Zero N: Number features and ⊥

Luisa Martí[1]

Abstract
In this paper I demonstrate that there is an explanation of the number marking we see on nouns when they combine with the numeral *zero* which combines Martí's (Semant. Pragmat., 2020a, https://doi.org/10.3765/sp.13.3) account of the morphosyntax and semantics of the numeral-noun construction with Bylinina and Nouwen's (Glossa 3(1):98, 2018) semantics for *zero* and which does not need to appeal to any further principles (e.g., agreement).

Keywords Numerals · Number features · *Zero* · Agreement · Plurals · Cross-linguistic variation

1 Introduction

In some languages, the numeral *zero* combines with morphologically plural count nouns, as exemplified in (1) for English (cf. Krifka 1989; Borer 2005). In others, such as Turkish (2), it combines with morphologically singular nouns (Turkish requires the use of a morphologically singular noun for all numerals, despite having morphologically plural nouns; Bale et al. 2011; Scontras 2014; Martí 2020a, among others):

(1)   *English*
       one {apple | *apples}
       zero/two/fifty-five {apples | *apple}

(2)   *Turkish*
       sıfır/bir/iki/üç/yirmi üç   {çocuk | *çocuk-lar}
       zero/one/two/three/twenty-three boy.SG   boy-PL
       'zero/one/two/three/twenty-three boy(s)'
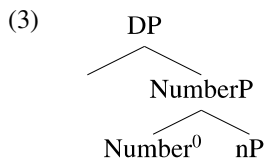
✉ L. Martí
   luisa.marti@qmul.ac.uk

[1]   Queen Mary University of London, London, UK

In this paper I demonstrate that there is an explanation of these patterns that combines Martí (2020a,b) account of the morphosyntax and semantics of the numeral[1] + noun construction with Bylinina and Nouwen's (2018) semantics for *zero* and that does not need to appeal to any further principles (e.g., agreement). The explanation has the overall advantage of accounting for both the number marking of nouns with *zero* (and other numerals more generally) and the semantics of the construction using just one set of tools. Included in this set of tools are Harbour's (2014) semantically contentful number features, which links the present account to his account of the cross-linguistic typology of grammatical number more generally, with potentially far-reaching consequences.

Section 2 introduces the crucial ingredients of Martí's proposal. Section 3 introduces the semantics for *zero* argued for in Bylinina and Nouwen (2018). Section 4 puts that together with the technology in Sect. 2 to derive the *zero* facts. Section 5 discusses issues related to plurality, agreement, and the typology of grammatical number that the account in Sect. 4 raises. Section 6 is the conclusion.

2 Martí (2020a,b) account of the numeral-noun construction

Martí's (2020a) account of the pattern in (1)-(2) minus the *zero* facts is as follows (Martí 2020b extends that account to languages with dual number and to complex numerals). Martí assumes the syntax in (3) for noun phrases without numerals, and that in (4) for phrases with numerals (cf. Borer 2005;[2] Harbour 2014; Scontras 2014, and many others):[3]

(3)

$$
\begin{array}{c}
\text{DP} \\
\diagup \diagdown \\
\text{NumberP} \\
\diagup \diagdown \\
\text{Number}^0 \quad \text{nP}
\end{array}
$$

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[1]I focus on cardinals in this discussion and put aside decimals and ordinals. It does not seem difficult to extend the account proposed below to at least decimals, as suggested by Amy Rose Deal (p.c.), but I leave that task for a future occasion.

[2]Borer (2005, pp. 114-118) proposes an explanation of these facts within the exoskeletal approach she defends there. Among other differences, on her account plural morphology is not semantically plural. One can view my proposal here as an alternative to hers. For more discussion on the relationship between morphological and semantic plurality, see Sect. 5.

[3]I assume that these phrases are DPs, though nothing in the account here follows from this choice of label. Material irrelevant for our purposes is possible between DP and NumberP. nP is a nominal sub-constituent that is taken to contain a root and a nominalizer, n^0, which converts that root into a noun and gives rise to the denotation in (5).

(4)
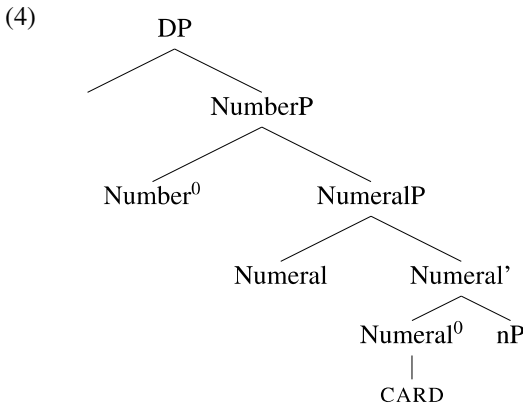
Following Harbour (2014), nP in both (3) and (4) denotes a join semilattice (cf. Link 1983) in all cases. For just three individuals, a, b, and c, we have:

(5)   ⟦nP⟧ = {a, b, c, ab, ac, bc, abc}

NumeralP is realized only in (4), with a numeral (*one*, *two*, etc.) generated as its specifier. $Numeral^0$ hosts Scontras's (2014) cardinality predicate (cf. Hackl 2001, and others), in (6), a function which takes a predicate P, furnished by nP, and a number, furnished by the numeral, and returns a new predicate such that each of its members is in P and is of that numerosity ('#x' stands for 'the numerosity of x'):

(6)   ⟦CARD⟧ = λPλnλx. P(x) & #x = n

(7)   ⟦two CARD nP⟧ = λx. ⟦nP⟧(x) & #x = 2

NumberP hosts number features, which, following Harbour (2014), are both semantically contentful and morpho-syntactically relevant. These number features are thus taken to be responsible for the number semantics of nouns (and other nominal entities, such as pronouns or demonstratives in the languages where these show number morphology) and their morphological shape. NumberP is realized in both trees, given that it is necessary in the account of number marking found in noun phrases both with and without a numeral. Martí follows Harbour's (2014) theory of NumberP-projecting features, where only three features are possible: [±atomic], [±minimal], and [±additive] (for the first two, see also Harbour 2011). With these three features, and a number of additional constraints, Harbour generates all and only the attested grammatical number systems found in the languages of the world—that is, the full cross-linguistic typology of number (see Sect. 5 for more discussion of this point). Only two of those features will be necessary for us, [±atomic] and [±minimal], whose semantics is as follows:[4]

(8)   ⟦+atomic⟧ = λP.λx. P(x) & atom(x)
        ⟦−atomic⟧ = λP.λx. P(x) & ¬atom(x)

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[4]These denotations are simplified here in ways that don't affect matters in any important way. See Martí (2020a) for more on this. A full account for the numeral-noun construction across languages will need to take the remaining feature, [±additive], into account. See Sect. 5 for more on this.

(9) $[\![+\text{minimal}]\!] = \lambda P.\lambda x.\ P(x)\ \&\ \neg\exists y\ P(y)\ \&\ y\sqsubset x$
$[\![-\text{minimal}]\!] = \lambda P.\lambda x.\ P(x)\ \&\ \exists y\ P(y)\ \&\ y\sqsubset x$

The feature [±atomic] is sensitive to the atomic nature of the members of $[\![nP]\!]$:

(10) $[\![\text{NumberP}]\!] = [\![+\text{atomic}]\!]([\![nP]\!]) = \lambda x.\ [\![nP]\!](x)\ \&\ \text{atom}(x) = \{a,\ b,\ c\}$

(11) $[\![\text{NumberP}]\!] = [\![-\text{atomic}]\!]([\![nP]\!]) = \lambda x.\ [\![nP]\!](x)\ \&\ \neg\text{atom}(x) = \{ab,\ bc,\ ac,$ abc}

[±Minimal] is sensitive to whether the members of the denotation of its argument have ([−minimal]) or do not have ([+minimal]) proper parts in it:

(12) $[\![+\text{minimal}]\!]([\![nP]\!]) = \lambda x.\ [\![nP]\!](x)\ \&\ \neg\exists y\ [\![nP]\!]\ (y)\ \&\ y\sqsubset x = \{a,\ b,\ c\}$

