Reciprocity and alternatives
Towards a modal interpretation of reciprocals.

Alda MARI
Institut Jean Nicod, Paris

January 22, 2008

In this paper I present a new view of reciprocity as related to modality. It is a very very preliminary version. But the core of the idea is there. Please, forgive typos.

1 Overview

This paper is a contribution to the understanding of the conditions that allow the expression of reciprocity *each other* to combine with asymmetric predicates leading to the so-called linear ordering configurations (1).

(1) The tables are stacked on top of each other

Linear orderings are an open problem for a unified theory of reciprocity, which, in a nutshell, can be stated in the following terms.

The semantic spectrum of *each other* is notoriously wide. Theoreticians agree that three schema are particularly significant in this spectrum: strong reciprocity, weak reciprocity and linear orderings (see e.g. Beck, 2001; Gillon, 2003). Linear orderings are irreconcilable with strong and weak reciprocity. Strong reciprocity is an all-all interpretation; weak reciprocity is an all-some interpretation (2b).

(2) a. Strong reciprocity $\forall x \in P\ \forall y \in P\ (x \neq y \rightarrow Rxy)$

b. Weak reciprocity $\forall x \in P\ \exists y, z \in P\ (x \neq y \wedge x \neq z \wedge xRy \wedge zRx)$

These two interpretations cannot capture linear orderings since the first and last element of a linear order do not fulfill the requirement of the "all" part of these two rules.

On the other hand, the rule for liner orderings in (3) cannot be generalized to weak and strong reciprocity since it does not force the relation to be strongly reciprocal whenever there are only two elements and the predicate is non-asymmetric, contrary to expectation.

(3) Linear orderings: $\forall x \in P\ \exists y \in P(x \neq y \wedge Rxy \vee Ryx)$

The problems brought in by asymmetric predicates extend well beyond their incompatibility with other attested reciprocal configurations[1].

1. linear orderings are compatible with *each other* with the exception of comparatives (in simple sentences) and this, irrespective of whether the antecedent group is small ((4a) and (4b)) or large ((4c) and (4d)),

   (4) a. #The two trees are taller than each other
   b. #The two sets outnumber each other
   c. #The skyscrapers are taller than each other for miles
   d. #These sets outnumber each other

2. "normal" linear orderings are preferable with large groups ((5b) and (5c)),

   (5) a. ??The two men buried each other on this hillside
   b. The members of this family have inherited the shop from each other
   c. The settlers have buried each other on this hillside for centuries

3. there is a preference in directionality (Fiengo and Lasnik, 1973; Langendoen, 1978),

   (6) a. #They preceded each other into the elevator
   b. They followed each other into the elevator
   c. #The plates are stacked underneath each other
   d. The plates are stacked on top of each other

4. only spatial and spatio-temporal asymmetric relations accept two-membered pluralities.

   (7) a. The two books are lying on top of each other
   b. You put these two bowls inside each other

[1]Most of the facts below have been pointed by Beck (2001).

The last piece of data is crucial for two reasons. First, it seems to point to the fact that with non-symmetric predicates, two-membered pluralities require a strong reciprocal interpretation, whereas with asymmetric predicates two-membered pluralities are admitted in a configuration that concurs with the transitive one, depicted in (8).

(8)

Secondly, it raises the issues of stating under what conditions two membered pluralities are acceptable, since for the same kind of configuration (8), (7) is grammatical whereas (9) is not.

(9) #The two men are father of each other

In our account we challenge the view that this difference is due to the symmetric vs. asymmetric distinction. It can be summarized as follows.

Along the lines of Dalrymple et al. (1998), we are going to assume that *each other* is a polyadic quantifier that binds two variables, both ranging over one set, the restricted domain of quantification, the second variable being a n-ary relation[2].

(10) $Each\ Other(A, \lambda x_1, x_2, ..., x_n(Rx_1, x_2, ..., x_n)$

However, different from Dalrymple et al. (ibid.), we are not going to assume any parametric variation of the quantifier itself. Our hypothesis is that the interpretation of an *each other* sentences requires associating pairs of entities that stand in the relation R to time-world coordinates.

Assume for the sake of simplicity, a set of cardinality 2. We write $\{a, b\}$ for an unordered set and $\{[ab]\}$ for an ordered pair of entities a and b.

Each pair consists of two different elements[3], and together, pairs needs to satisfy the weak reciprocal relation of Langendoen (1978), in (2b).

There are two different readings of the quantifier, depending on whether the weak reciprocal interpretation depends only on worlds and not on times, or else depends both on the time and the worlds.

[2]To our knowledge only Moltmann, 1997 argues against interpreting *each other* as a polyadic quantifier. Arguments provided by Dalrymple et al. and followed by most of the subsequent research on the matter are strikingly in favor of the first view.

[3]We will be using the notion of maximal distance elaborating the distinctness condition of Heim, Lasnik and May (1992) for both one-set covers and more-than-one subset covers.

