Distributivity over pairs of events and entities[1]

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Abstract. This paper aims to offer a formal semantic account of distributivity as introduced by prepositions *per* in Italian and *de* in Romanian. These prepositions occur in the configuration [Card N1 Prep N2] (where Card conveys cardinality and N2 is obligatorily a sortal noun), and are specialised in introducing a type of distributive configuration called ratio hereafter. It is shown that the *per/de* configuration shares properties with phenomena analysed in two separate lines of investigation in the literature, one concerned mainly with nominal distributivity, and the other with relations between events. Like nominal distributive markers, *per/de* signals an obligatorily distributive interpretation of the DP it is a part of. Like 'every time' sentences, the *per/de* construction involves a distributive relation between key events and share events. It is proposed that *per/de* introduces distributivity by the selection and matching of a share nominal and an overt or covert key event. Distributivity is formalised via a matching function that resorts to a (possibly overt) universal quantifiers over event-entity pairs.

Keywords: distributivity, ratio, matching function.

1. Introduction

1.1. Marking distributivity

Italian and Romanian exhibit a particular distributive configuration featuring a nominal phrase containing preposition *per* and *de* respectively. In order to appreciate the peculiarity of this configuration, it is useful to recall that two types of distributive configurations are widely attested across languages, see the entry on distributive numerals (Gil, 2005) in the WALS. One option is to mark distributively the sorting key in the standard terminology by (Choe, 1987), the other is to overtly mark the distributed share. Italian marks distributivity on the key and allows quantifier floating, like English and French among various Western European languages, and like other languages, see (Safir and Stowell, 1988; Junker, 1995; Zimmermann, 2002; Bobalijk, 2002; Champollion, 2017) among many scholars.

(1) a. Hanno preso tre pesci ciascuno. (Italian)
have.3PL caught three fish each
'They caught three fish each.'

b. Ils ont attrapé trois poissons chacun. (French)
they have caught three fish each
'They caught three fish each.'

The second strategy (marking distributivity on the share) is present in Romanian (2a), Albanian, various other East European languages, and many other languages, see the Tlingit example (2b) from (Cable, 2014) and work by Choe (1987); Gil (1988); Oh (2006); Henderson (2012, 2014); Farkas (2015) and many other scholars.

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(2) a. Au prins câte trei peşti. (Romanian)
have.3PL caught DIST three fish
'They caught three fish each.'

b. Nás'gigáa xáat has aawasháat (Tlingit)
three.DIST fish 3plS.3O.caught
'They caught three fish each.'

Expressions of ratio in Italian and Romanian [2] seem to offer a point of convergence between the two strategies. Both languages use a similar configuration in order to express ratios, where a preposition marks the key. This is also the case for English, French (Tovena, 2016) and various other languages. Italian uses preposition *per* and Romanian uses preposition *de*, in a construction that can be schematised as [Card N1 Prep N2], where N2 is a sortal noun, Card conveys cardinality and N1 is a noun.

(3) a. James Bond a mâncat două măsline de martini. (Romanian)
James Bond has eaten two olives DE martini
'James Bond ate two olives per martini.'

b. James Bond ha mangiato due olive per martini. (Italian)
James Bond has eaten two olives PER martini
'James Bond ate two olives per martini.'

c. James Bond ate two olives per martini.

The interpretation of the examples in (3) is that for each martini that James Bond drank, there were two olives that he ate, i.e. the preposition enforces a distributive interpretation.

1.2. Forms of distribution

Preposition *per/de* is a share-key relator, where the share is N1, the key is N2, the relation N1:N2 is best described as a ratio, and the key (N2) provides the unit (the ratio of olives to martinis is 2 to 1). Importantly, a closer look at the distribution of these constructions in the two languages reveals that certain semantic and pragmatic constraints are involved, to the effect that not all contexts in which it is acceptable to say that the ratio of N1s to N2s is n to m, is the *per/de* construction an acceptable paraphrase. To anticipate, we will claim that N2 is constrained to be interpreted as participant in some event distinct from the main clause event (eating in (3)), an event that may be either overt or covert (presumably a drinking event in (3)). A first key remark concerns the pluralities of events that are built.

