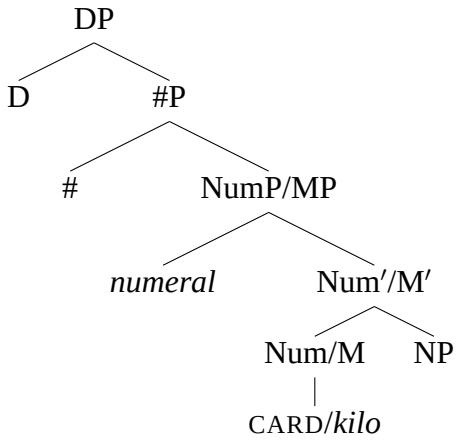


(32)



Given the similarities between CARD and measure terms like *kilo*, our innovation is to treat measure terms as an instance of the Num^0 head. This move requires us to conceive of NumP more generally, taking it to be a measure phrase counting either atoms (CARD) or something more abstract (*kilo*). In both cases the measure is specified by the head of the phrase.

(33)



One advantage of this move is that it allows us to account for number marking on measure terms. Under Sauerland's (2003) system, where # occurs as the sister to DP, absolute atomicity of the individual denoted by DP determines number morphology. However, in *one kilo of apples* vs. *two+ kilos of apples* the number of apples measuring 1 or 2+ kilos is irrelevant to the number morphology on *kilo*. Number marking on measure terms is determined instead by the value of the numeral present: only with *one* do we have singular morphology. Our claim is that in English the measure specified by the head of #'s sister determines the measure μ relevant to the one-ness presupposition of SG.

(34) a. $[\![\text{SG}]\!] = \lambda P: \forall x \in P[\ \boldsymbol{\mu}(x) = 1\ ].\ P$
b. $[\![\text{PL}]\!] = \lambda P.\ P$

With cardinal numerals, CARD is the closest head to # and so the measure relevant to the one-ness presupposition of SG is cardinality. Because SG checks for one-ness on the basis of cardinality in the presence of cardinal numerals, the singular/plural distinction on basic nouns like *book* is sensitive to the semantic number of the predicate in question: when the predicate is closed under sum formation and contains pluralities in its denotation we no longer satisfy the one-ness presupposition of SG and so PL must be used, resulting in plural morphology. Only when the predicate is semantically singular, and thus atomic, will the one-ness presupposition of SG be met on the basis of cardinality. We thus maintain our coverage of number marking on basic nouns from above, preserving the intuition that singular morphology indexes reference to atoms and plural morphology indexes reference to pluralities (in most cases; see Fn. 3).

Assuming that the measure in the one-ness presupposition of SG is supplied by the closest head, measure terms both specify the relevant measure for which one-ness must be satisfied (e.g., μ_{kg}, μ_{degree}, μ_{lb}, etc.) and have number morphology expressed on them (*kilo* vs. *kilos*). Here's why: like CARD, measure terms occupy the head of #'s sister. Also like CARD, measure terms supply a measure: μ_{kg} in the case of *kilo*, μ_{degree} in the case of *degree*, etc. As in the case of CARD, the

measure supplied by the measure term is the measure that must equal 1 for every member of the predicate-denoting complement of #. Crucially, when the numeral co-occurring with the measure term is *one*, everything in the denotation of #'s sister will necessarily measure 1 with respect to the measure supplied by the measure term, allowing for singular morphology. When the numeral co-occurring with a measure term is something other than *one*, nothing in the sister of # will measure 1 with respect to the measure supplied by the term, and so PL must be used.

In sum, we have claimed that the measure relevant to the one-ness presupposition of SG is underspecified, and that in English this measure is supplied by the head closest to #. In the case of cardinal numerals, cardinality determines number morphology: CARD is the head of #'s sister and CARD measures cardinality. In the case of measure terms, the specific measure supplied by the given term determines number morphology. With *kilo*, everything in MP must measure 1 kilo in order for the one-ness presupposition of SG to be satisfied; only when the numeral *one* appears with *kilo* does this state of affairs holds. In this way, we account for number marking on measure terms in the presence of numerals, which, as we have seen, is sensitive to the numeral present and not to the number of individuals referenced. In the next section we see how our assumptions about relevant measures may be extended to provide an account for the cross-linguistic variation in number marking discussed in Section 3.1.

