On the morphosyntactic representation of dependent quantification: distance distributivity, dependent indefinites, and Skolemization[1]

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Abstract. It is commonly assumed that distance distributive elements like binominal *each* are operators that may or may not be related to other instances of the word *each* (e.g., floated *each*). We propose instead that binominal *each* is a bound variable in the Skolem term denoted by the indefinite noun phrase that *each* appears adjacent to. We argue that this approach captures various generalizations about the distribution of distance distributive elements within and across languages, and in particular it unifies distance distributivity with dependent indefinites as instances of the more general idea that languages sometimes morphologically mark 'dependent quantification.'

Keywords: distance distributivity; indefinites; typology; choice functions; Skolemization; variables; dependent quantification.

1. Introduction

The word *each* can appear as a prenonimal quantifer (1a), as a floated quantifier (1b), or as a distance-distributive element (1c), so-called 'binominal each' (Safir and Stowell, 1988).

(1) a. PRENOMINAL: Each boy lifted a table.
b. FLOATED: The boys each lifted a table.
c. BINOMINAL: The boys lifted a table each.

The sentences in (1) are equivalent; they all assert that for each boy x, there is a table y such that x lifted y. At some level of logical analaysis, then, they are $\forall\exists$ sentences. How do these sentences come to have a $\forall\exists$ meaning? This meaning is transparently reflected in the surface structure of (1a), but it is less so in (1b) and (1c). Consider (1c). If *each* is a distributive quantifier that universally quantifies over the set of boys, how does it manage to do this from a distance?

A quite straightforward analysis of (1c) is suggested by Heim et al.'s (1991) analysis of (1b). First consider a minimal variant of (1b) in which *each* has been removed, as in (2) below: the resulting sentence is ambiguous between a collective reading under which *the boys* refers to a

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plural individual, (2a), and a distributive reading under which the set of boys serves as the domain for a universal quantifier, (2b).

(2) The boys lifted a table.
  a. COLLECTIVE/REFERENTIAL READING: The boys collectively lifted a table.
  b. DISTRIBUTIVE/QUANTIFICATIONAL READING: The boys each lifted a table.

Note that the reading in (2b) is paraphrased by (1b). Furthermore, the surface forms of (2) and (1b) are similar, differing only in whether there is an overt *each*. It might thus be worth considering the possibility that (2) under its reading (2b) has the same logical form as (1b). Suppose we assume with Heim et al. (1991) that the reading in (2b) is derived by insertion of a covert distributive operator, D, whose meaning is identified with the meaning of floated *each*: $[[D]] = [[\textit{each}]]$.[2] Structurally, it is assumed that *the boys* combines with D to create a universal quantifier *the boys* D whose meaning can be paraphrased as *the boys each*. The $\forall\exists$ LF thus follows with the indefinite object remaining in the scope of the universal quantifier *the boys* D in (2b) and *the boys each* in (1b); the only relevant difference between them is whether the distributor is the covert D or its overt variant *each*. Assuming this, the LF for (1c) could be derived if *each* could swap its relative order with the VP, in (1c) *lifted a table*.

The proposal is clearly committed to the idea that floated and binominal *each* are the same lexical item, and that – despite surface appearances – these instances of *each* are different from prenominal *each* (see also Kobuchi-Philip, 2006). Note also that under this analysis no new lexical entries are needed to accommodate binominal *each* into the grammar; the stipulations instead would all have to do with the rules that would allow *each* in (1c) to appear in surface form far away from its LF position (transparently realized in (1b)). Under the current analysis this might be due to principles governing overt movement or linearization of structures. There are other ways of avoiding lexical stipulations to accommodate binominal *each*. For example, Champollion (2012) posits floated *each* as the basic entry and derives others via type-shifting operations. Call any approach that aims to reduce binominal *each* to floated *each* a 'reductionist operator' account: under such proposals binominal *each* is an operator that is not listed in the lexicon as a separate entry, but is intead the result of the application of some grammatical rule to an already existing entry for floated *each*.