What is interesting about these constructions as opposed to the two types of strategies of marking nominal distributivity, on the key and on the share, mentioned above in (1) and (2), is that *per/de* seems to relate the share and the key within the same DP, which makes it a very local configuration. At the same time, the share and key must be participants in distinct events. Thus, ratio expressions, cf. (3), are instances of distributive configurations that stand out because, as just said, they have a sorting key that is not part of the argument structure of the clause hosting

[2]This term is understood more generally to apply to an ordered pair of numbers that expresses a multiplicative comparison of quantities.

it. Key and share do not belong to the same argument structure, which brings the construction closer to biclausal distributive phenomena such as *every time* sentences.

Carrying out the task of analysing ratio expressions provides a promising starting point for establishing a connection between two theoretical strands in the literature on distributivity, one concerned mainly with nominal distributivity and illustrated by the preceding examples as well as by the English example in (4c), and the other concerned mainly with inter-sentential phenomena and illustrated by the English sentences in (4a) and (4b).

(4) a. Every time I go to the bakery, I meet a friend.
b. For every rain drop that falls, a flower grows.
c. They caught three fish each.

Let's take a comparative look at *per* in (3) and *every time/drop* in (4a,b). The interpretation of the Italian and Romanian sentences with *per/de* in (3) above resembles the interpretation of (4a) in that the events of meeting a friend are matched onto events of going to the bakery and, correspondingly, the events of drinking a martini are matched onto events of eating two olives. It is similar to the interpretation of (4b) in that the growing of a flower events are matched onto raindrop falling events, parallel to the martinis being matched to eating two olives.

One difference between (3) and (4a,b) is that the latter are biclausal. Moreover, in the former example, the description of the events of drinking is covert (when it is overt, it is expressed as participles or other deverbal adjectives denoting non-stative eventualities). A third difference is that in (3), but not in (4a,b), there is a relevant key entity which is obligatorily distributed. This is the key entity introduced by the preposition. In the 'every time' sentence, one finds no such entity, that is, *a friend* is not prevented from getting a wide scope interpretation. In (4b), the key is a nominal and the share is eventive, which is the opposite of the constructions discussed here.

Let's now turn to broadly comparing *per* in (3) and other distributive markers, illustrated with binominal *each* in (4c). Sentence (3) resembles (4c) in that the latter constrains the interpretation to associate each agent of catching onto themes of catching of cardinality three, within some subevent, so that more than three fish are caught overall. Likewise, each martini is associated with two olives. A difference between these two cases is that in (3) the martinis are not participants in the main clause events of eating, while in (4c) there is only one event description over all, a catching type of event, that is multiply instantiated and where key and share entities (*they* and *fish*) are co-participants.

In short, on the one hand, *per/de* signals an obligatorily distributive interpretation of the DP it is a part of, like nominal distributive markers as in (4c). On the other hand, *per/de* constructions involve a distributive relation between key events and share events, i.e. the share and key entities are not participants in the same events, like 'every time' sentences and Boolos sentences illustrated in (4a,b). The gist of our analysis is that *per/de* introduces distributivity by the selection and matching of a share nominal and an overt or covert key event.

The remainder of the paper is organised as follow. Some of the properties of the prepositions *per* for Italian and *de* for Romanian in their distributive uses are reviewed in section 2. These

uses appear to be more constrained than with specialised counterpart prepositions such as English *per* and German *pro*, relatively to the noun that can restrict the key, and the availability of the key event. Then, we turn to 'every time' sentences and event-related readings. Section 3 opens with a quick review of some similarities between these biclausal sentences and the distributive configuration at hand, and we recall the analyses proposed in the literature, which rely on matching functions. In all these cases, a matching function denotes sets of pairs of events. On the contrary, sentences of the 'Ships passing through the lock' type, have been claimed optionally to involve universal quantification over event-objects pairs. We look at them in section 4, where we collect elements that contribute to our proposal that is presented in section 5. We assume that the prepositions *per/de* in configuration [Card N1 *per/de* N2] syntactically combines with the distributive key (N2), but semantically it relates a plurality of key events—each each having an atomic key participant—to a plurality of share entities. As a matter of fact, the preposition sets up a match, but the matching elements do not have the same semantic type. The events associated with each of the shares are introduced somewhere else in the clause, depending on the position of the constituent expressing the share. Finally, section 6 concludes the paper.