(13) $[\![-\text{minimal}]\!]([\![nP]\!]) = \lambda x.\ [\![nP]\!](x)\ \&\ \exists y\ [\![nP]\!]\ (y)\ \&\ y\sqsubset x = \{ab,\ bc,\ ac,\ abc\}$

In the simplest case, the argument of [±minimal] is nP, hence (12) and (13), though, as we will see shortly, this is not always the case. The argument of [±atomic] is always nP. [±Atomic] and [±minimal] give rise to the same result whenever their argument is nP. However, Harbour (2011) shows that [±atomic] and [±minimal] come apart in a number of interesting cases, including pronominal systems with an exclusive and inclusive first person distinction (where $[\![+\text{atomic}]\!]$ (P)$\neq$ $[\![+\text{minimal}]\!]$(P)), number systems with a dual (which combine the two features, so that dual number arises from the feature combination $[\![+\text{minimal}]\!]([\![-\text{atomic}]\!](P)))$, and number systems with a trial (where [±minimal] repeats, so that trial number arises from the feature combination $[\![+\text{minimal}]\!]([\![-\text{minimal}]\!]([\![-\text{atomic}]\!](P))))$. Martí (2020a) argues that one further case where [±atomic] and [±minimal] come apart is precisely in their combination with numerals, as shown below. For a more detailed explanation of these arguments, see Martí (2020a, pp. 9–14).

Martí's account for English is as follows (cf. Scontras 2014), a language in which [+atomic] is realized as ∅ and [−atomic] is realized as *-s*:[5]

(14)

a. $[\![[+\text{atomic}]\ [_{nP}\ \text{boy}]]\!] = \lambda x.\ [\![[_{nP}\ \text{boy}]]\!](x)\ \text{and atom}(x)$ → *boy*

b. $[\![[-\text{atomic}]\ [_{nP}\ \text{boy}]]\!] = \lambda x.\ [\![[_{nP}\ \text{boy}]]\!](x)\ \text{and}\ \neg\text{atom}(x)$ → *boys*

c. ✗$[\![[+\text{atomic}]\ \text{two CARD}\ [_{nP}\ \text{boy}]]\!]$ → ~~*two boy*~~

d. $[\![[-\text{atomic}]\ \text{two CARD}\ [_{nP}\ \text{boy}]]\!] = \lambda x.\ [\![[_{nP}\ \text{boy}]]\!](x)\ \&\ \text{card}(x) = 2$ → *two boys*

e. $[\![[+\text{atomic}]\ \text{one CARD}\ [_{nP}\ \text{boy}]]\!] = \lambda x.\ [\![[_{nP}\ \text{boy}]]\!](x)\ \&\ \text{card}(x) = 1$ → *one boy*

f. ✗$[\![[-\text{atomic}]\ \text{one CARD}\ [_{nP}\ \text{boy}]]\!]$ → ~~*one boys*~~

(14a) is the only source for the singular DP *boy* and gives rise, correctly, to a singular semantics for it. In (14a), the NP *boy* and the resulting DP *boy* have different syntactic structures and different semantics, despite sounding the same. This is in part because [+atomic] in English is spelled out as ∅. (14b) gives rise to the plural form *boys* and assigns it an exclusive plural semantics, more on which in Sect. 5. (14c) is empty, as there are no atoms in a set of, exclusively, plural individuals of numerosity 2 (or 'twosomes', for short), so it is assumed to lead to ungrammatical-

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[5]Anomalous combinations are marked with the symbol '✗' here and throughout.

ity (more on which below). Thus, *two boy* is ungrammatical in English. (14d) is the only source for *two boys* and gives rise, correctly, to a set of boy twosomes as its semantics. (14e) is the only well-formed source for *one boy*, and also gives rise to the correct semantics. (14f) is ill-formed, since ⟦one CARD nP⟧ is a set of atoms, and [−atomic] cannot combine with it. It is the only source for *one boys*, which is thus correctly predicted to be ungrammatical. Notice that the denotation of nP is assumed to be as in (5) in all cases—whether the noun surfaces in its singular or plural form is determined by the interaction of that denotation with the semantics of the Number^0 and Numeral^0 heads in (14). The English use of morphologically singular and plural forms in this paradigm thus follows from an interaction between morphological and semantic assumptions. More precisely, the fact that numerals greater than 1 combine with morphologically plural nouns in English follows from the fact that only in the case of such numerals does ⟦numeral CARD [$_{nP}$ boy]⟧ satisfy the requirements of [−atomic]. *One*, on the other hand, is the only numeral where ⟦numeral CARD [$_{nP}$ boy]⟧ satisfies [+atomic]—this is how its special status in languages like English is derived.

Martí (2020a, p. 10, ft. 14) follows Gajewski (2002) (see del Pinal 2019; Chierchia 2021 for refinements) in assuming that certain kinds of semantic ill-formedness lead to ungrammaticality, and it is worth being explicit here about what this implies for the treatment of outputs such as (14c) or (14f). Not all informationally trivial sentences are ungrammatical, as illustrated in (15):

(15)   a.   Every woman is a woman.
        b.   No woman is a woman.

Gajewski argues, however, that there is type of triviality that *does* lead to ungrammaticality systematically—that is, there are sentences, called L-analytic sentences, whose ungrammaticality is due to their triviality. (14c), (14f) and other cases discussed here involve L-analyticity—the semantics delivers an L-analytic trivial meaning, and the expressions that carry such meanings are ungrammatical. In Gajewski's framework, any instance of triviality that remains a triviality no matter which content words are used, while keeping function words constant, leads to ungrammaticality. The logical structure of the examples in (15) is as follows:

(16)   a.   [Every X is a Y]
        b.   [No X is a Y]

Not all replacements of the variables X and Y lead to triviality. For example, (16a) is not trivial if X is replaced with the predicate *woman* and Y is replaced with the predicate *feminist*—indeed, the sentence *Every woman is a feminist* is informative. Thus, (15a) is not ungrammatical, even if it is uninformative.

Taking (14c) as an illustrative case for our purposes, we have the structure in (17a), where the content word *boy* has been replaced with the variable X; in (17b), that structure is embedded further into a sentence (assuming that number features, numerals, CARD, *in* and *the* all form part of the functional vocabulary of a language, which seems reasonable):

(17) a. [[+atomic] two CARD [$_{nP}$ X]]

   b. [There are [[+atomic] two CARD [$_{nP}$ X]] in the Y]

No matter what replaces the variables X and Y, (17b) always leads to a contradiction (since (17a) is always empty by virtue of the semantics of the feature, the numeral and CARD). Thus, the expressions that spell out (17a) and (17b) are ungrammatical (e.g., *two boy*, *There are two boy in the garden*). Similar remarks hold for Turkish below (see (18d) and (18f)).

Martí's analysis of the Turkish pattern (minus the *zero* facts) in (2) is as follows. Turkish is a [±minimal] system in this account: [+minimal] spells out as Ø and [−minimal] as –*lAr*. We have (for *iki* 'two', *bir* 'one', and *çocuk* 'boy'):

(18) a. $[\![[+\text{minimal}] [_{nP} \text{çocuk}]]\!] = \lambda x. [\![[_{nP} \text{çocuk}]]\!](x) \&$
       $\neg \exists y [\![[_{nP} \text{çocuk}]]\!](y) \& y \sqsubset x$ → *çocuk*

   b. $[\![[-\text{minimal}] [_{nP} \text{çocuk}]]\!] = \lambda x. [\![[_{nP} \text{çocuk}]]\!](x) \&$
       $\exists y [\![[_{nP} \text{çocuk}]]\!](y) \& y \sqsubset x$ → *çocuklar*

   c. $[\![[+\text{minimal}] \text{iki CARD} [_{nP} \text{çocuk}]]\!] = \lambda x.$
       $[\![\text{iki CARD} [_{nP} \text{çocuk}]]\!](x)$
       $\& \neg \exists y [\![\text{iki CARD} [_{nP} \text{çocuk}]]\!](y) \& y \sqsubset x$ → *iki çocuk*

   d. ✗$[\![[-\text{minimal}] \text{iki CARD} [_{nP} \text{çocuk}]]\!]$ → ~~*iki çocuklar*~~

   e. $[\![[+\text{minimal}] \text{bir CARD} [_{nP} \text{çocuk}]]\!] = \lambda x.$
       $[\![\text{bir CARD} [_{nP} \text{çocuk}]]\!](x)$
       $\& \neg \exists y [\![\text{bir CARD} [_{nP} \text{çocuk}]]\!](y) \& y \sqsubset x$ → *bir çocuk*

   f. ✗ $[\![[-\text{minimal}] \text{bir CARD} [_{nP} \text{çocuk}]]\!]$ → ~~*bir çocuklar*~~

