19. Quantification – theoretical perspectives

Vadim Kimmelman & Josep Quer

1. Introduction

The study of quantificational expressions is one of the central domains in the field of natural language semantics. Probably every language has means of expressing quantification, but quantifiers in natural languages are not straightforwardly parallel to logical quantifiers. Over the past 30 years a lot of research has been done to exactly describe and explain the properties of quantifiers in diverse languages (see Keenan 2006; Matthewson 2008; Keenan & Paperno 2012, Paperno & Keenan 2017 for a cross-linguistic perspective). However, quantification in sign languages is severely understudied. This chapter offers an overview of existing research on this topic, and discusses some ideas for future research. Before proceeding to the discussion of sign languages, the necessary theoretical background is introduced in this section.

The most well studied type of quantification concerns the so-called D-quantifiers, that is, adnominal determiners with quantificational functions, such as English *all, each, most, some,* etc. A D-quantifier together with a noun forms a quantifier noun phrase, such as *each boy* in *Each boy entered*. The meaning of the quantifier noun phrase (generalized quantifiers) is thus a function which maps properties (e.g., *entered*) to truth values, and thus the meaning of a quantifier is a function from properties to generalized quantifiers. Keenan (2006) argues that the meaning of quantifiers is better characterized in set theoretical terms, for instance "ALL (A) (B) is true iff A $\subseteq$ B". In this representation it also becomes clear that the structure of a quantificational expression has three main parts: the operator – the quantifier itself (ALL), the restrictor (A), and the nuclear scope (B).

There are different semantic types of quantifiers. Some quantifiers (*some, many, two*) are existential: they can be used in existential contexts, such as *There are two cats in the garden*. An important subtype of existential quantifiers is cardinal quantifiers, which express cardinality, including numerals. Other quantifiers (*all, each*) are universal, and they cannot be used in such contexts.[1] Often a distinction is made between collective (*all*) and distributive (*each*) universal quantifiers. Finally, there are also proportional quantifiers, such as *most* and *half*. In addition, complex quantifiers can be built through combination of multiple quantifiers: *Some but not more than half of the students came.*

In addition to D-quantifiers, all natural languages seem to have A-quantifiers, that is, quantifiers which are not bound to a particular argument, but which are instead combined with predicates and quantify over events. For instance, *John always walks to work* means that the set of events in which John goes to work is a subset of events in which John walks. Such quantifiers can also be existential (*often, never*), universal (*always*), or proportional (*mostly, usually*), although it is somewhat difficult to differentiate between existential and proportional A-quantifiers. A-quantifiers can be adverbial, but they can also be verbal affixes. However, a verbal affix can also quantify over arguments (Evans 1995), so the boundary between D- and

A-quantifiers is not always straightforward; therefore, we discuss lexical quantifiers (both D- and A-) separately from morphological modifiers with quantificational meaning.

One of the most important properties of quantifiers in natural languages is that when two or more quantifiers are combined in one sentence, scope ambiguities can arise. For instance, *Some teacher graded every paper* can either mean that there is one specific teacher who has graded all papers (*some* scopes over *every*), or that for every paper there is a teacher who graded it (*every* scopes over *some*). A scope ambiguity can also arise between a D- and an A-quantifier, as in *Two boys sang three times.*

Keenan & Paperno (2012) discussed the results of a typological survey of classifiers in 18 natural languages, and came up with a list of generalizations.[2] For instance, they found that all these languages have both D- and A- existential quantifiers, and also all have both D- and A- universal quantifiers. All languages in their sample also distinguish distributive and collective universal quantifiers. Proportional D- and A-quantifiers have been found in all languages as well. Finally, all languages showed some scope ambiguities.

There is no principled reason to expect that sign languages would diverge from the generalizations formulated above. Thus, we also expect to find both D- and A-quantifiers of different semantic types, as well as scope ambiguities. However, we also expect to find some effects of the visual modality, such as iconicity, or use of space, that have been shown to fundamentally affect both the syntactic and the semantic domains of sign languages (Sandler & Lillo-Martin 2006; Meier 2012; see also Schlenker (2018) and Chapter 23 for a discussion of modality effects on semantics specifically). Based on the previous research on quantification in sign languages, we further discuss the following issues: lexical quantifiers (Section 2), quantificational morphology (Section 3), and structural aspects of quantification (Section 4). Throughout the chapter we point out to possible modality effects, but we also specifically address them in the last subsection.

2. Lexical quantifiers

To clarify the terminology, in this section we discuss quantifiers which are lexical, that is, they are separate signs with quantificational meanings. In Section 3 we discuss morphological modification which can apply to verbs (but not only verbs) to express quantificational meanings.

2.1. D-quantification

It comes as no surprise that sign languages have lexical D-quantifiers. At least one type of quantifiers is documented for most sign languages, namely numerals, which are usually reported in dictionaries. There is considerable research on numerals in both urban and rural sign languages (see Zeshan et al. 2013 and references therein). However, such research is primarily focused on phonology and morphology of numerals, and on the questions of numeral

bases and strategies of constructing larger numerals, while such questions as possible scope ambiguities are not discussed.