2. The distribution of *per/de*

As mentioned in the introduction, the Italian and Romanian ratio constructions display a narrower distribution as opposed to sentences of the type *The ratio of N1s to N2s is n to m.* The same contrast is observed if we compare It./Rom. *per/de* to English *per* and German *pro*. Firstly, it should be possible to instantiate N2 with a measure expression in principle, and this is the case in German (5) and the English translations. However, in Italian and Romanian, *per/de* cannot be used if N2 is a measure noun. The two languages employ a distinct preposition or no preposition when N2 is a measure, as illustrated in (6).

(5) a. drei Mahlzeiten pro Tag
three meals per day
'three meals per day'

b. zehn Ziegel pro Quadratmeter
ten tiles per square=meter
'ten tiles per square meter'

c. fünfzig Kilometer pro Stunde
fifty kilometer per hour
'fifty kilometers per hour' (German)

(6) a. John earns 20 euros per hour.

b. Gianni guadagna 20 euro l'ora. (Italian)
Gianni earns 20 euros the=hour
'Gianni earns 20 euros per hour.'

c. Ion câştigă 20 de euro pe oră. (Romanian)
Ion earns 20 of euros PE hour
'Ion earns 20 euros per hour.'

Second, even when N2 is a sortal noun, the constructions of the form [Card N1 Prep N2] are not acceptable in all the cases[3] where the corresponding English/ German constructions with *per/pro* are acceptable. An overt universal quantifier has to be used in these cases. Conversely, adding *every* in the English construction produces an ungrammatical result, see (7).

(7) a. [We are going to prepare the reception hall.]
We'll put **three wine bottles per (*every) table**.

b. [Vom decora sala de festivităţi.]
Vom pune **trei sticle de vin de ??(fiecare) masă**. (Romanian)
will put three bottles of wine DE every table

c. [Prepariamo la sala del ricevimento.]
Metteremo **tre bottiglie di vino per ?(?ogni) tavolo**. (Italian)
put.FUT three bottles of wine PER every table

In the sentences in (7), the spatial connection between the tables and the bottles of wine that are to be placed on them is not enough to legitimate the distributive relation in the absence of the universal quantifier. Moreover, (7) does not support a part-whole relation as in (8).

(8) a. In this school, there are **twenty students per (*every) class**.

b. In questa scuola, ci sono **venti studenti per ??(ogni) classe**. (Italian)
In this school, there are twenty students PER every class

c. În această şcoală sunt **douăzeci de studenţi de ??(fiecare)** clasă. (Romanian)
In this school are twenty of students DE every class

The only cases where *per/de* can be followed by a bare noun are those where this noun is associated with some non-stative eventuality, one that is different from the eventuality description provided by the main verb. The associated event can be retrieved in two ways: it is either mentioned in previous discourse/ part of the common ground or provided overtly in cases where N2 itself is event-denoting or otherwise via the modification of a participial adjective.

(9) a. The restaurant will provide two coffees per customer for free.

b. Il ristorante offre gratuitamente due caffè per avventore. (Italian)
the restaurant offers for free two coffee PER patron
'The restaurant will provide two coffees per customer for free.'

c. Restaurantul va oferi două cafele de client pe gratis. (Romanian)
restaurant.DEF will offer two coffee DE patron at for free
'The restaurant will provide two coffees per customer for free.'

Let's look at the following Romanian example involving an event-denoting adjective:

(10) Funcţionarul a înregistrat două plângeri de telefon ??(pierdut). (Romanian)
clerk.DEF has filed two complaints DE telephone lost
'The clerk filed two complaints per lost phone.'

[3] An issue that interferes is related to subcategorisation requirements. It does not sound natural to introduce with *per* the location in sentence with a three valency verb such as *mettere* in Italian.

