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RESEARCH

Dancing monkeys in Serbian and Korean – exhaustivity requirements on distributive share markers

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In some languages, distributive markers/quantifiers can attach to the argument that is being distributed (the distributive share), as opposed to the restrictor of the sentence (the distributive key). Researchers agree that distributive share markers can also distribute over events (and not only individuals), but disagree as to what these markers are semantically – universal distributive quantifiers or event plurality (pluractional) markers. In this paper, we experimentally probe spatial event distribution. On a universal quantification account, exhaustive distribution over a spatial distributive key is enforced, while on the pluractional analysis there is no such requirement. We carried out two picture verification experiments to test exhaustivity requirements in intransitive sentences with distributive share markers from two typologically different languages: the Serbian marker *po* and the Korean marker *-ssik*. We found evidence for an exhaustivity requirement over pluralities of non-atomic individuals (groups), but not over designated spatial locations. We interpret these findings as evidence that the semantics of (spatial) event distribution with distributive share markers involves a (spatial) distributive key. Specifically, *po/-ssik* have a universal quantificational force (with a meaning akin to *per (each)*) establishing a distributive relation between individual events and elements of the spatial distributive key. Plural individuals made salient in the visual input can serve to divide up the spatial key into chunks of space that have to be exhausted.

Keywords: event distributivity; event plurality; spatial distribution, exhaustivity; distributive share/key; atomicity

1 Introduction

The fundamental question of how so-called *distributive share* (DistShare) markers should be analyzed semantically is a matter of contention in the existing theoretical literature. A pervasive line of analysis takes DistShare markers to be universal distributive quantifiers, just like so-called *distributive key* (DistKey) markers, but that can distribute over implicit spatiotemporal arguments unlike DistKey markers (Choe 1987; Gil 1995; Zimmermann 2002b; Balusu 2006 a.o.). Other researchers, however, take DistShare markers to be pluractional markers, simply signaling event plurality *without universal quantification* (Matthewson 2000; Muller and Negrão 2012; Cable 2014; Knežević 2015; Pasquereau 2018 a.o.).

We bring novel empirical evidence to bear on these issues by experimentally probing whether DistShare markers exhibit a required feature of universal quantification – namely, that distribution over the members of the DistKey be *exhaustive*. While there is an ever-growing interest in the semantics of DistShare markers across languages, especially including lesser studied languages (see Gil 1982; 1995; Choe 1987; Farkas 1997; Oh 2006;

Zimmermann 2008; Henderson 2011; Cabredo-Hofherr & Etxeberria 2017 a.o.), these markers have hardly been investigated experimentally. Knežević (2015) and Knežević & Demirdache (2017; 2018) are among the few attempts to experimentally test DistShare marker interpretations, investigating the Serbian DistShare marker *po* with both adults and children. However, the focus in the theoretical literature has been mostly on individual and/or temporal (as opposed to spatial) distributive readings.

This paper reports on the first experimental investigations into spatial event readings, as well as the first investigation into exhaustivity effects with DistShare markers, testing Serbian and Korean, two typologically distinct languages that both have DistShare markers. The question our experiments sought to address was whether DistShare markers in Serbian and Korean should be analyzed as markers of event plurality, or as universal quantifiers requiring a DistKey over which distribution takes place exhaustively. To test for exhaustivity, we set up (with the first experiment and its follow up) different putative distributive keys. Our experimental results do indeed provide evidence that the event-distributive reading that DistShare markers yield involves a covert (spatial) DistKey that must be exhausted contra the event plurality hypothesis. But this exhaustivity requirement is not realized as initially expected under the universal quantification hypothesis: the exhaustivity requirement that speakers of both languages appear to impose is over *pluralities of non-atomic* individuals (groups), but not over designated spatial locations. We take this conclusion to argue in favor of a universal quantification analysis, on the assumption that DistShare markers can distribute over entities that are non-atomic such as time and space, as well as entities that are bigger than atoms – that is, groups/pluralities of atomic individuals.

The paper is organized as follows. Section 2 presents the basic concepts and issues underlying the analysis of DistShare markers in the literature and the two main lines of analysis investigated: universal distributive quantification and event plurality. Section 3 presents two picture verification experiments conducted to test exhaustivity requirements using Serbian and Korean. The results actually revealed exhaustivity requirements, over pluralities of non-atomic individuals (groups). Section 4 discusses how these findings relate to the existing theoretical research. We then develop an analysis of spatial event distribution along the lines of Zimmermann (2002b). DistShare markers are analyzed as locative prepositions with universal quantificational force (with a meaning akin to *per* (*each*)) establishing a distributive relation between individual events and elements of a spatial/temporal DistKey. Plural individuals made salient in the visual input can serve to divide up the spatial DistKey into relevant spaces that have to be exhausted. We close by discussing this account in the context of Champollion's (2016b) parameters of variation for distributivity operators. Section 5 concludes by pointing out directions for further experimental research.

2 Distributive share vs. Distributive key markers across languages

To illustrate the issues at stake, let's start with (1), uttered in the context of a birthday party with many presents and invitees, including four boys. (1) will be true if each of the four boys in the context has individually bought two presents, yielding a total of eight presents (bought by the boys). *Each* in (1) thus induces a distributive interpretation involving pairs of presents distributed over the atomic members of a contextually restricted set of boys. Importantly, the set of boys must be exhaustively distributed over, i.e. there cannot be a boy who did not buy two presents.

- (1) [Each boy] bought two presents.

Gil (1982; 1995) distinguishes two major typological classes of distributive markers crosslinguistically: Distributive key vs. Distributive share markers. The DistKey (or sorting key) refers to the set that is being distributed over, and the DistShare to what is being distributed (see also Choe 1987 and Zimmermann 2002b a.o.). Thus, in (1), the restriction *boy* of the universal quantifier *each* is said to serve as the DistKey and the NP *two presents* as the DistShare. Now consider a language that has DistShare markers, Serbian, which has the distributive marker *po*.¹ Consider the example in (2):

- (2) [Dečaci_{DistKey}] su kupili [_{numNP} **po** dva poklona_{DistShare}].
 boys.NOM AUX bought DISTR two presents.ACC
 a. ‘(The) boys each/individually bought two presents.’ – Individual distributive reading
 b. ‘(The) boys bought two presents at each/different place(s)/time(s).’ – (Spatial/Temporal) event distributive reading

As shown in (2), Serbian *po* forms a syntactic constituent with the NP serving as the DistShare (*dva poklona* “two presents”), i.e. the argument denoting what is being distributed. (2) yields the reading in (2a), where distribution is over the plurality of individuals denoted by the overt subject argument of the verb (*boys*), and which we refer to as an individual distributive reading (four boys and eight presents). Crucially, (2) actually yields the additional possible readings in (2b), where there is a plurality of events (of boys buying two presents) distributed over contextually salient spatial or temporal locations. For instance, four boys could have bought two presents on Monday and then again two presents on Tuesday (the end result is then four boys and four presents).² Note, importantly, that these spatial and temporal locations are implicit arguments of the verb (they are not denoted by an overt NP/DP in the sentence). We will refer to such readings as event distributive readings.

Importantly, for intransitive sentences, the only overt argument that *po* can syntactically combine with, and that can thus serve as the DistShare, is the single argument in subject position. In other words, the DistKey will have to be a covert spatio/temporal argument, which means that intransitive sentences only yield event distributive readings:

- (3) **Po** dva dečaka pevaju.
 DISTR two boys sing.PL
 ‘Two boys are singing at each/different place(s)/time(s).’

On the basis of a very broad and extensive typological overview of DistShare marking across languages, Gil (1982; 1995; 2013) claims that DistShare markers are typologically more marked than DistKey markers. Languages that have DistShare marking are typologically diverse, including Korean, Japanese, the majority of Slavic languages, Hungarian, German, Georgian, Karitiana, Hausa, and many others. We focus here on DistShare markers from two typologically unrelated languages, Serbian and Korean, that show similar syntactic and semantic properties.

¹ Serbian also has universal DistKey markers (quantifiers) *svi/svaki* (*all/every*). For discussion of *svaki* as well as its interaction with *po*, see Knežević & Demirdache (2018).

² While these examples are more easily available, there are other possible, but increasingly more complex, readings to get out of the blue (e.g. two groups of four boys each could have bought two presents, resulting in eight boys and four presents in total).

The DistShare marker *po* in Serbian attaches to numerals (henceforth *num*), reduplicated numerals (*num po num*), bare singular nouns (analyzed in Knežević (2015) as having a silent numeral *one*), and weak quantifiers such as *few* (e.g. *po nekoliko*).³ What is more, *po* can attach to any argument in the sentence, e.g. the direct object, the subject (or even both these arguments), or to adverbials. Importantly, Korean shows the same attachment possibilities for its DistShare marker, the particle *-ssik*, and the range of interpretations of *-ssik* sentences are similar to Serbian *po* sentences (see Oh (2001; 2006) for discussion of *-ssik*). For the purposes of this paper, however, we confine ourselves to distributive *po/-ssik* attaching to numeral phrases (*numPs*) in simple intransitive sentences.

The Korean example in (4) shows that the two properties that distinguish Serbian *po* (2) from the determiner *each* in English (1) carry over to *-ssik*:

- (4) Sonyen-tul-i [_{numNP} senmwul-ul twu-kay-*-ssik*_{DistShare}] sa-ss-ta.
 Boy.PL.NOM present.ACC two.CLF.DISTR buy.PAST.DEC
 a. ‘(The) boys each bought two presents.’
 b. ‘(The) boys bought two presents at each/different place(s)/time(s).’

Unlike determiner *each* that attaches to the NP serving as the DistKey (its restrictor *boy* in (1)), but just like *po*, *-ssik* attaches to the NP serving as the DistShare (*two presents*). It can also yield either the individual distributive reading in (4a), or the (spatial/temporal) event distributive reading in (4b). It is specifically the latter property – the availability of event distributive readings over implicit spatial or temporal arguments of the verb – which distinguishes distributive markers such as *po* or *-ssik*, on the one hand, from both determiner *each* in (1) and so called adnominal (or binominal) *each* in (5) on the other.

- (5) Adnominal *each*: The boys bought two presents each.