Although it is not a reliable research tool, a quick search of the website www.spreadthesign.com (a multilingual sign language dictionary containing signs from 41 sign languages s, as of June 2020) shows that D-quantifiers of all three major types (universal, existential, and proportional) are well represented. 28 languages have an equivalent for the meaning *all* and 29 languages have a sign for *each*, 29 languages have an equivalent for *some*, and 31 have a sign for *majority*.[3]

Some papers specifically discuss quantifiers in sign languages. For instance, Petronio (1995) discussed primarily verbal quantification in American Sign Language (ASL) (see Section 3), but her examples also include existential quantifiers, such as TWO and MANY. Partee (1995) also discusses a universal quantifier ALL in ASL. A more recent and complete discussion of quantifiers in ASL can be found in Abner & Wilbur (2017), who mention existential quantifiers SOME, SOMEONE, FEW, MANY, and NO, universal quantifiers #ALL (a lexicalized fingerspelling sequence) and EACH, and proportional quantifiers MOST and HALF, among others. For Catalan Sign Language (LSC), Quer (2012) found universal (ALL), existential (SOME), and proportional (MAJORITY) D-quantifiers.[4]

Kimmelman (2017) described quantifiers in Russian Sign Language (RSL) based on the questionnaire from Keenan & Paperno (2012). He found that all types of lexical D-quantifiers are well represented in RSL. For instance, RSL has existential quantifiers, such as numerals (ONE (cf. (1)), TWO, etc.), and others: SOME, MANY, NOBODY, NOTHING. It also has both collective (ALL) and distributive (EVERY) universal quantifiers (cf. (2)). Finally, it has proportional quantifiers, such as HALF (cf. (3)). Interestingly, as in many spoken languages, existential quantifiers can be used in existential constructions, while universal quantifiers cannot: consider example (4) where an existential quantifier MANY but not a universal quantifier ALL can be used.

(1)   INDEX1 BUY ORANGE ONE
     'I bought one orange.'   (RSL, Kimmelman 2017: 811)

(2)   a.   ALL BOY LATE
         'All boys were late.'   (RSL, Kimmelman 2017: 826)

       b.   EVERY QUESTION
         'Every question.'   (RSL, Kimmelman 2017: 818)

(3)   GIRL HALF SICK
     'Half of the girls were sick.'   (RSL, Kimmelman 2017: 826)

         <u>   er</u>
(4)   ROOMa INDEXa EXISTa MANY/(*ALL) BOY
     'There are many boys in the room.'   (RSL, Kimmelman 2017: 821)

In RSL, as in many spoken languages, some complex quantifiers can be built. For instance, numerals can be modified with approximately and exactly (5). In addition, juxtaposition of numerals is also used to express approximate quantity (6).

(5)　NEW YEAR CHAMPAGNE PEOPLE DRINK APPROXIMATELY 60 PERCENT
'Approximately 60% of people drink champagne at New Year.'

(RSL, Kimmelman 2017: 814)

(6)　WALL PICTURE HANG TWO THREE MAXIMUM FOUR
'There are two or three pictures on the wall, at most four.'

(RSL, Kimmelman 2017: 815)

Keenan & Paperno (2012) also observed that, in spoken languages, A-quantifiers are sometimes derived from D-quantifiers, but the opposite pattern is very rare. Kimmelman (2017) confirmed this for RSL: some A-quantifiers, such as ONE-TIME 'once' seem to be morphologically derived from numeral D-quantifiers, but there are no examples of D-quantifiers derived from A-quantifiers.

2.2. A-quantification

In opposition to D-quantification, Bach et al. (1995) group other ways of encoding quantification under the label A-quantification, which includes adverbs, auxiliaries, affixes and argument-structure adjusters. They introduce quantification "in a more constructional way" (Partee 1995: 544). Research on these strategies of expressing quantification is limited for sign languages. In this section adverbial quantifiers are addressed, including those that express generic quantification. For quantification over events yielding different aspectual meanings, see Malaia & Milković (Chapter 9).

The idea behind A-quantification stems from the analysis of indefinites by Kamp (1981) and Heim (1982), according to which indefinite expressions are non-quantificational and they just introduce a variable with descriptive content that must be unselectively bound by a quantifier. This quantifier can be the existential closure introduced at discourse level, but also an overt quantifier. An important piece of evidence to support this view is provided by sentences like (7a) and (7c): the sentences with indefinite subjects can be faithfully paraphrased as in (7b) and (7d), with D-quantifier subjects. The quantificational force has been shown to come from adverbials like *always* and *often*, which are called quantificational adverbs or Q-adverbs, since they are able to unselectively bind open variables in their scope (it has to be assumed that they take sentential scope, which is unproblematic for this kind of quantifiers). Next to Q-adverbs with universal and proportional quantificational force, there are Q-adverbs with existential force like *sometimes*, *twice* or *never* (cf. (7e, f)).

(7)　a.　A dog always makes good company.
　　 b.　All dogs make good company.
　　 c.　A cat often stays home.
　　 d.　Most cats stay home.
　　 e.　A cat never likes bathing.

f.   No cat likes bathing.

Unsurprisingly, sign languages also feature this type of quantificational adverbs, as in the RSL example in (8) or the ASL example in (9) (see also Abner & Wilbur (2017: 37-40, 44-45).

	re

(8)   IX1 WORK WALK ALWAYS1 ON-FOOT
      'I always go to work on foot.'   (RSL, Kimmelman 2017: 813)
(9)   JOHN ALWAYS LOSE PAPER
      'John always loses his papers.'   (ASL, Braze 2004: 38)

Although the interaction with indefinite expressions has not been extensively addressed, examples are found in the literature. For instance, in LSC the clausal negator NOTHING2[5] has been shown to be able to bind the empty variable slots in the right context, as in (10).

(10) a.   _____hs_____
           BRING NOTHING2
           'Nobody brought anything.'
      b.   ___hs___ ___hs___
           YESTERDAY NIGHT COME NOTHING2
           'Noone came last night.'   (LSC, Quer 2012: 85)

A case for which unselective quantificational binding has been described are generic and characterizing/habitual statements (Krifka et al. 1995). Quer (2012) shows that in LSC generic statements can be overtly marked with the sign ÉS 'it is' in clause final position, as illustrated in (11). It is taken to lexicalize the generic operator GEN. While specific or definite DP are accompanied by a pointing, arguments interpreted generically are not, as the subject in (11). As an indefinite description, the variable it introduces is unselectively bound by the generic operator.