If it is not made explicit in the context that we are talking about phones which have been lost, the construction with bare N2 is degraded. Adding *fiecare* ('every') rescues the construction, but, importantly, note that so does adding an eventive participial adjective as *pierdut* ('lost') in *de telefon pierdut* ('per lost phone').

Another remark, which applies to all of the examples provided so far, is that if the modifier is stative, adding it to the construction does not improve its acceptability, see the Romanian example in (11) and the Italian (12).

(11) ??Grădina zoologică are un surplus de o sută de vizitatori de specie
Garden.DEF zoological has a surplus of one hundred of visitors DE species
neobişnuită. (Romanian)
uncommon
'The zoo has an extra one hundred visitors per uncommon species.'

(12) ??Lo zoo ha ricevuto mille euro per animale morto (Italian)
DEF zzo has got thousant euros PER animal dead
'The zoo received one thousand euros per dead animal.'

3. 'Every time' sentences and the matching function

We have seen in the previous section that the construction with a bare N2, i.e. [Card N1 *per/de* N2], is sensitive to the retrieval of an event associated with the sorting key (N2), while the construction with a universal distributive quantifier, i.e. [Card N1 *per/de* UnivQuant N2], is not. To anticipate, the proposal in the following section will rest on the assumption that the construction with *per/de* and a bare N2 involves a covert event-related universal operator. The properties of the universal operator are presented in section 4. Also, the preposition introduces a matching function which relates the share nominal N1 (a participant in the main clause eventuality) to the key event (which is either overt or implicit, and which has N2 as a participant). In what follows, we will refer to the treatment of every time sentences in Rothstein (1995). The matching function will be one of the ingredients in the analysis of *per/de* constructions, which is laid out in section 5.

A relevant property of this construction is that there is a unique mapping between the key event (and its N2 participant) and the share nominal N1. This is necessarily the case for (3) because of the fact that drinking events are non-iterative, one-time events. Thus, in order to highlight the effect, we will look at iterable events as in (10) above instead. In the case of (10), it may be that the same phone is lost more than once, which means the ratio of complaints to phones is more than 2:1. Imagine that there is only one phone which was lost twice. Then there will be four complaints matching only one phone (4:1). This is a case of recycling individuals, as labeled by Krifka (1990). But, necessarily, the losing events have to be distinct from one another, so that the ratio of complaints to 'losings' is indeed 2:1. The same requirement was argued for in 'every time' sentences by Rothstein (1995), Landman (2004), as well as 'for every' sentences by Boolos (1981), see (13) and (14).

(13) Every time the bell rings, Mary opens the door. (=(4a))

(14) For every drop of rain that falls, a flower grows. (=(4b))

The two sentences above were argued to involve matching functions by Rothstein (1995), a claim that is based on the contrast with universal quantification in the nominal domain. Consider the simple example in (15a) and the formal representation she proposes in (15b).

(15) a. Every girl saw a film.
b. $\forall$x [GIRL(x)$\rightarrow$ $\exists$e [SEE(e) $\wedge$ Agent(e) = x $\wedge$
$\exists$(y)[FILM(y) $\wedge$ Theme(e) = y]]]

As Rothstein remarks, the formalisation (correctly) allows for the recycling of films, i.e. the same film may have been watched by two distinct girls on different occasions. By contrast, (13) and (14) above do not permit the situation where two ringing events are matched to the same door-opening and two raindrops are matched to the same flower-growing. This restriction is captured formally by Boolos by using the matching function noted F in his representation (16), and by Rothstein using the matching function noted M in her representation (17).