The nature of the relation determines which interpretation applies. If the relation is marked for non-affectedness, it is not required that it be actually reciprocated, but only that there are (at least two) possible worlds at the actual time, such that the two alternatives together stand in a weak reciprocal relation and are such that the speaker faithfully commits herself to the fact that any one could be realized.

(11) R is - affectedness

Example: The two books are on top of each other

	t_0
w_0	$[ab]$
w_1	$[ba]$

Requirement: $[ab]_{w0,t0}$ and $[ab]_{w1,t0}$ stand in a weak reciprocal relation and the speaker commits herself to the fact that the actual pair has been chosen at random among the two possible ones.

Interpretation: one of the two books is on top of the other; the actual configuration is chosen among different alternatives.

If the relation is marked for affectedness (Dowty, 1981; Testelec, 1998; Talmy, 2000; Beavers, 2006), the action needs to be reciprocated in the actual world, and in this case the constraints over pairs across time comes into play. In particular, the rule requires that there be at least two moments in time at which the members of two weak reciprocally related pairs stand in relation R.

(12) R is +affectedness

The boys hit each other

	t_0	t_1
w_0	$[ab]$	$[ba]$
w_1	$[ba]$	$[ab]$

Requirement: $[ab]_{w0,t0}$ and $[ab]_{w1,t0}$ stand in a weak reciprocal relation and the speaker commits herself to the fact that the actual pair has been chosen at random among the two possible ones, and $[ab]_{w0,t0}$ and $[ab]_{w0,t1}$ also stand in a weak reciprocal relation

Interpretation: there are pairs of boys at least weak reciprocally hitting each other in the actual world.

Our account, which gets rid of the symmetric vs. asymmetric distinction, is given by three claims: (i) *each other* is a polyadic quantifier that imposes a structure on pairs and on sets of pairs; (ii) pairs are assigned to world-time coordinates; (iii) the cutting-edge criterion for determining whether alternatives have to stand in a weak reciprocal relation across worlds, or across worlds and times is the affectedness feature of the relation.

The novelty here consists in introducing time-worlds coordinates into the account (sharpening the insights gained by Schein (2003) account based on events) and stating a criterion different from the symmetric asymmetric distinction, which better captures the data and so makes the right predictions.

In particular, the constraint that *each other* be associated with world-time coordinates, rules out cases like (9) where only one possible order is given for two entities and a relation *be father of*. This constraint not only explains the impossibility of using *each other* in comparative simple sentences, the preference for large groups, and the differences in directionality and but also provides other insights on the use of *each other*, such as what we are going to refer to as the "partitioning effect".

The primary aim of the paper is to explain the genesis of the linear order interpretation. We take weak reciprocity as he key factor ensuring in determining the transition from strong reciprocity to linear orderings. The machinery of time also generates relations stronger than weak reciprocity and, it is interesting to note, covers cases in which members gets involved more than once in relation R with all or some of other members.

The paper is structured as follows. In Section 2 we coniser three inspirational sources for this work. Since we treat *each other* as a polyadic quantifier, Section 2.1 overviews the contributions of Dalrymple et al. (1998). Since we simultaneoulsy treat individuals and collections, Section 2.2 discusses the issue of linear orderings as stated in the work of Schwarzschild (1996). Third, since we bound orders to alternatives, Section 2.3 considers Schein's (2003) move of binding individuals to events.

Section (3) is dedicated to our own account. We begin by presenting the definition of *each other* in set-theoretic terms (Section 3.1), first introducing the definition (3.1.1), then working through the $each - other$ structure for pairs and for sets of pairs (Section 3.1.2), finally considering some examples (Section 3.1.3). We introduce world-time coordinates in Section 3.2, first introducing two explicit modal interpretations (3.2.1), then presenting the new generalization (3.2.2) and finally showing how the different meaning schema of Dalrymple at al. (1998) are generated (3.2.3).

In section 4 we discuss the predictions of the account and in particular how the symmetric vs. asymmetric distinction is successfully replaced by the new generalization of affectedness vs. non-affectedness, proposing a solution to some long-standing problems related to linear orderings (Section 4.1). We then discuss the case of comparatives (4.2) and the question of the conditions for setting different possible orders considering the contribution of the NP in relation with "normal" linear orderings (Section 4.3). We consider some cognitive constraints pending on such orders according to attested data (Section 4.4). We finally mention how the account explains differences in directionality (4.5) and why *each other* gives rise to the partitioning effect (4.6), noted by Dimitriadis (to appear).

2 Polyadic quantification, covers, events, and beyond

It is difficult to do justice to the voluminous literature on reciprocals in a way that is mindful of recent work that aims to reconcile the many views and approaches. We will accordingly focus on three sources that are particularly relevant for the account that we are going to propose. In particular, we claim that (i) *each other* is a polyadic quantifier following Dalrymple et al. (1998); (ii) that one has to consider covers (e.g. Gillon 1992, Schwarschild, 1996); and finally that (iii) following Schein (2003), binding individuals to event-like entities allows us to gain insight into the matter. However, in the discussion that follows, we are going to point to the fact that the solutions proposed for linear orderings by these authors do leave room for improvement. We then propose (i) to trat *each other* as polyadic quantifier that does not require parametric variation. We argue (ii) that individual contributions to covers have to be taken into account, and finally that (iii) elaborating events into alternatives can allows us to gain further insights.