(11) __re__
      LION PREDATE+++ ÉS
      'The lion is a predator.'   (LSC, Quer 2012: 86)

The same phenomenon can be observed with the covert generic or habitual operator, as illustrated in (12) and (13) for LSC. Example (12) is a prototypical case of a donkey sentence, where the subject and object descriptions in the conditional antecedent are bare and not localized. Example (13) is an example of a characterizing or habitual predication again with an indefinite subject. In both cases, the bare nouns are unselectively bound by the generic or habitual operator.

_____br_____

(12)   [IF PEASANT HORSE THERE-BE] ALWAYS TAKE-CARE
       'If a farmer has a horse, he always takes care of it.'   (LSC, Quer 2012: 85)

<div style="text-align:center">br</div>

(13)   [FRIEND PERSON COME] IX1 3INVITE1
       'When a friend came, I would treat him/her.'/
       'When a friend comes, I treat him/her.'   (LSC, Quer 2012: 86)

Barberà & Quer (2015) note that in a generic statement like (14) the subject bare noun is in principle ambiguous between a bound reading (14a) and a specific one (14b): while in the former case the subject variable is unselectively bound in the restrictor of GEN, in the latter one the indefinite variable is existentially closed in the nuclear scope of the generic operator (see section 4.1 for details).

(14)   PARROT SPEAK ÉS
       a. 'A parrot speaks.'
       b. 'A certain parrot typically speaks.'   (LSC, Barberà & Quer 2015)

3. Quantificational morphology

Klima & Bellugi (1979) demonstrated that ASL verbs can undergo a large number of modifications, some of which express aspect, and others appear to quantify over events or the arguments of the verb. So for instance they described the following morphemes: [multiple], expressing actions to many and realized as a simple arc-shaped movement, and [exhaustive], encoding distributed action to each individual in a group and realized as an arc shaped movement with reduplication along the arc.

Petronio (1995) discussed these morphological markers from the quantificational perspective. She showed that ASL uses bare noun phrases in combination with morphological modification of the verbs. Compare (15a) to (15b): in both sentences the noun phrase is bare, but in the first case it is interpreted as singular, while in the second case it is interpreted as plural and quantified over. Quer (2012) showed that the same is true for LSC, where the [multiple] morpheme is used as a collective universal quantifier and the [exhaustive] morpheme as a distributive one (16).[6]

<div style="text-align:center">t</div>

(15)   a.   DOCTORa MONEY ANN GIVEa
            'Ann gave money to the doctor.'   (ASL, adapted from Petronio 1995: 610)

<div style="text-align:center">t</div>

       b.   STUDENTa BOOK ANN GIVEa-exhaustive
            'Ann gave a book to each student.'   (ASL, adapted from Petronio 1995: 611)

(16)   a.   PERSONpl STUDENT INDEX^THREE INDEX1 1ASK3-multiple
            'I asked the three students.'   (LSC, adapted from Quer 2012: 89)

       b.   PERSONpl STUDENT INDEX^THREE INDEX1 1ASK3-exhaustive

'I asked each of the three students.'   (LSC adapted from Quer 2012: 89)

Interestingly, the same morphological markers can attach to other elements in the sentence, not just to verbs, as Quer (2012) showed for LSC. Consider (17), where the same marker attaches to the verb ASK, to the numeral ONE, and to the possessive marker POSS.

<div align="right">re</div>

(17) STUDENT ONE-exhaustive TEACHER POSS-exhaustive ASK-exhaustive
      'Each student asked his/her teacher.'   (LSC, adapted from Quer 2012: 90)

Kimmelman (2015a, 2015b, 2017) demonstrated that this is also true for RSL. In this language, the distributive morpheme can attach to verbs, nouns, numerals, pronouns, and even to the lexical quantifier EVERY, as (18) shows. Thus, it is very difficult to characterize this marking as belonging to either A- or D-quantifiers, given its wide compatibility.

(18) EVERY-exhaustive MAN BUY BEER-exhaustive
      'Every man bought a beer.'   (RSL, Kimmelman 2015a)

Importantly, both in RSL and LSC, the morpheme can attach to both the distributed share (what is being distributed, the beers in (18)) and the distributive key (what is being distributed over, the set of men in (18)). Distributive and collective morphemes are not unattested in spoken languages; for instance, in Mayali quantification over arguments is often expressed through verbal morphemes (Evans 1995). However, it seems much less common (if attested) that the same morpheme would attach to different constituents in the sentence, and to both the distributive key and the distributed share (but see Champollion (2015) for a discussion of some cases in English, German, and Korean where distributivity is also expressed in multiple places in a sentence; also Kuhn (2017) for a formal analysis of dependent indefinites in ASL, and Kuhn (2019) for a more general discussion of the phenomenon).

   In addition to [multiple] and [exhaustive] there are other similar markers of plurality. For instance, Kuhn & Aristodemo (2017) show that in French Sign Language (LSF) there are at least two different markers of verbal plurality, which is also known as pluractionality: /rep/, which is a full repetition of the verb, and /alt/, which is an alternating repetition with two hands. Interestingly, these markers have different semantics. /rep/ is used to express distribution of events over time (19a), while /alt/ is used to express distribution of events over participants (arguments), or over both participants and time, but never over time only (19b,c).

(19) a. MY FRIENDS CL-area FORGOT-rep BRING CAMERA
          'My friends kept on forgetting to bring a camera.'
          OK: several times; each time, all forgot
          *: a single time; all forgot / several times; each time, a different one forgot
      b. GROUP PEOPLE BOOK GIVE1-alt
          'A group of people gave me books.'

c. *OFTEN ONE PERSON FORGET-alt ONE WORD
   Intended meaning: often one person forgets one word.
   (LSF, Kuhn & Aristodemo 2017: 10-11)

Quer (2019) confirms the existence of the same markers in LSC. Unlike LSF, however, LSC seems to be able to accommodate the interpretation of /alt/ occurring with singular arguments. In the LSC grammatical example corresponding to (19c) the accommodation can take place through variation in the spatial dimension (next to the temporal one), as illustrated in (20).

