Polyadic quantification in hybrid coordination

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Abstract

The aim of this paper is to provide a syntactico-semantic analysis of hybrid coordination, in which what is coordinated are phrases bearing different grammatical functions and different semantic roles. The proposed account improves on previous HPSG analyses by giving up the assumption that all conjuncts are dependents of the same head and, more importantly, by taking into account the syntax–semantics interface and providing semantic representations. This aspect of the analysis builds on and generalizes previous HPSG work on polyadic quantification.

1 Introduction

The empirical scope of this paper is what is known in the HPSG literature as Hybrid Coordination (HC; Chaves & Paperno 2007, Bîlbîie & Gazdik 2012) and what elsewhere is often called Lexico-Semantic Coordination (Sannikov 1979–1980, Mel'čuk 1988, Kallas 1993, Patejuk & Przepiórkowski 2012, and others). This phenomenon is illustrated with the attested (1)–(2).[1]

(1) Vam [nikto i ničego] ne predlagal eščë. (Russian)
you.DAT nobody.NOM and nothing.GEN NEG offered yet
'Nobody has offered you anything yet.' (Paperno 2012: 77)

(2) [Czego i ile] trzeba dostarczyć organizmowi?
what.GEN and how much.ACC should.IMPS provide.INF organism.DAT
(Polish)
'What – and how much – should one provide one's organism with?' (Patejuk & Przepiórkowski 2019: 30)

The main feature of HC is that the conjuncts bear different grammatical functions, e.g., subject and object in (1). In Slavic, as well as in some neighbouring languages (including Hungarian and Romanian), the conjuncts may be obligatory arguments, as in the two examples above. By contrast, in English and other Germanic languages, only optional dependents may be coordinated in HC (Browne 1972, Gračanin-Yüksek 2007, Haida & Repp 2011, Citko & Gračanin-Yüksek 2013), as in (3). The common view is that, in Germanic, such constructions are elliptical, so that, e.g., (3) has the underlying structure (4), while in Slavic and at least Hungarian they are not, i.e., different grammatical functions are coordinated directly in (1)–(2).[2]

[†]I am grateful for comments from HPSG 2021 reviewers and from the audiences of *HPSG 2021* and *Sinn und Bedeutung 26*; special thanks go to Frank Richter and Manfred Sailer. As always, all remaining errors are mine alone.

[1]IMPS in (2) and (15) stands for 'impersonal'; other annotations follow the Leipzig Glossing Rules.

[2]Convincing arguments against elliptical analyses in these languages are adduced, e.g., in Kazenin 2001 (for Russian) and in Lipták 2003 (for Hungarian); see also Skrabalova

(3) [What and why] did you eat? (Citko & Gračanin-Yüksek 2013: 11)

(4) What ~~did you eat~~ and why did you eat?

In this paper I am only concerned with the Slavic – non-elliptical – variety of HC, leaving the integration of Germanic – elliptical – HC into the analysis for future work.

Most of the literature on HC only deals with coordinated *wh*-items, as in (2) and (3). However, at least since Sannikov 1979–1980, it is clear that many other series of conjuncts are possible in HC, including: 1) *n*-words, as in (1), 2) universal quantifiers, as in (5), 3) various series of lexical items expressing existential quantifiers, as in (6)–(7), etc.[3]

(5) Zdes' [vsem i vsegda] kofe podavala ona sama.
here all.DAT and always coffee.ACC served.F.SG she.NOM self.NOM (Russian)
'Here she always served coffee herself to everyone.' (Paperno 2012: 77)

(6) Ponjal li [kto-nibud' i čto-nibud']? (Russian)
understood Q anyone.NOM and anything.ACC
'Has anyone understood anything?' (Paperno 2012: 77)

(7) Dopustim, [kto-libo i kogo-libo] pobedil. (Russian)
assume someone.NOM and someone.ACC defeated
'Assume that someone defeated someone.' (Paperno 2012: 80)

Also, almost all of the literature concentrates on the syntax of this construction, neglecting its semantic properties. The notable exception is Paperno 2012: ch.4, which proposes – but ultimately abandons – an analysis in terms of polyadic quantification, specifically, in terms of the resumptive lift (see, e.g., Keenan & Westerståhl 2011: 899). In Section 2, I summarize the arguments of Przepiórkowski 2021a that the analysis of HC in terms of polyadic quantification was on the right track, although the right lift to be applied here is a mereological variant of the standard cumulative lift (Keenan & Westerståhl 2011: 899), rather than the resumptive lift.

However, the main contribution of this paper is HPSG-theoretical. First, in Section 3, I extend the HPSG representations of specific polyadic quantifiers proposed in Iordăchioaia & Richter 2009, Iordăchioaia 2010, and Richter 2016 to polyadic quantifiers of arbitrary lift type. Second, after laying out my assumptions about the syntax of coordination in Section 4, in Section 5 I sketch the syntactico-semantic HPSG analysis of HC that assumes these representations. Finally, Section 6 concludes.

2007: §§2 and 5 on Czech, Gribanova 2009: 136–137 on Russian, Bîlbîie & Gazdik 2012: §3.3 on Hungarian, and Lipták 2011 for a typological overview.

[3] See Przepiórkowski & Patejuk 2014 and Patejuk 2015: ch.5 for similar examples from Polish.

2 Polyadic Quantifiers in Hybrid Coordination

Paperno (2012: ch.4) provides the only worked out semantic analysis of HC I am aware of. Following earlier suggestions in the literature (e.g., Comorovski 1996: 138–139), he analyses HC in terms of resumptive quantification. The general idea of resumption (or absorption, as it is called by syntacticians after Higginbotham & May 1981: 49) is that two (or more) occurrences of a quantifier over entities are analysed as a single quantifier of the same type but over tuples of entities, that is two occurrences of a quantifier Q are "lifted" to the single but more complex quantifier $Res^2(Q)$ defined as in (8).