As illustrated in (5), adnominal *each* appears to form a constituent with the NP serving as the DistShare (*two presents*) just like *po* or *-ssik*. Adnominal *each*, however, just like determiner *each* in (1), cannot distribute over implicit spatial or temporal arguments of the verb. Thus, in (5), the only possible DistKey is the overt subject DP argument of the verb, which results in simple individual distribution. Zimmermann (2002b) takes this difference to reflect a more general typological generalization – namely, that distributive markers that can also be used as determiners (e.g. *each*) are restricted to distributing over individuals.⁴

2.1 Distributive share markers as distributive universal quantifiers

The idea that DistShare markers might be analyzed as a type of universal quantifier dates back to at least Gil’s (1982) typological classification, according to which, DistShare markers, just like DistKey markers, are subtypes of universal quantifiers, as shown by the classification of universal quantifiers provided in Table 1 (Gil 1995: 349). DistShare and DistKey quantifiers differ from “simple universal quantifiers” (e.g. *all* in English) in that they enforce distributivity (do not permit collective readings).

The unifying assumption underlying this line of analysis is that the distributive interpretation that DistShare markers involve universal quantification. This is a common idea

³ In addition, *po* can modify adjectives and adverbs, can also be a verbal prefix (indicating past repeated actions) or a locative (distributive) preposition. This distribution is similar to that of pluractional markers (see Hofherr-Cabredo & Laca 2012; Newman 2012; Knežević 2015).

⁴ For further discussion of the differences between adnominal *each* in English, *elke* in Dutch, and *po* in Serbian, see Rouweler & Hollebrandse (2015) and Knežević (2015).

Table 1: A classification of *universal quantifiers* (Gil 1995: 349).

Language	Non-distributive	DistKey	DistShare
Warlpiri	∅	∅	∅
Hebrew	kol	∅	∅
English	all	every	∅
Maricopa	maɬ-čaamk	∅	maɬ-čaamxperk
Georgian	q'vela	q'oveli	q'vel-q'vela

that is present in the work of e.g. Choe (1987) for Korean *-ssik*, Gil (1990) for Japanese *-zut(s)u*, Faller (2001) for the Quechua particle *-nka*, Zimmermann (2002a/b) for German adnominal and adverbial *jeweils*, *po* in Czech, Bulgarian and Russian, *cîte* in Romanian and a dozen other languages, Balusu (2006) for reduplicated numerals in Telugu, or Zimmermann (2008) for reduplicated numerals in Hausa.

Choe (1987), like Gil (1982), was one of the first to stress that the unifying function of distributive markers crosslinguistically is to establish a dependency relation between two arguments of a predicate – serving respectively as the DistKey and DistShare – with distributivity derived by positing a universal quantifier interacting with an existential in its scope. He distinguishes between regular quantificational determiners that form a syntactic constituent with the DistKey argument (e.g. German *jeder*, or French *chaque*), from so-called *anti-quantifiers* which appear to form a syntactic constituent with the DistShare argument (e.g. Korean *-ssik*, adnominal *each* in English, and German *je(weils)*). Zimmermann (2002b) replaces the term anti-quantifier with the notion of *distance-distributivity* to refer to distributive items that appear (on the surface) to occur at a distance from their DistKey. He contends that distance-distributivity is “a superficial phenomenon. All instances of apparent distance-distributive quantifiers are reducible to regular adnominal quantifiers.” (Zimmermann 2002b: 21). On this proposal, Serbian *po* (2), Korean *-ssik* (4), English adnominal *each* (5) in English, and German adnominal *jeweils* (6) are all distance-distributive (DD) universal quantifiers.

Zimmermann then develops a uniform compositional analysis of distance-distributivity across languages, taking as a point of departure the analysis of adnominal *jeweils* in German which, just like Serbian *po* or Korean *-ssik*, yields both individual and event distributive readings, as illustrated with (6):

- (6) German (Zimmermann 2002b: 291)
- [**Jeweils** zwei Offiziere] haben die Ballerinen nach Hause begleitet.
each two officers have the ballerinas to home accompanied
a. ‘Each of the ballerinas was accompanied home by two officers.’
b. ‘Each time, two officers accompanied the ballerinas home.’

Jeweils in (6) forms a constituent with the subject NP *zwei Offiziere* “two officers” serving as the DistShare. On the individual distributive reading in (6a), distribution is over the direct object DP *die Ballerinen* “the ballerinas”, serving as the DistKey. While on this reading, *jeweils* occurs at a distance from its overt NP-restriction/DistKey, on the temporal/event distributive reading in (6b), distribution is over an implicit DistKey (a plurality of times/events) that is not overtly expressed in the clause, but must be recoverable from the linguistic context.⁵

⁵ We restrict our discussion here to adnominal *jeweils* which forms a constituent with a nominal expression corresponding to the DistShare expression. *Jeweils*, however, can also occur adverbially, yielding temporal

His proposal is that DD items such as *jeweils* are QPs embedded inside a PP, itself adjoined to the NP serving as the DistShare. On Zimmermann's proposal, DD quantifiers, just like regular quantifiers, combine syntactically with their restrictor. The difference is that the restrictor is not a lexical NP, but a pronominal NP which receives its value through coindexation with a DistKey provided by the context. P° , covert in the case of German, provides a relational variable R which specifies the relation that holds between the elements of the DistKey and DistShare. Accordingly, the denotation of the *jeweils*-DP is given in (7) and the analysis of the individual and event distributive readings of (6) are given in (8a) and (8b), respectively (see Zimmermann 2002b: 250):⁶

- (7) $[[\text{zwei Offiziere } P^\circ_j \text{ jewels}_i]] = \forall z [z \in Z_i \rightarrow \exists X [2\text{officers}'(X) \wedge *R_j(X)(z)]]$
 For every element z of a given set Z_i , there is a set X of two officers such that z and X stand in relation R_j to one another.'
- (8) a. $\forall z [z \in [\text{the ballerinas}_i]] \rightarrow \exists X [2\text{officers}'(X) \wedge \exists e [* \text{accompany}'(X, z, e)]]$
 For every element z of a given set of ballerinas, there is a group of two officers X and an event e such that X accompanies z in e .
- b. $\forall z [z \in Z_i \rightarrow \exists X [2\text{officers}'(X) \wedge \exists e [* \text{accompany}'(X, [\text{the ballerinas}], z) \wedge R(e, z)]]]$
 For every element z of a contextually salient set (of events) Z_i , there is a set X of two officers and an event e , such that the elements of X accompanied the ballerinas in e , and event e is related to event z by a temporal, causal, subpart, or other contextual relation.

On the individual distributive reading in (8a), the denotation of the DistKey *die Ballerinen* "the ballerinas" provides the value for the set variable Z_i , while the denotation of the transitive verb provides the value for the relation variable R , thus ensuring that the distributive relationship between the elements of the DistKey (here, *ballerinas*) and elements of the DistShare (here, *sets of two officers*) is one of accompanying the former home. On the temporal event distributive reading in (8b), the restriction variable Z_i ranges over a set of atomic events and must be anaphorically linked to an appropriate antecedent in (or constructed from) the preceding discourse, and the free relation variable R is assigned a value from the context. For example, if there is a ballet performance every Friday this

event distributive readings, as shown in (i), unlike *po*, which cannot occur in an adverbial position, as shown in (ii).

- (i) Peter hat jewels gewonnen.
 Peter has each.time won
 'Peter has won each time.'
- (ii) *Petar je po pobedio.
 Peter AUX DISTR won
 *'Peter has won each time.'

This yields a three-way distinction across DD elements: those like adnominal *each* in English which only allow individual distributive readings, those like adnominal *jeweils* and *po* which allow both individual and event distributive readings with an indefinite DistShare expression, and those like adverbial *jeweils*, which only allow event distributive readings.

⁶ The *-operator yields a cumulative predicate from a non-cumulative one. X stands for a variable over sets. As defined in Krifka (1998), a predicate P is cumulative iff when P applies to two distinct elements x and y , it also applies to the (mereological) sum of x and y , as stated in (i):

- (i) $\forall X \subseteq U_p [CUM_p(X) \leftrightarrow \exists x, y [X(x) \wedge X(y) \wedge \neg x = y] \wedge \forall x, y [X(x) \wedge X(y) \rightarrow X(x \oplus_p y)]]$

past year, then on this scenario, the DistKey is a set of Friday ballet performances and the relation between the elements of the DistKey and elements of the DistShare (here, events of two officers accompanying the ballerinas home) is plausibly one of temporal succession. Importantly, R can take on a variety of values, including temporal, causal, subpart, or other contextually determined relations.⁷ As the discussion in section 4.1 will show, the assumption that the values of Z and R are quite free and pragmatically determined will play an important role in capturing the truth conditions for spatial distribution with the DistShare markers *po* and *-ssik*.

Another analysis of DistShare markers involving universal quantification is that of Balusu (2006) and Balusu & Jayaseelan (2013) for reduplicated numerals (*RedNum*) in Telugu. On their proposal, event distributivity is an instance of distributive quantification, involving a Distributivity (D-) operator, a DistKey (the DP that is being distributed over), and a DistShare (the (RedNum)NP that is being distributed). In Balusu & Jayaseelan's (2013: 10) words, "a distributive operator is essentially a universal quantifier, that has a sorting key, i.e. the quantifier's restriction, and a distributive share, i.e. the quantifier's scope":

- (9) D-operator DistKey DistShare
 \forall set in restriction entities in scope

Balusu is one of the rare authors, to our knowledge, to address the issue of spatial event distribution and, in particular, the question of how to recover implicit spatial (as well as temporal) distributive keys from the context. Thus, consider the intransitive sentence in (10a), which only yields spatio/temporal event readings, since the only overt argument that can undergo numeral reduplication (and thus serve as the DistShare) is the subject argument. On Balusu's analysis, event distributive readings involve partitioning of an event into non-overlapping subevents along spatial or temporal dimensions using "a contextually salient method of division". And it is these spatial/temporal dimensions (event aspects) which serve as the covert DistKey. But how do we partition time and space? They are not inherently partitioned into minimal atomic units, and thus can only be partitioned into units along contextually salient parameters.

- (10) *Telugu* (Balusu & Jayaseelan 2013: 38)
 RenDu renDu kootu-lu egir-i-niyyi.
 Two two monkey.PL jump.PAST.PL
 'Two monkeys jumped in each location/time interval.'