We think there are reasons to doubt that any such reductionist account is viable. As we argue in the next section, reductionist approaches are challenged by distributional evidence that binominal *each* is to be treated as something special, different from floated *each* and different from prenominal *each*. We remind the reader of some of this evidence in the next section. It is perhaps because of such observations that several analyses of (1c) have proposed a special lexical entry for binominal *each*. For example, after presenting empirical evidence against the analyses of Blaheta (2003) and

[2] Simplifying for present purposes, we assume $[[D]] = \lambda X_e.\lambda P_{et}.\forall x \bullet\sqcap X : P(x)$ (here we interpret "$\bullet\sqcap$" as 'atomic-proper-part-of').

Zimmermann (2002a), Dotlačil (2012) proposes that binominal *each* is an operator that functions as the determiner of *a table* in (1c), and it introduces a distributivity operator which, in effect, extracts the atoms of the plural subject in compositional interpretation and allows the sentence to assert that each of the boys lifted a table.[3] Call any approach that accounts for (1c) by positing a lexical entry for binominal *each* a *lexical operator* account. The problem for such an approach is not that it cannot explain the peculiar properties of binominal *each* that we highlight in the next section; instead, the problem is that it can explain too much, because the researcher is free to stipulate whatever facts are needed in the lexical entry itself. We will see in particular that there are cross-linguistic expressions of distance distributivity, such as so-called 'dependent indefinites,' that involve no distributive element at all but instead are expressed through reduplication. If the account of binominal *each* is to be unified with languages that use such mechanisms, it is difficult to see how lexical stipulations about the inventory of distributive operators could be helpful.

The goal of our paper is to take steps toward resolving this tension between description and explanation. We provide a perspective on binominal *each* which aims to (i) capture the ways in which it is different from prenominal and floated *each*, and (ii) unify it with cross-linguistic expressions of distance distributivity such as dependent indefinites. We will argue that we can make progress toward this goal with the assumption that natural languages sometimes mark dependent quantification, although they vary according to choices that we try to identify. Under our proposal, markers of distance-distributivity like binominal *each* are not operators but are instead bound variables. Together with independently motivated assumptions about existential quantification in natural language, we will suggest that the approach has some welcome consequences that might improve our understanding of the interaction between morphosyntax and quantifier alternations. However, the approach replaces stipulations about semantic entries with stipulations about the overt realization of syntactic forms, and the approach makes predictions that in some cases seem to be at odds with the facts. Nevertheless, we hope the questions that are raised are worth pursuing.

2. Is Binominal *each* special?

2.1. Distributional evidence that dissociates binominal *each* from floated and prenominal *each*

There are various observations about the distribution of binominal *each*, many of them from the syntactic literature, that we take to be essential to any characterization of distance distributivity. First, Safir and Stowell (1988) noted that, unlike other instances of *each*, binominal *each* (i) cannot occur with an intransitive verb (cf. (3)), (ii) cannot remain in-situ when the object is displaced (cf. (4)), and (iii) must attach to an indefinite noun phrase, i.e., a noun phrase that can be analyzed with existential quantification (cf. (5)).

(3) Binominal *each* disallowed with intransitive verbs

a. PRENOMINAL: Each boy walked.

[3] The theory is formalized in Plural Compositional DRT (Brasoveanu, 2007).

b. FLOATED: The boys each walked.
c. BINOMINAL: *The boys walked each.

(4) Binominal *each* cannot remain in-situ when object is displaced
a. PRENOMINAL: How many tables did each boy lift?
b. FLOATED: How many tables did the boys each lift?
c. BINOMINAL: *How many tables did the boys lift each?

(5) Binominal *each* can only attach to an indefinite noun phrase.[4]
a. PRENOMINAL: Each boy lifted {a table/two tables/the table/no table}.
b. FLOATED: The boys each lifted {a table/two tables/the table/no table}.
c. BINOMINAL: The boys lifted {a table/two tables/*the table/*no table} each.

From these and other observations, Safir and Stowell (1988) conclude that binominal *each* is syntactically contained inside the NP it appears adjacent to on the surface, and moreover this host must be an indefinite noun phrase.