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

For example, in the varieties of English in which (9) means that no man loves any woman, the two occurrences of the generalized quantifier NO defined as in (10) are lifted to the resumptive quantifier $Res^2(\text{NO})$ defined in (11).

(9) No man loves no woman.

(10) $\text{NO}(A, B) \stackrel{\text{df}}{\equiv} A \cap B = \emptyset$

(11) $Res^2(\text{NO})(A, B, R) \stackrel{\text{df}}{\equiv} (A \times B) \cap R = \emptyset$

In the case of (9), the two original quantifiers range over the set of men and the set of women, while the lifted resumptive quantifier ranges over the set of man–woman pairs. That is, after the resumptive lift, the meaning of (9) may be represented as in (12) (or, more compactly, as in (13)), which – according to the definition in (11) – is true iff the Cartesian product $man \times woman$ has the empty intersection with the *love* relation, i.e., iff the *love* relation contains no pair $\langle x, y\rangle$ such that $man(x)$ and $woman(y)$.

(12) $Res^2(\text{NO})(\lambda x.man(x), \lambda y.woman(y), \lambda x\lambda y.love(x, y))$

(13) $Res^2(\text{NO})(man, woman, love)$

In terms of Lindström's (1966) typology of generalized quantifiers, NO as defined in (10) is of type $\langle 1, 1\rangle$ (it is a binary relation on sets, i.e., on unary relations), while the lifted quantifier $Res^2(\text{NO})$ is of type $\langle 1, 1, 2\rangle$, i.e., it is a ternary relation whose first two arguments are sets (i.e., unary relations), and the third argument is a binary relation. Both quantifiers are examples of polyadic quantifiers, which may be divided into monadic quantifiers such as NO, whose all arguments are sets, and properly polyadic quantifiers such as $Res^2(\text{NO})$, whose at least one argument is a proper (non-unary) relation.

On Paperno's (2012) analysis, such a resumptive lift is applied to quantifiers expressed by all conjuncts in HC. This rightly predicts that the meaning of (1) is that there is no person–thing pair in the offering relation, i.e., that nobody has offered anything. Similarly, in the case of (5) this analysis rightly predicts the meaning on which all (contextually relevant) person–time pairs are in the appropriate coffee serving relation. However, Paperno (2012) abandons this analysis, and for two good reasons.[4] The first reason is that the

[4]As a possible alternative, Paperno (2012: ch.5) sketches a game-theoretic analysis,

resumptive lift takes quantifiers of exactly the same kind (2 x NO, 2 x EVERY, etc.), while HC is not so strict, e.g.:

(14) Lično menja [vsë i počti vsegda] besit.
personally me everything.NOM and almost always drives.nuts (Russian)

'Everything almost always drives me nuts.' (Paperno 2012: 155)

In the case of (14), it is not clear whether the polyadic quantifier resulting from the resumptive lift should be Res^2(ALL) (which would wrongly mean that everything *absolutely always* drives me nuts) or Res^2(ALMOST ALL) (which would wrongly mean that *almost everything* rather than absolutely everything almost always drives me nuts). More importantly, in the case of some quantifiers the resumptive lift assigns wrong meanings to sentences, e.g., to (15):

(15) O nëm uže [mnogoe i mnogimi] napisano. (Russian)
about him already much.ACC and many.INS write.IMPS

'Many wrote a lot about him.' (Paperno 2012: 143)

According to the resumptive analysis, for this sentence to be true it must be the case that there are many person–content pairs in the relevant writing relation, for example, when just a single person wrote a lot. But in such a situation (15) is false, as it implies both that there are many people who wrote about him and that many bits of content were written.

In Przepiórkowski 2021a, I argue that Paperno's (2012) polyadic analysis is on the right track, but there is another polyadic lift that much better approximates the intended meanings, namely, the cumulative lift defined in (16) and illustrated with the constructed Polish sentence (17) (similar to the Russian (15)).

(16) $Cum(Q_1, Q_2)(A, B, R) \overset{\text{df}}{\equiv} Q_1(A, \pi_1(R')) \wedge Q_2(B, \pi_2(R'))$, where:

a. $R' = R \cap (A \times B)$
b. $\pi_1(R') = \{x : \langle x, y\rangle \in R'\}$
c. $\pi_2(R') = \{y : \langle x, y\rangle \in R'\}$

(17) Pisało już o tym [wielu filozofów i w wielu artykułach].
wrote already about this many philosophers and in many articles (Polish)

'Many philosophers wrote about this in many articles.'

In the case of sentence (17), the preliminary representation is that in (18).

(18) *Cum*(MANY, MANY)(*philosopher*, *article*, *write*)

That is, using the symbols in (16), $Q_1 = Q_2 =$ MANY, $A =$ *philosopher* (i.e., the set of philosophers), $B =$ *article* (the set of articles), $R =$ *write* (the "wrote about this" relation, whatever *tym* 'this' is in (17)). Additionally, R' is the writing relation R restricted to philosophers writing articles (so, e.g.,

which, however, also makes some wrong empirical predictions.

linguist–article, philosopher–book, and linguist–book pairs are removed from R), $\pi_1(R')$ is the set of philosophers who wrote in some articles about this, and $\pi_2(R')$ is the set of articles in which something was written about this by some philosophers. In effect, the meaning of (17) represented by (18) is that there are many philosophers who wrote about this in an article or other and there are many articles in which a philosopher or other wrote about this.

It may be verified that this standard cumulative lift leads to appropriate meanings of most HC sentences, but sometimes it is not sufficiently precise. In fact, this is the case with (17). Assume that in a given context five articles is many but five philosophers is not many – only 10 or more is. Then (17) does not truthfully describe a situation in which five articles were written by five different philosophers (there are not many philosophers), but it does truthfully describe a situation in which five articles were coauthored each by a different ensemble of philosophers, so that there are, say, twelve authors altogether. In this situation the extension of the writing relation also contains just five pairs, but in each pair the first argument is a plural entity consisting of a number of atoms (philosophers). Hence, a better representation of (17) is that given in (19), where the cumulative lift *Cum* is replaced by the cover lift *Cov* (Robaldo 2011; cf. Schwarzschild's 1996 covers) defined in (20).

