Polyadic cover quantification in heterofunctional coordination

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Abstract. In Heterofunctional Coordination conjuncts bear different grammatical functions, as in the attested *What and when to eat before workout*. While such English constructions are analysable in terms of ellipsis (cf. *What to eat ~~before workout~~ and when to eat before workout*), in Slavic they are often argued to involve direct coordination. The aim of this paper is to provide a semantic analysis of this phenomenon in Slavic, one that is based on a generalization of the cumulative polyadic lift, namely, on the cover lift.

Keywords: coordination, polyadic quantifiers, cumulative lift, covers, grammatical functions, Slavic, Polish

1. Heterofunctional coordination

In Heterofunctional Coordination (HC), illustrated with the Slavic examples (1)–(4), conjuncts bear different grammatical functions with respect to the head (as in (1)–(3)) or may even be dependents of different heads (as in (4), where – on the prominent interpretation – the dative *komu* 'who' is an argument of *wolno* 'may, be allowed', while the accusative *co* 'what' is an argument of *mówić* 'say, speak'):[1]

(1) [Ko i čime] je razbio staklo? (Serbo-Croatian)
who.NOM and what.INS AUX.3SG broke glass
'Who broke glass with (= using) what?' (Browne, 1972: 223)

(2) [Nikto i nikomu] ne pomogaet. (Russian)
nobody.NOM and nobody.DAT NEG helps
'Nobody helps anybody.' (Mel'čuk, 1988: 40)

(3) Obiecać można [wszystko i wszystkim]. (Polish)
promise may.IMPS everything.ACC and everybody.DAT
'One may promise everything to everyone.'
(National Corpus of Polish, Przepiórkowski et al. 2011, 2012, apud Patejuk 2015: 80)

(4) [Komu i co] wolno mówić o Chinach i w Chinach? (Polish)
who.DAT and what.ACC may say about China and in China
'Who may say what about China and in China?'
(`https://kulturaliberalna.pl/2019/05/16/sarek-cenzura-chiny/`)

The term Heterofunctional Coordination – appropriated from Grosu (1987: 426), who talks about English Heterofunctional Coordinate Constructions such as (5) – is more transparent than the terms usually used in the context of Slavic HC, namely, Lexico-Semantic Coordination (Sannikov 1979–1980, Mel'čuk 1988, Kallas 1993, Patejuk and Przepiórkowski 2012, and

[1] Translations of examples in this section are preliminary, to be made more precise in §2. Morphosyntactic abbreviations in glosses follow the Leipzig Glossing Rules, with the addition of IMPS marking impersonal verbs in (3) and (16).

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other works by the last two authors) and Hybrid Coordination (Chaves and Paperno, 2007, Paperno, 2012, Bîlbîie and Gazdik, 2012).

(5) [What and where] has John eaten (in the last five years)? (Grosu, 1987: 428)

However, as already noted in what seems to be the first mention of HC in the generative literature, i.e. Browne 1972, English HC differs from Slavic HC: it does not tolerate obligatory arguments among the conjuncts. Thus (5) is acceptable because both the direct object of EAT and its locative adjunct are optional, while a literal translation of (1) given in (6) is unacceptable because it involves a subject, which is obligatory in English.

(6) *[Who and with what] broke the glass? (Browne, 1972: 223)

The general consensus in the syntactic literature is that Germanic HC is biclausal, i.e., that it involves coordination of sentences and subsequent ellipsis, so (5) is acceptable because both underlying clauses in (7) are acceptable, while (6) is bad because the second clause in (8) is ill-formed.

(7) What ~~has John eaten~~ and where has John eaten?
(8) Who ~~broke the glass~~ and *with what broke the glass?

On the other hand, many arguments against such elliptical analyses of HC in Slavic and at least also in Hungarian may be found, e.g., in Kazenin 2001, Gribanova 2009: 136–137, and Paperno 2012: 99–102, 121 (for Russian), in Skrabalova 2007: §§2 and 5 (for Czech), and in Lipták 2003 and Bîlbîie and Gazdik 2012: §3.3 (for Hungarian).[2] Hence, in what follows I take it as established that Slavic HC does involve direct coordination of phrases bearing different grammatical functions.

As HC blatantly violates various syntactic likeness constraints on conjuncts postulated in the literature – including the generally assumed identity of syntactic categories (e.g., Williams 1981: §2 and Bruening and Al Khalaf 2020, among many others) and the identity of grammatical cases, where applicable (e.g., Weisser 2020)[3] – it is sporadically proposed (e.g., in Merchant 2017) that what looks like conjunction in HC is really a discourse marker, i.e., that HC is not coordination at all. But there are good arguments against this view, so the general consensus is that HC really is a kind of coordination (see, e.g., Paperno 2012: 89–90, fn.4, and Patejuk 2015: §5.3). First, in all HC languages, the element that occurs between phrases constituting HC has the same form as a coordinating conjunction in that language. If it were not a conjunction, then some exceptions would be expected. Second, this element follows the syntax of conjunction, and in particular it occurs immediately before the last phrase in HC, just as conjuncts do. Finally, and most importantly, a number of different conjunctions may occur in HC in a given language, including discontinuous conjunctions. Hence, I take it as established that HC is a kind of coordinate structure.

[2]The status of Romanian is more controversial; see, e.g., Bîlbîie and Gazdik 2012 and Citko and Gračanin-Yüksek 2013.

[3]See Patejuk and Przepiórkowski 2021 for a reply to and critique of Bruening and Al Khalaf 2020, and Przepiórkowski 2022 for a reply to Weisser 2020 and a more general defence of the coordination of unlikes.

It is not the case that just any dependents may be coordinated in HC languages; rather, only generalized quantifiers (GQs) may occur in HC, on the assumption that indefinites and *wh*-phrases are analysed as GQs. In fact, in Slavic, the coordination of heterofunctional *wh*-phrases, illustrated in (1), (4), and (9), is so frequent that most of syntactic works which deal with Slavic HC are only concerned with *wh*-questions. Nevertheless, (10) and (11), involving clear GQs, are perfectly acceptable answers to (9), unlike (12), which does not involve such quantifiers and which is unacceptable:[4]

(9) [Co i komu] dać? (Polish)
what.ACC and who.DAT give.INF
'What should I give and to whom should I give it?'