(20) JUAN PASSWORD FORGET-alt
     'Juan forgot the password (in different places).'   (LSC, Quer 2019: 13)

It thus seems that /alt/ in LSC is more flexible with respect to the parameters against which it can be interpreted. An additional pluractional marker /rep-arc/ is also reported in LSC. Combined with a motion verb, it yields a reading of plurality of locations, with a secondary temporal reading of plurality of times. This form is the one that has been characterized in the literature as [distributive/exhaustive], but Quer (2019) shows that in LSC it does not impose an exhaustive reading of the reduplicative morphology, as the felicitous continuation in (21) shows. The question remains whether the exhaustive reading attested sometimes with these forms derives from pure contextual conditions or not.

(21) SUPERVISOR SCHOOL GO-rep-arc, OTHER/SOME NOT
     'The supervisor went to some schools, to (some) others he didn't.'(LSC, Quer 2019: 14)

A large variety of verbal modifiers that express different types of distributive semantics has been found in RSL by Filimonova (2012). In addition to the abovementioned [exhaustive] morpheme, RSL also uses a two-handed alternating repetition [alt] (similar to LSF), but also a combination of two-handedness and an arc-shaped movement [2-multiple][7], whereby both hands move along a simple arc without reduplication, or a reduplicated arc-shaped movement [2-exhaustive]. Filimonova claimed that two-handed alternating repetition is often used to express uncontrolled processes (22a), while the [2-multiple] and [2-exhaustive] morphemes are used in situations when the subject is plural, and the object is distributed over (22b). It might be the case that [2-multiple] and [2-exhaustive] are actually compositional combinations of the [2 hands] morpheme expressing plurality of the subject, and [multiple] or [exhaustive] expressing object plurality or distribution over the object.

(22) a. SHEEP GROUP ONE WEEK DIE-alt ALL DESTROY
        'All out sheep died in a week.'   (RSL, adapted from Filimonova 2012: 86)
     b. CHILDREN INDEX$_{pl}$ ATTENTIVE LOOK-2-multiple
        [A teacher talking to children:] 'Children, you have to check [your works] carefully.'
        (RSL, adapted from Filimonova 2012: 89)

Given the observed cross-linguistic variation, it is clear that much more research is needed to pin down the (quantificational) properties of (verbal) modification in sign languages, and a lot of further interesting discoveries can be made in this domain of inquiry.

Finally, the discussion above concerned quantificational morphology of lexical verbs (plain and agreeing); however, whole-entity classifier predicates can also express quantification of the arguments. For instance, in ASL, using a semantic classifier with the Ƀ-handshape (glossed as CL1) means a singular entity moving (23a), while using a classifier with two extended fingers means that two entities are moving, while using a two-handed classifier predicate with four fingers extended (glossed asnCL1) can express the meaning of a undetermined plurality of entities (e.g., humans) moving (23b) (Petronio 1995; also see Filimonova 2012 for RSL).

(23) a. $\overline{\quad \text{top} \quad}$
          STOREa, MAN CL1: go-toa
          'The man went to the store.'
      b. $\overline{\quad \text{top} \quad}$
          STOREa, MAN CL44: go-toa
          'The men went to the store.'   (ASL, adapted from Petronio 1995: 614)

In addition to using the handshape, the movement and location in whole-entity classifier predicates can be used for quantification (Petronio 1995 among others). The predicate can be reduplicated in various points of space to express plurality and location of the argument, as in (24) from DGS, where the whole-entity predicate is repeated in three different locations.

(24) TABLE BOOK CLB(flat object): be-at-repa,b,c
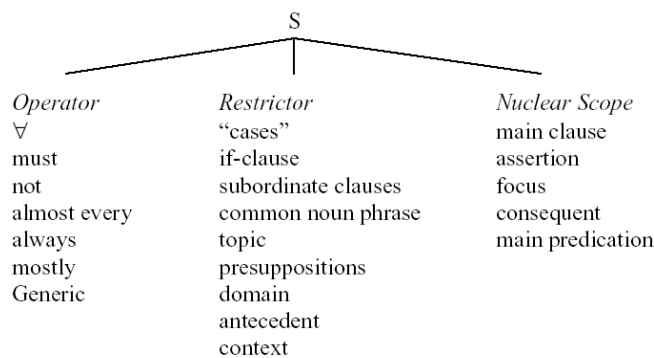   'Books are lying next to each other on the table.'   (DGS, Steinbach 2012: 125)

As with lexical verbs, classifier predicates with quantificational morphology can combine with bare noun phrases not specified for number, such that quantification is expressed only in the predicate (24).

4. Structural aspects of quantification

Together with lexical and morphological encoding of quantificational meanings, syntactic structure plays a crucial role in the way quantificational readings are conveyed. In this section tripartite structures, scopal interactions and spatial encoding of certain aspects of quantification are addressed.

4.1. Tripartite structures of quantification

In the study of natural language quantification a proposal has been made to try to ascertain how information-structural notions like topic and focus interact with the expression of quantificational structures (Partee 1992, 1995; Bach et al. 1995). Their focus-sensitivity is in the foundations of the proposal. The main hypothesis is that the topic/focus articulation determines the projection of quantificational tripartite structures, namely the semantic structuring of the quantification into Operator-Restrictor-Nuclear scope (see Section 1). Figure 1 illustrates this view in a schematic way, by featuring "a number of hypothesized syntactic, semantic, and pragmatic structures that can be argued to be correlated with each other and with the basic tripartite scheme" (Partee 1995: 545-546).