(19) $Cov(\text{MANY}, \text{MANY})(\mathit{philosopher}, \mathit{article}, \mathit{write})$

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

a. R', $\pi_1(R')$, and $\pi_2(R')$ are defined as in (16),
b. *at* maps a set of possibly plural objects into the set of atoms in these plural objects.

(19) is the kind of representation that the HPSG analysis proposed in the following sections will result in, although, in order to better reflect the actual HPSG representations, a slightly different – more explicit – notation will be used, upon which (19) will be rendered as (21).

(21) $Cov(\text{MANY}_x, \text{MANY}_y)(\mathit{philosopher}(x), \mathit{article}(y))(\mathit{write}(x, y))$

3 Polyadic Quantifiers in HPSG

The analysis proposed in this paper relies heavily on previous HPSG work on polyadic quantification (Iordăchioaia & Richter 2009, 2015, Iordăchioaia 2010, Sailer 2015, Richter 2016) stated within Lexical Resource Semantics (LRS; Richter & Sailer 2004, Richter & Kallmeyer 2009). In LRS, particular words and constructions constrain meaning representations of particular syntactic constituents, without necessarily specifying their complete meanings. For example, words expressing quantifiers, e.g., *many*, may specify the quantifier constant, i.e., MANY, and the variable bound by this quantifier, e.g., x, without determining whether this is a monadic quantifier or a part of a larger polyadic quantifier. In the notation introduced at the end of the previous section, the lexical contribution of *many* may be represented as in (22), with P representing the restriction and S representing the nuclear scope, both to be contributed by other words in the sentence. In the simplest case, e.g., in the sentence *Many philosophers arrived*, this may lead to the schematic representation of the NP *many philosophers* in (23) and the representation of the whole sentence in (24).

(22) $\ldots \textsc{many}_x \ldots (\ldots P(x) \ldots)(S(\ldots x \ldots))$

(23) $\ldots \textsc{many}_x \ldots (\ldots \mathit{philosopher}(x) \ldots)(S(\ldots x \ldots))$

(24) $\textsc{many}_x(\mathit{philosopher}(x))(\mathit{arrive}(x))$

However, under appropriate conditions, two or more constituents may turn out to be contributing to the same semantic representation. For example, in (17) the underspecified semantic contribution of *wielu filozofów* 'many philosophers' may be represented as in (23), and similarly for *wiele artykułów* 'many articles', see (25), and these two representations may turn out to be partial specifications of a larger representation, still underspecified in (26).

(25) $\ldots \textsc{many}_y \ldots (\ldots \mathit{article}(y) \ldots)(S(\ldots y \ldots))$

(26) $\ldots \textsc{many}_x \ldots \textsc{many}_y \ldots (\ldots \mathit{philosopher}(x) \ldots \mathit{article}(y) \ldots)(S(\ldots x \ldots y \ldots))$

In the analysis made more precise below, it is the conjunction that specifies that all conjuncts contribute to the meaning representation of a single cover polyadic quantifier. This way the representation of the coordinate phrase in (17) may be represented as in (27), still with a placeholder for the nuclear scope relation, and that of the whole sentence – as in (28) (= (21) above).

(27) $\mathit{Cov}(\textsc{many}_x, \textsc{many}_y)(\mathit{philosopher}(x), \mathit{article}(y))(S(x, y))$

(28) $\mathit{Cov}(\textsc{many}_x, \textsc{many}_y)(\mathit{philosopher}(x), \mathit{article}(y))(\mathit{write}(x, y))$

This kind of representation is a generalization of previous HPSG representations of polyadic quantifiers, as it makes explicit the kind of lift that is applied to monadic quantifiers (here, *Cov*, i.e., cover lift).

In the analysis of Romanian Negative Concord in Iordăchioaia 2010 and Iordăchioaia & Richter 2009, 2015, the underspecified representations of *niciun student* 'no student', *nicio carte* 'no book', and *nu a citit* 'not read' in (29) are given in (30)–(32) (assuming the notation of the current paper), and they all contribute to the single representation in (33).

(29) Niciun student nu a citit nicio carte. (Romanian)
no student not has read no book
'No student read any book.' (Iordăchioaia 2010: 97)

(30) $\textsc{no}_{\ldots x \ldots}(\ldots \mathit{student}(x) \ldots)(S(\ldots x \ldots))$

(31) $\textsc{no}_{\ldots y \ldots}(\ldots \mathit{book}(y) \ldots)(S(\ldots y \ldots))$

(32) $\textsc{no}_{\ldots}(\ldots)(\mathit{read}(\ldots))$

(33) $\textsc{no}_{x,y}(\mathit{student}(x), \mathit{book}(y))(\mathit{read}(x, y))$

This representation is interpreted in terms of the resumptive lift, although this lift is not mentioned explicitly in the representation. Also, as all the quantifiers taking part in the resumptive lift must be of the same kind (here: NO), it is sufficient to mention this quantifier constant in the representation only once. Finally, an interesting aspect of that analysis is that quantifiers of different Lindström (1966) type may jointly undergo the resumptive lift; in the case of (29), *niciun* and *nicio* are normally treated as the usual quantifiers of type $\langle 1,1 \rangle$ (i.e., a binary relation on sets), but the sentential negation *nu* is normally treated as logical negation, i.e., a quantifier of type $\langle 0 \rangle$. This is possible because, in the actual LRS analysis, all these quantifiers are underspecified as to their Lindström type.

By contrast, the HPSG encoding made explicit below assumes that only $\langle 1,1 \rangle$ quantifiers may be lifted. However, the gist of Iordăchioaia & Richter's analysis may be preserved by reanalysing the contribution of the negated verb from (32) to (34). That is, verbal negation is reanalysed as contributing a $\langle 1,1 \rangle$ quantifier over events. This, together with the slightly modified representations of the two negative phrases given in (35)–(36) (cf. (30)–(31)), leads to the Davidsonian representation of (29) given in (37) (cf. (33) above).