Balusu & Jayaseelan (2013: 40) explain the spatiotemporal portioning of the event described by (10) as follows: "What do *each time* and *each location* refer to? [...] The division of the spatial and temporal regions into units happens according to the context. The units need not be of equal duration in the case of temporal regions or of equal dimensions in the case of spatial regions. [...] Suppose that all the monkeys in the enclosure jumped up all at once but they jumped up in pairs holding to each other, then the spatial key

⁷ As we shall see, to extend Zimmermann's truth conditions to spatial/temporal distribution in Serbian/Korean would involve assuming that, in the truth conditions for e.g. sentence (3) above in the text, the variable Z is a set of spatial/temporal locations, and R is the relation *be located in*. (3) would thus come out meaning roughly "For every element z of a contextually salient set of temporal/spatial locations Z, there is a set X of two boys and an event e such that X sings in e and e is related to z because X is located in z." The specific extension we propose of Zimmermann's analysis to account for our empirical findings is spelled out in section 4.1.

reading is easily obtained. It could also be the case that the monkeys were not holding one another in pairs but that they were sitting at different points on the branches of the tree, and that there were two monkeys per branch. In such a situation too the spatial key reading is felicitous.”

2.2 Distributive share markers as event plurality markers

Another prominent line of analysis found in the literature takes DistShare markers to be *pluractionals*, i.e. markers of event plurality or *pluractionality* (a term coined by Newman 1980).

Pluractionals are markers on the verb or affecting the verb phrase, indicating event plurality in a wide variety of manners (Cabredo-Hofherr & Laca 2012). For instance, Muller & Negrão (2012) claimed that the distributive numerals in Karitiana should be analyzed as adverbial operators that pluralize the events and restrict the cardinality of the entities they modify. A plural event may involve the same action iterated several times (repetitions), (same) actions distributed in space, time, or affecting multiple participants or objects, either as a group or individually (Cusic 1981; Newman 2012; Lasersohn 1995). An example of temporal pluractionals in English would be adverbial phrases such as *again and again* or *time after time*.

Knežević (2015), and Knežević & Demirdache (2017; 2018)⁸ develop a pluractional analysis of Serbian *po*, building on Lasersohn (1995) and Cable’s (2014) analysis for Tlingit. Pluractional accounts have been defended for a typologically diverse set of DistShare markers, in languages such as Kaqchikel (Henderson 2011; 2014) and Karitiana (Muller & Negrão 2012), or St’at’imcets (Matthewson 2000).

There are two essential advantages for Knežević in using Cable’s analysis of the distributive marker *-gaa* in Tlingit.⁹ First, Cable provides a single, uniform account of both individual and event distributive readings of sentences with adnominal *-gaa*, deriving both readings from the same truth conditions. Sentences with *-gaa* are thus not taken to be ambiguous between individual and event distributive readings. Rather, the semantics for *-gaa* yields weak truth conditions holding under both readings. What this essentially means is that individual/participant distributivity is subsumed under event distributivity and is not treated as a separate reading. Second, these weak truth conditions predict that the semantics of distributivity with *-gaa* in Tlingit, just like with *po* in Serbian or *-ssik* in Korean, does not involve a DistKey that has to be atomically and exhaustively distributed over (section 2.2.1).

The readings that *-gaa* yields are illustrated in (11), together with the type of scenarios provided by Cable for individual/participant and event distributivity:

(11) *Tlingit* (Cable 2014: 576)

- a. Ax shaa yátx'i dǎxgaa keitl has aawashúch.
my female children two.DISTR dog they.bathed

⁸ We henceforth use Knežević to refer to the work developed in Knežević (2015) and Knežević & Demirdache (2017; 2018).

⁹ Note that *-gaa* also occurs adverbially, as shown in (i), yielding event distributive readings, as was the case with German *jewels*, but contrary to Serbian *po* which lacks an adverbial equivalent (see footnote 5)

(i) Ax shaa yátx'i dǎxgaa has aawashúch wé keitl.
my female children two.DISTR they.bathed those dog
'My daughters bathed those dogs two at a time.'

- b. ‘My daughters bathed two dogs each/two at a time.’
- | | | | | |
|------|-----------------|--------------|--------------|---------------------------------|
| i. | Bathings | Agent | Theme | Individual distributive |
| | e1 | Cléo | dog1 + dog2 | |
| | e2 | Kiya | dog3 + dog2 | |
| ii. | Bathings | Agent | Theme | Event distributive |
| | e1 | Cléo + Kiya | dog1 + dog2 | |
| | e2 | Cléo + Kiya | dog3 + dog2 | |
| iii. | Bathings | Agent | Theme | Individual + Event distributive |
| | e1 | Cléo | dog1 + dog2 | |
| | e2 | Cléo | dog3 + dog2 | |
| | e3 | Kiya | dog4 + dog5 | |
| | e4 | Kiya | dog6 + dog7 | |

Cable treats distributive numerals (distributive markers) similarly to adverbials such as *piece by piece*, as analyzed by Beck & von Stechow (2007). This analysis does not posit quantificational D-operators of any sort. (12) gives the semantics assigned to adnominal distributive numerals¹⁰ in Tlingit, and (13) the predicted truth conditions for the sentence in (11) (Cable 2014: 586).

$$(12) \quad [[\text{gaa}]] = [\lambda n_n : [\lambda Q_{\langle e, t \rangle} : [\lambda P_{\langle e, et \rangle} : [\lambda e_\varepsilon : \exists x. Q(x) \& P(x)(e) \& \langle e, x \rangle = \sigma_{\langle e', y \rangle} \cdot \text{participant}(e', y) \& |y| = n \& e' < e \& y < x}] \dots]$$

- (13) a. $\exists e. \exists x. *dog(x) \& *bathed(e) \& *Agent(e) = oy.*my.daughter(y) \& *Theme(e) = x \& \langle e, x \rangle = \sigma_{\langle e', z \rangle} \cdot z < x \& |z| = 2 \& e' < e \& \text{participant}(e', z)$
- b. There is a plural event *e* of bathing, whose agents are the speaker’s daughters and whose theme is a plurality of dogs *x* and the pair consisting of *e* and *x* is the sum of those pairs $\langle e', z \rangle$ such that *z* is a pair of dogs, *e'* is a (proper) part of *e*, and *z* participates in *e'*.

(13b) requires my daughters to have cumulatively bathed pairs of dogs, with each pair being the theme of some sub-event of the larger event. Now, these truth conditions are compatible with either the individual or the event distributive scenarios in (11i-ii), since on a cumulative interpretation, the number of agents (here, one or two) is left unspecified. Importantly, (11) is also correctly predicted to be true on a scenario such as (11iii) which instantiates both participant and event distributivity (e.g. my daughters each bathed two dogs at different times).

Knežević adapts the semantics of *-gaa* to *po* distributive numerals in Serbian.¹¹ As shown in (14), just like *-gaa*, *po* combines successively with a numeral *n* and a predicate *Q* supplied by the modified NP. It then takes as an argument a relation *P* between individuals and events and returns a predicate of events, holding of an event *e* iff there is an individual *x* such that *Q* holds of *x*, and the relation *P* holds between *e* and *x*. The conjuncts “ $e \in *e'_{nQ}$ & $e \notin e'_{nQ}$ ” require that *e* be a sum of events *e'* in which exactly *nQ* dogs participate, but

¹⁰ σ_x is the maximality operator involved in the semantics of definites DPs, $\sigma_{\langle x, y \rangle}$ a binary maximality operator applying to a two-place relation $Q(x)(y)$, and ε the semantic type of events.

¹¹ Note that *-gaa*, just like *po* and *-ssik*, can attach to the subject, the object or to both arguments of the predicate.

without itself being such an event. The claim is that the events described by a sentence with a *po* nNP must necessarily involve a number of participating individuals described by the NP that is a multiple of *n*.

- (14) a. $[[po]] = \lambda n. \lambda Q_{\langle e, t \rangle}. \lambda P_{\langle e, et \rangle}. \lambda e. e \in *e'_{nQ} \& e \notin e'_{nQ} \& \exists x Q(x) \& P(x)(e)$
 b. Dečaci kupaju **po** dva psa.
 boys bathe DISTR two dogs.ACC
 c. $\exists e. \exists y. \exists x. e \in *e'_{2dogs} \& e \notin e'_{2dogs} \& *boy(y) \& *dog(x) \& *bathe(e) \& *Agent(e)(y) \& *Theme(e)(x)$
 d. There is an event *e* constructed out of (sub)events *e'* each involving two dogs and *e* is an event of boys cumulatively bathing dogs.

The sentence in (14b) thus comes out to have the truth conditions in (14c). In particular, the events described by (14b) must be constructed out of events in which exactly two dogs participate as themes, without being events of that kind themselves. This means that the events described by (14b) must necessarily involve multiples of two dogs. (14b) will thus not hold in collective scenarios involving exactly two dogs in total. It will, however, be true as long as there are at least two subevents *e'* of one big event *e*, spatially or temporally separated, each containing exactly two dogs. That is, the number of dogs per subevent has to be two, but there may be as many pairs of dogs as there are subevents *e'* (the total number of dogs is therefore context-dependent). Furthermore, there is no specification in the semantics of how the agent participants partition across these events: the boys can participate collectively, individually, or in groups in the event *e*, the only requirement being that there be a bathing of two dogs per subevent *e'*.

In sum, *po*, on these proposals, is enforcing weak truth conditions, merely requiring that there be at least two events involving the number of entities denoted by the *-ssik* phrase. As we shall see in the next section, this crucially means the semantics of distributive numerals should not involve a DistKey that has to be atomically and exhaustively distributed over.

2.2.1 Lack of atomicity and exhaustivity requirements

As previously mentioned, on the semantics developed by Cable and Knežević, sentences with distributive numerals are true under event distributive scenarios such as (11ii), involving a partitioning into two subevents, each with agents acting collectively. This is one of the generalizations that leads Knežević to claim that distributive markers such as *po* are not distributive universal quantifiers: unlike distributive quantifiers such as *each*, which enforce a partitioning of their restrictor set (DistKey) into atomic members, DistShare markers like *po* do not require an atomic partition. So, for example, the Serbian and Korean sentence in (16) should be judged true under all the situations depicted in Figure 1,¹² while the English sentence in (15) is only compatible with the scenario in Figure 1a.