Binominal *each* also behaves like an anaphor in the sense of the binding theory. In particular, like reflexives, binominal *each* is subject to Condition A (Dotlačil, 2012; see also Hudson, 1970; Kayne, 1981; Burzio, 1986):

(6) Binominal *each* must be locally bound:
a. LOCAL BINDING: Mary said the boys lifted a table each/Mary said John loves himself
b. NON-LOCAL BINDING: *The boys said Mary lifted a table each/*John said Mary loves himself.[5]

Furthermore, note that binominal *each* doesn't seem to *add* anything to the sentences in which it occurs; for example, the meaning of (1c) is one of the readings of the corresponding sentence without *each* (sentence (2)). We know of no operators in natural language that manipulate the set of readings assigned to a sentence, but this is what binominal *each* seems to be doing.

This seems to be a peculiar combination of properties, and other *each*s like floated *each* do not share all of them. This makes it less attractive to derive binominal *each* as an instance of floated

[4] This evidence is further supported by the results of a recent offline questionnaire (DiGiovanni et al., 2015).

[5] The first sentence cannot mean that each of the boys said Mary lifted a table, and the second sentence cannot mean that John said Mary loves him.

each. At the same time, it does not seem to be an accident that the *each*s in (1) share the same overt form. For instance, the sentences in which they occur all express distributive universal quantification. In some other languages like Swedish the overt variants of *each* are not identical, but they are clearly related. For example, prenominal *each* is *varje* and binominal *each* is *var*, and there is also a possessive *varsin* that can be used to get at a similar meaning:

(7) Swedish: *varje, varsin, var*

a. PRENOMINAL:
Varje flicka drack en öl
each girl drank a beer
'Each girl drank a beer.'

b. POSSESSIVE:
Barnen läste **varsin** bok.
children.the read each.POSS book
'The children read a book each.'

c. BINOMINAL:
Flickorna drack en öl **var**.
girls.the drank a beer each
'The girls drank a beer each

The words *var, varje, varsin* are closely related in overt form and meaning, and they seem historically related. The German determiner *each* is *jeder* and its distance-distributive element is *jeweils* (Zimmermann, 2002b); these also seem related on their surface (we return to *jeweils* in section (2)). These observations might again call for a unified analysis of these different constructions. However, it is not clear how to reconcile this closeness with the cluster of properties identified above as peculiar to binominal *each*. Furthermore, once we turn away from Germanic languages we see a complete divorce between distance distributivity and the inventory of distributive quantifiers in the languages. Such languages continue to use morphological marking on indefinites to enforce a distributive reading of an otherwise ambiguous sentence, but the marker often bears no obvious relation to distributive quantifiers in the language. We now turn to some of this evidence.

2.2. Typological evidence that binominal *each* is part of a broader generalization

Many languages express distance distributivity with markers that are unrelated to prenominal and floated *each* but which nevertheless continue to share the cluster of properties identified for binominal *each*. For example, many languages express distance distributivity not by insertion of an apparently distributive lexical item, but by reduplication of the numeral in the indefinite noun phrase. For example, in East Cree (Junker, 2000), just as in English, a sentence like *the boys* *lifted two tables* displays a collective/distributive ambiguity (see (8a)), but unlike English, it disambiguates in favour of the distributive reading by reduplicating the numeral (see (8b); see also Farkas (1997) for Hungarian, Yanovich (2005) for Russian, Balasu (2005) for Telugu, a.o.).

(8) EAST CREE (JUNKER, 2000)

a. COLLECTIVE/DISTRIBUTIVE AMBIGUITY:
Peyakw waapiminh chii muweuch anchii awaashach.
one apple PAST eat those children
'The children ate one apple.'

b. DISTANCE DISTRIBUTIVITY VIA REDUPLICATION:
Paahpeyakw waapiminh chii muweuch anchii awaashach.
REDUP.one apple PAST eat those children
'The children ate one apple each.'

What is crucial, again, is that there is a collective/distributive ambiguity which is resolved by adding some morphology to the (necessarily) indefinite noun phrase. English does this with insertion of a lexical item, and East Cree does this by reduplicating the indefinite determiner. In fact, even in languages that express distance-distributivity by insertion of a lexical item, the lexical item often has no surface relation to distributive quantifiers in the language. Instead, what remains essential is that the element needs to appear adjacent to an indefinite noun phrase and that it is interpreted in the scope of a universal quantifier. Consider the Slavic distance-distributive element *po* (Pesetsky, 1982; Przepiórkowski, 2008), illustrated in (9) with an example from Serbo-Croatian:

(9) SERBO-CROATIAN *po*
Dječaci su kupili *po* dvije kobasice.
boys AUX bought PO two sausages
'The boys ate two sausages each.'