	S	
Operator	*Restrictor*	*Nuclear Scope*
$\forall$	"cases"	main clause
must	if-clause	assertion
not	subordinate clauses	focus
almost every	common noun phrase	consequent
always	topic	main predication
mostly	presuppositions	
Generic	domain	
	antecedent	
	context	

Figure 1. Tripartite structures generalized (Partee 1995)

On the basis of LSC data, Quer (2012) proposes that sign languages might tend to encode the tripartition of quantificational structures overtly. The tendency might be related to the fact that in general they encode information-structural notions overtly through syntax and non-manual markers. This can be readily observed in generic or habitual/characterizing sentences such as (12)-(13) above, repeated here as (25)-(26) for convenience. The overt Q-adverb ALWAYS in (25) and the covert generic or habitual operator in (26) are standardly understood to take scope over the whole sentence; the dependent clause in the left periphery is marked with brow raise, as topics are, and they realize the restrictor of the operator, which unselectively binds the free variables in it, giving rise to quantificational variability effects. The main clause predication constitutes the nuclear scope of the quantificational structure.

<div style="text-align:center">br</div>

(25) [IF PEASANT HORSE THERE-BE] ALWAYS TAKE-CARE
       'If a farmer has a horse, he always takes care of it.'   (LSC, Quer 2012: 85)

<div style="text-align:center">br</div>

(26) [FRIEND PERSON COME] IX1 3INVITE1
       'When a friend came, I would treat him/her.'/
       'When a friend comes, I treat him/her.'   (LSC, Quer 2012: 86)

This tendency is shown to surface in D-quantification, whereby the restrictor of the quantifier often appears as a topic in the left periphery, detached from the quantifier and marked by brow raise, as in the LSC case in (27).

        <u>   re</u>
(27) STUDENTS MAJORITY EXAM PASS
       'Most students passed the exam.'   (LSC, Quer 2012: 88)

A related but different case might be the split that is often found in complex *wh*-structures, where the *wh*-quantifier occurs on the right edge of the clause and its restrictor appears either as a left-edge topic marked with brow raise or in situ. This is exemplified for LSC in (28).

              <u>   fe</u>
(28) THIS MORNING STUDENT COME WHO
       'Which students came this morning?'   (LSC, Quer 2012: 87)

The tendency has been documented as well for quantified sentences in ASL, where the nominal restrictor of a D-quantifier of different types (universal, existential, numeral) appears either in situ or left-detached and marked with brow raise, as in (29a). If the restriction appears in situ, the quantifier cannot be left-detached (cf. (29b)).

        <u>   re</u>
(29) a. BOOK I WANT ALL/SOME/THREE
        'I want all/some/three books.'
              <u>   re</u>
      b. *ALL/SOME/THREE I WANT BOOK
            (ASL, adapted from Boster 1996, Partee 1995, Petronio 1995)

Wilbur & Patschke (1999), in trying to explain structures with brow raise marking in ASL, proposed that the non-manually marked constituent is the restriction of a [-wh] operator that occupies the A'-Specifier position of that operator. In this way, they unify the use of topics, focus, relative clauses, conditionals, yes/no questions, and *wh*-clefts in ASL (see also Abner & Wilbur 2017: 51-52).

      However, the overt expression of tripartite quantificational structures might be just a tendency rather than a hard-wired grammar rule in these sign languages. Focusing on RSL, Kimmelman (2015b) establishes that the tripartite structure, albeit attested as in (30a,b), is not always overtly marked, as in (30c).

        <u>   re</u>
(30) a. BOY ALL LATE
        'All boys were late.'
        <u>   re</u>
      b. BOY LATE ALL

c. ALL BOY LATE
   'All boys were late.'   (RSL, Kimmelman 2015b: 129)

He argues that the topicalized restrictor does not surface for free and that it induces a partitive reading of the quantified expression.

4.2. Scopal interactions

It is well-known that when two or more quantified expressions cooccur in the same sentence, they can give rise to scope ambiguities. The possibilities will be determined by the capacity to take larger scope that the position it occupies in syntax or not, which is determined lexically but also structurally. Thus, an English sentence like (31) can in principle yield the two readings reported in (31a) and (31b): in the (31a) reading the subject *two volunteers* has scope over the object *every candidate*, reflecting the surface hierarchical relationship between the two constituents. However, in the (31b) reading the object phrase takes scope over the subject.

(31) Two volunteers have campaigned for every candidate.
      a. 'There are two volunteers such that they have campaigned for all candidates.'
      b. 'For every candidate, there are two possibly different volunteers that have campaigned for him or her.'

Given the different modality of sign languages, the question can be asked whether factors like use of space or some other modality-specific factors block such possible ambiguities in quantificational readings. Although there is little research on this topic, it has been shown that ambiguous quantificational readings can arise among clause mate quantifier expressions in a sign language like LSC (Quer & Steinbach 2015: 153), as shown in (32).

$$\overline{\hspace{3.5cm}}^{\text{re}}$$
(32) STUDENT NEW GROUP_{dist} PROFESSOR TWO GUIDE
      a. 'There are two professors such that each has shown all the new groups of students around.'
      b. 'For every new group of students, there are two (possibly) different professors that have shown them around.'
                                            (LSC, adapted from Quer & Steinbach 2015: 153)

Similar scope ambiguities have been found for RSL, as exemplified in (33) (Kimmelman 2017). Kimmelman notes that two universal quantifiers like EVERY and ALL show slightly different possibilities of scope taking with respect to another quantifier depending on their syntactic function (and position), with ALL tending to take narrow scope.