(18a) and (18b) result, respectively, in a singular semantics for the DP *çocuk* 'boy' and an exclusive plural semantics for the DP *çocuklar* 'boys', as desired.[6] As Harbour (2011) notes, and as noted above, [±atomic] would have given the same result (see (14a) and (14b)). However, we obtain a different result in combination with numerals. For *iki çocuk* 'two boys' in (18c), we obtain a set of boy twosomes (they have no proper parts in $[\![\text{iki CARD} [_{nP} \text{çocuk}]]\!]$, which contains only boy twosomes). This is the only possible source for *iki çocuk*, so its correct morphology and semantics are derived. (18e) denotes a set of boy individuals composed of exactly one atom, these atomic boy individuals having no proper parts in $[\![\text{bir CARD} [_{nP} \text{çocuk}]]\!]$ (which contains only boy atoms). This is the only possible source for *bir çocuk* 'one boy'. [−Minimal] never gives rise to a well-formed result when combined with a numeral, as shown in (18d) and (18f), since [−minimal] selects from its input P those individuals that have proper parts in P, and there are no such parts in $[\![\text{iki CARD} [_{nP} \text{çocuk}]]\!]$, $[\![\text{bir CARD} [_{nP} \text{çocuk}]]\!]$, etc. Thus, that all numerals combine with morphologically singular nouns in Turkish follows from the fact that, for any numeral, $[\![\text{numeral CARD} [_{nP} \text{çocuk}]]\!]$ satisfies the requirements of only [+minimal], not [−minimal].

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[6]Turkish has inclusive plurals (see Renans et al. 2020; though see Görgülü 2012 for a different view). Following Martí (2020c), this can be accounted for by allowing NumberP not to be generated in Turkish, and assuming that this configuration is spelled out with the plural form. See Sect. 5 for more.

3 Bylinina and Nouwen's semantics for *zero*

Bylinina and Nouwen argue that *zero* is not an emphatic version of the negative quantifier *no* (at least when it combines with count nouns; see Chen 2018 and the end of Sect. 4 for more on this). *Zero* and *no* differ in distribution ((19)-(20)), polarity ((21)-(22)) and NPI-licensing ((23)-(24)), among other things (Zeijlstra 2007; De Clercq 2011; Gajewski 2011—but see Chen 2018 for more nuance on the issue of NPI licensing):

(19)   John owns four cars. Bill owns zero/thirteen (*ones).

(20)   John owns four cars. Bill owns *no/none.

(21)   No students love her, do/*don't they?

(22)   Zero people love her, *do/don't they?

(23)   No student has visited me in years.

(24)   * Zero students have visited me in years.

They argue for a treatment of *zero* in which, just like other numerals, it denotes a number, 0. Bylinina and Nouwen propose that the denotation of count nouns is not a (join) semilattice, as standardly assumed, but a full lattice, which includes the bottommost element, ⊥. ⊥ is of numerosity 0 and has no proper parts. Their proposal is to reconsider our view of pluralization as a full lattice formation. (5), repeated here as (25), is replaced with (26) (in order to keep these denotations distinct, our earlier, Harbour semantics will be referred to with a subscript 'H' (see Link 1983); the Bylinina and Nouwen-inspired semantics will be referred to with a subscript 'BN'):[7]

(25) $[\![nP_H]\!] = \{a, b, c, ab, ac, bc, abc)$

(26) $[\![nP_{BN}]\!] = \{⊥, a, b, c, ab, ac, bc, abc)$

The truth-conditions for a sentence like (27), instead of being those in (28), are now those in (29), where the new version of pluralization is assumed to apply to predicates other than count nouns (e.g., *in the text*) as well:[8]

(27)   There are typos in the text.

(28) $\exists x [typo_H(x) \ \& \ in\_the\_text_H(x)]$

(29) $\exists x [typo_{BN}(x) \ \& \ in\_the\_text_{BN}(x)]$

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[7]Bylinina and Nouwen do not decompose nouns into the more complex structures I have assumed here. (26) corresponds to their assumptions about the meaning of NPs.

[8]Just as in other accounts, predicates other than nouns, such as *in the text* or *pass the test*, need to be given the appropriate semantics if they are to compose appropriately with arguments whose denotation contains both atomic and non-atomic individuals. In Link (1983) and many others, the *-operator is in charge of this job. Bylinina and Nouwen replace that with an operator, which we can call the ^{x}-operator, that takes ⊥ into account. Harbour and Martí are different, since for them the basic denotation of nP already includes atomic and non-atomic individuals. The *-operator (or the ^{x}-operator, if we take into account Bylinina and Nouwen's arguments) is still needed in these accounts for the treatment of predicates that are not nouns (hence, in_the_text$_H$ and in_the_text$_{BN}$ in (28)/(29)). Depending on what one assumes to be the internal semantics of nPs, one might still postulate an *-operator (or ^{x}-operator) for nouns.

One important issue that Bylinina and Nouwen address is that, while a semantics like that in (28) requires there to be at least one typo in the text, correctly, (29) is a tautology, since for any predicate P, $P(\bot) = 1$. The same holds for the numeral-noun construction:

(30)   Zero students passed the test.

(31) $\exists x[\#x = 0 \;\&\; \text{student}_{BN}(x) \;\&\; \text{pass\_the\_test}_{BN}(x)]$

(31) is always true, independently of the number of students who passed the test, since one can always decide that $x = \bot$. In informal terms, the problem is that the truth-conditions for (31) are predicted to be those of *zero or more students passed the test*, which can never be falsified.

The solution proposed for (30) is to note that the semantics that this view provides for numerals is an *at least* semantics, and that exhaustification can generate the required stronger, *exactly* readings. Given the truth-conditions in (31), statements with other numerals are stronger. Uttering (30) signals that those stronger statements are false. We thus have, for (30):

(32) $\neg\exists y\,[\#y > 0 \;\text{student}_{BN}(x) \;\&\; \text{pass\_the\_test}_{BN}(x)]$

Taken together, (31) and (32) result in an *exactly* reading: there are zero or more students who passed the test, and there are no more than zero students who passed the test—so exactly zero did. Unlike other numerals, exhaustification is obligatory for *zero*, since no exhaustification leads to a defective, tautological interpretation. And, since the semantics of *zero* is not stronger in downward-entailing environments (the negation of a tautology is a contradiction), the *exactly* implicature still obtains in such contexts (cf. *Nobody read zero books*).

The solution for the more general problem that arises in (27), where there is no numeral to trigger exhaustification, is to assume that the existential quantifier that operates on statements without numerals is not classical $\exists$ but **E**, as in (33). This takes into account the fact that the denotation of NP now includes $\bot$ and results in the contingent (34) for (27):

(33) $\mathbf{E}x[\varphi] \Leftrightarrow \exists x[\#x > 0 \;\&\; \varphi]$

(34) $\mathbf{E}x\,[\text{typo}_{BN}(x) \;\&\; \text{in\_the\_text}_{BN}(x)]$

More precisely, Bylinina and Nouwen assume that both the **E**-operator and the $\exists$-operator may apply in sentences such as (27), but that, following Landman (2011), a contingent statement is better than a trivial one, that is, that a pragmatic principle against triviality is generally at work in natural language.