(10) Nie dawaj [nic i nikomu]! (Polish)
NEG give.IMP.2SG nothing.ACC and nobody.DAT
'Don't give anything to anybody!'

(11) Rozdaj [wszystko i wszystkim]! (Polish)
give.away.IMP.2SG everything.ACC and everybody.DAT
'Give away everything (and) to everybody!'

(12) *Daj [książkę i Marii]! (Polish)
give.IMP.2SG book.ACC and Maria.DAT
intended: 'Give a/the book to Maria.'

Just as (2) and (3), examples (10) and (11) involve the quantifiers *no* and *every*, but a wide range of natural language quantifiers may be used; the following examples from the National Corpus of Polish are among many cited in Przepiórkowski and Patejuk 2014 (see also Patejuk 2015: ch.6), and similarly wide-ranging attested Russian examples may be found in Paperno 2012: ch.3. These examples illustrate Heterofunctional Coordination involving the quantifiers *many* (see (13)), *some* (see (14)–(15)), and *not every* (see (16)).

(13) Konwertowałem [na wiele formatów i wieloma kodekami]... (Polish)
converted.1SG.M on many formats and many.INS codecs.INS
'I used to convert to many formats and using many codecs...'

(14) W tym całym procesie nieuniknione jest, że [gdzieś i ktoś] jakąś szkodę
in this whole process inevitable is that somewhere and somebody some harm
poniesie. (Polish)
suffer.FUT
'It is inevitable in this whole process that somebody will somewhere suffer some harm.'

(15) Zważmy, czy [komukolwiek, kiedykolwiek i do czegokolwiek]
consider.IMP.1PL whether anybody.DAT any.time and to anything
przydał się poradnik. (Polish)
was.useful REFL guide
'Let us consider whether the/a guide was of use to anybody, at any time, and for anything.'

(16) Poza tym [nie każdemu i nie zawsze] można transplantować nowy organ.
apart that not everybody.DAT and not always may.IMPS transplant new organ
(Polish)

[4] An acceptable answer would be just like (12) but without the conjunction *i* 'and'.

'Apart from that, one may transplant a new organ not to everybody and not always.'

In each of the examples above, all conjuncts involve the same quantifiers of Lindström (1966) type $\langle 1,1\rangle$ (e.g., 2 $\times$ *many* in (13) or 3 $\times$ NPI *some* in (15)), and this is overwhelmingly the case in HC, but we will consider some exceptions in the next section.

2. Polyadic quantification in HC

Previous semantic analyses of HC (discussed in §2.1), as well as the analysis proposed here (in §§2.2–2.3), are formulated in terms of polyadic quantifiers. Ordinary – monadic – quantifiers are relations on sets (Mostowski, 1957). For example, the logical quantifier $\forall$ may be understood as a property of sets (i.e., it is of Lindström type $\langle 1\rangle$), true iff the argument of $\forall$ is the whole domain. Similarly, the determiner *every* is usually taken to denote a binary relation on sets (i.e., a relation of type $\langle 1,1\rangle$), true if the first argument is a subset of the second argument. Words like *more*, as in *More dogs than cats bark*, may be analysed as denoting ternary relations on sets (i.e., of type $\langle 1,1,1\rangle$), true if – in the example at hand – the cardinality of the intersection of dogs and barking entities is greater than that of the intersection of cats and barking entities. Polyadic quantifiers generalize this view by allowing arguments to be arbitrary relations, not just unary relations (i.e., sets). For example, in (17), the two occurrences of *different* may be analysed as exponents of a single polyadic quantifier *different* defined as in (18) (see, e.g., Keenan and Westerståhl 2011: §19.3.2.1 and references there).

(17) Different people like different books.

(18) $\mathit{different}(A,B,R) \stackrel{\text{df}}{\equiv} \forall x_1,x_2 \in A.\ x_1 \neq x_2 \rightarrow \{y_1 \in B : R(x_1,y_1)\} \neq \{y_2 \in B : R(x_2,y_2)\}$

This quantifier takes three arguments: two sets and a binary relation, so it is of type $\langle 1,1,2\rangle$. According to this definition, (17) is true iff, for any two people, the sets of books they like are not identical.

Keenan and Westerståhl (2011) hypothesize that properly polyadic quantifiers expressed by natural languages bear regular relationships to ordinary monadic quantifiers, namely, via a handful of lifting operations.[5] One such lift is the basis of previous analyses of HC (see §2.1); the account proposed here will build on two other lifts (see §§2.2–2.3).

2.1. Resumptive lift?

Apparently, the only previous semantic accounts of HC are due to Paperno (2010, 2012). The two accounts in Paperno 2010 and in Paperno 2012: ch.3–4 assume the resumptive polyadic lift and they differ in the syntax–semantics interface: the earlier analysis assumes Chomskian syntax, and the later adopts categorial grammar.

In the simplest case, the resumptive lift takes a monadic quantifier Q of type $\langle 1,1\rangle$ and turns it into the polyadic quantifier $\mathit{Res}^2(Q)$ of type $\langle 1,1,2\rangle$ defined in (19):

[5] "Polyadic quantification in natural languages in general results from lifting monadic quantifiers" (Keenan and Westerståhl, 2011: 906).

(19) $Res^2(Q)(A,B,R) \stackrel{\text{df}}{\equiv} Q(A \times B, R)$

For example, if the monadic *all* is defined as in (20), then the resumptive $Res^2(all)$ is defined as in (21). It is straighforward to generalize Res^2 to Res^n for an arbitrary natural number $n \geq 2$.

(20) $all(A,B) \stackrel{\text{df}}{\equiv} A \subseteq B$
(21) $Res^2(all)(A,B,R) \stackrel{\text{df}}{\equiv} (A \times B) \subseteq R$

In some cases, this resumptive lift gives good results. For example, in the case of the Russian example (2) about nobody helping anybody, it leads to the following representation, which correctly predicts that the sentence is true when there are no ⟨person, person⟩ pairs in the helping relation.

(22) $Res^2(no)(person, person, help)$

However, in many other cases this lift leads to wrong truth conditions. On Paperno's (2010, 2012) resumptive analysis, the meaning of (11), about giving away everything and to everybody, may be represented as in (23), on the assumption that *wszystko* 'everything.ACC' is represented as $\lambda P.all(thing, P)$, *wszystkim* 'everybody.DAT' – as $\lambda P.all(person, P)$, and *rozdaj* 'give.away.IMP.2SG' – as the binary predicate *you_give*.