- (15) [**Each** boy_{DistKey}] is carrying [_{numNP} one piano_{DistShare}].

- (16) a. Dečac-i nose **po** jedan klavir.
 boy.PL.NOM carry DISTR one piano.ACC

¹² Although this has not been tested experimentally, we checked with a few Korean and Serbian informants who confirmed these judgments.

- b. Sonyen-tul-i phiano-lul han-tay-ssik nalu-ko iss-ta.
boy.PL.NOM piano.ACC one.CLF.DISTR carry.PROG.DEC
- i. ‘(The) boys each are carrying one piano.’
- ii. ‘(The) boys are carrying one piano at each/different place(s).’

The second generalization that leads Knežević to explicitly argue against a universal quantification analysis concerns another key property of universal quantifiers: the set denoted by the noun phrase serving as the DistKey (the restriction of Q°) must be exhausted. To quote Balusu & Jayaseelan (2013: 10): “the members of the distributive share need not be exhaustively used up when being distributed, whereas the members of the sorting key need to be exhaustively used up in being distributed over.”

Knežević contends that there are no exhaustivity requirements with *po*. That is, the plurality over which the *po* numNP is distributed (be it a plurality of individuals, times, spaces, or events) need not be exhausted. Thus, consider again the sentence in (15) and (16), but this time under the scenarios in Figure 2.

English adults judge (15) as true under the scenarios in Figure 2a (since all members of the set denoted by the DistKey (*boy*) are distributed over) and Figure 2b (the presence of additional, uncarried pianos is irrelevant to the truth conditions of (15) since there is no exhaustivity requirement on the DistShare). But English adults will judge (15) false under the scenario in Figure 2c because the members of the DistKey are not exhaustively used up.¹³

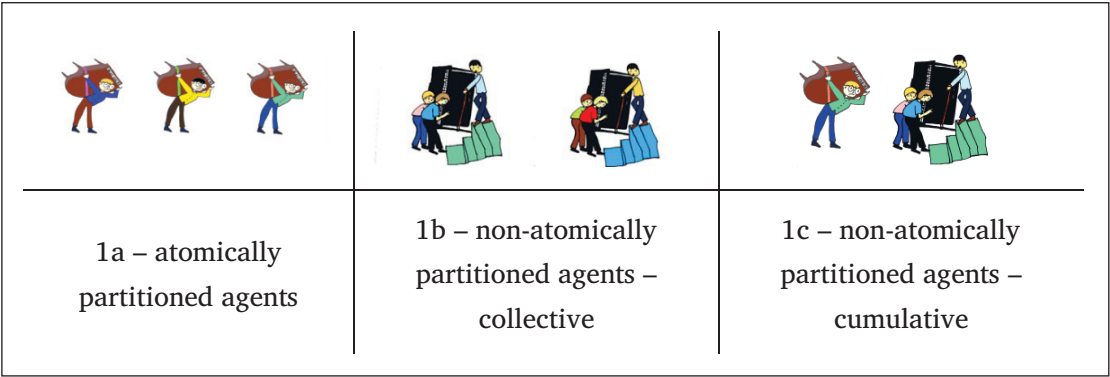


Figure 1: Atomic and non-atomic scenarios (event distributive readings) for the sentences in (15)/(16).

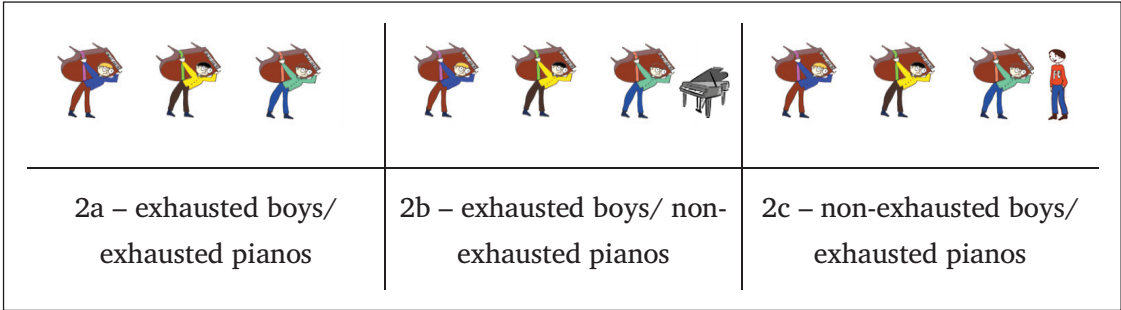


Figure 2: Exhausted and non-exhausted scenarios for the sentences in (15)/(16).

¹³ Note, however, as is well-known from the acquisition literature, children up to the age of 8 or 9 reject pictures like Figure 2b with universal quantifiers like (15) because of the extra object. This phenomenon is known as quantifier spreading (The child exhaustively distributes all boys over all pianos and all pianos over all boys in a one-to-one fashion; see Brooks & Braine 1996; Drozd 2001; Roeper et al. 2011).

In contrast, the Serbian example in (16) is predicted to be true in all of the situations depicted in Figure 2 on a Knežević/Cable pluractional account of the semantics of distributive numerals. In particular, the scenario under Figure 2c is compatible with the truth conditions provided by Knežević for sentences with distributive numerals: there is an event *e* constructed out of three (sub)events *e'*, each involving one piano exactly, and *e* is an event of boys cumulatively carrying pianos.

These requirements, however, were never a subject of experimental investigation, and have remained until now in the theoretical domain. This paper is thus the first attempt to experimentally test whether there are indeed (no) exhaustivity requirements on an implicit DistKey. We focus here on intransitive sentences in Serbian and Korean. The challenge here is how to establish conditions with a covert (spatial/temporal) DistKey (set of salient spatial/temporal units) that is either exhausted or not. Time and space are not inherently partitioned into minimal atomic units, and thus can only be partitioned into units along contextually salient parameters. The experimental set-up must thus provide some kind of contextual restriction that will impose a partitioning of the event into non-overlapping subevents along spatial or temporal dimensions.

3 Testing exhaustivity requirements with spatial event distribution

Assuming that a key diagnostic for the Universal Quantification (henceforth UQ) account is the exhaustivity requirement on the DistKey, we want to test experimentally whether distribution over the members of the putative DistKey has to be exhausted or not (as would be the case with the Event Plurality (henceforth EP) account). The experimental investigations reported here targeted specifically *spatial* event distribution, in Serbian and Korean, focusing on intransitive sentences¹⁴ with DistShare markers (*po* in Serbian (17a), *-ssik* in Korean (17b)):

- (17) a. Pleš-e **po** jedan majmun.
dance DISTR one monkey.NOM
- b. Wenswungi-ka han-mali-**ssik** chwum-ul chwu-koiss-ta.
monkey.NOM one.CLF.DISTR dance.ACC dance.PROG.DEC
- c. ‘DISTR one monkey is dancing at each location/in different locations.’

As previously mentioned, in intransitive sentences, where the sole overt argument of the verb is marked as a DistShare, the only available DistKey will be an implicit spatial or temporal argument of the verb – which means that the only available reading will be an event distributive reading over covert spatial or temporal locations. Assuming that the semantics underlying (17) does indeed involve exhaustively distributing events of a monkey dancing over implicit spatial/temporal locations, the question is then how to recover the covert spatial key from the context in order to test whether distribution over the spatial key must be exhaustive. Our experimental set-up was largely inspired by Balusu & Jayaseelan’s (2013) discussion of the contextual parameters involved in partitioning an event into relevant spatial locations in order to obtain a spatial DistKey reading (see discussion of (10) above).

The next section presents our experimental methodology, introducing the features that are common to both Experiments 1 and 2. This is followed by a more specific discussion of each experiment and their respective results.

¹⁴ Note that with transitive sentences, a number of confounding factors would have to be carefully controlled for in languages such as Serbian or Korean which have bare/determinerless nominals and freedom of word order, in particular, the interpretation of bare nominals in subject/topic position.

3.1 Experiment 1

Both Experiments 1 and 2 tested two DistShare markers, Serbian *po* and Korean *-ssik*. Although Korean and Serbian are typologically very different languages, *po* and *-ssik* show similar syntactic and semantic properties and we thus expect them to pattern alike in their interpretations.

Recall that in intransitive sentences, the only overt argument will be marked as the DistShare. This implies that quantification is over events along a spatial or temporal dimension and the DistKey is thus an implicit argument. Participants must therefore contextually infer the DistKey. We sought to control this process with a frame story that limits potential interpretations, and visual materials specifically designed to make spatial units contextually salient. We only used materials depicting spatial distribution (primarily for reasons of simplicity), but we believe our findings would carry over to temporal distribution.

General set-up: We used a children's visit to the zoo as a frame story for both experiments. This setting allowed us to have cages or caves as identifiable spatial units over which events could be distributed. This method of division into relevant spatial locations is adapted from Balusu & Jayaseelan's (2013) discussion of (10) above (scenarios involving monkeys on each branch of the tree). We varied the visual contexts (pictures) across subjects to test whether or not the spatial units need to be exhausted.

In our instructions we were careful not to explicitly mention cages/caves in order to ensure that there is no linguistically explicit argument that could potentially serve as a DistKey. Instead, the common context of the experiment was given at the beginning: "Peter and Mary went to the zoo with their class. They brought a camera and took pictures of animals they saw. After the visit, the teacher asked the children from the class to describe their photos. Are the children describing the pictures well?". Then, in a *yes-no* picture verification task (a variation of a truth value judgment task), the participants had to evaluate whether the descriptions of the photos were appropriate.

Test sentences: We started from the simplest structure – intransitive sentences, where *po/-ssik* is syntactically attached to the subject. The subject has to be interpreted as the DistShare, and the only alternative for the DistKey would be the implicit spatial units. In addition, we also used the lowest numeral, so the target phrase was *po one/ one-ssik*. Finally, the test items used a verb-subject word order for Serbian, see e.g. (17a), to avoid *po* occurring at the beginning of the sentence (since Knežević's (2015) previous research showed that *po*-initial sentences sound odd). The word order in Korean remained subject-verb, see e.g. (17b).

Our visual and discourse context aimed to make the cages/caves be considered as relevant spatial units and to serve as the (implicit) DistKey. We designed experimental conditions to try to investigate some basic questions about the different predictions that the theories presented above make. These predictions are spelled out in the section below.