2.1 *Each other* meaning schema and polyadic quantification

Since the work of Fiengo and Lasnik (1973) and Langendoen (1978), a trend in the study of reciprocals has consisted in identifying the meaning schema associated with *each other*. The work of Langendoen introduced the idea that all possible meanings can be ordered by entailment relations, the strong reciprocal schema being the strongest and linear ordering being the weakest.

By comparing reciprocal to plural sentences[4] Langendoen argues exten-

[4]

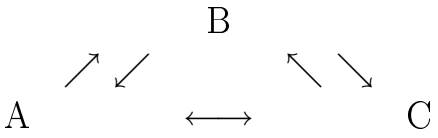
(13) a. The women released the prisoners

sively that weak reciprocity is the core meaning of *each other* and admits the impossibility of integrating linear orderings into a proper account of reciprocals.

In a similar vein, Dalrymple et al. (1998) discuss a set of attested meanings and establish the following list. [5].

1. *Strong Reciprocity*

   $| A | \geq 2$ and $\forall x, y \in A(x \neq y \rightarrow Rxy)$



2. Partitioned Strong Reciprocity

   Let covers and partitions be defined as usual.

   (15) a. Cover. A family of sets X covers a set S iff $\bigcup X = S$

   b. Partition. A family of sets X partitions a set S iff (i) $\bigcup X = S$; (ii) $\emptyset \notin X$; (iii) for each $Y, Z \in X$, if $Y \neq Z$, then $Y \cap Z = \emptyset$

   (16) Partitioned strong reciprocity. Let R be a binary relation on a set. R is partitioned strongly reciprocal iff, for each A in some partition of D, $R \mid A$ is strongly reciprocal.

   (17)
   $$\begin{array}{ccc} a & b & c \\ \updownarrow & \updownarrow & \updownarrow \\ d & e & f \end{array}$$

3. *Intermediate Reciprocity*[6]

   $| A | \geq 2$ and $\forall x, y \in A(x \neq y \rightarrow$ for some sequence $z_0, ..., z_m \in A(x = z_0 \wedge Rz_0z_1 \wedge ... \wedge Rz_{m-1}z_m \wedge z_m = y)$

---

   b. $(\forall x \in A)(\exists y \in B)(xRy) \wedge (\forall w \in B)(\exists z \in A)(zRw)$

   c. Interpretation: for all women there is a prisoner that she has released and for all prisoners, there is a woman that has released him.

(14) a. The boys hit each other

   b. By setting $A = B$ in (13b) $(\forall x \in A)(\exists y, z \in A)(xRy \wedge zRx)$

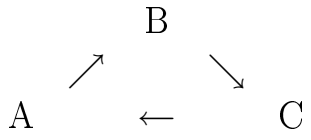
[5]Beck (2001) revisits this list and argues convincingly that strong reciprocity, weak reciprocity, and linear orderings have to be retained, arguing that the other senses follow by contextual weakening.

[6]If the relation is asymmetric, this amounts to interediate alternative orderings.

a $\longleftrightarrow$ b $\longleftrightarrow$ c $\longleftrightarrow$ d

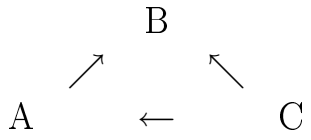
4. *Weak Reciprocity*

   $\mid A \mid \geq 2$ and $\forall x \in A\ \exists y \in A(x \neq y \wedge Rxy) \wedge \forall y \in A \exists x \in A(x \neq y \wedge Rxy)$



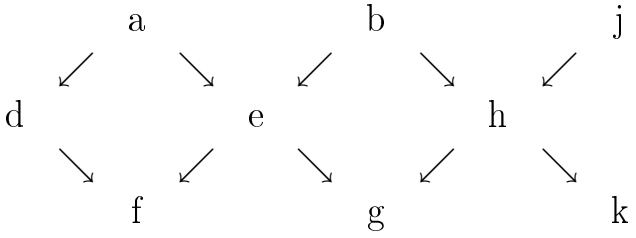
   via pragmatic weakening, from weak reciprocity *one-way weak reciprocity* can be obtained.