(34) $\ldots \textsc{no}_e \ldots (\ldots \mathit{event}(e) \ldots)(\mathit{read}(e \ldots))$

(35) $\ldots \textsc{no}_x \ldots (\ldots \mathit{student}(x) \ldots)(S(\ldots x \ldots))$

(36) $\ldots \textsc{no}_y \ldots (\ldots \mathit{book}(y) \ldots)(S(\ldots y \ldots))$

(37) $\mathit{Res}(\textsc{no}_e, \textsc{no}_x, \textsc{no}_y)(\mathit{event}(e), \mathit{student}(x), \mathit{book}(y))(\mathit{read}(e,x,y))$

Note the explicit representation of the kind of lift in (37).

Another lift, specific to some constructions involving complex NPs (inverse linking, telescoping), is proposed in Sailer 2015. For example, the representation of (38) proposed there is equivalent to (39) (which follows the notation assumed in this paper). Again, the kind of lift is not specified explicitly there. A more explicit representation, consistent with the technicalities below, is that in (40), where *CNP* stands for "complex NP lift".

(38) An apple in every basket is rotten. (Sailer 2015: 542)

(39) $(\textsc{every}_y, \textsc{some}_x)(\mathit{basket}(y), \mathit{apple}(x) \wedge \mathit{in}(y,x))(\mathit{rotten}(x))$

(40) $\mathit{CNP}(\textsc{every}_y, \textsc{some}_x)(\mathit{basket}(y), \mathit{apple}(x) \wedge \mathit{in}(y,x))(\mathit{rotten}(x))$

Finally, Richter 2016 provides an LRS analysis of *different*, as in (41), with the proposed representation equivalent to (42) in the notation assumed here. As in Richter 2016, Δ stands for the quantifier expressed by *different*.

(41) Every ape picked different berries. (Richter 2016: 601)

(42) $(\textsc{every}_x, \Delta_y)(\mathit{ape}(x), \mathit{berry}(y))(\mathit{pick}(x,y))$

The particular semantics of such polyadic quantifiers given in Richter 2016: 607 is conditioned on the presence of Δ among the quantifier constants. On the setup of the current paper, the representation of (41) would be as in (43), with Δ treated as a kind of lift and with the quantificational contribution of the bare plural (i.e., SOME) made explicit.

(43) $\Delta(\textsc{every}_x, \textsc{some}_y)(\mathit{ape}(x), \mathit{berry}(y))(\mathit{pick}(x,y))$

This paves the way to natural representations of examples with other quantifiers in the NP containing *different* (discussed in Richter 2016: 617–618), as in (44), where the quantifier is TWO:

(44) Every ape picked two different berries. (Richter 2016: 617)

(45) $\Delta(\text{EVERY}_x, \text{TWO}_y)(\mathit{ape}(x), \mathit{berry}(y))(\mathit{pick}(x, y))$

Representations such as (45) are human-readable versions of actual HPSG structures, so let me now be more precise about the nature of such structures. As common in LRS, I assume that full-fledged semantic representations are values of the LRS attribute defined on *sign* objects. Values of LRS are of sort *lrs* and contain some attributes with values of sort *me* (for "meaningful expression"), as shown in the fragment of the signature in (46).[5]

(46) A fragment of the signature assumed here:

```
top
  ...
  lrs EXCONT me
      INCONT me
      PARTS list(me)
  me TYPE type
    variable NUM-INDEX integer
    constant NUM-INDEX integer
    application FUNCTOR me
                ARG me
    abstraction VAR me
                BODY me
    equation ARG1 me
             ARG2 me
    negation ARG me
    l-const ARG1 me
            ARG2 me
      disjunction
      conjunction
      implication
      bi-implication
    gen-quantifier QUANT-RESTRS nelist(quant-restr)
                   SCOPE me
      mq
      lq LIFT lift
    lift
      res
      diff
```

[5]In the case of list values, the sorts of objects on such lists are informally indicated in the signatures given here (e.g., `nelist(quant-restr)`); in the full grammar, this information is encoded via appropriate constraints (as in (55)–(56) below).

```
    cnp
    cov
    ...
quant-restr VAR variable
            RESTR me
  every
  some
  no
  many
  ...
type
  atomic-type
    entity
    truth
  complex-type IN type
               OUT type
integer
  zero
  non-zero PRE integer
```

This fragment is based on that in Iordăchioaia 2010: ch.5, itself based on Sailer 2003: ch.3. The main difference is the definition of generalized quantifiers, *gen-quantifier*, which in Iordăchioaia 2010: 161 looks like this:

(47) The *gen-quantifier* fragment of the signature in Iordăchioaia 2010: ch.5:

```
gen-quantifier VAR list(variable)
               RESTR list(me)
               SCOPE me
  every
  some
  no
```

As no other polyadic lifts are considered in Iordăchioaia 2010: ch.5, this simple definition of *gen-quantifier* is sufficient for the representation of the resumptive lift: when two or more usual quantifiers are so lifted, the list of variables VAR and the corresponding list of restrictions RESTR are longer than one. For example, the representation in (33) (i.e., $\textsc{no}_{x,y}(\mathit{student}(x), \mathit{book}(y))(\mathit{read}(x, y)))$ is a shorthand for the following more explicit structure:[6]

[6]Bits in frames are shorthand representations of the underlying structures; for example $\boxed{x}$ may stand for $\begin{bmatrix} \mathit{variable} \\ \textsc{num-index} \begin{bmatrix} \mathit{non\text{-}zero} \\ \textsc{pre}\ \mathit{zero} \end{bmatrix} \\ \textsc{type}\ \mathit{entity} \end{bmatrix}$ (i.e., for e-typed variable number 1), etc.