3.1.1 Method and design

Subjects: 53 adult native speakers of Serbian (mean age: 26.35; 37 female, 14 male, 2 unspecified) and 26 native Korean speakers (mean age: 34.00; 17 female, 8 male, 1 unspecified) completed a 5-minute Picture Verification task that was available online. All Serbian participants and 6 Korean participants were recruited through social media and did not receive remuneration. The remaining 20 Korean participants were recruited through Amazon Mechanical Turk and were paid 65 cents for completing the experiment. All participants gave their consent before starting the experiment.

Design and procedure: we used a 1×3 design with the same type of test sentence and three different types of pictures as illustrated in Figure 3: A: *Exhausted*, B: *Non-exhausted*

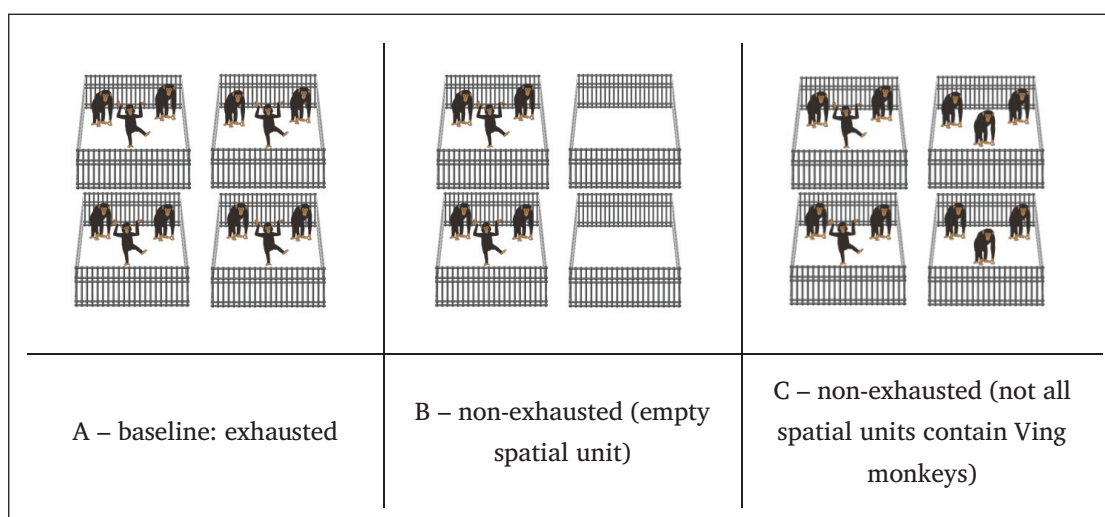


Figure 3: Examples of three test pictures paired with test sentences in Serbian (18a) and Korean (18b), giving three test conditions.

(empty spatial units) and C: Non-exhausted (not all spatial units contain Ving monkeys). The experiment was preceded by detailed written instructions and a common context for all items, discussed above.

Items: 12 unique sentences (target items) were created using 16 different animals and eight verbs.¹⁵ Each verb was presented no more than twice in a target sentence (see Appendix B for the complete list of items that were used for the target items and fillers). Each condition had four observations and each participant saw only one condition combination per item (see Figure 3 for test pictures where the background has been removed for visual clarity. See Appendix B for an actual picture from the experiment).

Picture A was considered to be the baseline condition, in which spatial units (cages) are considered exhausted since they each contain a dancing monkey. Pictures B and C showed non-exhausted situations. Picture B showed two spatial units with monkeys carrying out the target action, and two empty spatial units. Picture C showed two cages with a monkey carrying out the target action and two cages with monkeys that are not carrying out the target action. We always used two non-exhausted spatial units/cages, rather than one, to avoid singling out the odd situation in the picture. All three conditions showed four salient spaces in a rough 2×2 grid formation, and the position of the different types of spaces, e.g. a cage vs. empty area, varied across items.

As previously stated, the test sentences all had imperfective intransitive verbs and the following structure: [Verb [po-1(one)-Subject]] for Serbian (17a/18a) and [[Subject-1(one)-ssik] Verb] for Korean (17b/18b).¹⁶

- (18) a. Pleš-e [po jedan majmun].¹⁷
dance DISTR one monkey.NOM

¹⁵ There was one additional non-exhausted condition (for the same test sentence) in the original design, involving spatial units with *other animals V-ing*, e.g. hippos dancing in two of the cages. We considered this condition to be a filler since it does not help in answering our research question. When this condition is included, animals and actions were balanced across items.

¹⁶ The characters in the experiment we set up were animals typically found in a zoo: bears, parrots, owls, canaries, hippos, rhinos, elephants, monkeys, chimps, gorillas, giraffes, zebras, horses, lions, tigers and panthers. The verbs were: to jump, to cry, to sing, to dance, to sit, to lay down, to wave and to fly.

¹⁷ The actual animal in the picture is a chimpanzee but we use the term *monkey* in the examples because it is a more common word.

- b. [Wenswungi-ka han-mali-**ssik**] chwum-ul chwu-ko iss-ta.
monkey.NOM one.CLF.DISTR dance.ACC dance.PROG.DEC
- c. ‘DISTR one monkey is dancing (at different locations/each location).’

Control items were 12 numerically quantified sentences with a Verb-*three*-Subject(plural) pattern (e.g. “Three tigers are sleeping” with one of the three pictures corresponding A, B or C). These items had four *yes* and eight *no* responses and were used as true controls – participants who made errors on more than 10% of control items were excluded. Each participant also saw four filler items (see footnote 15). In sum, each participant saw 12 target items, 4 filler items and 12 control items, amounting to 28 items in total.

3.1.2 Predictions

What responses do we expect based on the two major lines of research? If we take the core assumption underlying the EP account, all three pictures should be accepted (see Table 2), since the only requirement is to have at least two events, and all scenarios satisfy this requirement. If DistShare markers are a type of universal quantifier, then there must be a DistKey that has to be exhausted. Because we made the linguistically implicit spatial DistKey salient in the frame story and visually relevant in the individual items, these spaces are contextually salient and the best candidate for the DistKey. The condition with Picture A, the baseline, should be accepted. But a UQ account predicts that the two other pictures, Picture B and Picture C, should be rejected because there are contextually relevant spaces where no monkey is jumping. Also note that neither theory requires all the monkeys in the context to satisfy the VP (*dance*), since the NP *one monkey* is marked as the DistShare.

3.1.3 Results

The results show us that the baseline picture (A) and the picture with non-exhausted spatial units (empty cages/caves) (B) were overwhelmingly accepted (90.1% and 84.4% respectively for Serbian and 96.1% and 97.1% respectively for Korean), unlike the picture with non-exhausted spatial units in which no monkey is V-ing (C) (10.4% for Serbian and 8.6% for Korean) (see Figure 4).

Table 2: Predictions according to EP and UQ accounts on all test pictures in Experiment 1.

		Picture A	Picture B	Picture C
Predictions	EP	✓	✓	✓
	UQ	✓	✗	✗

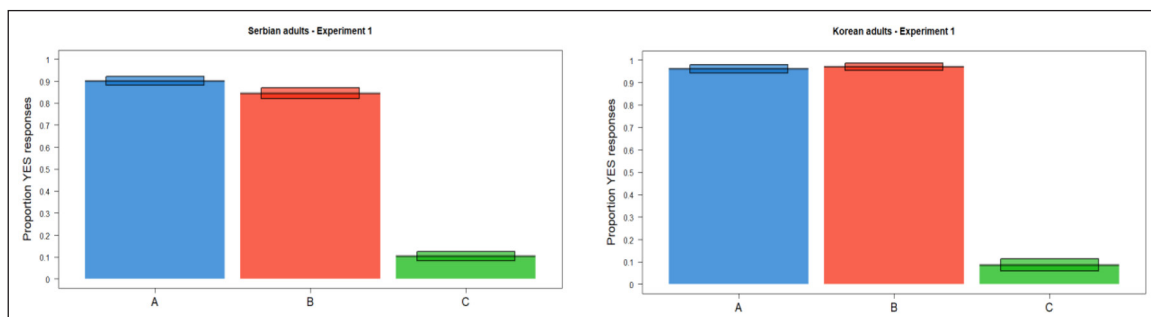


Figure 4: The results show the proportion of YES responses of Serbian (left) and Korean adults (right) with the standard error bars for Picture A (blue), Picture B (red) and Picture C (green) conditions.

We performed a repeated measures mixed-effects logistic regression using `glmer()` function of the `lme4` package (Bates et al 2015) in R (R Core team 2014) for each language. We started all analyses with a full and random intercept model that included *Picture Type* (with levels A, B and C) as the only predictor (fixed factor) and *Subjects* and *Items* as random factors. AIC values¹⁸ were compared to determine which model fit the data best, with a complex model being preferred over a simpler model only if its AIC value is two or more points lower. For both Serbian and Korean, model comparison did not show an effect of the *Items*, so this random factor was removed. For both languages, the best fitting model retained the fixed factor *Picture Type* and the random factor *Subjects*, with a random slope by-*Subjects* for *Picture Type* (see the best model formulas for each language and the output in Appendix A). The reference point was Picture A, and we see no significant difference between Picture A and Picture B for Serbian ($\beta = -1.70$, z-value = -0.50 , $p = 0.62$) or Korean ($\beta = -0.93$, z-value = -0.14 , $p = 0.89$). There was a highly significant difference between Picture A and Picture C for both Serbian ($\beta = -16.60$, z-value = -4.79 , $p < 0.001$) and Korean ($\beta = -18.92$, z-value = -2.83 , $p < 0.001$).

We also combined data from both Serbian and Korean in one model, including a new fixed factor *Language* with the levels *Serbian* and *Korean*. Models that included *Language* were not significantly different from models without. This means that there is no significant difference between Serbian and Korean participants in their responses.

3.1.4 Discussion

Going back to Table 2, we see that the baseline (Picture A) is accepted across the board, as expected on all accounts. Picture B is also strongly accepted as predicted on the EP, but not the UQ hypothesis. The situation is reversed for Picture C, which is overwhelmingly rejected as predicted on the UQ, but not the EP hypothesis – see the updated table (Table 3).