$$\overline{\hspace{4cm}}^{\text{re}}$$

(33) VACATION STUDENT EVERY IX_{pl} READ BOOK PUSHKIN POSS

      'During the vacation every student read a book by Pushkin.'

      a. everyone read the same book: one > every.

      b. everyone read one book, maybe different ones: every > one

                                                   (RSL, Kimmelman 2017: 828)

Ambiguity is also noted to arise in questions with a universally quantified subject and a *wh-*object, as in (34).

$$\overline{\qquad\qquad\qquad\qquad\qquad\qquad\qquad}^{\text{re}}$$

(34) STUDENT EVERY IX_{pl} ANSWER QUESTION WHICH

      'Which question did every student answer?

      a. everyone answered the same question: one > every

      b. everyone answered one question, maybe different ones: every > one

                                                 (RSL, Kimmelman 2017: 828)

Bare nouns enter scope interactions with quantified NPs that result in different interpretations, as argued by Petronio (1995) on the basis of the ASL example (35). Out of the blue, the preferred interpretation is (35a), but additional context elicits the two additional interpretations in (35b) and (35c).

$$\overline{\qquad}^{\text{re}}$$

(35) BOOK, TWO STUDENT BUY

      a.   'Two students each bought a book.'

      b.   'Two students together bought a book.'

      c.   'Two students bought books.'   (ASL, Petronio 1995: 607)

Languages differ, though, in the range of possible interpretations, and for instance, the corresponding structure in LSC only yields reading (35b) in the unmarked case. Readings (35a) and (35c) only obtain with additional morphological marking on the verb (dual and random reduplication (allocative) morphology), respectively (Quer et al. 2017: 614). Kimmelman (2017) also observes that D-quantifiers interact with A-quantifiers in RSL, as attested in (36).

(36) BOY TWO COME THREE-TIMES

      'Two boys came three times.'

      a.   three times > two boys

      b.   two boys > three times   (RSL, Kimmelman 2017: 828)

Nevertheless, structures are also found where no such ambiguities arise. A good example of this is the effect of the distributive morphology (see Section 3 above) in an LSC example like (37), where the numeral in the subject phrase, the possessive in the object phrase and the agreement verb ASK are all marked for distributivity. Localization in signing space of the

arguments and directionality of the verb path from and towards the respective locations excludes any type of scope ambiguity: the subject distributes over the object set.

$$\overline{\phantom{\text{STUDENT ONE TEACHER POS}}\text{re}\phantom{\text{S}}}$$

(37)   STUDENT ONE$_{dist}$ TEACHER POSS$_{dist}$ ASK$_{dist}$

'Each student asked his/her teacher.'   (LSC, Quer 2012: 90)

For similar examples of the use of space for scope disambiguation in ASL, see Abner & Wilbur (2017: 54-55).

4.3. Quantifiers and space

The central use of space in the signed modality leads to the expectation that some aspects of quantification will resort to the possibilities afforded by this medium (see Schlenker 2018 and Chapter 23). In fact, a number of results reported in the literature point in this direction. Since some of them are summarized in more detail in other chapters, in this section they are only briefly reported upon.

Indefinite expressions in LSC have been shown to distinguish overtly between non-specific and specific interpretations (Barberà 2015): whereas non-specific indefinites and definites are articulated on a lower plane, non-specific indefinites are realized at a higher location, as illustrated in (38) (see Barberà, Chapter 18). A similar interpretive distinction marked with height has been found in Turkish Sign Language (TID) by Kelepir et al. (2019), with the additional finding that a [±lateral] feature encodes clusivity (inclusive vs. exclusive reference)

(38)   WHO^IX-3$_{pl.up}$ MONEY 3-STEAL-3$_{up}$

'Someone stole the money.'   (LSC, Barberà & Quer 2013: 254)

For ASL, Davidson & Gagne (2014) interpret differences in the height of quantifiers as contrasts in the size of sets quantified over: larger sets are articulated higher than smaller sets, which are articulated lower. Thus, the higher the location, the larger the widening of the set, as illustrated in (37).

(39)   *Context: Signer is discussing her friend getting a nanny for her children.*

a. IX$_1$ WILL FIND SOMEONE$_{LOW}$

'I will find someone (among the usual group).'

b. IX$_2$ MUST FIND SOMEONE$_{HIGH}$

'You need to find someone (anyone)!'   (ASL, Davidson & Gagne 2014: 114)

Note that the distinctions are not seen as binary, but with intermediate levels of height. The proposal is not only illustrated with indefinites, but also with plurals and negative quantifiers.

Another interesting case initially described in Schlenker et al. (2013) for ASL and LSF is the role of space in the possibility of having anaphoric reference to the complement set of a quantifier when a subset has been established for a plural set. In the absence of an overt subset of the larger plural set, anaphorically referring to the complement set of the quantifier is not possible, as in English. However, if the subset quantified over has been made explicit, as in (40a) a subsequent pronoun directed to the complement can pick up the complement set, as illustrated in (40b). This anaphoric possibility is excluded in English and can be interpreted as a result of the iconic encoding of the sets in space (for details, see Schlenker, Chapter 23).

(40) a. POSS1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS
          'Most of my students came to class.'
      b. IX-arc-b b-STAY HOME
          'They stayed home.'   (Schlenker et al. 2013: 98)

Finally, as discussed in Section 4.2, spatial localization can be used to disambiguate potentially ambiguous sentences with multiple quantifiers (Quer 2012, Abner & Wilbur 2017). Thus, referential use of space being one of the major modality-specific phenomena (Schlenker 2018) is also responsible for some modality-specific patterns in quantification.