(16) a. For every drop of rain that falls, a flower grows.
b. $\forall$x [DROP-THAT-FALLS(x) $\rightarrow$ $\exists$e [GROW(e) $\wedge$
$\exists$y [FLOWER(y) $\wedge$ Theme(e) = y $\wedge$ F(e) = x]]]

(17) a. Every time the bell rings, Mary opens the door.
b. $\forall$e [RING(e) $\wedge$ Theme(e) = the-bell $\rightarrow$ $\exists$e' [OPEN(e') $\wedge$
Agent(e') = Mary $\wedge$ Theme(e') = the-door $\wedge$ M(e') = e]]

This type of function is a surjection, with the main clause constituent (OPEN(e') and GROW(e) in (17) and (16) respectively) corresponding to the domain of the function and the constituent introduced by *every* corresponding to the co-domain (RING(e) and DROP-THAT-FALLS(x) respectively). This allows for there to be two or more door-openings after only one bell-ringing, but requires at least one door-opening matched to each bell-ringing. By the same reasoning, the F function allows for there to be two or more flowers that grow, but necessarily no raindrop falls without at least one flower growing.

In a similar fashion, we will propose that *per/de* constructions schematised as [Card N1 *per/de* N2] introduce a matching function of the type match(N1) = e2, where e2 is the event that the key nominal is a participant in. For instance, in (10), the matching function will be **match (x) = e**, where x is an entity type variable that ranges over share entities (e.g. complaints) and e is an event type variable that ranges over key events (e.g. losing events, with phones as themes). This is the opposite of the Boolos sentence in (14), where the domain consisted of events and the co-domain of entities.

4. 'Ships passing through the lock' event-related readings

Doetjes and Honcoop (1997) refine the analysis of Krifka (1990) of sentences such as (18) below, which has two distinguishable readings: one in which we strictly count objects (ships) and one in which we count ship-passing events.

(18) Last year, four thousand ships passed through the lock.

Thus, the same state of affairs—in which, for example, there were 4000 ships and they passed through the lock twice, making it 8000 passings—may be truthfully expressed in two ways: *4000 ships passed through the lock* (object-related or OR reading) and *8000 ships passed through the lock* (event-related or ER reading). The event-related reading is presumably an option which all determiners have (under certain conditions). Doetjes and Honcoop (1997) show how strong quantifiers such as *every* can get an event-related reading only if they have an event in the restriction. These determiners always have an alternative default version where they bind only an entity variable, in which case they get the object-related reading. His example is with *most*, but the same is true of *every* or any other strong quantifier.

(19) Last year, most ships passed through the lock.
   a. object-related:
   most ships are such that each of them passed through the lock last year.
   b. event-related:
   *most events in which a ship passed through the lock (last year) occurred last year.

(20) Most ships that passed through the lock transported radioactive waste.
   a. object-related:
   most ships that passed through the lock are such that each transported radioactive waste.
   b. event-related:
   most events in which a ship passed through the lock were events in which a ship transported radioactive waste.

Doetjes and Honcoop (1997) claim that the quantifier comes by default with a version in which it binds an entity type variable x and optionally, if there is an event in the restrictor as in (20), the quantifier can bind an event-object pair of variables ⟨e,x⟩, where e is an event-type variable and x is an entity-type variable. This is relevant for the distributive configuration under discussion in this paper. We suggest that *per/de* selects a DP headed by a silent universal which obligatorily ranges over event-object pairs.

Doetjes and Honcoop (1997) do not talk about any matching function in the case of event-related readings, but they do mention some restrictions (which only apply to event-related readings) on the events in the restrictor, namely that the restrictor event has to precede the main clause event or be somehow causally connected to it. In our case, the matching function would be responsible for the requirement that there should be an (indirect) connection between key and share events.

As a consequence, we assume that *per/de* can introduce a DP headed by an overt *every*, which ranges over entity type ⟨x⟩ variables or optionally also over event-entity pairs ⟨e,x⟩ as below. We follow Doetjes and Honcoop (1997) in noting the type of the variable on the universal quantifier.

(21) a. per ogni classe/ de fiecare clasă (per every class)
   b. Card N1 PER/DE OGNI,FIECARE$_{\langle x\rangle / \langle e,x\rangle}$ N2

Conversely, *per/de* can head a silent universal operator with a more restricted distribution, ranging only over event-entity pairs of variables ⟨e,x⟩, as below:

(22) a. per classe/ de clasă ('per every class')
b. Card N1 PER/DE ($\forall_{\langle e,x\rangle}$) N2

The following section spells out the details of the analysis.