   $\mid A \mid \geq 2$ and $\forall x \in A\ \exists y \in A(x \neq y \rightarrow Rxy)$



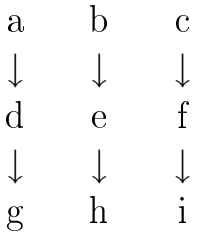
5. *Intermediate Alternative Reciprocity*

   $\mid A \mid \geq 2$ and $\forall x, y \in A(x \neq y \rightarrow$ for some sequence $z_0, ..., z_m \in A(x = z_0 \wedge (Rz_0z_1 \vee Rz_1z_0) \wedge ... \wedge (Rz_{m-1}z_m \vee Rz_mz_{m-1}) \wedge z_m = y)$

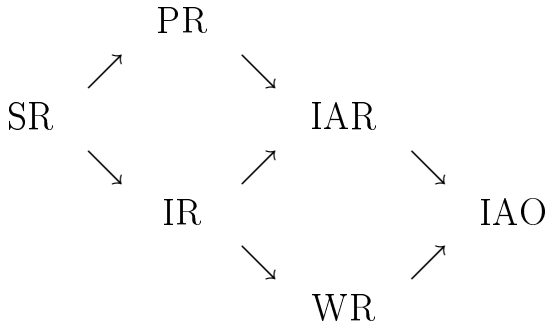


6. *Inclusive Alternative Ordering*

   $\mid A \mid \geq 2$ and $\forall x \in A \exists y \in A(x \neq y \rightarrow (Rxy \vee Ryx))$



Dalrymple et al. (ibid.) treat *each other* as a polyadic quantifier, and these meanings follow from a variation of its quantificational force depending in particular on two parameters: (i) whether all or only some entities are involved with all other entities and (ii) whether the relation is symmetric or asymmetric. The set of meanings can be ordered by entailment and linear orderings happen to occupy the weakest position.



The *strongest meaning hypothesis* regulates the selection of the appropriate meaning in context. Roughly, the hypothesis states that the strongest meaning compatible with contextual information is selected. This hypothesis raises two issues, the second of which directly concerns the question of asymmetry.

First, as Dalrymple et al. (ibid.) observe, the context being vague enough for allowing no-matter-what configuration, it is not necessarily the strongest one that happens to be realized[7]. For (18), in a sufficiently loose context, one would mistakenly expect that the strongest configuration is exclusively realized. Nenetheless, as observed by Fiengo and Lasnik (1973), partitioned strong reciprocity is preferred.

(18) The boys hit each other

Secondly, the strongest meaning hypothesis rules out all but the weakest meaning, thus allowing comparative sentences which present the same configuration as linear orderings.

Under our account, *each other* is treated as a polyadic quantifier without any parametric variation. One of our tasks is to explain all schema listed above, while ruling out comparative sentences without *ad hoc* stipulations.

2.2 Individual contributions to collections

A different line of investigation for reciprocals has tackled the issues of their relation to pluralities (Higginbotham, 1980; Gillon, 2003; Schwarzschild,

[7]See also Beck (2001)

1996; Winter, 2001). This section is dedicated to the discussion of Schwarzschild's suggestion of considering, for linear orderings, the contribution of individuals to the collections they belong to instead of collections *per se*, a move that is at the core of our own account.

The main purpose of Schwarschild's theory is to grasp the relation between subsets. For (19) the intended interpretation is that according to which the cows talk to the pigs and the pigs talk to the cows. This interpretation is obtained by the interaction of three elements: the cover operator, the part operator, and the meaning of *each other*. The mechanics is the following. The cover operator, introduced by the VP, provides a division of the entities (in this case, the cover contains two sets: that of cows and that of pigs). The part operator, also introduced by the VP, selects each of these sets in turn. The function *Each Other* ($= g(each\ other)$ provides, for each of the sets selected by Part (x_i), a different subset x_r such that x_i and x_r stand in the relation provided by the VP. The definition of *each other* also makes sure that x_r belongs to the same antecedent set (indexed by j).

(19) The cows and the pigs talk to each other

(20) (The cows and the pigs)$_j$ $Part_i(Cov)$(talk to $EachOther(x_i)(x_j)$)

For (20), this weak reciprocal interpretation yields the interpretation according to which the cows talked to the pigs and the pigs talked to the cows. Crucially nothing is said about interspecies individual talking.

For (21), the same mechanics is intended to grasp the interpretation according to which there is a stack of alternating bowls and saucers.

(21) The bowls and the saucers were stacked on top of each other

Assuming a two-subset partition consisting of bowls on the one hand and of saucers on the other, the rule generates the configuration in (22), which is trivially infelicitous, since the bowls cannot stand, at the same time, both on top of, and below the saucers.

(22)
$$\begin{array}{cc} & Bl \\ & \downarrow \\ \# & Sc \\ & \downarrow \\ & Bl \end{array}$$

In order to save a weak reciprocal account, Schwarzschild proposes a solution that appeals, for linear orderings, to an intermediate cover, which is not that provided by the NP.

Assuming that Bl is the set of of bowls $Bl = \{bl_1, bl_2\}$, and Sc the set of saucers $Sc = \{sc_1, sc_2\}$. Since bl_1 and bl_2 **individually** contribute **to the subsets** Bl and sc_1 and sc_2 individually contribute to the subset Sc, the function *EachOther* is satisfied and (23), as intended, is admitted.

(23)
bl_1 contributes for Bl
$\downarrow$
sc_1 contributes for Sc
$\downarrow$
bl_2 contributes for Bl
$\downarrow$
sc_2

This treatment, while integrating pluralities into the account effectively for most of the cases, fails to account for the problems of linear orderings in that the core notion of cover becomes problematic. In particular, the treatment proposed for (21) is different from that of (19). One must in fact assume that there are different subcells of bowls and saucers.