(23) $Res^2(all)(thing, person, you_give)$

According to (21), (23) is true iff all pairs in the set $\{\langle x,y\rangle : thing(x) \wedge person(y)\}$ belong to the *you_give* relation, i.e., it coincides with the ordinary iteration of quantifiers: each thing is given away to each person.

However, this reading of (11) is pragmatically disfavoured: one thing is normally given away just once to one recipient, and not many times to diverse recipients. Rather, what (11) is understood to mean is that each thing should be given away (to this or that person) and that each person should be a recipient (of this or that thing). This is a weaker meaning than the resumptive analysis would predict.

While the handful of Russian HC examples with universal quantifiers considered in Paperno 2012: ch.4 are, according to the author, compatible with the resumptive analysis, Paperno (2012: ch.4) himself notes that examples with some of the other quantifiers receive wrong truth conditions on his analysis. One such quantifier is *many*, here illustrated with the attested Polish example (13) about converting to many formats and using many codecs. On the resumptive analysis, for this sentence to be true it is sufficient that there be many elements in the set $\{\langle x,y\rangle : format(x) \wedge codec(y)\}$ that belong to the *convert* relation. One situation that makes this true is when many codecs were used to convert to just one format: then there are many ⟨format, codec⟩ pairs in the *convert* relation, even if they all involve the same single format. But in this situation (13) is intuitively clearly false: it is true only if there are both many different codecs and many different formats.

This is one of two main reasons for which Paperno 2012 eventually rejects the resumptive analysis of HC. The second reason is that the resumptive lift may take place only when all

quantificational expressions are based on identical monadic $\langle 1,1 \rangle$ quantifiers (e.g., all involve *many*, as in (13)). This condition is almost always met, but there are exceptions (Paperno, 2012: 155–156). An attested[6] Polish example illustrating this problem is (24).

(24) Żują [wszyscy i prawie wszędzie]. (Polish)
chew.3PL all and almost everywhere
'Everybody chews and it is done almost everywhere.'

Here, the resumptive representation would have to be either (25) or (26), but both give wrong truth conditions; what (24) is saying is that everybody chews but chewing does not necessarily happen at all places.

(25) $Res^2(all)(person, place, chew)$
(26) $Res^2(almost_all)(person, place, chew)$

After abandoning the two resumptive analyses of Paperno 2010, 2012: ch.3–4, a third – game-theoretic – analysis is outlined in Paperno 2012: ch.5. While various details are left out in that outline, it is clear that the analysis only works for quantifiers which are upward monotone (on the right position), so it does not in particular handle examples such as the Russian (2) or the Polish (10) and (16). Moreover, it appears that this analysis is equivalent to the branching analysis with the option of treating some quantifiers collectively. For example, on the analysis of Paperno 2012: ch.5, the chewing example (24) would have the branching reading according to which there is a set of all people and a set containing almost all places, and each person chews in each of these places. (The other options, with all people or all places understood collectively, are not available here.) While such a situation is truthfully described by (24), the actual interpretation of (24) is much weaker; as alluded to above, this sentence is saying that each person is engaged in the act of chewing (here or there) and that chewing (by this or that person) takes place in almost all locations. Also the other examples discussed in this section do not conform to the game-theoretic analysis of Paperno 2012: ch.5. The ensuing section argues that, instead of assuming a resumptive or branching lift, an analysis in terms of another standard polyadic lift is much closer to the mark.

2.2. Cumulative lift

The discussion of some HC examples in the previous subsection already suggested that their actual meaning is cumulative, rather than resumptive, branching, or the usual iterative (linear, scoping). Let me illustrate this with yet another attested[7] example:

(27) Tu krytykują [wszyscy i wszystkich]. (Polish)
here criticize all.NOM and all.ACC
'Here everybody criticizes somebody and everybody is criticized by somebody.'

[6] https://www.rp.pl/swiat/art8299891-przekleta-roslina-zrodlem-rzadkiej-przyjemnosci
[7] http://szymonadamus.pl/cala-prawda-o-kupowaniu-komentarzy/

This sentence is true when everybody criticizes everybody (as in the usual iterative reading, coinciding with both the branching reading and the resumptive reading), but its actual meaning is weaker. For (27) to be true, it is enough that everybody criticizes somebody or other and that everybody is criticized by somebody or other.

This reading is given by the cumulative lift, as defined for the binary case in (28):

(28) $Cum(Q_1,Q_2)(A,B,R) \stackrel{\text{df}}{\equiv} Q_1(A,\pi_1(R')) \wedge Q_2(B,\pi_2(R'))$, where:
  a. $R' = R \cap (A \times B)$
  b. $\pi_1(R') = \{x : \langle x,y\rangle \in R'\}$
  c. $\pi_2(R') = \{y : \langle x,y\rangle \in R'\}$

In the case of (27), $Q_1 = Q_2 = all$, $A = \{x : person(x)\}$, $B = \{y : person(y)\}$, and $R = \{\langle x,y\rangle : criticize(x,y)\}$. Then R' is the restriction of $R = criticize$ to people criticizing people: $R' = \{\langle x,y\rangle : criticize(x,y) \wedge person(x) \wedge person(y)\}$, and $\pi_1(R')$ and $\pi_2(R')$ are the sets of first and second arguments of this restricted relation, i.e., $\pi_1(R')$ is the set of people who criticize somebody or other and $\pi_2(R')$ is the set of people criticized by somebody or other. This leads to the following representations of the two conjuncts defining the cumulative lift:

(29) $Q_1(A,\pi_1(R')) = all(\{x : person(x)\},\{x : \exists y.person(y) \wedge criticize(x,y)\})$
(30) $Q_2(B,\pi_2(R')) = all(\{y : person(y)\},\{y : \exists x.person(x) \wedge criticize(x,y)\})$

So $Cum(all,all)(person,person,criticize)$ is true iff everybody criticizes somebody or other and everybody is criticized by somebody or other. This is indeed the intuitive meaning of (27).

The restriction of R to the Cartesian product of the restrictions of the two quantifiers is needed here. Otherwise, the two conjuncts in the representation of (27) would be as in (31)–(32).