First, note that *po* is morphologically distinguished from the distributive universal quantificational determiner *každogo*, and Slavic *po* is sometimes syntactically analyzed as a preposition.[6] Second, when Slavic *po* appears in subjects with a downstairs universally quantified object, the universal quantifier *must* outscope the indefinite (see (10); note that the surface string *jabloku* is consistent with a definite and an indefinite interpretation, but *po* disambiguates in favour of the indefinite):[7]

[6] For discussion see e.g., Kuznetsova (2005), Przepiórkowski (2008, 2010), Milačić (2014).

[7] See Przepiórkowski and Patejuk (2013) and Harves (2003) for relevant discussion; example (10) is in Russian, from Harves (2003).

(10) *Po* ENFORCES A ∀∃ INTERPRETATION
Po jabloku upalo s každogo dereva.
PO apple fell from every tree
'A (different) apple fell from every tree.'

There seems to be no way around a ∀∃ reading when *po* occurs in a sentence. In fact, the higher universal quantifier need not even be overt. For example, in the Bulgarian example in (11) (from Champollion 2012), the higher quantifier is probably a higher covert universal quantifier over times/situations/events; for example, the intended meaning here is that every morning, there is a set of five miles that Mary runs before breakfast.[8]

(11) HIGHER ∀ CAN BE COVERT
Mariya byaga *po* pet mili predi zakuska.
Mary runs PO five miles before breakfast
'Mary runs five miles before breakfast (every morning).'

In fact, the German *jeweils* also seems to allow distribution over individuals and – when there is no overt quantifier over individuals – also over times/events/situations (Zimmermann, 2002b):

(12) GERMAN *jeweils* DISTRIBUTES OVER INDIVIDUALS AND TIMES

a. INDIVIDUALS:
Die Jungen kauften **jeweils** drei Würstchen.
the boys bought each three sausages
'The boys bought three sausages each.'

b. TIMES:
Jeweils ein Apfel war verrottet.
each one apple was rotten
'One apple was rotten each time/in each basket.'

When the higher universal quantifier is covert, as in (11) and (12b), the context provides a domain, but the *force* of the quantifier is universal.

[8]For the purposes of this paper we will not take a stance on what the domain is in these cases. They are abstract, contextually determined entities that are universally quantified over. See Lewis (1975) and Heim (1990) (among others) for arguments that covert universal quantifiers of this kind might be needed for independent reasons.

2.3. Summary

We have seen that binominal *each* has distributional restrictions that suggest it should not be assimilated with floated or prenominal *each*. At the same time, cross-linguistically we find that distance-distributive markers need not have any connection to distributive quantifiers in the language (e.g., they can be numerals). Instead, they are required to occur on indefinite noun phrases and they enforce a $\forall\exists$ interpretation. At the same time, languages differ in the ways in which these constraints are satisfied. For example, some languages mark the indefinite with a new lexical item while others reduplicate the numeral. Languages also differ concerning constraints on the higher universal quantifier: English requires the binder to be a locally c-commanding quantifier over individuals, while Slavic allows covert quantifiers over times. In the next section we propose that these constraints teach us that natural language provides certain morphosyntactic means for expressing *dependent quantification* in ways that we hope to make precise.

3. Morphological marking of dependent quantification

What we have cross-linguistically is a class of sentences that receive a $\forall\exists$ interpretation when $\exists$ is morphologically marked (e.g., *the boys lifted a table each*), and the sentence without this marking (e.g., *the boys lifted a table*) can also receive a $\forall\exists$ interpretation as one of its readings. Call the marked sentence S^+ and the unmarked variant S^- (we will use S^- to refer to either the sentence or to its distributive reading – we hope no confusion arises). The intuition we would like to pursue is that the equivalence between S^+ and S^- is formally represented. Specifically, we suggest that S^+ and S^- are alternative pronunciations of the same LF. Crucially, under our proposal distance distributive elements are *not* overt realizations of the covert distributor D, nor do they realize any other distributive operator. Instead, we propose that they are the overt realization of a variable that is also present but unpronounced in S^-. This is a stipulation about the syntax-phonology interface, but we believe it can be made natural – reducing to a local choice – with antecedently motivated assumptions about existential quantification in natural language, and in particular with the assumption that *dependent quantification* can be explicitly represented in the grammar.

