Distance distributivity and Skolemization

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1. Introduction The sentence *The boys bought a sausage* has two readings. On the collective or referential reading, the boys as a group bought a sausage. On the distributive or quantificational reading, each individual boy bought a sausage. Here, any of the commonly assumed proposals for deriving these readings will suffice (e.g., Link 1983; Heim, Lasnik & May 1991). Our interest is with the semantics of so-called 'binominal *each*', which forces the distributive reading:
(1) The boys bought a sausage *each*.
Binominal *each* is sometimes called a 'distance distributive' (DD) element (Zimmermann 2002a) because it is attached to an element, the so-called 'distributed share' (Choe 1987; *a sausage* in (1)), but distributes over a non-local constituent, the 'sorting key' (Choe 1987; *the boys* in (1)). DD elements are realized in many languages, including Slavic (Pesetsky 1982; Przepiórkowski 2008) and Scandinavian (Teleman, Hellberg & Andersson 1999 vol. 2, p.388; Zimmermann 2002a):
(2) Dječaci su kupili *po* jednu kobasicu. (Serbo-Croatian)
boys AUX bought PO one sausage
(3) Pojkarna köpte *varsin* korv. (Swedish)
boys.the bought each.POSS sausage
The Serbo-Croatian preposition *po* and the Swedish possessive *varsin*, like English binominal *each*, force a distributive reading: (2) and (3) are equivalent to (1).

2. The challenge Several generalizations about DD elements have not, to our knowledge, received a unified account. We highlight four such generalizations common to the above languages and attempt to account for them in section 3. In section 4, we explore an extension to our proposal with the aim of accounting for apparent cross-linguistic variation.

Taking (1) as our running example, the generalizations we wish to highlight are: (i) The DD element forms a constituent with the distributed share (Hudson 1970; Safir & Stowell 1988; *a sausage each* is a constituent). (ii) The distributed share must be semantically indefinite (Postal 1974; Safir & Stowell 1988; *the boys bought* {*two/many/*the/*no*} *sausages each*). (iii) The DD element is 'anaphorically related to' the sorting key (Hudson 1970; Burzio 1986). (iv) (1) is truth-conditionally equivalent to one of the readings of a minimal variant of (1) derived by removing *each*. Specifically, (1) is equivalent to the distributive reading of *the boys bought a sausage* (Dotlačil 2012).

The syntactic literature on the distribution and apparent anaphoric nature of binominal *each* says little about the semantics of DD elements or the sentences containing them. Semantic pro-

posals, on the other hand, seem to introduce semantic machinery that is not independently motivated. Previous proposals provide novel lexical entries for DD elements (e.g., Zimmermann 2002a; Blaheta 2003; Kobuchi-Philip 2006; Dotlačil 2012), but this allows the researcher to essentially stipulate in the entry whatever properties are desired. Our goal is to pursue a more conservative approach that only reuses semantic machinery already needed to account for sentences without DD elements. Specifically, we propose that DD elements are an overt realization of variables present in LFs of sentences like *the boys ate two sausages*. Binominal *each* is thus like floated *each* in being an overt reflection of a bound variable (Kayne 1981; Belletti 1982; Sportiche 1988).

3. Our proposal: Skolemization Building on an insight of Zimmermann (2002b), we propose an analysis of DD elements that crucially involves Skolemization. However, we hope to implement his suggestion in a more straightforward way by avoiding some of the problematic assumptions in his proposal, such as the counter-intuitive assumption that the DP *a sausage each* contains a small-clause and a PP and denotes an open proposition. The starting point of our proposal is that the DD element is attached to indefinite NPs in sentences with the logical form in (4) (cf. (iv) above):

(4) Logical Form of (1), (2), and (3): $[\forall x : A(x)][\exists y : B(y)][R(x, y)]$

A way to paraphrase this meaning is to say that there is a function f such that for each way of selecting an individual x that satisfies A, f maps x to an entity $f(x)$ such that $f(x)$ satisfies B and $R(x, f(x))$. The formal process of 'Skolemization' does this. It takes a logical form like $\forall x \exists y R(x, y)$, where crucially $\forall > \exists$, and eliminates the existential quantifier by introducing a Skolem function f which 'maps' the x's to y's.

(5) Skolemization of (4): $[\forall x : A(x)][R(x, f(x, B)]$

Skolem functions have been motivated elsewhere in semantic theory, and in particular in the choice-functional treatment of indefinite noun phrases (e.g., Reinhart 1997; Winter 1997; Kratzer 1998; Matthewson 1999; Chierchia 2001; Schwarz 2001, 2004; Schlenker 2006). The Skolem Normal Form posits a sequence of existential quantifiers over Skolem functions, followed by a sequence of universal quantifiers, followed by an open formula. Thus, a sentence like *The boys ate a sausage* on its $\forall > \exists$ reading can be assigned the following LF:

(6) The boys ate a sausage

(6a) LF: $\exists f[\forall x : boy(x)][ate(x, f(x, sausage)]$ (for the distributive reading of (6))

(6b) Meaning: there is a function f such that, for any way of selecting a boy x, f maps the boy x to a sausage $f(x)$ such that x ate $f(x)$.

To this antecedently motivated system we add only the assumption that DD elements are an optional *spellout* of the variable argument to the Skolem function f; if the variable is realized as *each*, we get the sentence in (1), but if it is realized as null we get the (ambiguous) sentence in (6). This accounts for each of (i)-(iv) (cf. section 2): (i) *each* and *a sausage* are both arguments to f, (ii) the inherent indefiniteness of the distributed share follows from the essential connection between Skolemization and existential quantification, (iii) the anaphoric nature of DD elements follows from the fact that in the Skolem Normal Form the variable x that is realized as *each* is bound by the higher universal quantifier, and (iv) the equivalence between (1) and the distributive reading of (6) follows directly (they are different pronunciations of the LF in (5)).

4. Typological variation Slavic *po* differs from *each* and Swedish *varsin* in the following ways: (A) it can attach to subjects: *Po jabloku upalo s každogo dereva* (Russian; PO apple fell from each tree; 'A (different) apple fell from each tree'); (B) it can distribute over an NP that is not overtly expressed in the sentence: *Po edna yabulka beshe izgnila* (Bulgarian; PO one apple was rotten; '(In each basket) one apple was rotten'); and (C) it can distribute over salient occasions (cf. German

jeweils; Zimmermann 2002a): *Mariya byaga po pet mili predi zakuska* (Bulgarian; Mary runs PO five miles before breakfast; 'Mary runs five miles before breakfast (every morning)').

To capture (A)-(C) we need the relevant sentences to generate LFs like (5). In (A) this is achieved by assuming that *each tree* can QR to take wide-scope, and in (B) and (C) we assume that the universal quantifier can be a covert quantificational adverb higher in the clause (e.g., Lewis 1975), and that predicates can take time or situation arguments (e.g., Heim 1990).

The introduction of Skolem functions makes it natural to ask whether there are constraints on the class of admissible functions. Swedish *varsin*, for example, only admits one-to-one and onto functions (Teleman, Hellberg, & Andersson 1999, vol 2, §144, p.388; e.g., in (3) distinct boys are mapped to distinct sausages, and each sausage is paired with some boy). English and Slavic do not demand that the function be onto, but there seems to a very strong preference at least for one-to-one functions (e.g., it would be very strange to utter (1) if any boys shared a sausage).