(31) $Q_1(A,\pi_1(R)) = all(\{x : person(x)\},\{x : \exists y.criticize(x,y)\})$
(32) $Q_2(B,\pi_2(R)) = all(\{y : person(y)\},\{y : \exists x.criticize(x,y)\})$

That is, (27) would be predicted to mean that everybody criticizes (anything or anybody) and everybody is criticized (by anything or anybody). This hypothetical representation would make the sentence true in a situation where everybody criticizes some *thing*, e.g., a film (and, say, everybody is criticized by one specific person, with no other criticizing going on). But, intuitively, such a situation is not truthfully described by (27).

Unlike the resumptive lift, the cumulative lift does not presuppose the identity of the underlying $\langle 1,1\rangle$ quantifiers, so examples such as (24) are not problematic:

(33) $Cum(all,almost_all)(person,place,chew)$

According to (28), (33) (and, hence, (24)) is true iff everybody chews at some place or other and if at almost every place there is some chewing going on by some person or other. This is exactly the cumulative meaning discussed in the previous subsection.

Such cases of lack of complete parallelism of the underlying $\langle 1,1\rangle$ quantifiers are exceedingly rare, but they are not limited to the possibility – discussed in Paperno 2012: 155–156 – of one

quantifier being modified by something like *exactly* or *almost*, as in (24). A more dramatic difference in the two quantifiers is witnessed in the attested[8] (34).

(34) Przybyło ich [aż 200 w różnym wieku i z aż 23 klubów
arrived them as.many.as 200 in different age and from as.many.as 23 clubs
sportowych]... (Polish)
sport
'As many as 200 of them in different ages came from as many as 23 sport clubs.'

Here, the underlying $\langle 1,1 \rangle$ quantifiers are the complex quantifiers meaning 'as many as 200' and 'as many as 23'. The only pragmatically acceptable interpretation of (34) is cumulative, where 200 people represent 23 sport clubs between them. Because different $\langle 1,1 \rangle$ quantifiers are involved, the resumptive interpretation is not possible at all. On the branching interpretation, each of the 200 people would represent the same 23 clubs, and on the iterative interpretation, each of them would represent possibly different 23 clubs; neither of these two readings is available here.

The lack of the requirement of identity of the underlying $\langle 1,1 \rangle$ quantifiers is the strength of the current account, but also its weakness: the vast majority of naturally occurring HC examples do involve identical quantifiers, and there are strong restrictions on how different the quantifiers may be. For example, an attempt to replace one of the universal quantifiers in (27) with an existential quantifier results in semantic unacceptability:

(35) #Tu krytykują [wszyscy i niektórych]. (Polish)
here criticize all.NOM and some.ACC
intended: 'Here everybody criticizes somebody and some are criticized by somebody.'

The acceptability improves somewhat, when the existential quantifier is replaced by *many*:

(36) ?#Tu krytykują [wszyscy i wielu]. (Polish)
here criticize all.NOM and many.ACC
intended: 'Here everybody criticizes somebody and many are criticized by somebody.'

Similarly, while (34) is fully acceptable, the simplified version in (37), lacking *aż* 'as many as', is not.

(37) #Przybyło ich [200 i z 23 klubów sportowych]... (Polish)
arrived them 200 and from 23 clubs sport
intended: '200 of them came from 23 sport clubs.'

But adding *ponad* 'over' to each numeral makes the sentence more or less acceptable again:

(38) ?Przybyło ich [ponad 200 i z ponad 23 klubów sportowych]... (Polish)
arrived them over 200 and from over 23 clubs sport
intended: 'Over 200 of them came from over 23 sport clubs.'

[8] https://co-slychac.pl/554/Mi%C5%84skie-sztuki-walki/Kraina-wojownik%C3%B3w

It might seem that the relevant constraint on HC is morphological: all quantifiers must share a sufficiently prominent morpheme. For example, the quantifiers in (38) share *ponad* 'over', in (34) – *aż* 'as many as', in (24)–(27) – *wsz-* 'all', in (13) – *wiel-* 'many', etc., while no such shared morpheme may be found in the unacceptable (35) or (37).[9] However, many of the other acceptable examples of HC do not share a morpheme; this is especially true of the questions in (1), (4), (9), but also of many of the non-interrogative examples culled from the National Corpus of Polish in Przepiórkowski and Patejuk 2014, e.g.:

(39) Wizję może mieć [każdy i wszędzie]. (Polish)
vision.ACC may have everybody.NOM and everywhere
'Everybody may have a vision, and everywhere.'
(Przepiórkowski and Patejuk, 2014: 109)

(40) A na NK albo Face nie zapraszam też [kogo bądź i jak leci] :). (Polish)
and on NK or Face not invite.1SG also who ever and as flies
'Also, I don't invite to NK or Facebook just anybody and without any thought.'
(Przepiórkowski and Patejuk, 2014: 110)

In (39), the two universal quantifiers have roots *każd-* 'every' and *wsz-* 'all', while in (40) different morphemes occur in *kogo bądź* 'just anybody', lit. 'who ever', and in the idiomatic *jak leci* 'automatically, without any thought', lit. 'as flies'.

So it seems that the constraint on the similarity of conjuncts in HC is semantic, after all, but difficult to characterize precisely: they must express some common message. This may be the same or sufficiently similar kind of underlying $\langle 1, 1 \rangle$ quantifiers, as in most of the examples in this paper; apparently modifying one of the universal quantifiers with *prawie* 'almost', as in (24), satisfies the sufficient similarity, but replacing it with *wielu* 'many', as in (36), stretches this similarity to the breaking point, and replacing it with an existential quantifier, as in (35), goes beyond this breaking point. But the common message may be more subtle, as in (34), involving *aż* 'as many as', where both conjuncts imply that the relevant numbers are high, perhaps higher than expected; and a similar inference may also be made in the case of (38), involving *ponad* 'over'.

I leave the precise characterization of the parallelism constraint in Slavic HC as an open problem. However, it is interesting that apparently the same constraint holds in the case of English HC, as discussed in Grosu 1987, 1985. Take the following pair of examples (italics mark emphasis, acceptability judgements are Grosu's):

(41) *John has written [*two* pages and to *one* girl] today. (Grosu, 1987: 446)
(42) John has written [*five* books and to *fifteen* publishers] already! (Grosu, 1987: 446)

Grosu (1987: 448) notes that (42) is acceptable because both conjuncts convey the message that "John is (or has been) a prolific writer"; in fact, this sentence bears some similarity to (34), with the 'as many as' meaning implied rather than overtly expressed. On the other hand, no such common message is transparent in (41) – hence its diminished acceptability. This reveals another open problem which is outside the scope of the paper: a uniform account of Slavic and

[9] Actually, the two numerals in (37) – 200 (*dwieście*) and 23 (*dwadzieścia trzy*) – happen to share the morpheme *dw-* 'two', but this is accidental sharing, rather than sharing of a "sufficiently prominent morpheme".