4.3. Relevant measures

In addition to predicting the English pattern of number marking for both basic and measure nouns, we must also introduce sufficient flexibility into our system so that it may account for the patterns in Turkish and Western Armenian. Our approach will be to derive both the English and the Turkish facts and then assume variation within Western Armenian such that it can employ either the English or the Turkish system.

Recall that in Turkish all numerals require singular morphology, which necessitates SG in numeral-noun constructions. With numerals greater than one, this means that we have SG in the presence of a semantically plural property. This combination is problematic because of the way we have aligned semantic and morphological number: we have no way to allow singular-marked nominals to receive a plural interpretation. As was our strategy in accounting for measure terms in the previous subsection, here we will again take advantage of the flexibility allowed for in the selection of the measure μ in the one-ness presupposition of SG. In English we said that μ is supplied by the head closest to #, but this needn't be the case in all languages.

Another possible measure for the one-ness presupposition of SG is relativized to the property with which # composes: $\mu_{P\text{-}atom}$. Here we need a notion of relative atomicity: counting as atomic not with respect to the entire domain, but rather with respect to a specific predicate. P-atoms are the

smallest elements of P, that is, those elements of P that have no other elements of P as parts.[12] $\mu_{P\text{-}atom}$ is thus the cardinality measure relativized to a specific predicate.

(35) $\mu_{P\text{-}atom}$(y) is defined only if y∈P; when defined: $\mu_{P\text{-}atom}$(y) = |{x∈P: x≤y & ¬∃z∈P[z<x]}|

(36) ⟦NumP⟧ = ⟦two CARD *boy⟧ = {a+b, a+c, b+c}

In the presence of cardinal numerals, # composes with a predicate as in (36). Every member of this predicate has no parts which are also members of the predicate, therefore every member of this predicate measures 1 P-atom. Supposing $\mu_{P\text{-}atom}$ to be the measure relevant to the # heads, SG may, and by Maximize Presupposition *must* be used with (36). In fact, all numeral-noun combinations will have a quantized denotation wherein the elements share a common cardinality, so it will necessarily be the case that every member measures 1 P-atom. In other words, with $\mu_{P\text{-}atom}$ as the measure relevant to SG's one-ness presupposition, we predict singular morphology with all numerals. This is the pattern in Turkish-like languages.[13]

One way to view the distinction between the Turkish and English patterns of number marking in the presence of numerals is as a difference in whether the one-ness presupposition of SG is relativized to the complement of # (e.g., NumP/MP; $\mu_{P\text{-}atom}$) or to the head of its complement (e.g., Num^0/M^0). In Turkish we find the former strategy: because numerals, crucially those greater than one, quantize the properties that they modify into relative atoms, the one-ness presupposition of SG relativized to $\mu_{P\text{-}atom}$ will always be satisfied in the presence of a numeral. In English, we saw that the head of #'s sister supplies the relevant measure: either cardinality in the case of cardinal numerals (supplied by CARD) or the specific measure supplied by measure terms.

Our account makes a prediction about number morphology on measure terms in Turkish. Every member of a predicate like *two kilos of apples* will measure 1 P-atom. In order to measure more than 1 P-atom, an individual would have to measure two kilos and be a part of a different individual that also measure two kilos. But this is impossible. We therefore expect singular morphology on measure terms like *kilo* with all numerals in Turkish, which is precisely what we find in (37).

(37) a. elma-dan bir kilo(*-lar)
apple-ABL one kilo-PL
'One kilo of apples'

b. elma-dan iki kilo(*-lar)
apple-ABL two kilo-PL
'Two kilo of apples'

Recall that in Western Armenian we find optionality between the English and Turkish systems:

[12] Note that our notion of relative atomicity differs from that found in Rothstein (2010), where atoms are defined relative to a context and not to a predicate.