The postulation of the **E**-operator, which is necessary for sentences such as (27) once we assume $\bot$, seems rather stipulative. In addition, the classical $\exists$-operator still needs to be assumed in this system, as use of the **E**-operator in sentences such as (30) results in a contradiction. Bylinina and Nouwen argue that $\bot$ is desirable also in the case of sentences with downward monotone degree quantifiers such as *fewer than n*, *at most n*, etc. A sentence like *fewer than 10 students passed the exam* will fail to come out true in situations in which no students passed the test unless $\bot$ is assumed to be part of the denotation of count nouns. Furthermore, the polarity behavior of *zero*

N, as they show, can be explained once ⊥ is assumed. Despite the stipulative flavor of the **E**-operator, it seems necessary once we include ⊥ in the denotation of common nouns.

Another issue is where the two existential operators are used. While Bylinina and Nouwen, following Hackl (2001), assume that a MANY predicate has the function of introducing ∃-quantification and combining numerals and predicates, Scontras and Martí, as discussed in Sect. 3, assume that ∃-quantification is introduced elsewhere in the structure (cf. CARD in (6)). This difference does not have consequences for us. It is still the case in both views that the distribution of the ∃ and **E** operators is different (∃ for numerals, **E** in other cases)—embedding the ∃-operator as part of the semantics of MANY does not change this. Below, I assume (6) and, as far as existential quantification that comes from elsewhere in the structure is concerned, the ∃-operator for numerals, and the **E**-operator for noun phrases without numerals. As we will see, as far as the denotation of features is concerned, the **E**-operator is necessary.

Importantly, in full lattices, ⊥ is not considered an atom (for something to count as an atom, it has to have ⊥ as its only proper part; since, ⊥=⊥, ⊥ cannot be a proper part of ⊥) (see Davey and Priestley 2002, p. 113). If ⊥ is not an atom, then it is a non-atom.

4 The morphology and semantics of *zero N*: a proposal

Given these assumptions, the account proposed here for the full pattern in (1)-(2) is as follows. For English, to the derivations in (14), repeated as (36a)-(36f), we add (36h) and (36i). Recall that we are assuming (26), repeated in (35) for convenience:

(35) $[\![nP_{BN}]\!] = \{\bot, a, b, c, ab, ac, bc, abc)$

(36)

a. $[\![[+atomic]\,[_{nP}\ boy]]\!] = \lambda x.\ [\![[_{nP}\ boy]]\!](x)$ and atom(x)   → *boy*

b. $[\![[-atomic]\,[_{nP}\ boy]]\!] = \lambda x.\ [\![[_{nP}\ boy]\,]\!](x)$ and ¬atom(x)   → *boys*

c.   ✗$[\![[+atomic]\ two\ CARD\ [_{nP}\ boy]]\!]$ → ~~*two boy*~~

d. $[\![[-atomic]\ two\ CARD\ [_{nP}\ boy]]\!] = \lambda x.\ [\![[_{nP}\ boy]]\!](x)\ \&\ card(x) = 2$ → *two boys*

e. $[\![[+atomic]\ one\ CARD\ [_{nP}\ boy]]\!] = \lambda x.\ [\![[_{nP}\ boy]]\!](x)\ \&\ card(x) = 1$ → *one boy*

f.   ✗$[\![[-atomic]\ one\ CARD\ [_{nP}\ boy]]\!]$ → ~~*one boys*~~

g. $[\![zero\ CARD\ [_{nP}\ boy]]\!]\ (= \{\bot\})$

h.   ✗$[\![[+atomic]\ zero\ CARD\ [_{nP}\ boy]]\!]\ (= \emptyset)$ → ~~*zero boy*~~

i. $[\![[-atomic]\ zero\ CARD\ [_{nP}\ boy]]\!]\ (= \{\bot\})$ → *zero boys*

Using (35)/(26) instead of (25)/(5) does not change our earlier results. To see this for a case with just three individuals a, b and c, together with ⊥, we have:

(37) $[\![+atomic]\!](\{\bot, a, b, c, ab, ac, bc, abc\}) = [\![+atomic]\!](\{a, b, c, ab, ac, bc, abc\}) = \{a, b, c\}$

That is, $\perp$ is not an atom. We obtain a different result with [−atomic]:

(38) $[\![-\text{atomic}]\!](\{\perp, a, b, c, ab, ac, bc, abc\}) = \{\perp, ab, bc, ac, abc\} \neq$
        $[\![-\text{atomic}]\!](\{a, b, c, ab, ac, bc, abc\}) = \{ab, bc, ac, abc\}$

This is unproblematic, however. Exclusive plurals as in (36b) (and inclusive ones) now include $\perp$, but the solution Bylinina and Nouwen invoke in (34) applies here. In (36c)/(36d) and (36e)/(36f), since $|\perp| = 0$, $\perp$ is neither in $[\![\text{two CARD } [_{\text{NP}} \text{ boy}]]\!]$ nor in $[\![\text{one CARD } [_{\text{NP}} \text{ boy}]]\!]$, so the results when the number features get added is as before.[9]

For English *zero*, we have the following. Just as it was the case for sets of non-atoms, the only member of the set containing $\{\perp\}$, which arises from (36g), does not satisfy the requirements of [+atomic] (36h): $\perp$ is not an atom. If $\perp$ is not an atom, then it is a non-atom, so (36g) satisfies the requirements of [−atomic] (36i). Thus, the reason that with both *zero* and any numeral greater than 1 English uses the plural morphological marker on the noun is the same: both non-atoms and $\perp$ are non-atoms.

Turning now to Turkish, recall that the semantics of Harbour's feature [±minimal], repeated here, makes use of the ∃-operator:

(39) $[\![+\text{minimal}]\!] = \lambda P \lambda x. \ P(x) \ \& \ \neg \exists y \ P(y) \ \& \ y \sqsubset x$
        $[\![-\text{minimal}]\!] = \lambda P \lambda x. \ P(x) \ \& \ \exists y \ P(y) \ \& \ y \sqsubset x$

Since we are adopting Bylinina and Nouwen's system, the question arises as to whether this semantics needs revision. Given that, with the introduction of $\perp$, atoms now have proper parts ($\perp$ is a proper part of any atom), the semantics for [±minimal] that we need is as in (40), which uses the **E**-operator:[10]

(40) $[\![+\text{minimal}]\!] = \lambda P \lambda x. \ P(x) \ \& \ \neg \mathbf{E} y \ P(y) \ \& \ y \sqsubset x$
        $[\![-\text{minimal}]\!] = \lambda P \lambda x. \ P(x) \ \& \ \mathbf{E} y \ P(y) \ \& \ y \sqsubset x$

For Turkish we now have (for *iki* 'two', *bir* 'one', *sıfır* 'zero' and *çocuk* 'boy'):

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[9]As a reviewer correctly points out, this makes $[\![[-\text{atomic}] [_{\text{nP}}]]\!]$ pick out a discontinuous area of the lattice (since $[\![-\text{atomic}]\!](\{\perp, a, b, c, ab, ac, bc, abc\}) = \{\perp, ab, bc, ac, abc\}$) and, thus, non-convex (similarly to Link 1983; Landman 2011). This very interesting observation takes us back to Harbour's (2014, pp. 210–212) discussion of convex meanings. Harbour's Convexity condition (his (32)), that all basic meanings be convex, might seem at odds with the proposal in the text, but a way out of this problem is to view the condition as applying only to the feature that Harbour is concerned with here, [±additive]. The issue, however, deserves more careful consideration, something that I leave for future research.

[10]Thanks to Greg Scontras for discussion of this point. The question arises as to what consequences this change in the semantics of [±minimal] has in Harbour's system. I demonstrate below that number systems that use just this feature on nouns can be accounted for as before. Since $\perp$ is excluded by [−minimal], any complex number value based on [−minimal] is derived without interference by $\perp$, as before. Complex number values where [+minimal] is not the first feature that operates on NP will also work as before. There might be an issue with number values of pronouns based on [+minimal] or [−atomic] (cf. (38)), where $\perp$ will be present, since it might be asked whether the **E**-operator applies with pronouns, but I do not explore this issue here.