(48) $$\begin{bmatrix} \textit{no} & \\ \textsc{var} & \langle \boxed{x}, \boxed{y} \rangle \\ \textsc{restr} & \langle \boxed{\textit{student}(x)}, \boxed{\textit{book}(y)} \rangle \\ \textsc{scope} & \boxed{\textit{read}(x,y)} \end{bmatrix}$$

A constraint is needed to ensure that values of VAR and RESTR are lists of the same length.

By contrast, the signature in (46) makes it possible to represent various kinds of polyadic lifts, and the correspondence between quantifier constants, variables, and restrictions is conspicuous. For example, (28) – repeated below as (49) – is a shorthand for (50).

(49) $\textit{Cov}(\textsc{many}_x, \textsc{many}_y)(\textit{philosopher}(x), \textit{article}(y))(\textit{write}(x,y))$

(50) $$\begin{bmatrix} \textit{lq} & \\ \textsc{lift} & \textit{cov} \\ \textsc{quant-restrs} & \left\langle \begin{bmatrix} \textit{many} & \\ \textsc{var} & \boxed{x} \\ \textsc{restr} & \boxed{\textit{philosopher}(x)} \end{bmatrix}, \begin{bmatrix} \textit{many} & \\ \textsc{var} & \boxed{y} \\ \textsc{restr} & \boxed{\textit{article}(y)} \end{bmatrix} \right\rangle \\ \textsc{scope} & \boxed{\textit{write}(x,y)} \end{bmatrix}$$

The sort *lq* – lifted quantifier – is one of two subsorts of *gen-quantifier*, the other being *mq* – monadic quantifier. In the lexicon, *wiele* 'many' is underspecified as being of sort *gen-quantifier*, which can lead to a lifted representation of the kind exemplified by (50), or the usual monadic representation, as in (24) – repeated below as (51) – whose more explicit structure is shown in (52).

(51) $\textsc{many}_x(\textit{philosopher}(x))(\textit{arrive}(x))$

(52) $$\begin{bmatrix} \textit{mq} & \\ \textsc{quant-restrs} & \left\langle \begin{bmatrix} \textit{many} & \\ \textsc{var} & \boxed{x} \\ \textsc{restr} & \boxed{\textit{philosopher}(x)} \end{bmatrix} \right\rangle \\ \textsc{scope} & \boxed{\textit{arrive}(x)} \end{bmatrix}$$

The two subsorts of *gen-quantifier* differ not only in the presence (on *lq*) or absence (on *mq*) of the LIFT attribute, but also in how many *quant-restr* objects (quantifiers with their restrictions but without the scope) may occur in the QUANT-RESTRS list: exactly one in the case of monadic quantifiers, but more than one in the case of lifted quantifiers:

(53) $\textit{mq} \rightarrow \begin{bmatrix} \textsc{quant-restrs}|\textsc{rest} & \textit{elist} \end{bmatrix}$

(54) $\textit{lq} \rightarrow \begin{bmatrix} \textsc{quant-restrs}|\textsc{rest} & \textit{nelist} \end{bmatrix}$

Most of the constraints on semantic representations defined in Iordăchioaia 2010: ch.5 carry over to the present setup, but the ones referring directly to the representation of quantifiers must be modified accordingly. In particular, the relevant complex term principle on *gen-quantifier* (Iordăchioaia 2010: 162) is now:

(55) $\textit{gen-quantifier} \rightarrow \left(\begin{bmatrix} \text{TYPE } \textit{truth} \\ \text{QUANT-RESTRS } \boxed{1} \\ \text{SCOPE}|\text{TYPE } \textit{truth} \end{bmatrix} \wedge \texttt{quant-restr-list}(\boxed{1}) \right)$

(56) $\forall \boxed{1} (\texttt{quant-restr-list}(\boxed{1}) \leftrightarrow$
$(\boxed{1}\textit{elist} \vee$
$\exists \boxed{2} \exists \boxed{3} (\boxed{1} \begin{bmatrix} \text{FIRST } \boxed{2}\textit{quant-restr} \\ \text{REST } \boxed{3} \end{bmatrix} \wedge \texttt{quant-restr-list}(\boxed{3}))))$

Note that *quant-restr* – the sort of objects in the QUANT-RESTRS list – is *not* a subsort of *me*, so it does not have a type as a whole. However, the restriction within it has the semantic type t:

(57) $\textit{quant-restr} \rightarrow [\ \text{RESTR}|\text{TYPE } \textit{truth}\ ]$

In the next two sections we will see how to arrive at semantic representations such as (50).

4 Syntax of Coordination

There are various intuitions about the headedness of coordinate structures. One, dominant in HPSG, is that such structures are not headed at all. Another, still frequent in Chomskian linguistics even though it was convincingly refuted in Borsley 2005, is that they are headed by the conjunction. Yet another, expressed in various traditions including dependency grammars, is that they are multiheaded, i.e., that each conjunct is in some sense a head of the coordinate structure. Here, I adopt this last view, as it makes the statement of certain constraints easier. Technically, I assume the fragment of the signature in (58), together with constraints (59)–(60).

(58) A fragment of the signature assumed here:

```
phrase
  non-headed-ph DTRS nelist
  headed-ph HD-DTRS nelist
    multi-headed-ph
    singly-headed-ph NHD-DTRS nelist
      hd-subj-ph
      hd-comp-ph
      ...
```

(59) $\textit{singly-headed-ph} \rightarrow [\ \text{HD-DTRS}|\text{REST } \textit{elist}\ ]$

(60) $\textit{multi-headed-ph} \rightarrow [\ \text{HD-DTRS}|\text{REST } \textit{nelist}\ ]$

Coordinate structures are signs of sort *multi-headed-ph*, i.e., their only daughters attribute is HD-DTRS of length at least two. If it were assumed that only the same categories may be coordinated, then the Head Feature Principle (HFP) might be formalized as in (61), but for reasons that will become clear momentarily I assume the encoding of HFP in (62).