Before analyzing S^+ and S^-, consider more transparent $\forall\exists$ sentences like (13a) (= (1a)) and its familiar first-order logic representation in (13b) (we assume restricted quantifier notation):

(13) $\forall\exists$ SENTENCES
  a. Each boy lifted a table
  b. $[\forall x : boy(x)][\exists y : table(y)](lifted(x, y))$

An important property of $\forall\exists$ quantifier-alternations is that choice of witness for the existential quantifier *depends* on choices made for the universal quantifier: choices of tables will vary with choices of boys. In $\exists\forall$ alternations there is no such dependence (cf. *there is a table that was* *lifted by each boy*). The notation in (13b) does not formally represent this dependence between the variables, but the so-called 'Skolem Normal Form' of (13b) does: it articulates in the LF itself that there is a function f such that for each boy x, $f(x)$ is a table associated with individual x and x lifted $f(x)$; the sentence is true just in case there is such a function (i.e., just in case there is a Skolem function for the sentence).[9]

(14) SKOLEMIZATION:
$\exists f[\forall x : boy(x)[(lifted(x, f(x, table)))]]$

It is known that whenever (13b) is satisfiable (14) is too.[10] Thus, there are two quite plausible candidates for the 'right' representation of *each boy lifted a table*: (13b) and (14). Is there any reason to pick one representation over the other? There is a large literature on the relative (dis-)advantages of a choice-functional treatment of indefinites (Skolemized or not), including the apparent island-escaping behaviour of indefinites, and the (im-)possibility of branching quantification.[11] We will not enter that important discussion here. However, we hope our discussion here might be relevant to it. Specifically, we believe access to Skolem functions, as in (14), might allow us to unify dependent-indefinites and distance-distributivity as instances of the following generalization:

(15) MORPHOLOGICAL MARKING OF DEPENDENT QUANTIFICATION:
Languages may optionally mark dependent quantification.

Recall from our discussion above that $\forall\exists$ is the only case of dependent-quantification in first-order logic.[12] It is thus unsurprising that these are precisely the configurations that give rise to this apparent optionality, as evidenced by the optional marking of $\exists$ in sentences like *the boys lifted a table (each)*. Our proposal is that the distributive reading of *the boys lifted a table* (= S^-) and *the boys lifted a table each* (= S^+) both have the LF in (14), and that the optional pronunciation is possible because of (15). The higher universal quantifier is generated by *the boys* D (where

[9]More generally, every first-order formula has a Skolem Normal Form. First, any first-order formula can be converted into a prenex normal form with a string of universal quantifiers followed by a string of existential quantifiers. Skolemization eliminates all existential quantifiers and replaces them with Skolem terms, functions f which take as input values for the universal quantifier governing the eliminated existential and returning values for the existential that make the proposition true. For example, the Skolem Normal Form for $\forall x\exists y\forall u\exists w(R(x, y, u, w))$ is $\exists f\exists g\forall x\forall u(R(x, f(x), u, g(x, u)))$. When the existential outscopes any universal quantifier, e.g., in a $\exists\forall$ configuration, the Skolem term returns a constant. For example, the Skolem Normal Form for $[\exists x : Ax][\forall y : By](R(x, y))$ would be $\exists f[\forall y : By](R(f(A), y))$. Here the function is a pure choice-function.

[10]The following statement is equivalent to the Axiom of Choice (e.g., Bell, 2009): $[\forall x \in A][\exists y \in B](R(x, y)) \Rightarrow \exists f : A \to B[\forall x \in A](R(x, f(x)))$.

[11]On the connection to exceptional scope, see e.g., Reinhart (1997); Winter (1997); Schwarz (2001, 2004); Chierchia (2001); Schlenker (2006); Matthewson (1999); Kratzer (1998). On the connection to branching quantification, see e.g., Hintikka (1973); Barwise (1979); Sher (1990); Schlenker (2006).

[12]Natural languages of course extend beyond the resources of first-order quantification. See section 4.