Taking stock: Our findings suggest that it is not necessary to exhaust spatial units. Participants accepted Picture B with e.g. cages without monkeys. However, the rejection of Picture C suggests that there is some form of exhaustivity requirement after all, since cages with monkeys need to contain a dancing monkey to be acceptable. We state the resulting descriptive generalizations in (19):

- (19) **Generalization 1:** Empty contextually relevant spatial units (e.g. cages) need not be exhausted, i.e. they need not satisfy the VP (by containing e.g. one dancing monkey). While spatial units that contain individuals that fit the description of the subject NP, e.g. monkeys, must exhaustively satisfy the denotation of the VP (by containing e.g. one dancing monkey).

Table 3: Predictions and results on all test pictures in Experiment 1.

		Picture A	Picture B	Picture C
Predictions	EP	✓	✓	✓
	UQ	✓	✗	✗
Actual results		✓	✓	✗

¹⁸ An AIC (Akaike information criterion) decrease of more than two indicates that the goodness of fit of the model improved significantly (Akaike 1974).

The overall experimental results thus seem to be a challenge to both theoretical approaches of DistShare markers: the assumed UQ hypothesis makes predictions that are too strong, while the EP hypothesis makes predictions that are too weak. To recapitulate, participant responses suggest there is no exhaustivity requirement on individual monkeys, because Picture A is accepted; there also seems to be no exhaustivity requirement on spatial units (cages) because Picture B is accepted; however, participant responses suggest that there is an exhaustivity requirement on groups of monkeys in cages. Thus, our findings are compatible with a UQ account since this account correctly predicts there is an (implicit) spatial DistKey that needs to be exhausted. The logical follow-up question is then: what is the relevant DistKey and how is it recovered from the linguistic and visual input? We know now that cages alone were not taken to be the relevant spatial locations, so the participants must be reacting to something else in the experiment. When examined more closely, the visual context, in fact, gives three possibilities to restrict the domain of quantification – (a) cages, (b) groups (here, triplets) of monkeys in cages, or (c) groups (here, triplets) of monkeys. The UQ account tested in Experiment 1 rules out option (a) as the DistKey, i.e. cages as delimited spaces. We henceforth refer to this first option as DistKey_{CAGE}. We now need to determine whether (b) groups of monkeys in cages or (c) groups of monkeys are serving as the DistKey. We refer to these two other options as DistKey_{CAGED GROUP} and DistKey_{GROUP}, respectively. Experiment 2 was designed to test these two options.

3.2 Experiment 2

3.2.1 Method and design

Subjects: 31 adult native speakers of Serbian (mean age: 29.77; 23 female, 6 male, 2 unspecified) and 30 adult native speakers of Korean (mean age: 35.00; 24 female, 6 male) participated in a picture verification task. The experiment was done online and took approximately five minutes.

Design and procedure: we again had a 1 × 3 design but changed two picture types from Experiment 1 (see Figure 5). Picture A was modified to create Picture A1: *Exhausted spatial units + monkey V-ing outside cages* and Picture C was modified to create Picture C1: *Exhausted + no monkey V-ing outside cages* showed groups of monkeys not bounded by explicit spatial units.¹⁹ These pictures were designed to assess how necessary spatial delimitation is. Control items and test sentences remained the same.

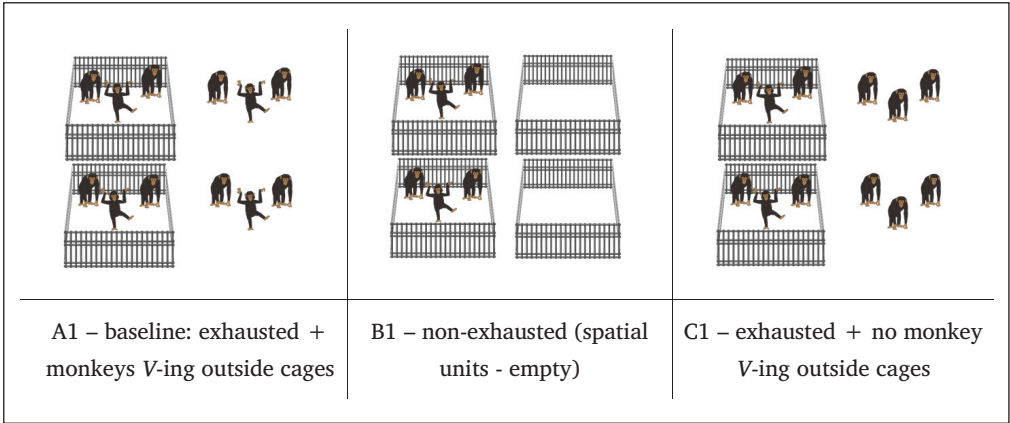


Figure 5: Pictures used in Experiment 2. Groups of monkeys appear outside clearly delimited spatial units in A1 and C1.

¹⁹ Picture B is named B1 but it is the same as in the previous experiment, to balance the design and have a type of filler since, in essence, we are only testing pictures A1 and C1.

3.2.2 Predictions

The first experiment showed that a $\text{DistKey}_{\text{CAGE}}$ account taking cages to be the relevant spatial DistKey is not correct, but the other two possibilities are to take groups of monkeys in cages ($\text{DistKey}_{\text{CAGED GROUP}}$) or only groups of monkeys ($\text{DistKey}_{\text{GROUP}}$) to be the spatial DistKey . This means that C1 is the crucial condition since it can tell us what the domain of quantification for *po/-ssik* sentences is. (see Table 4).

3.2.3 Results

Figure 6 shows that participants accept Conditions A1 (96.8% for Serbian and 77.1% for Korean) and B1 (90.9% for Serbian and 80.5% for Korean), but reject C1 (24.2% for Serbian and 20.8% for Korean). The results match the predictions of $\text{DistKey}_{\text{GROUP}}$, as seen in Table 5.

For analysis, we again performed a repeated measures mixed-effects logistic regression using `glmer()` function of the `lme4` package (Bates et al 2015) in R (R Core team 2014). The analysis and the procedure were identical to those used in Experiment 1. We started all analyses with a full and random intercept model that included *Picture Type* (with levels A1, B1 and C1) as the only predictor (fixed factor) and *Subjects* and *Items* as random factors. AIC values were compared to determine which model fit the data best, with a complex model being preferred over a simpler model only if its AIC value is two or more points lower. Model comparison showed that the model with the lowest AIC values for Serbian included the fixed effect of *Picture Type* and a random effect of *Items* and *Subjects*, plus a random slope for *Picture Type* for *Subjects* (the reference level (the Intercept) was set to be B1).

Table 4: Predictions according to the two possible DistKeys that must be exhausted.

		Picture A1	Picture B1	Picture C1
Predictions	$\text{DistKey}_{\text{CAGED GROUP}}$	✓	✓	✓
	$\text{DistKey}_{\text{GROUP}}$	✓	✓	✗

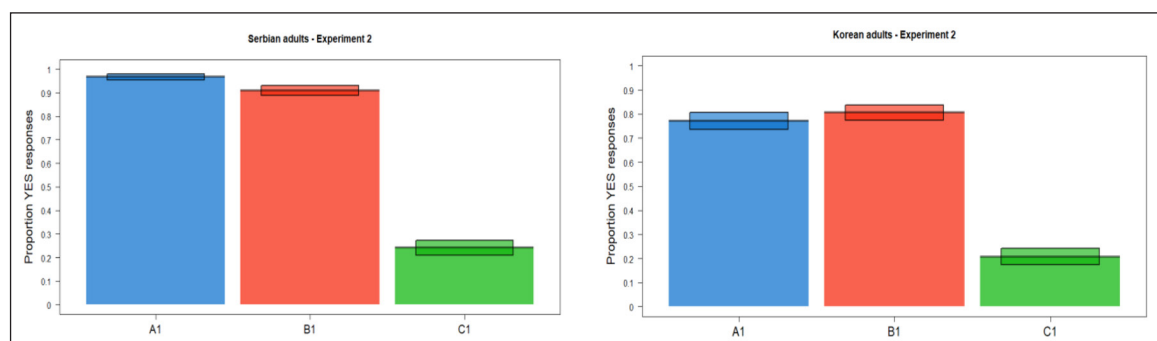


Figure 6: The results show the proportion of YES responses of Serbian (left) and Korean (right) adults with the standard error bars for Picture A1 (blue), Picture B1 (red) and Picture C1 (green) of the (new) conditions.

Table 5: Predictions and results on all test pictures in Experiment 2.

		Picture A1	Picture B1	Picture C1
Predictions	$\text{DistKey}_{\text{CAGED GROUP}}$	✓	✓	✓
	$\text{DistKey}_{\text{GROUP}}$	✓	✓	✗
Actual results		✓	✓	✗

The model showed that B1 and A1 were not significantly different ($\beta = 0.31$, z value = 0.10, $p = 0.92$), and that B1 had significantly higher rates of acceptance than C1 ($\beta = -11.41$, z value = -4.43 , $p \leq 0.001$). The best model for Korean did not include the Items and had a random slope for *Picture Type* for *Subjects*. Again, A1 was not significantly different from B1 ($\beta = 4.31$, z value = 1.46, $p = 0.15$) and C1 was significantly different than B1 ($\beta = -9.99$, z value = -3.99 , $p \leq 0.001$). The full model is given in Appendix A. Finally, when the data was combined, the model with *Language* as the fixed factor showed no significant difference compared to the model without *Language*, meaning that Serbian and Korean participants responded similarly to the conditions.

3.2.4 Discussion

The question we asked for Experiment 2 was whether we are exhausting groups (triplets) of monkeys in cages, what we called $\text{DistKey}_{\text{CAGED GROUP}}$, or simply (cageless) groups of monkeys, i.e. $\text{DistKey}_{\text{GROUP}}$. The results (the rejection of Picture C1 in particular) clearly favor the latter answer – cages are completely irrelevant for the evaluation of the test sentences and it is only the groups of monkeys that need to be exhausted. We thus modify our previous descriptive generalization stated in (19), as in (20):

- (20) **Generalization 2:** Empty contextually relevant spatial units (e.g. cages) need not be exhausted, i.e. they do not satisfy the VP (by containing e.g. one dancing monkey). Each (contextually/visually salient) group (here – triplet) of individuals (e.g. monkeys) must be exhausted (must satisfy the VP by containing e.g. one dancing monkey).²⁰

We conclude that these groups/triplets of monkeys are defining the spatial locations that are considered relevant and, as such, must be exhausted. But why did the participants choose the triplets to be the relevant spatial *DistKey* and not the cages? In the pictures, they are equally (visually) relevant. In fact, as mentioned before, the visual input yields three potential *DistKeys* that can serve as the implicit restriction of a universal quantifier – cages, triplets of monkeys in cages, or just triplets of monkeys.