(41)   a. $\llbracket$[+minimal] [$_{nP}$ çocuk] $\rrbracket$ = λx. $\llbracket$[$_{nP}$ çocuk]$\rrbracket$(x) &
         $\neg$**E**y $\llbracket$[$_{nP}$ çocuk]$\rrbracket$(y) & y⊏x   → *çocuk*

       b. $\llbracket$[−minimal] [$_{nP}$ çocuk]$\rrbracket$ = λx. $\llbracket$[$_{nP}$ çocuk]$\rrbracket$(x) &
          Ey $\llbracket$[$_{nP}$ çocuk]$\rrbracket$(y) & y⊏x   → *çocuklar*

       c. $\llbracket$[+minimal] iki CARD [$_{nP}$ çocuk]$\rrbracket$ = λx.
         $\llbracket$iki CARD [$_{nP}$ çocuk]$\rrbracket$(x) &
         $\neg$**E**y $\llbracket$iki CARD [$_{nP}$ çocuk]$\rrbracket$(y) & y⊏x   → *iki çocuk*

       d.   ✗$\llbracket$[−minimal] iki CARD [$_{nP}$ çocuk]$\rrbracket$ → ~~iki çocuklar~~

       e. $\llbracket$[+minimal] bir CARD [$_{nP}$ çocuk]$\rrbracket$ = λx.
         $\llbracket$bir CARD [$_{nP}$ çocuk]$\rrbracket$(x) &
         $\neg$**E**y $\llbracket$bir CARD [$_{nP}$ çocuk]$\rrbracket$(y) & y⊏x   → *bir çocuk*

       f.   ✗$\llbracket$[−minimal] bir CARD [$_{nP}$ çocuk]$\rrbracket$ → ~~bir çocuklar~~

       g. $\llbracket$sıfır CARD [$_{nP}$ çocuk]$\rrbracket$ (= {⊥})

       h. $\llbracket$[+minimal] sıfır CARD [$_{nP}$ çocuk]$\rrbracket$ (= {⊥})   → *sıfır çocuk*

       i.   ✗$\llbracket$[−minimal] sıfır CARD [$_{nP}$ çocuk]$\rrbracket$ (= ∅)   → ~~sıfır çocuklar~~

Let's begin with (41a) and (41b). With the semantics in (40), we have, for three elements a, b and c, plus ⊥:

(42) $\llbracket$+minimal$\rrbracket$({⊥, a, b, c, ab, ac, bc, abc}) = {⊥, a, b, c}

(43) $\llbracket$−minimal$\rrbracket$({⊥, a, b, c, ab, ac, bc, abc}) = {ab, ac, bc, abc}

Since both ⊥ and atoms have no proper parts of numerosity greater than 0 (⊥ has no proper parts at all, and atoms have only ⊥ as a proper part, but ⊥ does not have numerosity greater than 0), they count as minimal and are included in (42). Plural individuals are not, since they do have proper parts of numerosity greater than 0. Since neither ⊥ nor atoms have proper parts of numerosity greater than 0, they are excluded in (43). Plural individuals are, on the other hand, included now because they have proper parts of numerosity greater than 0. The denotation of morphologically singular nouns in (41a) now includes ⊥; the use of the **E**-operator that Bylinina and Nouwen invoke for bare plurals in English is invoked here as well, and we correctly predict that DPs such as *çocuk* are semantically singular, as before (cf. (18a)). The denotation of morphologically plural DPs such as *çocuklar* is just as before (cf. (18b)).

In (41c)/(41d) and (41e)/(41f), since |⊥| = 0, ⊥ is neither in $\llbracket$iki CARD [$_{nP}$ çocuk]$\rrbracket$ nor in $\llbracket$bir CARD [$_{nP}$ çocuk]$\rrbracket$, so the results when the number features get added are as before.

Turning now to the account of *zero N* in Turkish, the only member of the set containing {⊥} (41g) satisfies the requirements of [+minimal], ⊥ has no proper minimal parts at all. Thus (41h) gives rise to the correct morphology and semantics for *sıfır çocuk* 'zero boys'. On the other hand, ⊥ is not non-minimal, so [−minimal] cannot successfully apply to {⊥}, and we obtain the result in (41i), namely, **sıfır çocuklar*. Thus, the reason why with any numeral including *zero* Turkish uses the singular morphological marker on the noun stays the same: atoms, non-atoms and ⊥ are all proper-part-less once the numeral has combined with [CARD [$_{nP}$ çocuk]].

Two important issues about the analysis presented above need addressing before proceeding. The first one has to do with L-analyticity and the role it plays in the anal-

ysis of *zero*—for example, (36h), being L-analytic, leads to ungrammaticality in the analysis of English above (recall also (14c) and (14f)). No matter what replacements of X and Y we carry out in (44), (44a) will always be empty, and sentences of for example the form in (44b) (e.g., **There are zero boy in the garden*) will always be a contradiction (and, thus, ungrammatical):

(44) a. [[+atomic] zero CARD [$_{nP}$ X]]
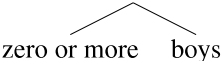   b. [There are [[+atomic] zero CARD [$_{nP}$ X]] in the Y]

Interestingly, *zero* seems at first sight to pose a special challenge for this view, as argued by an anonymous reviewer. Indeed, (45) is a trivial, but grammatical, sentence:

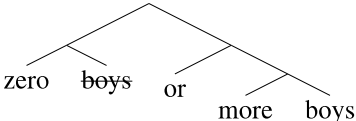(45) There are zero or more boys in the garden

The sentence is clearly uninformative, a tautology. It is equally clear to speakers that the sentence is grammatical. However, the sentence seems L-analytic, because any replacement of the content words in the example renders it still uninformative:

(46) There are zero or more Xs in the Y

However, whether (45) is indeed a problem for this approach depends on its syntactic analysis, I claim. One possible analysis treats *zero or more* as a (complex) modifier, on a par perhaps with *at least three boys* or *more than three boys*. In that case, we'd have the following basic structure:

(47)

zero or more   boys

Another possibility is as follows:

(48)

zero   ~~boys~~   or
              more   boys

(49) There are zero ~~boys~~ or more boys in the garden

Under this fully compositional analysis, the underlying structure of *zero or more boys* is more complex than meets the eye and includes a phrase headed by *or* as well as nominal ellipsis. If (47) is the correct analysis, (45) may indeed be considered an L-analytic sentence which is nevertheless grammatical, a problem for Gajewski's view and thus also a problem for the analysis of *zero* defended here. However, if (48) is the correct analysis, then there is no problem, since not every substitution of the lexical material in (48) leads to triviality. (50) doesn't:

(50) ?There are zero apples or more pears in the garden.

(50) may be odd, particularly out of the blue (since it is necessary to resolve the comparison of *more*, something which may be alleviated in the right context). But it is certainly not trivial, with a meaning akin to "there are no apples or more than

a certain number of pears in the garden" (true in a situation in which there are no apples in the garden, false in a situation in which there are some apples but no pears in the garden). This would make (45) non-L-analytic, and, thus, not a problem for the present account.

The issue is, then, analysis-dependent, and making progress on it involves deciding on the correct analysis. In fact, there are arguments for and against (48). Adopting (48) would presumably entail that the analysis of the related (51) is as in (52):

(51)   ?There are zero boys or more ~~boys~~ in the garden

(52)
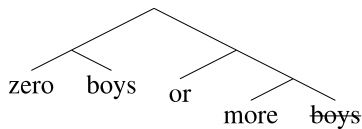
But *zero or more boys* and *zero boys or more* are, interestingly, not equivalent. *Zero boys or more* conveys that the number of boys was large (if not fully known), which is at odds with there being zero boys in the garden (hence the oddness of (51)), whereas *zero or more boys* is entirely neutral in that respect.[11] Conversely, the analysis in (48) sets *zero or more* apart from numeral modifiers such as *at least* or *more than*, which seem genuinely different. For example, both (53) and (54) are true and felicitous in a context in which the speaker is certain that Sue drank three beers and one vodka (and nothing else):

(53)   Sue drank more than three beers.