D is a distributor, cf. note 2), and the lower indefinite *a table (each)* realizes the Skolem term $f(x, table)$.[13] The variable x can be realized as zero, resulting in S^-, or it can be realized as *each*, in which case S^+ is produced. Of course if the variable is left unrealized, the sentence S^- is ambiguous between a collective and a distributive reading; on the collective reading, there is no quantifier-dependence, and the indefinite is thus a pure choice function: $f(table)$ (see note 9).

More generally, we follow Steedman (2011) in assuming that indefinites like *a table* denote *variable-arity* Skolem terms: $f(x_1, \ldots, x_k, table), 0 \leq i \leq k$. We furthermore assume that x_i is licensed as an input to f only if there is a higher universal quantifier $\forall x_i$ (cf. **Mary read a book each*). Thus it will always be possible to understand *a table* as denoting $f(table)$ (corresponding to so-called 'wide-scope indefinites'), but if there is a higher universal quantifier $\forall x_i$ it may be possible to understand *a table* as $f(x_i, table)$. How many variable arguments can there be in a Skolem term? Formally any number from 0 (a Skolem constant) to the number of higher universal quantifiers is allowed. However, there are reasons to think the higher quantifiers (if any) that may govern variables in the Skolem term are tightly constrained. First, because of the Condition A facts noted in section (2.1), the variable arguments to Skolem terms (in English) must be specified as anaphors in the sense of the binding theory, and thus only *locally* c-commanding quantifiers may govern a variable in a Skolem term. A universal quantifier that is too far up will not be able to do this. For example, there is no distributive reading of *the boys said Mary lifted a table* (this sentence cannot mean that the boys each said Mary lifted a table; there is a single, collective telling event). Second, when there are *two* possible governing quantifiers, it seems that the grammar forces speakers and hearers to pick one. For example, in (16c) below, the sentence cannot mean that each teacher gave each student a possibly different book, even though *the teachers* and *the students* can both bind into *a student each* (cf. (16a), (16b)). The sentence either means that each teacher gave the collection of students a (possibly different) book, or it means that the teachers collectively gave each student a (possibly different) book; only one binder seems to be permitted.

(16) ONLY ONE GOVERNING QUANTIFIER ALLOWED

a. The teachers gave Mary a book each.
b. Mary gave the students a book each.
c. The teachers gave the students a book each.

For the moment, we therefore tentatively assume that there can be maximally one binder, i.e., that $0 \leq k \leq 1$.

In the appendix we provide a more explicit statement about our assumptions concerning the syntax, semantics, and pronunciation of Skolem terms. Here we would like to highlight ways in which the

[13] As noted earlier (note 9), Skolem terms generally have variable arity. The terms can be $f(table), f(x_1, table), f(x_1, x_2, table)$, and so on. We will see evidence below that natural languages constrain the arity of these functions. See also the appendix.

approach captures the generalizations discussed in section (2). First, the observation that only indefinites can host binominal *each* follows from the independently motivated assumption that indefinites denote Skolem terms and nothing else does. Second, the binding facts follow from the assumption that English binominal *each* is a bound-variable (NB: the variable must be stipulated to be an anaphor). We might thus expect to find variable-like behaviour in other constructions. For example, we seem to find crossover effects with binominal *each*:

(17) CROSSOVER EFFECTS

a. A table was lifted by the boys (only collective reading allowed)
b. A table {*each} was lifted by the boys.

Finally, the connection to so-called 'dependent indefinites' is clear: given (15), languages may mark dependent quantification, but it seems they have options concerning the way in which this is done.[14] At the moment, the typology suggests that there are two ways of marking this dependence: reduplicating the indefinite (RED) or inserting a new lexical item (LI). Languages also differ in the constraints on the domain of the higher universal quantifier (see Champollion, 2012): all languages allow the higher quantifier to quantify over individuals, but some are restricted to distributing only over individuals (I), while some also distribute over times/situations/events (T), while some further allow quantification over worlds (W) (we seem to have an implicational hierarchy: any language that allows distribution over worlds also allows distribution over times, and any language that allows distribution over times also allows distribution over individuals). We can thus state the typology in terms of the two independent choices: how the indefinite is marked vs what may be quantified over. In (18) we present a table showing the possible choices a language can make, together with examples of languages known to us that make one or the other choice.