We speculate the following: Our participants had to recover the spatial key on the basis of two inputs provided by the experimental materials – visual and linguistic input. They ignored the cages since they are not mentioned in the linguistic input. Monkeys, on the other hand, are mentioned in the linguistic input and they are also salient in the visual input, by being shown in clear groups of three, all distant from each other, resulting in four clearly separated groups of monkeys (two in the case of the B conditions). This suggests that when the preceding discourse context does not explicitly provide the spatial *DistKey*, and the visual context is ambiguous as to what the right restriction is, participants seem to use a strategy of prioritizing linguistic cues.

There is one caveat to this explanation. Namely, there is a 24% acceptance rate for Picture C1 for Serbian and 20% for Korean, which is higher than the 10%/8% found in the previous experiment. A Mann-Whitney U test indicated that the frequency of yes answers for Experiment 1 ($Mdn = 0$) was significantly lower than for Experiment 2 ($p < 0.01$), so we examined individual response patterns for Picture C1 more closely. Only 4/31 Serbian participants and 4/30 Korean participants accepted C1 100% of the time (and also accepted Picture B1 and A1 100% of the time). This observation is interesting

²⁰ The groups of monkeys may contain other irrelevant individuals (animals) as well, but as long as there is one monkey dancing in that relevant group, the generalization holds. This, however, is a separate observation already discussed by McKercher and Kim (1999) and confirmed by several Serbian informants.

because, although it concerns a small subset of participants, these participants do appear to show exactly the pattern of responses predicted on the event plurality account (all three pictures accepted). On the other hand, this could easily be noise in the data and since we, unfortunately, do not have these speakers' explanations for the reason they accepted all the conditions, we cannot make any further inferences. Lastly, some Korean speakers (4/30) systematically rejected all three conditions, resulting in lower acceptance rates even for the A1 (baseline) condition. We speculate the reason for this low rejection rate may be that the pictures in Experiment 2 are showing a complex scene and that some participants are very strict in their judgments, meaning that the sentence may not be informative enough to capture everything that is happening in the picture. We leave this as a speculation only, stressing again that this observation was statistically insignificant.

4 General Discussion

The question our experiments sought to address was whether DistShare markers in Serbian and Korean should be analyzed as markers of event plurality, or as universal quantifiers requiring an implicit DistKey over which to distribute exhaustively. Let's recapitulate our main experimental conclusions (stated as Generalizations 1 in (19) and 2 in (20)).

- (21)
- a. The results showed that individual members of the DistShare (e.g. monkeys) need not be exhausted, as expected.
 - b. The result showed that the spatial argument made salient by the visual context (i.e. cages/caves) need not be exhausted.
 - c. There is, however, evidence leading us to conclude that there is an implicit DistKey: the set of triplets/groups of monkeys provided by the visual context that needs to be exhaustively distributed over.²¹

We unpack the consequences of these observations in the following sections, and suggest a possible universal quantifier analysis based on Zimmermann's account.

4.1 Distribution over pluralities of non-atomic individuals

Our results provide intriguing evidence for a covert spatial DistKey. The visual context supplies spatially separated groups/triplets of monkeys. This plurality, which is itself made up of plural/non-atomic individuals, serves as the DistKey over which the members of the DistShare (dancing monkeys) are distributed.

These conclusions clearly clash with the assumed predictions of the event plurality analysis. Instead, they appear to provide evidence for the UQ accounts: (i) distributive markers have an essentially relational function, that of establishing a relation between members of the DistKey and members of the DistShare, and (ii) there is an exhaustivity requirement on a DistKey. In our experiments with our materials we found that the members of the DistShare contribute to spatially define the DistKey that has to be exhausted.

To account for these findings, we suggest an analysis of event distributive readings for both Serbian and Korean along the lines of Zimmermann (2002b) as presented in

²¹ It is important to bear in mind that distribution is taking place over pluralities/triplets of monkeys, *not* individual monkeys, for the very simple reason that the numeral NP *one monkey* is marked as the DistShare. We see clear empirical evidence for this in the ceiling acceptance for the baseline A/A1 condition that does not exhaust the individual monkeys.

section 2.1.²² Consider again the intransitive sentences in (22b) and (22c), together with their German translation in (22a):

- (22) a. [Jeweils ein Affe] tanzt.
DISTR one monkey.NOM dances
b. Pleš-e [po jedan majmun].
dances DISTR one monkey.NOM
c. [Wenswungi-ka han-mali-ssik] chwum-ul chwu-ko iss-ta.
monkey.NOM one.CLF.DISTR dance.ACC dance.PROG.DEC
'DISTR one monkey is dancing.'

DD quantifiers across languages are assumed to have the uniform underlying structure in (23a). Although all languages with DD quantifiers express the DistShare overtly, languages differ with regards to which parts of the postnominal PP is overtly spelled out. In particular, adapting Zimmermann, *po* in Serbian would be taken to spell out a complex prepositional head derived via incorporation of a silent universal Q° into the overt P° -head, as shown in (23b). The PP is base-generated right-adjoined to the DistShare NP ($[_{AP} \text{one}] [_{NP} \text{monkey}]$). While in Korean, this PP will stay in its base position,²³ in Serbian it raises to the Specifier of the whole DP (as does *jeweils* in German), yielding the observed surface order (23c):

- (23) a. $[_{DP} D^\circ [_{NP} [_{NP} NP_{DistShare}] [_{PP} P^\circ [_{QP} Q^\circ \text{je} [_{NP} \text{weil-s}_{DistKey}]_{QP}]_{PP}]_{NP}]_{DP}]$
b. $[_{DP} D^\circ [_{NP} [_{NP} [_{AP} \text{one}] [_{NP} \text{monkey}]_{DistShare}] [_{PP} [_{P^\circ + Q^\circ} \text{po} [_{QP} \text{t}_{each} [_{NP} \text{pro}_{DistKey}]]]]]]]$
c. $[_{DP} [_{PP} [_{P^\circ + Q^\circ} \text{po} [_{QP} \text{t}_{each} [_{pro}_{DistKey}]_k] [D^\circ [_{NP} [_{NP} [_{AP} \text{one}] [_{NP} \text{monkey}]_{DistShare}]]]]]]]$

We now focus specifically on the analysis of Serbian, but conjecture that a similar analysis could be applied to Korean as well. Zimmermann's compositional analysis provides a relational variable R specifying the relation that holds between the elements of the DistKey and DistShare. The denotation for the PP headed by *po* is given in (24a). It will combine with its argument, the value of the numeral NP in (24b), to yield the proposition in (24c):

- (24) a. $[[[_{PP} \text{po}_j \text{ each } \text{pro}_i]]] = \lambda P. \forall z [(z \in Z_i) \rightarrow \exists X [P(X) \wedge *R_j(X, z)]]$
b. $[[[_{NP} \text{one monkey}]]] = \lambda X. 1\text{monkey}'(X)$
c. $[[[_{NP} \text{one monkey } \text{po}_j \text{ each } \text{pro}_i]]] = \forall z [z \in Z_i \rightarrow \exists X [1\text{monkey}'(X) \wedge *R_j(X, z)]]$
For every element z of a contextually salient set Z_i , there is a set X of one monkey such that X and z stand in relation R_j to one another.

²² We choose to adopt Zimmermann's proposal that DD items have a core prepositional meaning introducing a free relation variable R for two correlated reasons: First, *po* is indeed a proposition with the meaning in some contexts of *per (each)* (see (25a) in the text below). Second, the proposal that the value of the relation R holding between the DistShare and the DistKey is pragmatically determined by context allows us to capture the idea that event distribution here is over triplets of monkeys, with R in the case at hand being the relation holding between monkeys and the triplets they belong to. We thank a reviewer for insightful discussion of this point.

²³ Note that there is also evidence from Korean for this analysis since, as Zimmermann (2002b) himself mentions: the postnominal DistShare marker *-ssik* is a particle treated as a postposition.

The numeral NP²⁴ *one monkey* in (24a) (which forms the DistShare) denotes a property that is predicated of the set variable that is bound by the existential quantifier in the nuclear scope of the universal. This ensures that elements of the DistShare are distributed over elements of the implicit restriction of the universal quantifier.

The indexed variable pro_i in (24) provides the restrictor of the universal quantifier, that is, the DistKey. For event-distributive interpretations, pro_i is simply left free, and understood to denote a salient plurality (of events, on Zimmermann's analysis of temporal event distributive readings; see discussion of (8b)) that is recoverable from the context. Our experimental results tell us that the DistKey in (24) is understood to be the set of sets/triplets of monkeys made salient by the visual and linguistic input.

Turning now to the value of the relation variable R contributed by *po*, recall that for participant distributive construals, its value is provided by an overt relation-denoting expression in the clause (e.g. by the denotation of the verb in (8a)). For event distributive interpretations, its value is pragmatically determined by the context (preceding discourse and extra-linguistic context), together with world knowledge (see discussion of (8b)). Zimmermann claims that R can take on a variety of temporal, locative, as well as other values (in particular, causation, temporal succession/overlap/inclusion, homogeneous subpart, etc.).

Focusing now specifically on Serbian, we can extend this analysis and assume that the value of the free relation variable R is constrained/determined in part by the core lexical meaning of *po* as a locative preposition. Evidence for the status of *po* as a locative preposition, with plausibly (universal) quantificational content, is provided by the uses of *po*, illustrated in (25), from Knežević (2015: 134–137) who points out that the earliest diachronic use of *po* is that of a spatiotemporal preposition. Note, in particular, that the translation provided for *po* in (25a) is very close to what we want as a value for R in (24), i.e. one dancing monkey *per* triplet, and that we could paraphrase *po* in (25a) as *per (each)*. This falls out nicely on the assumption that *po* spells out incorporation of a universal quantifier into a prepositional head, which we take to have a meaning akin to that of *per*.²⁵

- (25) a. pet automobila **po** stanovniku. *Quantitative locative*
 five car.GEN.PL DISTR inhabitant.LOC.SG
 'five cars per inhabitant.'
- b. Igračke su (svuda) **po** *Spatial-denoting locative*
 toy.NOM.PL AUX.3.PL (everywhere) DISTR
 podu.
 floor.LOC.SG
 'The toys are all over the floor.'
- c. Ivan spava **po** danu. *Temporal-denoting locative*
 Ivan.NOM sleep.3.SG.PS.IMPF DISTR day.LOC.SG
 'Ivan sleeps throughout/during the day.'