Germanic HC which predicts apparently the same parallelism constraints despite the different syntax of HC in the two language families (underlying ellipsis in Germanic but not in Slavic).

Returning to Slavic HC, the cumulative lift gives the right truth conditions also in the case of non-upward monotone quantifiers. This is immediately clear in the case of the quantifier *no* and the Negative Concord examples (2) and (10), but these examples do not discriminate between the cumulative and resumptive analysis. Let us consider (2), repeated below as (43).

(43) [Nikto i nikomu] ne pomogaet. (Russian)
nobody.NOM and nobody.DAT NEG helps
'Nobody helps anybody.' (Mel'čuk, 1988: 40)

On the cumulative interpretation defended in this paper, the helping relation restricted to people helping people is empty: the set of first arguments of this restricted relation is empty, and so is the set of second arguments. Equivalently, on the resumptive interpretation, the intersection of the set of pairs $\{\langle x, y\rangle : person(x) \wedge person(y)\}$ and the helping relation is empty.

More interesting are examples such as (44) below.

(44) W pracy [mało kto i mało kogo] tak naprawdę lubi. (Polish)
at work few who.NOM and few whom.ACC so really likes
'Hardly anybody really likes hardly anyone at work.' (Patejuk 2015: 140)

According to the cumulative analysis, there are few likers and few likees in the 'people liking people at work' relation. On the other hand, according to the resumptive analysis, there are few ⟨liker, likee⟩ pairs in that relation. These interpretations result in different truth values in the following situation: there are 50 people at work, one person is very popular and liked by everybody else, and nobody else likes anybody else. (I am assuming that the 'liking at work' relation is irreflexive.) In this situation, there are few ⟨liker, likee⟩ pairs (49 out of $50 \times 49 = 2450$), so (44) is true in this situation on the resumptive analysis. But there are many likers (49 out of 50), so (44) is false on the cumulative analysis. While a well-designed survey is needed to decide this beyond any doubt, my own intuition is that (44) is indeed false in this situation, i.e., that it is interpreted cumulatively, and not resumptively.

Similarly for the attested (16), repeated below as (45).

(45) Poza tym [nie każdemu i nie zawsze] można transplantować nowy organ.
apart that not everybody.DAT and not always may.IMPS transplant new organ
(Polish)
'Apart from that, one may transplant a new organ not to everybody and not always.'

In this example, *nie zawsze* 'not always' seems to quantify not over times or specific events, but over circumstances. On the resumptive analysis, this sentence is true in the situation where just one person cannot undergo transplantation in just one circumstance, but intuitively (45) does not truthfully describe this situation. Instead it seems to be saying that some people cannot undergo transplantation and that transplantation is impossible in some circumstances.

Paperno (2012: §4.3.4) briefly considers the possibility of cumulative interpretation of HC and rejects it, so let me finish this section by considering his reasons for this rejection. The first is based on the following constructed example:

(46) [Vse i vsex] pobedili. (Russian)
everybody.NOM and everybody.ACC defeated.
'Everybody defeated everybody.' (Paperno 2012: 128)

Paperno (2012: 129) claims that the meaning of (46) is that given by resumption and, equivalently, iteration and branching, i.e., everybody must have defeated everybody else for this sentence to be true. I do not share this intuition about the Polish equivalent of (46); in fact, I find it difficult to imagine a situation about which it would be truthfully uttered. Note, however, that the similar attested Polish example (27) (about everybody criticizing and everybody being criticized) clearly has a reading that is not equivalent to the resumptive, iterative, and branching interpretation; it is true when everybody criticizes some – not necessarily all – people, and when everybody is criticized by some – not necessarily all – people.

The following attested[10] Polish example, one that is linearly more similar to (46) (in both the coordinate structure is preverbal), makes it absolutely clear that the intended reading is not resumptive (not iterative, not branching):

(47) Teraz już [wszyscy i wszystkich] monitorują, sąsiad – sąsiada, pracodawca – pracownika, mąż – żonę, żona – dzieci, bank – ciebie, USA – twój telefon, policja – twoje osiedle, Win7 – twój komputer, urząd skarbowy – twoje konto. (Polish)
now already everybody.NOM and everybody.ACC monitor, neighbour.NOM neighbour.ACC employer.NOM employee.ACC husband.NOM wife.ACC wife.NOM children.ACC bank.NOM you.ACC USA.NOM your.ACC phone.ACC police.NOM your.ACC neighbourhood.ACC Win7 your.ACC computer.ACC office.NOM tax.NOM your.ACC account.ACC
'Now everyone is monitoring and everyone is monitored; neighbour is monitored by neighbour, employee by employer, wife by husband, children by wife, you by your bank, your phone by USA, your neighbourhood by the police, your computer by Win7, your account by the tax office.'

The second argument against the cumulative interpretation is based on the attested (48).

(48) Ja [vsë i vsem] prošču. (Russian)
I.NOM everything.ACC and everybody.DAT condone.FUT.
'I will condone everything to everyone.' (Paperno 2012: 129)

Here Paperno (2012: 129) constructs the following situation, of which this sentence is supposed to be false, while the cumulative interpretation predicts that it should be true. An action *a* of person *A* and an action *b* of person *B* both offended the speaker, as did an action *c* performed

[10] https://proline.pl/?n=microsoft-rejestruje-adresy-ip-osob-piracacych-windows

jointly by A and B. The speaker will forgive A for a and B for both b and c, but won't forgive A for c. According to Paperno, everybody is forgiven and all actions are forgiven, so (48) is true on the cumulative interpretation, but not all ⟨person, action⟩ pairs are forgiven, so the sentence is false on the resumptive interpretation, which coincides with the author's intuition about the falsity of (48) in this situation. However, this argument is based on the assumption that when $A \oplus B$ is the agent of action c, the relevant forgive relation may contain $\langle A, c\rangle$ without containing $\langle B, c\rangle$. I do not share the intuition that it is possible to forgive only one person for the whole action performed jointly by two or more people; rather, this person can be forgiven for his or her contribution to this action, rather than the whole action. That means that a coherently defined forgive relation should either contain $\langle A \oplus B, c\rangle$ (and possibly also the distribution to atoms, i.e., both $\langle A, c\rangle$ and $\langle B, c\rangle$), or otherwise, in the scenario described in Paperno 2012, it should contain something like $\langle A, c \restriction A\rangle$, where $c \restriction A$ stands for A's contribution to action c. But in this latter case, the cumulative interpretation, just as the resumptive interpretation, predicts the sentence to be false, as not all (complete) actions are forgiven.