5. The proposal: a silent event-related universal operator and a matching function

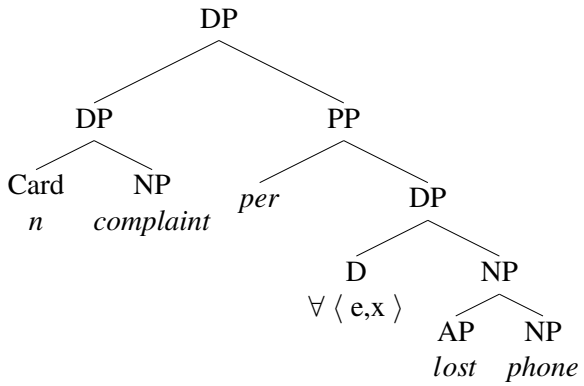
Let's take (23) as an illustration of the ratio configuration [Card N1 *per/de* N2]. We assume that syntactically *per/de* combines with the distributive key (N2), but semantically it relates a plurality of key events (losing in (23)), each having an atomic key participant (phone), to a plurality of share entities (complaints).

(23) Funcţionarul a înregistrat două plângeri de telefon pierdut.
Clerk-DEF has filed two complaints DE telephone lost
(Romanian)

'The clerk filed two complaints per lost telephone.'

The telephone-losing events are the key. The variables that are picked out by the matching function are the key events (losing) and the share participants (complaints, which are the theme of the filing events). We assume that the *per/de* phrase is a modifier of the share DP, and the key event variable is a modifier of the key noun phrase (typically a participial adjective, as in the examples concerning lost phones). Even in cases in which no modifier is present we assume that the key NP is either eventive itself (e.g. *per participant*, or has a covert eventive modifier, e.g. in the case of (3), *(DRUNK) martini*. In any case, an event variable is required on the sorting key in order to meet the selectional specifications of the preposition. The structure for (23) is as provided in (24) where the share is a full DP before it combines with *per/de*.

(24)



(25) a. [[telephone]] = λr [telephone(r)]
b. [[lost]] = λzλe'[losing(e') ∧ Theme(e') = z]

The event description is a modifier of the key noun phrase. The entries in (25) combine by predicate modification.

(26) [[lost telephone]] = λzλe'[losing(e') ∧ Theme(e') = z ∧ telephone(z)]

In words, *lost telephones* is interpreted as the set of entities in the denotation of the predicate 'telephone' each of which is a participant in an event e'.

The entry for *per/de* is provided in (27).

(27) [[per]] = $\lambda P_{<e,vt>} \lambda x \lambda e \lambda Q \lambda n$ [∀⟨ e,x ⟩ [P(e,x) →
[∃y Q(y) ∧ |y|=n ∧ match(y) = e]]]

Per/de selects a complex predicate of events and entities P, as well as the entity and event variables x and e. This is the sortal key constituent. The share constituent is represented above as a nominal property Q and a cardinal n. The preposition then relates the key and the share via the universal operator, such that for every phone that is part of a complex predicate P (lost phone), there is a y which is in the extension of property Q (complaint) such that y has cardinality and the matching function applies to y (two complaints), returning the value e (the losing event).

6. Conclusion

The prepositions *per* for Italian and *de* for Romanian we have looked at, in their distributive interpretation in the configuration [Card N1 *per/de* N2], albeit extremely restrictive in their distribution, are of theoretical import because they display not only a local form of distributivity (a share-key dependency within the nominal domain), but also a local interdependence between events and nominal participants. As such, the configuration brings together properties which have been addressed separately, in distinct constructions, on the one hand in the literature on nominal distributivity, and on the other hand in works focusing on event plurality and distributivity.

We have outlined an account that brings together reflections produced in both lines of study, and appeals to options exploited in both directions of investigation. This account of *per/de* constructions is to be included among the proposals which posit a very close-knit relation between nominal phrases and events/situations. To name just a few, let us recall the quantificational variability effects on definite DPs, e.g. see Hinterwimmer (2008), situational pronouns on the universal quantifier *every*, e.g. see Kratzer (2004), and on definite determiner, e.g. see Schwarz (2009).

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