Assuming that the choice is determined on the basis of contextual information, and that in fact the NP structure is not the only source for covers, one runs into the problem of comparatives. The solution provided for (21) should straightforwardly apply to a case like (24), which, in fact, is ungrammatical. It could well be the case that some of my mother's relatives are taller than some of my father's relatives and vice versa. Schwarzschild notes that for both (21) and (24) we get the same kind of linear-type interpretation. There should be no difference in the acceptance, and the problem needs a solution.

(24) *My relatives are taller than each other

In the account that follows, we assume that only the antecedent NP provides the proper structure of the domain.

2.3 Going parsonian

A third line of research that goes back to Heim, Lasnik, and May (1992) has worked to prove that the interpretation of *each other* is a $\forall\forall$ one: the "other" element would contribute, besides the universal force of the distributor *each*, another universal quantifier, allowing us to obtain the strong reciprocal interpretation.

Schein (2003) states that *each* and *other* contribute a definite description capturing the meaning of reciprocal sentences as: each x in the group denoted

by the antecedent of the pronoun ... those in the same group, other than x. The novelty of the account is to associate such descriptions with parsonian events.

With regard to linear orderings, this offers an interesting analysis. For, *the tables are stacked on top of each other*, the LF assigned is as follows.

(25) $\exists E[theX : plates[X]](stack[E]\&Theme[E,X]\&$
$[\iota X : Theme[E,X][Eachx : Xx][iE' : Overlaps[E',E]\&Theme[E',x]]$
$[\exists E" : t(E") \leq t(E')][iY : Others[x,Y]\ Theme[E",Y]]on-top-of[E',x,Y])$

Paraphrase: the plates stack,

(with) them each stacking

on top of the others stacked.

Schein explains, p. 346 "... even the bottom plate is stacked on whatever plates there are if any that have already been stacked. The second-order definite description, the others, should not itself be taken to assert the existence if those it describes ...".

Though appealing, the introduction of virtual entities in the account seems a dangerous move, which, in particular, does not get rid of comparative cases, which are generated as grammatical by the rule. Similarly, the account cannot tease apart (7a) from (9).

Pushing further the insight that binding individuals to events has allowed us to gain, this problem can be solved if individuals bound to events are replaced by pairs bound to alternatives.

With these elements in mind, we now turn to our account.

3 Polyadic quantification and alternatives

In this section we present our own account starting with the definition of the quantifier in section 3.1, which involves three crucial ingredients: each-otherly structured pairs, each-otherly structured sets of pairs, and the notion of alternative. We first introduce the definition in Section 3.1.1, we then define each-otherly structures for pairs and sets of pairs in Section 3.1.2 working through some examples in Section 3.1.3. In Section 3.2 we make explicit the notion of alternative, presenting a new generalization that overwrites the symmetric vs. asymmetric distinction. We first present the two modal interpretations (3.2.1), and then state the new criterion for teasing them

apart together with some examples in relation with asymmetric predicates (3.2.2). We finally further illustrate our purpose with restating Dalrymple et al. (1998) meaning schema in our framework (3.2.3).

3.1 Defining *each other*

3.1.1 Overview

Endorsing the arguments for a quantificational theory of *each other*, we assume along the lines of Dalrymple et al. (1998) that it is a polyadic quantifier of type <1,2> that binds two variables, both ranging over one set, the restricted domain of quantification. The second variable is an n-ary relation, that we assume here to be, for simplicity, binary.

(26) $EO(A, \lambda xy(Rxy))$

In set theoretic terms, the definition of *each other* can be stated as follows:

(27) $EO(A, R) = 1$ iff
$B \in \{X \subseteq A \times A \mid [\exists D_1^{eo}, D_2^{eo}, ..., D_n^{eo} \in X \text{ s.t. } (D_1^{eo}, D_2^{eo}, ..., D_n^{eo})^{seo}]$
Paraphrase: B is a set of pairs of A s.t. there exist different elements called D^{eo} that form a structure called D^{seo}

D^{eo} and D^{seo} are defined in the following section, for one-set covers and more-than-one subset covers. The unification of these two cases, requires us to define the notion of *maximal distance*.

3.1.2 The terms D^{eo} and D^{seo} and the definiton of *each other*

Let A be the antecedent set and $A_1, A_2, ..., A_p$ be a cover of A.

The following definition of maximal distance states that if the cover consists of only one subset, then two elements are maximally different iff they are different; if the cover consists of more than one subset, than, two elements are maximally different iff they belong to different subsets. The idea is that the NP provides a cover via descriptions of the entities in the subsets. Entities that share the same descriptions, are "less different" than two entities which do not share it: a cow is "more different" from a pig than from a cow.

(28) Def. Given a cover $A_1, A_2, ..., A_p$ we say that a and $b \in A$ are at **maximal distance** provided that

- if $p = 1$, $a \neq b$

- if $p \geq 2, \exists i, j \in \{1, ..., p\}, i \neq j, a \in A_i \wedge b \in A_j$ (a and b belong to two different subsets of the cover)

In the following definitions for D^{eo} and D^{seo}, the reader will recognize a weak reciprocal account stating that a D^{seo} is a structure such that, for any element of A there is a pair where it is the agent and a pair where it is the patient.