In summary, given that arguments against the cumulative interpretation of HC are questionable, and given the number of attested examples for which the cumulative interpretation – but not iteration, resumption, or branching – gives the right truth conditions, I conclude that the cumulative account presented in this subsection is on the right track.

2.3. Cover lift

However, the cumulative lift should be generalized to correctly handle plural entities. Consider the following constructed sentence, currently true about the forthcoming handbook of Lexical Functional Grammar.[11]

(49) Na potrzeby handbooka ma zostać napisanych [aż 45 rozdziałów i przez
for purposes handbook is.to become written as.many.as 45 chapters and by
aż 50 autorów]. (Polish)
as.many.as 50 authors.
'For the purposes of this handbook, as many as 45 chapters are to be written by as many as 50 authors.'

The simplified cumulative representation of this sentence is (50):

(50) $Cum(45,50)(chapter, author, written_by)$

According to this representation, when the *written_by* relation is restricted to chapters to be written by authors (and to the context of the LFG handbook), there are 45 different first arguments of this restricted relation (i.e., 45 chapters; true) and 50 different second arguments. This second condition is false; in fact there are only 41 different groups of authors, as some chapters are to be written by the same authors; some of the pairs in this relation are: ⟨*Agreement*, Haug⟩, ⟨*LFG and Dependency Grammar*, Haug⟩, ⟨*Glue Semantics*, Asudeh⟩, ⟨*Morphology*, Asudeh⊕Melchin⊕Siddiqi⟩, ⟨*Long-distance dependencies*, Kaplan⊕Zaenen⟩,

[11] https://langsci-press.org/catalog/book/312

etc. What makes (49) true is that authors are counted individually, rather than as Linkian (1983) groups such as Kaplan⊕Zaenen.

The generalization needed to account for examples such as (49) consists in replacing the cumulative lift defined in (28) (repeated below as (51)) with the cover lift in (52), where *at*, defined in (53), turns sets of possibly plural entities into sets of atoms in these entities.[12]

(51) $Cum(Q_1,Q_2)(A,B,R) \stackrel{\text{df}}{\equiv} Q_1(A,\pi_1(R')) \wedge Q_2(B,\pi_2(R'))$

(52) $Cov(Q_1,Q_2)(A,B,R) \stackrel{\text{df}}{\equiv} Q_1(A,at(\pi_1(R'))) \wedge Q_2(B,at(\pi_2(R')))$

(53) $at(S) \stackrel{\text{df}}{\equiv} \{x : atom(x) \wedge \exists y \in S.\, x \leq_m y\}$, where $\leq_m$ is the mereological 'part of' relation

As discussed in Robaldo 2011, cumulative, branching, and collective readings fall out as special cases of such cover interpretations. For example, on the collective reading of the attested[13] (54) – the first reading given there – the first argument of the meeting relation is the plural entity consisting of all people. On the distributive reading, one that is perhaps more readily available, everybody meets with this or that person – this argument is implicit – at some place, so the first arguments of the relation are atomic entities.

(54) Spotykają się [wszyscy i wszędzie]. (Polish)
meet REFL everybody.NOM and everywhere
'They all meet at some place or other and such meetings take place everywhere.' or
'Everybody meets with somebody or other at some place or other and such meetings take place everywhere.'

In both cases, the cover lift provides the right truth conditions, by mapping plural entities to the set of their atoms, as needed in the first reading. Another – constructed – example, where the only reading is collective, is (55).

(55) Pentagon okrążają [wszyscy i podczas każdej demonstracji]. (Polish)
Pentagon.ACC surround all and during each demonstration
'They all surround the Pentagon during each demonstration.'

Here, as in English, the subject of *okrążają* 'surround' must be plural, so mapping to atoms defined in (52)–(53) is necessary to get the right domain of quantification.

In summary, while the vast majority of naturally occurring examples of HC in Polish are properly modelled by the cumulative lift in (51), its generalization – the cover lift in (52) – is needed to handle cover cases such as (49) and collective predicates, as in (54)–(55).

[12]The name of this lift refers to Schwarzschild's (1996: 84) paired covers. An extension to arbitrary $n \geq 2$ is straightforward.

[13]`http://wizytauwrozki.pl/story/show/474/Strzez_sie_Andrzejek_bez_prawdziwej_wrozki`

3. HC vs. non-HC readings

In the preceding section I argued that HC in Polish – and, by extension, in other Slavic languages – results in the cumulative reading or, more generally, in the cover reading. But it is well-known that coordination is not required to express cumulative and cover meanings. For example, the following simplified non-HC version of the handbook example (49) is also most naturally understood as expressing the cover reading:

(56) Aż 45 rozdziałów ma zostać napisanych przez aż 50 autorów.
as.many.as 45 chapters is.to become written by as.many.as 50 authors.
(Polish)
'As many as 45 chapters are to be written by as many as 50 authors.'

The difference between HC and non-HC versions – apart from the fact that, as discussed in §2.2, HC emphasizes some common message conveyed by the conjuncts – is that non-HC versions also have iterative (linear, scopal) readings, which HC versions lack. So, (56) may be understood as saying that 45 chapters have each possibly different 50 authors, while this reading is not available in the HC version in (49). For example, in the situation where all 45 chapters are to be written by disjoint groups each consisting of 50 scholars, so that there are $45 \times 50 = 2250$ authors altogether, (56) could be understood as true, while (49) does not have a reading that is true in this scenario.

Similarly for the chewing example (24), whose non-HC version is (57):

(57) Wszyscy żują prawie wszędzie. (Polish)
all chew.3PL almost everywhere
'Everybody chews almost everywhere.'

Here, the cumulative reading is not readily available; the most natural reading of (57) is iterative: everybody chews almost everywhere. Somebody, who does not agree with the statement expressed by (57), could legitimately retort that no, this is not true, some of them chew only at home. In the case of the HC version in (24) such a reply would be incongruous – it would not contradict (24).