(61) HFP presupposing the Law of the Coordination of Likes (Williams 1981), i.e., not assumed here:

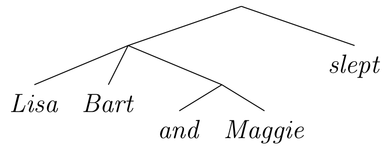
$$\begin{bmatrix} \textsc{ss|loc|cat|head } \boxed{1} \\ \textsc{hd-dtrs } \langle \ldots, \begin{bmatrix} \textsc{ss|loc|cat|head } \boxed{2} \end{bmatrix}, \ldots \rangle \end{bmatrix} \rightarrow \boxed{1} = \boxed{2}$$

(62) HFP assumed here:

$$\begin{bmatrix} \textsc{ss|loc|cat|head } \boxed{1} \\ \textsc{hd-dtrs } \langle \begin{bmatrix} \textsc{ss|loc|cat|head } \boxed{2} \end{bmatrix} \rangle \end{bmatrix} \rightarrow \boxed{1} = \boxed{2}$$

I assume the "almost flat" structure of coordination (Abeillé & Chaves 2021: §3), so that *Lisa, Bart, and Maggie slept* has the structure in (63).

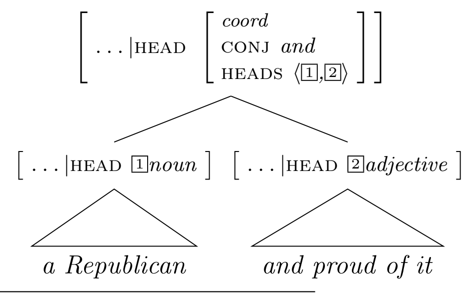
(63)



As in much of the HPSG literature, I treat conjunctions as markers attaching to the immediately following conjuncts (see Abeillé & Chaves 2021: §3.1 and references therein).

On the other hand I do not follow the linearization-based approach to the coordination of unlikes, but rather allow for the direct coordination of unlike grammatical categories, as argued, e.g., in Levine 2011 and Abeillé & Chaves 2021: §6 (cf. Patejuk & Przepiórkowski 2021). The only HPSG analysis of coordination that I am aware of which makes it possible to coordinate different categories is that sketched in Yatabe 2004 and formally substantiated in Przepiórkowski 2021b: §4, so I'll also assume it here. On that analysis the category of the coordinate structure is not that of the conjuncts, but rather a special category, call it *coord*, which encodes the kind of conjunction (CONJ) and the heads of all conjuncts (here HEADS, instead of Yatabe's 2004 ARGS).[7] For example, *a Republican and proud of it* (Sag et al. 1985: 117), i.e., a coordination of an NP and an AP, has the HEAD value shown in (64).

(64)



[7]Having such a special category is not an optimal solution, as it is subject to some of the criticisms in Borsley 2005, especially, that there are no predicates which would subcategorize for this category. A conceptually cleaner solution is to assume that coordinate structures do not have any syntactic category above the categories of its conjuncts, as proposed within LFG in Przepiórkowski & Patejuk 2021, but it is not clear to me how to implement this idea in HPSG.

5 HC at the Syntax–Semantics Interface

After laying out my assumptions about the semantic representation of polyadic quantifiers and about the syntax of coordination, it is high time to present – or rather sketch, for lack of space – the complete syntactico-semantic analysis of Hybrid Coordination. I will illustrate it with the simple – but attested[8] – example (65), with the intended representation in (66) (i.e., $\mathit{sell}(x, y)$ is true iff "they" will sell x to y).

(65) Sprzedadzą wszystko i każdemu… (Polish)
sell.FUT.3PL all.ACC and everybody.DAT
'They'll sell everything and to everybody.'

(66) $\mathit{Cov}(\textsc{every}_x, \textsc{every}_y)(\mathit{thing}(x), \mathit{person}(y))(\mathit{sell}(x, y))$

The first piece of the puzzle is syntactic: how do hybrid coordinations come into being, how do they combine with the rest of the sentence? An answer is suggested by the common observation (e.g., in Gribanova 2009: 138) that, in the case of multiple *wh*-questions, *wh*-phrases may be coordinated in those languages that allow for multiple *wh*-fronting. Thus, in Polish both (67)–(68) are fine, while both literal English translations are not acceptable.

(67) Kto kiedy przyszedł? (Polish)
who when came
'Who came when?' (cf. *Who when came?)

(68) Kto i kiedy przyszedł? (Polish)
who and when came
'Who came and when?' (cf. *Who and when came?)

So in languages like Polish, there must be a rule or construction that makes it possible to realize all extracted *wh*-phrases in one go, as a coordinate structure. I generalize this postulate to all of HC, i.e., I assume that also in examples such as (65), which do not involve *wh*-phrases, all phrases ultimately realized as conjuncts are first extracted from their base positions (i.e., from the extended ARG-ST; Bouma et al. 2001) and placed in SLASH.[9] The bottom and middle of the dependency are unremarkable, but what needs to be added to the standard HPSG theory of unbounded dependencies is the possibility to realize a number of SLASH elements in one bulk, as a coordinate structure; in (69), *head-hc-filler-ph* is a subsort of *head-filler-ph*:

(69) *head-hc-filler-ph* →

$$\begin{bmatrix} \textsc{nonlocal}|\textsc{slash}\ \{\boxed{2_1},\ldots,\boxed{2_m}\} \\ \textsc{hd-dtrs}\ \left\langle \left[\textsc{nonlocal}|\textsc{slash}\ \{\boxed{1_1},\ldots,\boxed{1_n},\boxed{2_1},\ldots,\boxed{2_m}\}\right] \right\rangle \\ \textsc{nhd-dtrs}\ \left\langle \left[\textsc{hd-dtrs}\ \left\langle \left[\textsc{local}\ \boxed{1_1}\right],\ldots,\left[\textsc{local}\ \boxed{1_n}\right] \right\rangle\right] \right\rangle \end{bmatrix}$$

(for some $n > 1, m \geq 0$)

[8] https://komediowy.pl/spektakl/gladiatorzy-sprzedazy-dzien-zycia-przedstawiciela-handlowego/

[9] In particular, unlike in Chaves & Paperno 2007, they are allowed to be dependents of different heads; see, e.g., Patejuk 2015: §5.2 and (2) above.