It is however worth going through the detail of the definition, since at some point, pairs will be explicitely associated with world-time coordinates in a new framework.

(29)

i. An each-other term D^{eo} is a pair of maximally different elements of A.

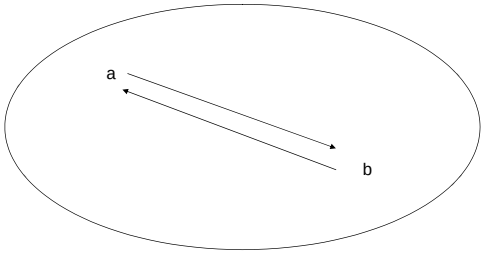
ii. An each-other structure D^{seo} is a set of D^{eo} $\{D_i^{eo} := (a_i, b_i), i = 1, ...p\}$ s.t.
(i) $\bigcup_{i=1}^{p} D_i^{eo} = A$ i.e. the sum of the D_i^{eo} is A
(ii) $\exists i_1, i_2 \in \{1, ...p\}, a_i 1 \neq a_i$ i.e. any two subsequent elements of each pair are different
(iii) $\forall i \in \{1, ...p\}, \exists j \in \{1, ...p\}, a_i = b_j$ i.e. any first element of each pair is the last one of a different pair
(iv) $\forall j \in \{1, ...p\}, \exists i \in \{1, ...p\}, a_i = b_j$ i.e. any lasrt element of each pair is the last one of a different pair

3.1.3 Examples

One set covers (card $A = 2$) For one-set covers, and **non-asymmetric** cases, the rule states that there have to be at least two *eo* structured pairs. In (31) these are $D_1^{eo} = \{[ab]\}$, $D_2^{eo} = \{[ba]\}$. These are in fact the only two possibilities that satisfy the *seo* sructure, since any element is the agent and the patient of a pair. The definition rules out $\{[ab], [ab]\}$ and $\{[ba], [ba]\}$ since both elements of each pair are not both agents qnd patients, as well as $\{[ab], [bb]\}$ and $\{[ba], [aa]\}$, since the requirement of maximal distance is not satisfied.

(30) The two boys are looking at each other

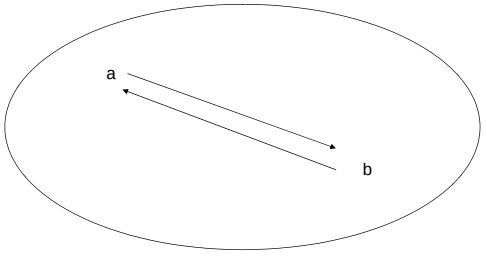
(31)



Similarly, for **asymmetric** cases, (29) states that there have to be at least two *eo* structured pairs. In (33), as in (31), these are $D_1^{eo} = \{[ab]\}$, $D_2^{eo} = \{[ba]\}$ since this is the only possibility of obtaining a well-formed D^{seo}.

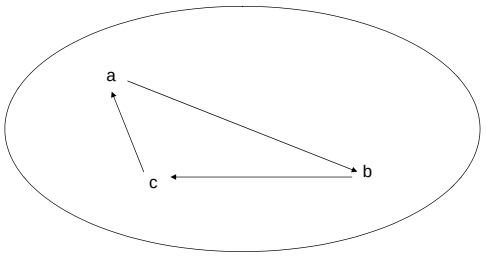
(32) The two tables are stacked on top of each other

(33)



For one-set covers and a set $A =\geq 3$, $\{a, b, c\}$, the rule correctly rules out two D^{seo} terms: $\{[ab], [cb]\}$ and $\{[ab], [ac]\}$.

(34)



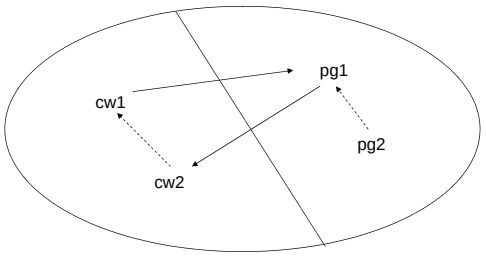
At this point one might ask what it means in the asymmetric case to say that there exists a well-formed D^{seo} term $\{[ab],[ba]\}$. The answer to this question will be provided when worlds and times are introduced in the account. Before we provide an full answer to this question, it is worth going through cases of more than one subset cover to settle the framework for introducing the tools for the explicit modal interpretation.