Following Zimmermann, the value of R is contextually determined and can take on a variety of meanings, that is, temporal, locative, subpart, causal, or other contextual relation.

²⁴ A numeral *n* is taken to denote the property of being a set of *n* elements. The complex predicate *n monkeys* thus denotes the complex property of being a set containing *n* monkeys, abbreviated " $\lambda X. n\text{-monkeys}(X)$ ".

²⁵ Indeed, Carlson & Filip (2001: 452) explicitly argue that "the [Czech verbal] distributive prefix *po-* also involves universal quantification, because it requires that the property expressed by its base verb be attributable to each such unit, namely to each **atomic** individual member or to each **relevant group** into which the domain of interpretation is divided." (emphasis added).

We take the relevant relation that *po* establishes between the DistKey (the set of triplets of monkeys in the visual input) and the DistShare (a set of one monkey) to be the element-of relation (\in). This constrains each subset/triplet of monkeys Z given in the visual input to contain as one of its members a subset X of one monkey that is dancing.

The truth conditions ultimately derived for (22) are given in (26):

- (26) $\forall Z [Z \in Z'_i \rightarrow \exists X [1\text{monkey}'(X) \wedge \exists e [*dance'(X, e) \wedge R(e, Z)]]]$
 For every set Z that is an element of a contextually salient set of sets Z'_i , there is a set X of one monkey and an event e , such that X dances in e , and event e is related to Z in that $X \in Z$.

For Zimmermann, event distribution involves distribution of events over an (implicit) plurality of events. Importantly, (26) yields an event-based distributive interpretation, even though distribution here is over non-atomic individuals (groups of monkeys). Recall, in particular, that when quantification is over individuals, the DistShare and the DistKey correspond to arguments of the verb and the value for the relation variable R in the meaning of PP is provided by the denotation of the verb. This ensures that, in the case of (8a) for instance, the distributive relation involves individual ballerinas and groups of two officers, and is one of accompanying the former home. (26), on the other hand, involves quantification over events, since *po* is establishing a relation between individual events and elements (Z) of the DistKey (Z'_i), and the value of the relation variable R is determined by the context. By imposing few constraints on either Z or R , Zimmermann's proposal allows us to nicely capture the generalization that the triplets of monkeys provided by the visual input serve as the DistKey, with each triplet having to contain, as one of its elements, a dancing monkey. Since both Z and R are pragmatically determined, the interesting question is then why Z did not end up ranging over cages (with R as a locative relation) so that distribution of dancing monkeys would be over cages and not triplets of monkeys. We offered a speculative answer to this question in section 3.2.4, suggesting that participants use both the visual input (triplets of cageless/caged monkeys) and the linguistic input (mention of monkeys) provided by the experimental materials) to recover the spatial DistKey.

On the proposal defended here, the truth conditions in (26) differ from those for run-of-the-mill cases of quantification over events only in that the members of the spatial DistKey are plural individuals (i.e. groups of monkeys). We take up this issue in the context of Champollion's (2016b) parameters of variation for distributivity operators.

4.1.1 Distribution over spatio/temporal locations

Recall that not all DD items also distribute over spatio/temporal aspects of events. Those that double as determiners (e.g. *each*) cannot, while DD items such as *jewels* or *po* can. Champollion (2016b: 4) takes this semantic variation to reflect the parameter settings for distributivity operators: granularity and dimension. Granularity specifies the "size of the entities over which we distribute: e.g. atoms or amounts of space or time." Dimension specifies the domain of distributivity: either participants/theta-roles or space/time intervals. These parameters interact. If the granularity parameter is set to atoms (as is the case for *each*), then distribution over spatial/temporal dimensions is excluded: since time is a continuous and non-count dimension, there are no atoms to distribute over. If granularity is left unspecified (as is the case for *jewels*), distribution over non-count dimensions like time is possible.

Clearly, the granularity parameter for *po/-ssik* is unspecified since they can distribute over entities that are non-atomic such as time, as well as entities that are bigger than

atoms – that is, groups/pluralities of atomic individuals. Crucially, however, in the latter case, distribution is over spaces, distribution is *not* over participants. Indeed, it cannot be over the theta-role dimension, if only because the agent argument is itself marked as the DistShare. The (locations of the) groups of monkeys serve to divide up the spatial key, to partition the spatial region into relevant spatial units that have to be exhausted. So why can *po/-ssik* distribute over pluralities of non-atomic individuals? The answer, we suggest, is because this is yet another instance of distribution over the *spatial* dimension.²⁶ We sought to capture this with the analysis developed for (22) in (25–26). Locative *po* establishes a distributive relation between individual events (of monkeys dancing) and plural individuals (triplets of monkeys), requiring that there be *one dancing monkey per each triplet of monkeys*. The pluralities provided by the visual context thus serve to divide up the DistKey into chunks of space.

We close by pointing out that this raises the issue of whether atomic individual/participant-based distributive readings could not also be subsumed under spatial distributivity, which is a controversial issue in the literature. As Cusic (1981) and Lasersohn (1995) point out, although two atomic individuals can occupy the same space at different times, *they cannot occupy the same space at the same time* (Lasersohn 1995: 250). The idea then is that (atomic) participant distribution could be made to fall out from spatio/temporal distribution: with events occurring simultaneously, distribution over singular individuals would reduce to distribution over different spatial locations (since each atomic individual defines his/her own spatial location), and with events occurring over different times, to distribution over different temporal locations. We leave these issues open for further research.

5 Conclusion

This paper experimentally probed the issue of whether DistShare markers show exhaustivity requirements in two typologically very different languages, testing the Serbian marker *po* and the Korean marker *-ssik*. The empirical findings were as follows. The sentence “DISTR one monkey is dancing” in Serbian and Korean is true on a spatial event-distributive reading if, in each caged group of monkeys (provided by the visual input), there is a monkey dancing, and remains true when empty cages are added. When non-caged groups of monkeys are added, the sentence remains true only as long as in each of these non-caged groups, a monkey is dancing.

We took our empirical findings from Experiment 1 (corroborated by Experiment 2) to provide evidence that the (spatial) event-distributive reading that DistShare markers yield, involves a covert (spatial) DistKey that must be exhausted. This conclusion argues in favor of a UQ analysis. The question, however, is how the spatial DistKey is identified since it remains an implicit argument that must be recovered via context and pragmatics. Having established in Experiment 1 that the DistKey was not ranging over cages, we tested with Experiment 2, two other hypotheses made available by the visual input – namely, that the spatial DistKey was either triplets of monkeys in cages, or merely triplets of monkeys (whether they are caged or not). The later hypothesis neatly proved to be the correct one. We suggested an analysis of spatial event distribution along the lines of Zimmermann (2002b): *po/-ssik* is a locative pre/postposition with universal quantificational force (roughly *per (each)*) establishing a distributive relation between individual events (of monkeys dancing) and plural non-atomic individuals (triplets of monkeys) serving as the DistKey, requiring that there be one dancing monkey per each

²⁶ It goes without saying that quantification over groups coincides with quantification over spatial locations occupied by these subgroups only to the extent that the subgroups in question occupy distinct spatial locations. That is, if groups occupy the same location at different times, then we are distributing over time intervals and not space. Likewise, if two different groups have the same participants, then distribution will again necessarily be temporal (since the same individual cannot occupy at the same time two different spaces).

triplet of monkeys. This proposal receives empirical support from uses of *po* as a locative (quantitative, spatial, or temporal) preposition. Moreover, it nicely captures Gil's (2013: 222) definition of distributive numerals: "The meanings of sentences containing distributive numerals can be described in terms of a binary semantic relationship of distributivity that obtains between an expression containing the distributive numeral, the distributive share, and some other expression in the sentence, the distributive key. This relationship may be expressed by means of the English preposition *per*, in accordance with the formula share *per* key."

By experimentally probing the question of how spatial DistKeys are recovered from the context (specifically, highlighting how both the linguistic and the visual input made available together play a role in determining the relevant domain restriction) we hope to have also contributed novel empirical evidence to bear on a long standing question in the literature, that of how implicit quantifier domains are recovered (Von Stechow 1994; Stanley & Gendler Szabó 2000).²⁷

An obvious next step is to investigate how well the analysis developed here extends to transitive sentences. The added complexity is that since transitive sentences have two arguments, while one of them will serve as the DistShare (and as such be marked by *po*), the other (unmarked argument of the verb) can potentially serve as an overt DistKey, thus yielding an individual-distributive reading. This further gives a strong competitor to event-distributive readings and again the challenge is in setting up the experiments, but here to test both individual and event-distributive readings. This is one of the directions of investigation we are currently developing.

Another line of investigation would be to test the hypothesis put forth that the critical reading that sentence (22) yields arises as an instance of distribution over the spatial dimension: distribution over non-atomic members of a plurality of individuals is possible because the pluralities (made available by the visual input) can serve to divide up the DistKey into chunks of space. The prediction would then be that no such reading should arise if distribution is set up to be temporal, that is, over chunks of time and not space.

We hope that our work has shown the benefit of experimental data for probing empirical generalizations and their theoretical accounts, and as such will encourage further experimental research into the different uses of DistShare markers so that we can investigate and comprehensively evaluate the best approach to semantically describe such markers.

Abbreviations

ACC = accusative, AUX = auxiliary, CLF = classifier, DEC = declarative, DISTR = distributive, LOC = locative, NOM = nominative, PAST = past, PL = plural, PROG = progressive.

Additional Files

The additional files for this article can be found as follows:

- **Appendix A.** Complete model outputs for Experiments 1 and 2. DOI: <https://doi.org/10.5334/gjgl.858.s1>
- **Appendix B.** Experimental items in Serbian and Korean. DOI: <https://doi.org/10.5334/gjgl.858.s1>

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²⁷ We thank an anonymous reviewer for emphasizing this important point.

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Competing Interests

The authors have no competing interests to declare.

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