In words, in this kind of phrase, at least two SLASH elements are removed from the head daughter and realized as multiple heads within the non-head daughter; that is, the non-head daughter is a coordinate structure (on the assumption that only coordinate structures are of sort *multi-headed-ph* introduced in (58)).[10] This leads to the syntactic structure of (65) given in Figure 1.

For the syntax–semantic interface, I assume the usual principles of LRS, only some of which need to be adjusted. The intended values of attributes INCONT (internal content) and EXCONT (external content) are given in Figure 2. The values of PARTS are mostly omitted, as they are analogous to those in the usual LRS analyses of quantifiers. The only remarkable aspect of PARTS here is that the conjunction introduces the value of LIFT, namely, *cov* (rendered as *Cov* in the tree).

The representations in Figure 2 are simplified in various ways. For example, in the node for *wszystko* 'everything', the representation in (70) is a simplified version of (71), where – as above – framed representations hide more complex underlying structure.

(70) $$\begin{bmatrix} \text{EXCONT } \boxed{1}\ldots\text{EVERY}_x\ldots(\ldots\boxed{2}\ldots)(\ldots) \\ \text{INCONT } \boxed{2}\mathit{thing}(x) \end{bmatrix}$$

(71) $$\begin{bmatrix} \text{EXCONT } \boxed{1}\begin{bmatrix} \mathit{gen\text{-}quantifier} \\ \text{QUANT-RESTRS } \boxed{0} \end{bmatrix} \\ \text{INCONT } \boxed{2}\boxed{\mathit{thing}(x)} \\ \text{PARTS } \left\langle \boxed{1}, \boxed{1a}, \boxed{2}, \boxed{2a}\boxed{\mathit{thing}} \right\rangle \end{bmatrix} \wedge \begin{bmatrix} \mathit{every} \\ \text{VAR } \boxed{1a}\boxed{x} \\ \text{RESTR } \boxed{8} \end{bmatrix} \in \boxed{0} \;\wedge\; \boxed{2} \lhd \boxed{8}$$

The two basic LRS principles, the INCONT PRINCIPLE and the EXCONT PRINCIPLE, are standard:[11]

(72) INCONT PRINCIPLE
In each *lrs*, the INCONT value is an element of the PARTS list and a component of the EXCONT value.

(73) EXCONT PRINCIPLE
Clause 1:
In every phrase, the EXCONT value of the non-head daughter is an element of the non-head daughter's PARTS list.
Clause 2:
In every utterance, every subexpression of the EXCONT value of the utterance is an element of its PARTS list, and every element of the utterance's PARTS list is a subexpression of the EXCONT value.

Another basic principle, the LRS PROJECTION PRINCIPLE, needs to be modified slightly:

[10] This construction is subject to additional semantic and pragmatic constraints (regarding the similarity of the quantifiers expressed by the conjuncts and the information status of the coordinate structure), which I do not attempt to state here.

[11] Here and below I cite or modify the versions of these principles found in Iordăchioaia & Richter 2015 (mostly taken from Richter & Kallmeyer 2009).

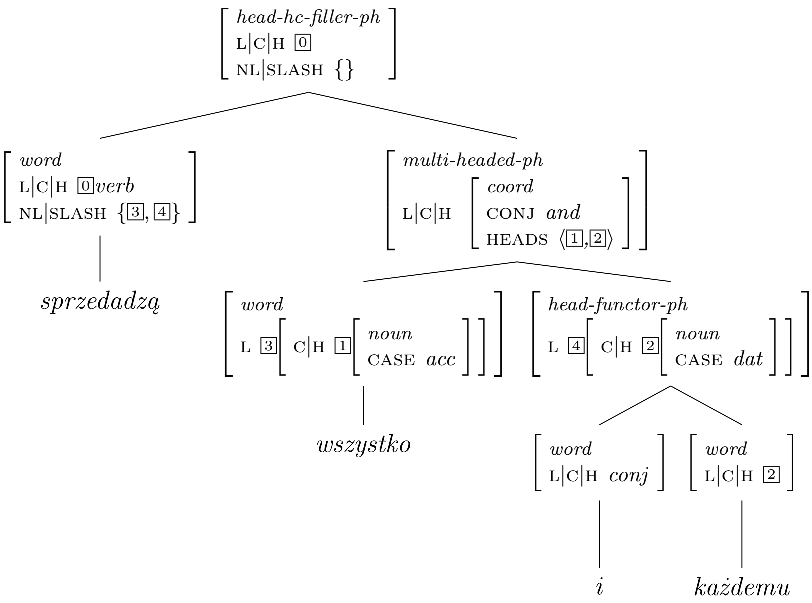


Figure 1: Syntactic structure of (65)