More than one subset covers

(35) The cows and the pigs talked to each other

Here the interspecies talking is to be captured. This is achieved by considering individual contributions to collections. In figure (36) D_1^{eo} is the ordered set: $\{[cw_1, pg_1]\}$, D_2^{eo} is the ordered set $\{[pg_1, cw_2]\}$, with the resulting D^{seo} term $\{[cw_1, pg_1],[pg_1, cw_2]\}$ being well formed: cw_1 and cw_2 count, in fact, for the same subset. It is also worth noting that there might be other talkings going on, which do not contribute to the computation $[cw_2, cw_1]$ and $[pg_2, pg_1]$

(36)

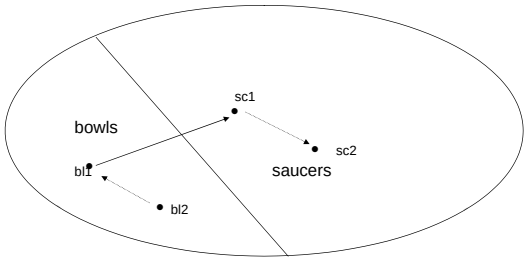


Any of the following D^{seo} terms is correctly ruled out by the theory:
$\{[cw_1, cw_2], [pg_1, cw_2]\}$, since $\{[cw_1, cw_2]\}$ is an ill-formed D^{eo} term;
$\{[cw_1, cw_2], [pg_1, pg_2]\}$, since both D^{eo} are ill-formed;
$\{[cw_1, pg_2], [cw_2, pg_1]\}$ is an ill-formed D^{seo} term.

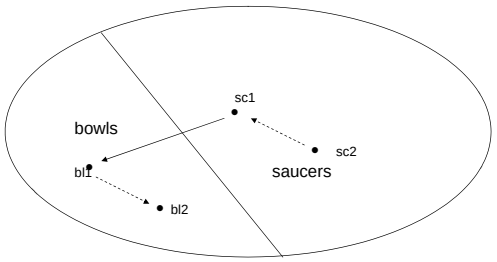
For **asymmetric** cases one will obtain (38) and (39), where $D^{eo}_1 = \{[bl_1, sc_1]\}$ and $D^{eo}_2 = \{[sc_1, bl_1]\}$ are well-formed and the resulting $D^{seo} = \{[bl_1, sc_1], [sc_1, bl_1]\}$ is also well-formed. Again, the explicit modal interpretation will tell us what to do with such set.

(37) The bowls and the saucers are stacked on top of each other (= (21))

(38)



(39)



If the covers contain **more than two subsets** (40), then definition (29) correctly rules out (41) and (42). In the first configuration, all pairs are ill-formed D^{eo} terms since their elements are not maximally different. In the second one, there are no patient cows. We omit here Venn diagrams and represent D^{eo} in line:

(40) The cows the pigs and the horses talked to each other

(In the schema that follows each line corresponds to an alternative).

(41)
$$\begin{array}{lccc} & c_1 & \rightarrow & c_2 \\ \# & p_1 & \rightarrow & p_2 \\ & h_3 & \rightarrow & h_4 \end{array}$$

(42)
$$\begin{array}{lccc} \# & c_1 & \rightarrow & p_1 \\ & c_2 & \rightarrow & h_3 \end{array}$$

(43), instead is felicitous.

(43)
$$\begin{array}{ccc} c_1 & \rightarrow & p_1 \\ c_2 & \rightarrow & h_2 \\ c_3 & \leftarrow & h_3 \end{array}$$

The question we have now to consider is the status of such D^{seo} terms, or, in other words, what alternatives correspond to.

3.2 Alternatives: times and worlds

It is possible to associate to definition (27) two explicit modal interpretations, which are driven by the semantics of the relation R.

We first consider the two modal interpretations (3.2.1), we then present a new generalization for teasing them apart (3.2.2), considering in particular the asymmetric cases, and we finally illustrate our purposes by restating the Dalrymple et al. (1998) meaning schema in the new terms (3.2.3).

3.2.1 Epistemic alternatives

To begin with, we assume the Thomason (1984) classical $T \times W$-frame.

(44) A $T \times W$-frame is a structure $< W, T, \leq, \sim >$ where W and T are disjoint nonempty sets; $<$ is a transitive relation on T which is also irreflexive and linear; and $\sim$ is a relation in $T \times W \times W$ such that (i) for all $t \in T, \sim_t$ is an equivalence relation; (ii) for all $t, t' \in T$ and $w, w' \in W$ if $w \sim_t w'$ and $t' \leq t$ then $w \sim_{t'} w'$.

It is crucial to note that $\sim_t$ is epistemic accessibilty between possible worlds, bearing an index to time.

A model in this frame, is a tuple $< W, T, <, \sim, \Delta^{eo}, V >$ where $W, T, <, \sim$ are as above, Δ^{eo} is a set of ordered pairs, and V is a valuation function that assigns ordered pairs to $T \times W$.

Crucial to our approach is the assumption that time is linear, but moments in time can overlap.

The resulting picture is a set of epistemic alternatives assigned to world-time coordinates. The actual history is on the w_0 axis.