[13] Note that the approach correctly predicts singular agreement with all numerals in Turkish even if semantic plurality in such languages is not mere sum-formation, *, but something stronger such as closure under sum less the atoms, * (cf. Link, 1983; for arguments in favor of this stricter approach to plurality in Turkish, see Bale et al., 2011a,b).

numerals greater than one optionally combine with either singular- or plural-marked nouns. To account for this optionality, simply assume that each of these strategies above (phrasal vs. head) is available when selecting the measure relevant to SG's presupposition. When the phrasal strategy is pursued, one-ness is relativized to P-atoms and so singular-marked nominals appear with numerals greater than one; when the English-type, head-based strategy is pursued one-ness is sensitive to cardinality, and so we find plural-marked nominals with these numerals.

We appear to have not only an account of number marking on basic and measure nouns in English, but also an account of the cross-linguistic variation observed in patterns of number marking.

5. Discussion

In our account of number marking in the presence of numerals, we have considered data from three domains. First, we looked at basic nouns like *book* in English whose morphological number depends solely on the semantic number of the property denoted by the nominal. We also considered measure terms like *kilo*, assuming that these measure terms are nouns, at least to the extent that they should be handled by the same system that treats morphological number on basic nouns. Finally, we examined cross-linguistic variation in patterns of number marking, drawing data from Turkish and Western Armenian.

Our account relied on three assumptions: 1) cardinal numerals are formed on the basis of the functional element $\text{CARD}_{\langle\langle e,t\rangle,\langle n,\langle e,t\rangle\rangle\rangle}$, 2) measure terms, like CARD, are relations between numerals and individuals, and 3) morphological number is determined by the head of the functional projection #P, which serves as an identity map on the property denoted by the nominal.

(38) a. $[\![\text{SG}]\!] = \lambda P: \forall x \in P[\ \mu(x) = 1\ ].\ P$
b. $[\![\text{PL}]\!] = \lambda P.\ P$

SG carries with it a one-ness presupposition which ensures that every member of the nominal's denotation measure 1 with respect to some relevant measure μ. In English, we saw that μ is supplied by the head of the complement of #; in the case of cardinal numerals, cardinality determines morphological number. With measure terms, μ is supplied by the measure itself; this accounts for why morphological number on these nouns is sensitive solely to the numeral present.

Cross-linguistic variation in patterns of number marking falls out once we allow variation in the selection of μ: in English μ is relativized to the head of #'s sister; in Turkish, where all numerals occur with singular-marked nouns, μ is relativized to the phrasal complement of # on the basis of P-atoms.

(39) $\mu_{P\text{-}atom}(y)$ is defined only if $y \in P$; when defined: $\mu_{P\text{-}atom}(y) = |\{x \in P: x \leq y\ \&\ \neg\exists z \in P[z < x]\}|$

In Western Armenian, where the pattern of number marking is intermediate between the English and the Turkish systems, there is optionality in the selection of μ: either the head or the phrasal approach may apply. Our account of this variation makes do with a uniform syntax and semantics for numerals across these languages (cf. the variation in numeral semantics proposed in Bale et al., 2011a) within a standard semantics framework (cf. the OT account of Farkas and de Swart, 2010).

Ongoing work aims to extend the system presented here to mass nouns, which are unable to compose with numerals or appear with plural morphology. The strategy will be to attribute a countability (i.e., atomicity) presupposition to #. In doing so, we hope also to provide an account of the monotonicity constraints on measure terms in pseudo-partitives (Schwarzschild, 2006):

(40) a. two inches of cable
b. *two degrees of water
c. two liters of water

Here is a sketch of the motivating intuition: just as a part of water still holds the property of being water, so does a part of something measuring two degrees hold the property of measuring two degrees. Thus, one and the same mechanism should rule out the nominals that would produce a denotation structured in this way.

Acknowledgments

This paper would not have been possible without the guidance and support of Gennaro Chierchia, to whom I offer a special thanks. Thanks also to Uli Sauerland, who generously shared his time to discuss the ideas presented here. I am greatly indebted to Beste Kamali and Süleyman Ulutaş for the help that they provided with the Turkish facts. Finally, I thank the audience and organizers of *Sinn und Bedeutung 17*.

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