(54)   Sue drank at least three beers.

(55) is different in this regard, in a way that suggests that *beers* plays a role that goes beyond its role in (53) and (54):

(55)   Sue drank three or more beers.

(55) is false if the speaker is certain that all that Sue drank is three beers and one vodka.[12,13] The analysis in (48), extended to numerals such as *three*, can capture this fact, and is sufficiently different from analyses of *at least* and *more than*[14] to warrant the contrast with them. I do not pursue the analysis of (45) further here, but I hope to have demonstrated that it is not obvious that such cases necessarily represent a problem for the analysis of *zero* in terms of L-analyticity pursued here.

The second issue that needs addressing is that *zero* can combine with mass nouns in English (e.g., *zero sugar*), as well as with what Chen (2018) calls nominal degree predicates (as in, e.g., *zero tolerance*), which are typically uncountable. There is an argument to be made, as suggested by a reviewer, that *zero* shouldn't be treated as a

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[11] Thanks to Sarah Felber, Bruce Morén-Duolljá and Barbara Partee for discussion of these observations.

[12] (54) conveys the idea that the speaker is not completely certain that Sue drank vodka, but both examples are compatible with a state of affairs in which Sue drank it, in addition to the three beers.

[13] Thanks to Rick Nouwen (p.c.) for the examples and the observations just presented.

[14] See Geurts and Nouwen (2007) and Nouwen (2010), among others.

numeral, since generally numerals cannot combine with mass nouns (*three sugar*) or with nominal degree predicates (*two tolerance*). Chen (2018), however, suggests that *zero* might be ambiguous in English between a numeral semantics (which combines with plural count nouns in English), and a degree quantifier semantics. It is the latter that we see in examples with nominal degree predicates, as she argues, and, judging from the behavior shown below on (substance) mass nouns, with these nouns as well. That the *zero* that appears with regular count nouns (abbreviated to $zero_{count}$) and the *zero* that appears with nominal degree predicates and mass nouns ($zero_{uncount}$) might be different lexical items is suggested by, for example, the fact that only $zero_{count}$ (and numerals more generally) is possible in certain comparative constructions or accepts modification by *absolutely*:

(56)   a.   Naomi certainly has more than zero/three/ten publications!
        b.   ??Naomi certainly has more than zero confidence in this contest!
        c.   ??Tom certainly has more than zero flour in his cupboard!

(57)   a.   *Naomi purchased absolutely zero/five jackets!
        b.   Tom has absolutely zero interest in physics.
        c.   These cookies have absolutely zero flour.

Further evidence for the ambiguity hypothesis for English *zero* is that not all languages seem to treat their *zero* as ambiguous in this way—an item that is lexically ambiguous in one language need not be so in the next. Cantonese *ling4* might be a case in point. Chow and Morzycki (2021) show that *ling4* is compatible (without a classifier) with unit nouns (58) and with 'chance' predicates (59), but cannot combine with classifiers and nouns like *gau2* 'dog', setting it apart from all other numerals in the language (60):

(58)   ling4 seoi3
        zero   year
        'Zero years old'

(59)   ling4 gei1 wui2
        zero   chance
        'Zero chance'

(60)   ??ling4 (zek3)   gau2
        zero   CLASSIFIER dog
        'Zero dogs'

This makes it plausible to think that Cantonese *ling4* is unambiguously a degree quantifier, not a cardinality expression/numeral.[15] Thus, we need not take the appearance of *zero* with mass nouns or nominal degree predicates in a language like English as

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[15]Chow and Morzycki argue that Cantonese lacks ⊥ in its ontology, which of course has the consequence of preventing *ling4* from behaving like a numeral (if Bylinina and Nouwen are right).

evidence against the treatment of *zero* as a numeral—there are plausibly two *zeros* in English.[16],[17]

5 Plurality, agreement and the typology of grammatical number

Two key aspects of the account in Martí (2020a,b) need further discussion and justification: the type of explanation proposed for the facts in (1) and (2) and the semantic contribution assumed for morphological plurality.

Facts such as those in (1) and (2) are often thought of as morpho-syntactic facts, usually in terms of agreement (or concord) between the noun and the numeral. For example, English may be taken to show that nouns agree in the plural with the numeral in this construction, and that the numeral *one* is special in that it does not support such agreement (or it calls for singular agreement, which is null in English). Turkish can be taken to show that in some languages agreement is lacking, or that it is in the singular by default (see Alexiadou 2019—Ionin and Matushansky 2006, 2018 argue instead for 'semantic' agreement, as discussed below). In contrast, no appeal to agreement or any further mechanism is made in Martí's account, or the account presented above for *zero*, where compositional semantics plays a crucial role in the explanation. Which account is to be preferred?

The adoption of Martí (2020a,b), and, ultimately, Harbour (2014), also raises the issue of the proper account of the semantics of plurality. To see this, consider that [−atomic] generates only an exclusive semantics for plural forms, that is, a semantics of non-atoms, and non-atoms only, as we saw in (14b). As is well-known, however, many languages have both inclusive and exclusive plurals, inclusive plurals conveying a meaning which involves both atoms and non-atoms. How are inclusive plurals to be accounted for in an approach, like the one pursued here, in which exclusive plural meanings are derived semantically? Indeed, one popular analysis, discussed by Sauerland (2003) and many others,[18] and which Scontras (2014) uses in his own proposal,

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[16]In Western Armenian (Bale and Khanjian 2014, p. 5, ft. 4), Hungarian (Csirmaz and Szabolcsi 2012) or Slovenian (Lanko Marušič p.c.), *zero* never combines with nouns:

(i)   *Western Armenian*

        *zero {dəgha | dəgha-ner}, meg {dəgha | *dəgha-ner}, yergu {dəgha | dəgha-ner}
        zero {boy.SG boy-PL   one {boy.SG *boy-PL   two   boy.SG boy-PL
        'zero boys, one boy, two boys'

Scontras (2014) and Martí (2020a) account for the *zero*-less pattern in Western Armenian as well; Martí argues that Western Armenian has access to both the English [±atomic] number system and the Turkish [±minimal] number system. Bylinina and Nouwen suggest that this language does not license *zero* syntactically in the numeral-noun construction. Another possibility is to assume that, while the language does have the numeral *zero* (which, as before, denotes 0 and can be used to talk about mathematical calculations), the semantics of its noun phrases never contains ⊥. Yet another possibility is that the ontology of Western Armenian just doesn't have ⊥ at all, like Chow and Morzycki (2021) argue for Cantonese. I leave further investigation of these options for future research.

[17]The account of the full pattern with *zero* in (1)-(2) works in Scontras's (2014) original account as well, which, recall, is based on a Sauerland-style view of plurality. Scontras's account does not use Harbour's features but is compatible with Bylinina and Nouwen's analysis.

[18]See Krifka (1989, 1995), Ivlieva (2013), Lasersohn (1995, 2011), Mayr (2015), Sauerland et al. (2005), Spector (2007), Yatsushiro et al. (2017) and Zweig (2009). Farkas and de Swart (2010) and Grimm (2013)

takes it that singular features presuppose singularity and plural features are semantically vacuous, which is at odds with (14). In this and other Sauerland-style analyses, there isn't a feature like [−atomic] alongside [+atomic] that generates an exclusive reading for plural forms. Instead, plural forms are always semantically weak, with exclusive, stronger readings arising pragmatically. As Martí (2020c) argues, however, a Sauerland-style view of plurality is incompatible with Harbour (2014). What arguments are there for the view of plurality in Harbour (2014)?

In this section I argue that there are two important advantages, related to these issues, that Martí's proposal and, thus, the proposal presented above on *zero*, has against competitors. The first advantage has to do with theoretical economy, and the second with empirical coverage.