So, while the cover lift may be generally available in language, it is obligatory in HC.

4. Compositionality?

Compositionality is a well-known problem for analyses assuming polyadic lifts. For example, the cover lift may be represented an in (58), but where in the syntactic tree should a constituent with this meaning occur?

(58) $\lambda Q_{1\langle et,\langle et,t\rangle\rangle}.\lambda Q_{2\langle et,\langle et,t\rangle\rangle}.\lambda A_{et}.\lambda B_{et}.\lambda R_{\langle e,et\rangle}.Cov(Q_1,Q_2)(A,B,R)$

Consider for example the following simplification of example (14); its schematic syntactic tree, intended meaning representations, and semantic types of particular nodes are given in Figure 1.

(59) [Gdzieś i ktoś] jakąś szkodę poniesie. (Polish)
somewhere and somebody some harm suffer.FUT
'Somewhere, somebody will suffer some harm.'

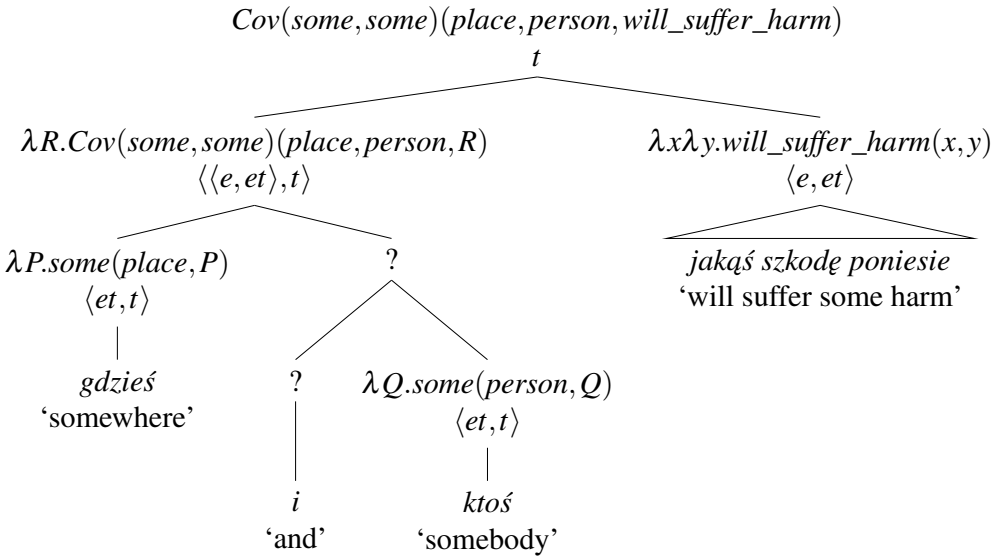

Figure 1: A schematic syntactic tree of (59) with the intended meaning representations and semantic types of particular constituents

This tree and the semantic representations indicated there are simplified in various ways (they are extensional, *jakąś szkodę* 'some harm' is built-in into the predicate *will_suffer_harm*, which is assumed to be a two-place predicate of places and people, etc.), but it is sufficient to demonstrate the problem: there is no place in the syntactic tree for the cover lift operator defined in (58). It would be natural to take (58) as the meaning of the conjunction in HC, but while the lift expects two quantifiers of semantic type $\langle et, \langle et, t\rangle\rangle$ (i.e., of Lindström type $\langle 1, 1\rangle$), the conjuncts have already the restrictions built-in, so they are quantifiers of semantic type $\langle et, t\rangle$ (Lindström type $\langle 1\rangle$). Intuitively, the cover lift operator should have access to the semantic representations of the two conjuncts, be able to prise them apart, and take parts of these representations as arguments. It is not clear how to make this intuition compatible with the standard approach to compositionality.

This problem is not specific to the cover lift analysis proposed above, but it is also faced by the analyses based on the resumptive lift. Paperno (2010, 2012) suggests two ways of saving compositionality, but in both cases the analyses are syntactically highly *ad hoc* and not independently motivated, so the cost of adopting them is prohibitively high. Moreover, they are specific to the account of HC in terms of the resumptive lift, rejected above, and cannot be carried over to the analysis argued for in this paper.

In the proposal based on derivational syntax, Paperno 2010, 2012: §4.5.2 assumes that words apparently expressing quantifiers do not express them at all but rather require the presence of an empty quantifier that agrees with them. In the case of HC, the meaning of the conjunction is the Cartesian product operator: it takes two sets defined by the (restrictions of the) conjuncts, i.e., places and people in the case of (59), and forms the set of all ⟨place, person⟩ pairs. So

the coordinate structure has no quantificational force at all. It is only the empty quantifier that "agrees" with the coordinate structure (i.e., *some*, in the case of (59)) that quantifies over this set of pairs, leading to the resumptive interpretation. No independent evidence is offered for the claim that apparently quantificational expressions are not directly quantificational and require an agreeing phonetically empty quantifier.

The analysis assuming categorial syntax (Paperno, 2012: §§3.7–3.8, 4.5.1) builds on the observation that conjuncts in HC often contain *wh*-roots. For example, in (59) the roots of the existential *gdzieś* 'somewhere' and *ktoś* 'somebody' are the *wh*-words *gdzie* 'where' and *kto* 'who'. According to that analysis, HC always starts as the coordination of such *wh*-words, semantically forming the corresponding set of pairs (again, of places and persons, in the case of (59)). Then, a special "quantifying rule" transforms such a coordination of *wh*-words, by providing it with the resumptive quantificational semantics, by changing the syntactic category of the whole structure, and, importantly, by modifying the phonological shape of each conjunct (adding *-ś* to each, in the case of (59)). The obvious problem that this proposal faces is the fact that in many instances of HC particular conjuncts are not morphologically related to *wh*-words. For example, *wszystko* 'everything' in (3) and (11) does not have as its root *co* 'what', *wiele* 'many' in (13) is not related to any *wh*-word, and similarly for at least some of the conjuncts in (16), (24), (27), (34), (39), (46)–(49), (54)–(55), etc.