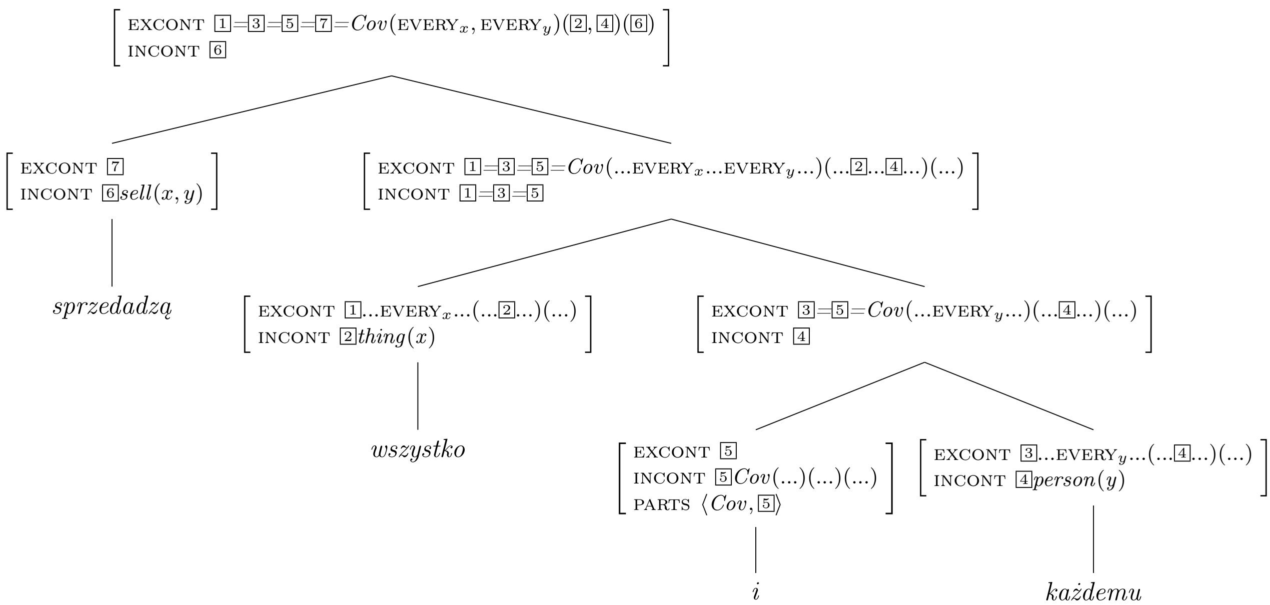


Figure 2: Values of LRS in Figure 1 (simplified)

(74) LRS PROJECTION PRINCIPLE
In each *phrase*,

1. the EXCONT values of each head and the mother are identical,
2. the INCONT values of the head and the mother are identical,
3. the PARTS value contains all and only the elements of the PARTS values of the daughters.

The slight modification concerns the EXCONT part, which mentions *each* head. This way, in the *multi-headed-ph* in Figure 1 representing *wszystko i każdemu* 'everything and to everybody', the EXCONT value of this phrase is equated with EXCONT values of both head daughters, in a step towards the creation of a polyadic quantifier. Note that a similar modification is impossible in the case of the INCONT part, as INCONT values of the two heads cannot be unified into a single representation. Rather, an additional clause the SEMANTICS PRINCIPLE is needed that equates EXCONT and INCONT in coordinate structures:[12]

(75) SEMANTICS PRINCIPLE, coordination clause
In *multi-headed-ph*, INCONT and EXCONT values are identical.

As formulated here, these principles apply to all multi-headed phrases, i.e., to all coordinate structures, not just to HC. This assumes that all coordinate structures may be analysed via the creation of a polyadic quantifier partially specified by all conjuncts – a hypothesis that I intend to explore in future work. But getting rid of this assumption is easy; it is sufficient to postulate a special subsort of *multi-headed-ph* specific to HC, say, *hc-ph*, and to formulate all relevant principles in terms of *hc-ph* rather than *multi-headed-ph*.

To be applicable to Slavic, the "quantifier–restriction" clause of the SEMANTICS PRINCIPLE (Clause 1 in Iordăchioaia & Richter 2015: 631) must be modified to reflect the fact that, in Slavic, quantifiers are not necessarily determiner non-heads, but may be expressed by adjective non-heads, or numeral or nominal heads. That is, that clause should rely less on the morphosyntax of the two constituents, and more on their semantics. However, I do not attempt such a reformulation here, and besides it is not needed in the case of example (65) and Figures 1 and 2, which feature type $\langle 1 \rangle$ quantifiers *wszystko* 'everything' and *każdemu* 'everybody', with the restriction already built-in.

What is at work in the case of the running example – at the level of *head-hc-filler-ph* – is the "quantifier–scope" clause (Clause 2 in Iordăchioaia & Richter 2015: 631); here is a modified version applicable to HC:

(76) SEMANTICS PRINCIPLE, quantifier–scope clause
If the non-head is an NP or a multi-headed phrase and its an EXCONT value is of sort *gen-quantifier*, then the INCONT value of the head is

[12]Instead of numbering particular clauses of the SEMANTICS PRINCIPLE, which is not mnemonic and may be inconsistent across different versions of this principle, I give them descriptive names, e.g., "coordination clause".

a component of SCOPE within the EXCONT value.

This version is slightly reformulated with respect to that in Iordăchioaia & Richter 2015: 631: it explicitly refers to *gen-quantifier* and SCOPE, i.e., it does not shy away from HPSG technicalities. But it is also extended by allowing the quantifier to be not only NP, but also a coordinate structure. This works for the example at hand, but – just as in the case of the "quantifier–restriction" clause discussed in the previous paragraph – it is not satisfactory, as it overtly relies on the morphosyntax of the construction. What seems to be missing here, and in LRS in general, is a more general and uniform rule of semantic composition, similar to the type-driven composition assumed (Klein & Sag 1985) in other semantic frameworks.

The final clause needed in the running example is this:

(77) SEMANTICS PRINCIPLE, functor–head clause
If the functor in *head-functor-ph* is a conjunction, then EXCONT values of this phrase and the conjunction are identical.

This way, the conjunction's $Cov(...)(...)(...)$ EXCONT is identified with the conjunct's $Cov(...\text{EVERY}_y...)(...\boxed{4}...)(...)$ EXCONT, thus making sure that the quantifier introduced by that conjunct takes part in the cover lift.

6 Conclusion

While there is abundance of syntactic and semantic work on coordination, hybrid coordination has been neglected so far: almost all of the literature only deals with syntax (and most of it only with coordinated *wh*-phrases), and the only worked out semantic analysis, that of Paperno 2012, is known not to make the right predictions. I hope to have somewhat ameliorated this situation by providing an account at the syntax–semantics interface that builds on both Paperno's (2012) account and HPSG work on polyadic quantification, but attempts to improve on both.

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