The argument about theoretical economy is that the set of tools needed in the proposal presented here to explain the number morphology of the noun in the numeral-noun construction (singular or plural in the case of English, singular in the case of Turkish) is the same set of tools that accounts for its semantics. This is because Harbour's number features, which are at the core of the proposal, have both semantic (they are semantically contentful) and morphosyntactic (they are realized morphosyntactically) implications. An explanation that relies on an independent mechanism, such as (semantic) agreement or concord, to explain the morphological make-up of the noun still needs to be complemented by an account of the semantics of the construction. In the proposal above, one and the same set of tools is responsible for both aspects of the construction, which, everything else being equal, is preferable. The same argument applies in the case of *zero*: there is no need to appeal to agreement, concord or some other morphosyntactic process to explain the *zero*+noun facts above, as one and the same set of tools accounts for both the semantics and the morphosyntax we observe in this construction.

Contrast this with, e.g., Ionin and Matushansky's (2006, 2018) account. On that account, numerals have the semantics of modifiers (similarly to our NumeralPs above) and that semantics is such that numerals combine with noun denotations containing atoms only (i.e., singular nouns). Their denotation for a numeral like *two* is in (61), which makes use of the notions of partition (62) and cover (63) (see Ionin and Matushansky 2018, pp. 13, 78, as well as Higginbotham 1981, p. 110; Gillon 1984; Verkuyl and van der Does 1991; Schwarzschild 1994):

(61) $[\![two]\!] = \lambda P_{<e,t>}.\lambda x: \exists n \forall z\ P(z) \rightarrow |z|{=}n\ .\exists S_{<e,t>} \prod(S)(x)\ \&\ |S|{=}2\ \&\ \forall s{\in}S\ P(s)$

(62) $\prod(S)(x) = 1$ iff S is a cover of x, and $\forall z, y{\in}S\ [z{=}y \lor \neg\exists a\ [a{\leq}z\ \&\ a{\leq}y]]$

(63) A set of individuals C is a cover of a plural individual X iff X is the sum of all members of C: $\sqcup C = X$

Minus the presupposition, the numeral *two* takes a set P of individuals as its argument and returns a set of individuals x that complies with the following conditions: there is a set S of non-overlapping individuals such that $\sqcup S = x$, the cardinality of S is 2,

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propose an ambiguity account that is compatible with the proposal in Martí (2020a,b) (see Martí 2020c for more on this). Kiparsky and Tonhauser (2012) provide a useful overview of the main issues.

and P holds of all members of S. The constraint against overlapping individuals in (62) is crucial to avoid counting an element more than once. Applying *two* to a set of atoms returns a set of twosomes, each of which is composed of exactly two non-overlapping atoms. The argument of a numeral in this approach is presupposed not to contain plural individuals: if it did, we would not be able to guarantee that, e.g., *two boys* contains strictly boy twosomes—we'd leave open the possibility of finding a plural boy individual x in its denotation composed of, say, four atoms organized into two non-overlapping plural individuals y and z such that the sum of y and z is x. The presupposition in (61) ensures that P does not contain plural individuals, since different plural individuals will have different cardinality—in a set of atoms, however, all of its members have the same cardinality of 1. Ionin and Matushansky consider the existence of languages like Turkish, where the noun that accompanies a numeral is always morphologically and semantically singular, as direct evidence for their approach. The existence of languages like English prompts them to appeal to semantic agreement: *s-* marking on *boys* in *three boys* reflects, in their analysis, the fact that *three boys* is a set of plural individuals, not that *boys* is.

In the approach defended here, there is no need to appeal to a separate mechanism of semantic agreement in languages like English. Nouns in the numeral-noun construction appear marked the way they do across languages because of the number features assumed to operate in NumberP and their combination with a universal numeral semantics (recall (14) for English-like languages, and (18) for Turkish-like languages). Crucially, these assumptions *both* explain the marking on the noun *and* generate the correct semantics for numeral-noun phrases. All other things being equal, this should be the preferred approach, as it is much more economical.

Are all other things equal? Some might argue that they are not. After all, as Ionin and Matushansky (2018, pp. 94-109) argue, the numeral-noun construction displays surprising properties in some languages, and sometimes patterns differently from constructions where nouns appear without numerals. Examples they discuss include Miya (where plural marking inside the numeral-noun construction is argued to follow the same pattern as plural agreement on verbs, and is different from plural marking on nouns without numerals; cf. Schuh 1989, 1998), or languages where the number marking on the noun depends on the numeral it combines with (e.g., in Standard Arabic, simplex cardinals greater than 10 use singular marking on the noun, whereas lower numerals combine with plural nouns; see Zabbal 2005). Thus, one might argue that the numeral-noun construction requires special treatment anyway, and, from this perspective, appealing to a special, separate mechanism might seem reasonable. However, I take it that the null hypothesis is that the shape of nouns in the numeral-noun construction is related in some way to the shape of those nouns in other contexts, especially when it is the same. Martí (2020a,b) and the present paper are attempts at explaining the behavior of nouns in the numeral-noun construction as something that is related to the behavior of nouns more generally, and, as such, are, at least, worth considering. It is appealing, as this paper demonstrates, that the properties of *zero*-phrases can also be understood within the same set of assumptions.[19]

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[19]Martí (2020b) shows that Martí (2020a) is compatible with a decompositional approach to complex numerals like the one Ionin and Matushansky (2006, 2018) advocate. For remarks on Miya in the context of the theory presented here, see Martí (2020a).

Harbour's (2014) number features, which are at the core of the explanation proposed here, have ample independent justification in that they help derive the complex set of generalizations that characterize the typology of grammatical number across languages. This typology, known since Greenberg (1966) and discussed in great detail in Corbett (2000), is concerned not just with the number values that are (un)attested cross-linguistically (singular and plural, but also dual, trial, paucal, minimal, augmented, greater plural, global plural, and others), but with the kinds of number systems that are (un)attested in the languages of the world. For example, one cross-linguistically robust generalization is that there is no language that has the dual number value without also having the plural value. Another one is that there is no language that has the trial number value without also having the dual. Thus (see Harbour 2014: p. 186):

(64)   Trial requires dual
        Dual requires singular
        Singular requires plural
        Plural requires singular or minimal
        Unit augmented requires augmented
        Minimal requires augmented or plural
        Augmented requires minimal
        Greater paucal requires (lesser) paucal
        Paucal requires plural
        Greater (and global) plural requires plural or augmented

Harbour's proposal accounts for the generalizations in (64)—that is, for the meaning, expression and combination of grammatical number values—with a remarkably small set of tools, which includes the features and assumptions discussed in Sect. 2, in addition to the feature [±additive] and the assumption that one and the same number feature may repeat (neither of which is discussed here because the number values they help to account for, such as paucal or trial, are not expressed in English or Turkish). Thus, the account proposed above allows us to see the numeral-noun construction, including the *zero* facts, as part of a much larger explanation, that of the semantics and morphosyntax of grammatical number more generally. The advantage of this is not just that the tools used to account for that construction are justified independently, it's that we now have a series of expectations about, e.g., possible and impossible morphological marking on the noun in the construction as a factor of the grammatical number of the language in question. For singular-plural languages, the facts may be as in (1) or as in (2), with no other combinations allowed. Specific and testable predictions are made for languages with more number values, the details of which are left for future research. I know of no other account of the numeral-noun construction that has the power to make cross-linguistic predictions in this fashion.[20]

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[20]As a reviewer points out, Ionin and Matushansky's proposal is in principle compatible with Harbour's account if one assumes that the numeral-noun construction is a special case. Hence, adopting their approach need not entail not capturing the cross-linguistic typology of grammatical number that he achieves. This is true, but my earlier criticism, that Ionin and Matushansky's hypothesis regarding the number marking on the noun in the numeral-noun construction is not the null hypothesis, still stands.

Moving on now to the issue of empirical coverage, let's begin by noting the argument in Martí ([2020c](#)) that a Sauerland-style view of plurality is incompatible with Harbour ([2014](#))—note that her argument is concerned both with Sauerland's ([2003](#)) specific proposal and, more generally, with *any* proposal that postulates an unambiguous approach to the lexical semantics of the plural. The problem is how to account for languages where plurals can be interpreted either inclusively or exclusively, English being one of them, as exemplified in (65) (exclusive interpretation: Lina ate more than one tomato) and (66) (inclusive interpretation: Lina didn't eat a single tomato):

(65)   Lina ate tomatoes.