In summary, the outlines of the syntax–semantic interface in Paperno 2010, 2012 may be compositional in a technical sense, but only at the cost of introducing considerable and not independently motivated complication at the syntactic level; in other words, this approach to compositionality violates Dowty's (2007: 30) methodological requirement of syntactic economy. Moreover, the categorial grammar analysis is based on the wrong assumption that conjuncts in HC must be morphologically related to *wh*-words. Finally, these proposals, based on the idea that the meaning of the conjunction is the Cartesian product operator, do not carry over to non-resumptive lifts, such as the cumulative lift and the cover lift proposed in this paper.

For this reason, for the purposes of furnishing the semantic analysis above with a syntax–semantics interface, I propose an analysis that can also be claimed to be compositional, but only assuming a less standard notion of compositionality. The analysis is based on model-theoretic syntax; it is couched within Head-driven Phrase Structure Grammar (HPSG; Pollard and Sag 1994, Müller et al. 2021) and it relies on the approach to semantics within HPSG which is known as Lexical Resource Semantics (LRS; Richter and Sailer 2004), and especially on the analysis of Negative Concord presented in Iordăchioaia and Richter 2015 and on other LRS analyses involving polyadic quantification presented in Sailer 2015 and Richter 2016. Technical details of the current account are presented in Przepiórkowski 2021; below I outline just some of the intuitions behind this account.

First of all, LRS is a representational framework and it assumes that lexical entries contribute possibly underspecified descriptions of components of meaning. For example, *ktoś* 'somebody', instead of contributing the fully specified representation $\lambda Q.some(person, Q)$ (as in Figure 1), introduces the representation in (60).

(60) *ktoś* 'somebody': $\ldots some_x \ldots (\ldots person(x) \ldots)(R(\ldots x \ldots))$

Here, R stands for a (normally unary) relation that will be provided by the syntax–semantics interface (so no lambda notation is needed), while ellipses (…) signal that this representation

might be part of a larger representation of a polyadic quantifier, built on additional $\langle 1,1 \rangle$ quantifiers (see $\ldots some_x \ldots$), with more restrictions on more variables (see $\ldots person(x) \ldots$) and with a relation of higher than unary order (see $R(\ldots x \ldots)$). In the simplest (usual) case, when no polyadic quantifier is formed, (60) boils down to (61), equivalent to $\lambda Q.some(person, Q)$ in the usual compositional setup.

(61) *ktoś* 'somebody': $some_x(person(x))(R(x))$

However, the syntax–semantics interface makes it possible to equate the partially-specified representation in (60) with that of another quantifier in the sentence, e.g., *gdzieś* 'somewhere':

(62) *gdzieś* 'somewhere': $\ldots some_y \ldots (\ldots place(y) \ldots)(R(\ldots y \ldots))$

Then, the result is a polyadic quantifier partially specified in (63).

(63) $\ldots some_y, \ldots, some_x \ldots (\ldots place(y), \ldots, person(x) \ldots)(R(\ldots y, \ldots, x \ldots))$

If no other quantifiers contribute to this representation and if cover quantifiers are the only polyadic quantifiers admitted by the grammar, then this representation becomes fully specified as in (64):

(64) $Cov(some_y, some_x)(place(y), person(x))(R(y,x))$

Second, given that cover lift is obligatory in Heterofunctional Coordination, I assume that the contribution of the HC conjunction is the underspecified representation in (65) and that the syntax of HC requires the identification of this representation with those of all conjuncts.

(65) *i* 'and': $Cov(\ldots)(\ldots)(\ldots)$

This requirement immediately accounts for the fact that all conjuncts must be quantifiers, as only quantifiers are underspecified in a way that makes their identification possible. In the case of (59), this leads to the representation of the coordinate structure given in (64) above, still underspecified with respect to the identity of the relation *R*, and to the fully specified representation of the whole sentence in (66) (cf. Figure 1).

(66) $Cov(some_y, some_x)(place(y), person(x))(will_suffer_harm(y,x))$

On some views of compositionality, this analysis is not compositional. The reason is that, given that the semantic representations of the conjunction and all conjuncts get identified, all these nodes – and not only the top node in the tree – end up with the same semantic representation given in (66). That is, syntactic constituents contain bits of semantic representation introduced outside of these constituents. This violates the expectation that "each linguistic constituent has a well-formed and complete denotation that does not depend on any linguistic element external to that expression" (see Dowty 2007: 48–49 for discussion). On the other hand, the proposed analysis satisfies the weaker notion of compositionality, sometimes called Frege's Principle (Dowty, 2007: 23), on which "The meaning of a sentence is a function of the meanings of the

words in it and the way they are combined syntactically." Moreover, unlike the analyses proposed in Paperno 2010, 2012, this analysis does not require more complex syntactic structures (as in his derivational analysis) or structure-changing operations (as in his categorial analysis), so it satisfies Dowty's (2007: 30) syntactic economy requirement about compositionality.

5. Conclusion

Given the number of syntactic works on Heterofunctional Coordination, it is surprising that prior semantic analyses of HC seem to be limited to those in Paperno 2010, 2012. The aim of this paper has been to point out empirical and theoretical problems with those analyses and to propose an account in terms of a polyadic cover lift – a generalization of the cumulative lift. This account covers a wide range of attested examples of HC in Polish involving diverse quantifiers, both upward and downward monotone. Moreover, a (weakly) compositional analysis of HC at the syntax–semantics interface has been sketched, whose full technical details are presented in Przepiórkowski 2021.

A notable omission of this paper is the demonstration that the proposed analysis extends to the most frequent cases of HC, namely, those involving *wh*-questions, as in (1), (4), or (9). I believe that this follows immediately from the existential force of *wh*-phrases, but this needs to be demonstrated in detail. Another avenue of research concerns the possibility of a uniform analysis of HC in Germanic and Slavic, despite their different underlying syntax (elliptical and non-elliptical). As pointed out in §2.2, such a uniform analysis is called for because in both language families conjuncts in HC must satisfy similar parallelism constraints (which still await a precise characterization). Finally, just as the resumptive analyses of Paperno 2010, 2012, the current account assumes a special lexical entry for the conjunction in HC, with a dedicated meaning. This assumption is ill at ease with the fact, observed in Patejuk 2015: §5.3, that various conjunctive coordinators may participate in HC in Polish, not just *i* 'and', so all of them would have to be ambiguous between the logical conjunction and the cover lift meaning proposed here. An account assimilating HC to other uses of conjunctions should be preferred, if it covers the same or larger set of empirical facts.

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