5. Conclusions

Despite the limited research on quantification in sign languages, it seems safe to conclude that, as expected, the core properties that have been identified cross-linguistically in spoken languages are clearly present in languages in the signed modality: the division of labor between D-quantification and A-quantification is well established, the same arrays of quantifiers appear in their lexicons, and scopal interactions among quantifiers follow the usual patterns. However, some facts of the visual-manual modality have also been shown to be at play. The possibility to use simultaneous morphemes and signing space favors the marking of verbal plurality (or pluractionality) and distributivity through this means, for instance. Overt encoding of information-structural notions also interacts with the realization of tripartite quantificational structures. In addition, spatial distinctions have been shown to be at work in the expression of non-specific expressions or the size of sets involved in quantified phrases. More research is needed in a broader set of sign languages, but the results obtained so far justify the incorporation of sign language results in the comprehensive analysis of quantification in natural languages, as already proposed in Bach et al. (1995), Paperno & Keenan (2017), for instance.

Acknowledgments

Notes

[1] Set-theoretically, existential quantifiers are intersective, and universal quantifiers are co-intersective (see Keenan 2006 for the definitions).

[2] Note that the 18 languages do not represent a balanced typological sample, so the generalizations should be considered with some caution.

[3] Note that for some languages on the website many more signs have been collected than for others, so one cannot conclude that some languages lack these quantifiers altogether based on the website.

[4] Although it is debatable whether those are indeed D- and not A-quantifiers, according to Quer (2012).

[5] Note that despite the gloss, this sign conveys sentential negation and it does not work as a D-quantifier in the language. It always appears sentence-finally.

[6] Note, however, that in these examples the morphological marker on the verb is combined with a plurally marked NP; this is also possible in ASL (Petronio 1995).

[7] These notations were not used by Filimonova (2012), but we introduce them here for uniformity. Superficially, some of these forms look reminiscent of the allocative determinate and indeterminate forms in ASL as reported in Klima & Bellugi (1979), but a proper comparison has not been undertaken.

References

Abner, Natasha & Ronnie Wilbur. 2017. Quantifiers in American Sign Language. In Denis Paperno & Edward L. Keenan (eds.), *Handbook of quantifiers in natural language: Volume II*, 21–59. Cham: Springer.

Bach, Emmon, Eloise Jelinek, Angelika Kratzer & Barbara Partee. 1995. Introduction. In Emmon Bach, Eloise Jelinek, Angelika Kratzer & Barbara Partee (eds.), *Quantification in natural languages.* 1–11. Dordrecht: Kluwer.

Barberà, Gemma. 2015. *The meaning of space in sign language. Reference, specificity and structure in Catalan Sign Language discourse*. Berlin: De Gruyter Mouton & Ishara Press.

Barberà, Gemma & Josep Quer. 2013. Impersonal reference in Catalan Sign Language (LSC). In Laurence Meurant, Aurélie Sinte, Mieke van Herreweghe & Myriam Vermeerbergen (eds.), *Sign language research, uses and practices: Crossing views on theoretical and applied sign language linguistics*, 237–258. Berlin & Nijmegen: De Gruyter Mouton & Ishara Press.

Barberà, Gemma & Josep Quer. 2015. Conveying genericity in Catalan Sign Language (LSC). Presentation at the First SIGGRAM Meeting, Universitat Pompeu Fabra. April 21–22, 2019.

Boster, Charles T. 1996. On the Quantifier-Noun Phrase split in American Sign Language and the structure of quantified Noun Phrases. In William H. Emondson & Ronnie B. Wilbur (eds.), *International Review of Sign Linguistics, Volume 1,* 159–208. Mahwah, NJ: Lawrence Erlbaum.

Braze, David. 2004. Aspectual inflection, verb raising and object fronting in American Sign Language. *Lingua* 114(1). 29–58.

Champollion, Lucas. 2015. Every boy bought two sausages each: Distributivity and dependent numerals. In Ulrike Steindl, Thomas Borer, Huilin Fang, Alfredo García Pardo, Peter Guekguezian, Brian Hsu, Charlie O'Hara, & Iris Chuoying Ouyang (eds.), *Proceedings of the 32nd West Coast Conference on Formal Linguistics,* 103–110. Somerville, MA: Cascadilla Press.

Davidson, Kathryn & Deanna Gagne. 2014. Vertical representation of quantifier domains. In Urtzi Etxeberria, Anamaria Falaus, Aritz Irurtzun & Bryan Leferman (eds.), *Proceedings of Sinn und Bedeutung 18*. 110–127.

Evans, Nick. 1995. A-quantifiers and scope in Mayali. In Emmon Bach, Eloise Jelinek, Angelika Kratzer & Barbara Partee (eds.), *Quantification in natural languages,* 207–270. Dordrecht: Kluwer.

Filimonova, Elizaveta V. 2012. Sredstva vyraženija distributivnoj množestvennosti v russkom žestovom jazyke (Means of expressing distributive plurality in Russian Sign Language). In Olga V. Fedorova (ed.), *Russkij žestovij jazyk: pervaja lingvističeskaja konferentsija (Russian Sign Language: the first linguistic conference),* 82–97. Moscow: Buki Vedi.

Heim, Irene. 1982. *The semantics of definite and indefinite Noun Phrases*. Amherst: University of Massachusetts at Amherst dissertation.

Kamp, Hans. 1981. A theory of truth and semantic representation. In Jeroen Groenendijk, Theo Janssen & Martin Stokhof (eds.), *Formal methods in the study of language, Part 1*, 277–322. Amsterdam: Mathematisch Centrum.

Keenan, Edward L. 2006. Quantifiers: semantics. In Keith Brown (ed.), *Encyclopaedia of language and linguistics Vol. 10*, 302–308. Amsterdam: Elsevier.

Keenan, Edward L. & Denis Paperno. 2012. Overview. In Edward L. Keenan & Denis Paperno (eds.), *Handbook of quantifiers in natural languages,* 941–949. Dordrecht: Springer.