(66)   Lina didn't eat tomatoes.

In a Sauerland-style approach, only the inclusive interpretation is lexically/grammatically specified; the exclusive interpretation is derived, e.g., as an implicature.

Martí's argument is as follows: if a language with inclusive plurals is analyzed as not making use of [−atomic], as one would do in a Sauerland-style approach, the prediction Harbour makes is that such a language should have no number values that are built on [−atomic], such as dual or paucal. This prediction is wrong, since languages with inclusive plurals and duals (or paucals) exist. Therefore, if one is to keep both Harbour's account of number, which is the only one currently capable of accounting for the crosslinguistic typology of number, and an account of inclusive plurality, one must choose, instead, an ambiguity account of plurality (see Martí [2020c](#) for more on what such an account could look like, following Farkas and de Swart [2010](#)).

As Martí shows, it won't do to keep [−atomic] but make it semantically empty (or the identity function) across the board, thus allowing plurals to be unambiguously inclusive semantically: it is the *exclusive* semantics that Harbour gives to [−atomic] that is crucial in deriving other number values. For example, consider the derivation of the dual given the semantics of the features assumed earlier. A singular-dual-plural system uses both [±atomic] and [±minimal], as follows:

(67)   a. $[\![[+\text{minimal } [+\text{atomic nP}]]]\!] = \{a, b, c, d, e\ldots\}$ (singular)
         b. $[\![[-\text{minimal } [+\text{atomic nP}]]]\!] = \{\ \}$[21]
         c. $[\![[+\text{minimal } [-\text{atomic nP}]]]\!] = \{ab, bc, ac, be, \ldots\}$ (dual)
         d. $[\![[-\text{minimal } [-\text{atomic nP}]]]\!] = \{abc, bce, abcd, acde, \ldots\}$ (plural)

If [−atomic] had no semantic contribution, the dual wouldn't be assigned the correct semantics—we'd have, as its denotation, not the set of plural individuals of numerosity 2 in (67c), but the set $\{\bot, a, b, c, d, e\ldots\}$, which is incorrect as the denotation of the dual. This entails a significant loss of empirical coverage. One might argue against the use of [±atomic] to derive at least some of these systems, using [±minimal] instead, and repeating it to derive number systems with duals, but this will not solve the problem. A singular-dual-plural system would be derived as follows:

(68)   a. $[\![+\text{minimal nP}]\!] = \{\bot, a, b, c, d, e\ldots\}$ (singular)

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[21] Since (67b) is empty, there is no piece of morphology that a language is expected to use to spell out this feature combination—that would entail, unreasonably, that a language would dedicate specific resources to spelling out something that always leads to ungrammaticality.

b. $[\![$[−minimal [+minimal nP]]$]\!]$ = { }

c. $[\![$[+minimal [−minimal nP]]$]\!]$ = {ab, bc, ac, be, . . . } (dual)

d. $[\![$[−minimal [−minimal nP]]$]\!]$ = {abc, bce, abcd, acde, . . . } (plural)

(68) doesn't help either.[22] Turkish is, in our Harbour-inspired approach, a [±minimal] language, but it also has inclusive plurals (recall footnote 6). To account for that while adopting the unambiguous treatment of inclusive plurals that takes the relevant feature to be semantically null, we'd have to say that [−minimal] is also semantically empty/the identity function. The earlier problem of empirical inadequacy resurfaces: the correct semantics of the dual can no longer be generated. The same reasoning applies to other number values that are based on [−atomic] in Harbour's theory, such as paucals. We could give up Harbour altogether, of course, but then we lose the account of the typology of number in (64). The problem is, thus, not which feature is responsible for plurality, but the fact that certain features are used in Harbour's system, and to great effect, as parts of complex, compositionally-derived, number values, and changing the semantics of those features entails losing the account of those values and/or the typological generalizations from (64) they are involved in.[23,24]

Thus, abandoning the non-ambiguity, Sauerland-style view of plurality, Martí shows that it is possible to account for the number marking and semantics of the numeral-noun construction in English *and* for its exclusive and inclusive plurals by assuming that plural forms are ambiguous between an exclusive, [−atomic]-based semantics, and an inclusive semantics. In this approach, inclusive plurals in English arise from the ability to not generate NumberP in numeral-less noun phrases. That is, English has both inclusive and exclusive plurals because its (numeral-less) plural forms spell out either (69) or (3) (with [−atomic], as in (14b)):

(69)

```
        DP
       /\
         nP
```
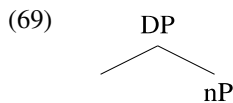
The choice between the two is regulated e.g., by the Strongest Meaning Hypothesis (Farkas and de Swart 2010).

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[22]Harbour (2014, p. 205) proposes a constraint on feature repetition such that combinations like [+F, +F] and [−F, −F] are ruled out, having to do with the need to prevent the system from generating unattested number values such as quadral, quintal, and so on. (68d) would be problematic for this constraint, but this is a smaller problem than the one discussed in the text.

[23]Likewise, Martí (2020c, pp. 55–57) shows that postulating that a language may use [−atomic] in the derivation of the dual (or paucal), but not in the derivation of the plural, is problematic as well.

[24]The interpretation of plurals in *exactly*-phrases (e.g., *exactly one student brought wine bottles to the party*) is a well-known problem for ambiguity accounts (see Spector 2007; Farkas and de Swart 2010, p. 34, ft. 25) that the current account inherits. Non-ambiguity accounts deal with such problems more easily. However, non-ambiguity accounts are not compatible with Harbour (2014), as argued above, so giving it up to account for the *exactly* facts involves giving up the account of the cross-linguistic typology of number that Harbour manages to achieve. Both accounts have their drawbacks. What I think is really interesting here is that a crucial consideration in the assessment of the different options is the cross-linguistic typology of number.

6 Conclusion

In this paper I have added *zero* to Martí ([2020a,b](#)) account of the numeral-noun construction. Two of the main language types that Martí's framework accounts for are exemplified by English and Turkish, and it is those two types of patterns with *zero* that the analysis proposed here has been shown to account for. Importantly, the proposal makes use of the same technology (number features, a certain structural relationship between them and numerals) that Martí uses to account for the numeral-noun construction more generally, assumptions that are combined here with Bylinina and Nouwen's analysis of the semantics of *zero*. Together with Martí, this paper demonstrates that the theory of grammatical number in Harbour ([2014](#)), from which the number features used here are taken, can be extended quite straightforwardly to cover a new empirical domain in a range of languages. That a small number of assumptions can account for such a large array of data, i.e., the numeral-noun construction *plus* the cross-linguistic typology of grammatical number that the features were originally designed to capture, should be seen as one of its major advantages.

In a nutshell, the noun that accompanies *zero* in English shows the same number marking (plural) as the noun that combines with numerals greater than 1 because ⊥ is not an atom (like the non-atoms of English plural forms, absent in singular forms). The noun shows the same number marking (singular) as the noun that combines with all numerals in Turkish because ⊥ does not have proper parts of numerosity greater than 0 (like the members of the denotation of Turkish singular forms, absent in plural forms). Crucial to this explanation is the idea that, while English number is sensitive to atomicity, Turkish number is sensitive to minimality, an idea inherited from Scontras's account. Once these ideas are properly implemented, the number marking on the noun that accompanies *zero* (and other numerals) follows without further stipulation.

The analysis presented here does not appeal to any agreement mechanism to explain the shape of the noun in the construction, and derives that shape (e.g., marked with *-s* in English, or not marked with *-lAr* in Turkish) from the interplay of Harbour's semantically-contentful number features and a fairly standard syntax and semantics for numerals. The analysis also demonstrates that the Sauerland-style view of plurality is not a necessary ingredient in the account of the full pattern in (1)-(2), and thus, that an account of the numeral-noun construction need not rely on certain views on plurality.

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