(18) TYPOLOGY: MARKING $\exists$ VS CONSTRAINTS ON DOMAIN OF $\forall$

	RED	LI
I	Hungarian (Farkas, 1997)	English (Champollion, 2012)
T	Telugu (Balasu, 2005)	German (Zimmermann, 2002b)
W	?	Russian (Pereltsvaig, 2008)

To illustrate, we have seen that English is a $[I, LI]$ language. Given our discussion in section (2) languages like Serbo-Croation and German are $[T, LI]$ languages. We fill out the cells of the table with examples of languages that have been documented in detail elsewhere (for reasons of space we avoid fuller discussion, and we refer the reader to the relevant literature). At the moment, we do not know of any $[W, RED]$ language, but the possibility of such a language is suggested.

[14]Thus, unlike the approach in Brasoveanu and Farkas (2011), which takes quantifier *independence* as central (following Hintikka's Independence-Friendly Logic), we take quantifier dependence as central, and Skolem functions are a central way of making this dependence explicit. We hope to return in future work to a fuller comparison.

4. Concluding remarks

We have proposed to unify distance distributivity with dependent indefinites as instances of the more general idea that languages can mark dependent quantification. Under our proposal, distance-distributive elements are not operators, but are instead the overt realization of a bound variable in a Skolem term. No new semantic machinery is assumed, but the data here seem to argue for a choice-functional treatment of indefinite noun phrases. In fact, the representation of quantifier-dependence via Skolem functions takes choice to be central to quantification more generally; choices of values for $\exists$ will vary with choices for values for $\forall$.

Many questions are raised. For example, the approach predicts that as far as the grammar is concerned any $\forall\exists$ configuration should allow for marking of $\exists$. Thus, a sentence like (19) should be acceptable:

(19) #/? Every boy read a book each

Some speakers report the sentence as acceptable (see Szabolcsi, 2010 for discussion), which might be taken as support for our proposal. Unfortunately, the sentence seems marked to many speakers, at least compared with the perfect (1c). If these negative judgments are representative, they would need to be explained. Dotlačil (2012) suggests an economy condition on the use of binominal *each*: it may be used only if the sentence without it is not already distributive. In a sentence like (19), overtly realizing *each* seems to serve no function, but it is not clear why this should matter if the LF has a variable inside there anyways. We hope to return to this in future work.

A further question concerns possible extensions to c-commanding quantifiers other than $\forall$. The core of our proposal concerns quantifier-dependence: choices of values for existential quantifiers depend on choices of values for other variables. There seems to be no *a priori* reason why this should be limited to $\forall\exists$ configurations. Again, more data are needed to see the appropriateness of quantifiers other than $\forall$, but here we report our judgments on some potentially interesting cases:

(20) {#Many/#most/#no/three} boys read a book each

Finally, we might also inquire into constraints on which functions f are admissible (see e.g., Kratzer, 1998). For example, there is a strong intuition that f must be 'one-to-one,' and there are suggestions that in Swedish this is mandatory (e.g., Teleman et al., 1999).

A. Appendix for binominal *each* in English

(21) INDEFINITE NOUN PHRASES: SYNTAX-SEMANTICS

a. The LF representation of an indefinite NP *a(n) B* is a variable-arity Skolem Term, with variation assumed here to be limited to either nullary Skolem terms (= $f(B)$) or unary Skolem terms ($f(x, B)$).

b. A *nullary Skolem term* $f(B)$ is a choice-function on B, and a *unary Skolem term* $f(x, B)$ is a function mapping individual x and set B to an element of B.

c. A *choice function* is a function such that for any non-empty set P, $f(P) \in P$.

d. A unary Skolem term $f(x, B)$ is licensed only if the constituent *a(n) B* is locally c-commanded by an occurrence of $\forall x$.

(22) INDEFINITE NOUN PHRASES: SYNTAX-PHONOLOGY

a. Constituent $f(B)$ is pronounced *a(n) B*.

b. Constituent $f(x, B)$ is pronounced *a(n) B (each)*.

c. Among the set of phonological rules governing the pronunciation of variables, there is the following context-sensitive rule:
$x \rightarrow \{\emptyset$, *each*$\}/f(\_, Z)$ (x is any variable ranging over individuals and Z is any string).

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