Kelepir, Meltem, Aslı Özkul & Elvan Tamyürek Özparlak. 2018. Agent-backgrounding in Turkish Sign Language (TİD). *Sign Language & Linguistics* 21(2). 258–284.

Kimmelman, Vadim. 2015a. Distributive quantification in Russian Sign Language. Paper presented at *Barcelona FEAST*, May 4–6.

Kimmelman, Vadim. 2015b. Quantifiers in RSL: distributivity and compositionality. In Peter Arkadiev, Ivan Kapitonov, Yury Lander, Ekaterina Rakhilina & Sergei Tatevosov (eds.), *Donum Semanticum,* 121–134). Moscow: Jazyki Slavjanskoj Kuljtury.

Kimmelman, Vadim. 2017. Quantifiers in Russian Sign Language. In Denis Paperno & Edward L. Keenan (eds.), *Handbook of quantifiers in natural language: Volume II*, 803–855. Cham: Springer.

Klima, Edward S., & Ursula Bellugi. 1979. *The signs of language*. Harvard: Harvard University Press.

Krifka, Manfred, Francis Jeffry Pelletier, Gregory N. Carlson, Alice ter Meulen, Gennaro Chierchia & Godehard Link. 1995. Genericity: An Introduction. In Gregory N. Carlson & Francis Jeffry Pelletier (eds.), *The generic book*, 1–124. Chicago: The University of Chicago Press.

Kuhn, Jeremy. 2017. Dependent indefinites: The view from sign language. *Journal of Semantics 34*(3). 449–491.

Kuhn, Jeremy. 2019. Pluractionality and distributive numerals. *Language and Linguistics Compass* 13(2). e12309.

Kuhn, Jeremy & Valentina Arsitodemo. 2017. Pluractionality, iconicity, and scope in French Sign Language. *Semantics and Pragmatics* 10(6).

Matthewson, Lisa (ed.). 2008. *Quantification: A cross-linguistic perspective*. Bingley: Emerald.

Meier, Richard P. 2012. Language and modality. In Roland Pfau, Markus Steinbach & Bencie Woll (eds.), *Sign Language. An International Handbook* (*HSK - Handbooks of Linguistics and Communication Science*), 574–601. Berlin: Mouton de Gruyter.

Paperno, Denis & Edward L. Keenan (eds.). 2017. *Handbook of quantifiers in natural language: Volume II*. Cham: Springer.

Partee, Barbara. H. 1992. Topic, Focus, and Quantification. In Steven K. Moore & Adam Zachary Wyner (eds.), *Proceedings of SALT I*, 159–189. Cornell University: DMLL Publications.

Partee, Barbara H. 1995. Quantificational Structures and Compositionality. In Emmon Bach, Eloise Jelinek, Angelika Kratzer & Barbara Partee (eds.), *Quantification in natural languages.* 541–601. Dordrecht: Kluwer.

Petronio, Karen. 1995. Bare noun phrases, verbs and quantification in ASL. In Emmon Bach, Eloise Jelinek, Angelika Kratzer & Barbara Partee (eds.), *Quantification in natural languages,* 603–618. Dordrecht: Kluwer.

Quer, Josep. 2012. Quantificational strategies across language modalities. In Maria Aloni, Vadim Kimmelman, Floris Roelofsen, Galit Sassoon, Katrin Schulz, Matthijs Westera (eds.), *Selected papers from 18th Amsterdam Colloquium,* 82-91. Berlin: Springer.

Quer, Josep. 2019. Reduplication revisited: verbal plurality and exhaustivity in the visual-gestural modality. *Sensos-e* VI (1). sensos-e.v6i1.3459

Quer, Josep & Markus Steinbach. 2015. Ambiguities in sign languages. *The Linguistic Review* 32(1). 143–165.

Quer, Josep, Carlo Cecchetto, Roland Pfau, Caterina Donati, Markus Steinbach, Carlo Geraci & Meltem Kelepir (scientific directors). 2017. *SignGram Blueprint. A guide to sign language grammar Writing*. Berlin: De Gruyter Mouton.

Sandler, Wendy & Diane Lillo-Martin. 2006. *Sign language and linguistic universals*. Cambridge, UK: Cambridge University Press.

Schlenker, Philippe. 2011. Quantifiers and variables: Insights from Sign Language (ASL and LSF). In Barbara H. Partee, Michael Glanzberg and Jurģis Šķilters (eds.), *Formal Semantics and Pragmatics: Discourse, context, and models*. The Baltic International Yearbook of Cognition, Logic and Communication, Vol. 6.

Schlenker, Philippe. 2012. Generalized Quantification and Anaphora Across Ontological Domains: Evidence from ASL [squib]. *UCLA Working Papers in Linguistics* 17.

Schlenker, Philippe. 2018. Visible Meaning: Sign language and the foundations of semantics. *Theoretical Linguistics* 44(3–4). 123–208.

Schlenker, Philippe, John Lamberton & Mirko Santoro. 2013. Iconic Variables. *Linguistics and Philosophy* 36(2). 91–149.

Steinbach, Markus. 2012. Plurality. In Roland Pfau, Markus Steinbach & Bencie Woll (eds.), *Sign language: An International Handbook* (*HSK - Handbooks of Linguistics and Communication Science*), 112–236. Berlin: De Gruyter Mouton.

Wilbur, Ronnie B., & Cynthia Patschke. 1999. Syntactic correlates of brow raise in ASL. *Sign Language & Linguistics* 2(1). 3–41.

Zeshan, Ulrike, Cesar Ernesto Escobedo Delgado, Hasan Dikyuva, Sibaji Panda & Connie de Vos. 2013. Cardinal numerals in rural sign languages: Approaching cross-modal typology. *Linguistic Typology* 17(3). 357–396.