A R each other is true at w_0, t_0 iff[8]

(45) $\exists D^{eo}_{w0,t}$ &

$$[A = \bigcup_{t \in T \text{s.t.} \exists D^{eo}_{w0,t}}^{D^{eo}_{w0,t}}] \;\&$$

$[\forall t \in T \exists D^{eo}_{w0,t} [\exists w_1, w_2, w_3, ...w_n [[\forall i \in \{1, ...n\} \exists D^{eo}_{wi,t}] \wedge [(D^{eo}_{w0,t'}, D^{eo}_{w0,t'}, ..., D^{eo}_{wn,t'})^s$

Paraphrase: (i) there is an each otherly structured pair $D^{eo}_{w0,t}$ at w_0, t_0, (ii) for each moment in time there is an each-otherly structured pair such that A is the union of them. (iii) For all times, for which there is a D^{eo} at that time, there is a set of worlds, such that for all worlds at a given time there is a D^{eo} whose union is a D^{seo}.

Illustration:

[8] We omit the accessibility relation between worlds at a time t: w_i, w_{i+1} stands for $w_{i+1} \sim_t w_i$. t_i, t_{i+1} stands for $t' \leq t$.

a.

	t_0	t_1	t_2	...	...
w_0	$D^{eo}_{w0,t0}$	$D^{eo}_{w0,t1}$	$D^{eo}_{w0,t2}$	...	....
w_1	$D^{eo}_{w1,t0}$	$D^{eo}_{w1,t1}$	$D^{eo}_{w1,t2}$	...	....
...	...	...	...	...	...

(i) There is a D^{eo} at w_0, t_0

(ii) Each members of A is involved in a D^{eo} at some moment in time (again, times can overlap).

(iii) $(D^{eo}_{w0,t0}, D^{eo}_{w1,t0})^{seo}$ and $(D^{eo}_{w0,t1}, D^{eo}_{w1,t1})^{seo}$ and $(D^{eo}_{w0,t2}, D^{eo}_{w1,t2})^{seo}$

Cases:

One set cover, symmetric.

	t_0	t_1	t_2
w_0	$[ab]$	$[bc]$	$[ca]$
w_1	$[bc]$	$[ca]$	$[ab]$
w_2	$[ca]$	$[ab]$	$[bc]$

One set cover, asymmetric.

	t_0	t_1	t_2
w_0	$[ab]$	$[bc]$	$[cd]$
w_1	$[bc]$	$[cd]$	$[da]$
w_2	$[ca]$	$[db]$	$[ac]$

For two sets covers $\{\{\alpha_1, ...\alpha_n\}, \{\beta_1, ..., \beta_n\}\}$.

Symmetric cases.

	t_0	t_1	t_2
w_0	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$
w_1	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$
w_2	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$

Given the definition of maximal distance, rule (29ii) is satisfied, since for any subset in the cover, there is a D^{eo} in which one of its members is the agent and one of its members is the patient.

Asymmetric cases.

	t_0	t_1	t_2
w_0	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$
w_1	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$
w_2	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$

(46) $[\exists D^{eo} \wedge$

$\exists t_1, ...t_{nn\geq 2} \in T[[\forall i \in \{1, ...n\} \exists D^{eo}_{w0,ti}] \wedge [(D^{eo}_{w0,t0}, D^{eo}_{w0,t1}, ...D^{eo}_{w0tn})^{seo}]] \wedge$

$[\forall t \in T \exists D^{eo}_{w0,t}[\exists w_1, w_2, w_3, ...w_n[[\forall i \in \{1, ...n\} \exists D^{eo}_{wi,t}] \wedge [(D^{eo}_{w0,t'}, D^{eo}_{w0,t'}, ..., D^{eo}_{wn,t'})^{s}$

Paraphrase: (i) there is an each otherly structured pair $D^{eo}_{w0,t}$ at w_0, t_0, (ii) **for each moment in time there is an each otherly structured pair such that their union is a set of each otherly structured terms**[9]; (iii) For all times, for which there is a D^{eo} at that time, there is a set of worlds such that for all worlds at a given time there is a D^{eo} whose union is a D^{seo}.

Illustration:

a.

	t_0	t_1	t_2	...	...
w_0	$D^{eo}_{w0,t0}$	$D^{eo}_{w0,t1}$	$D^{eo}_{w0,t2}$	...	....
w_1	$D^{eo}_{w1,t0}$	$D^{eo}_{w1,t1}$	$D^{eo}_{w1,t2}$	...	....
...	...	...	...	...	...

(ii) $D^{eo}_{w0,t0}$, $D^{eo}_{w0,t1}$, $D^{eo}_{w0,t2}$ form an *seo* structure.

(iii) $(D^{eo}_{w0,t0}, D^{eo}_{w1,t0})^{seo}$ and $(D^{eo}_{w0,t1}, D^{eo}_{w1,t1})^{seo}$ and $(D^{eo}_{w0,t2}, D^{eo}_{w1,t2})^{seo}$

Cases:

One-set cover, symmetric.

	t_0	t_1	t_2
w_0	$[ab]$	$[bc]$	$[ca]$
w_1	$[bc]$	$[ca]$	$[ab]$
w_2	$[ca]$	$[ab]$	$[bc]$

One set cover asymmetric: the same as above is required.

	t_0	t_1	t_2
w_0	$[ab]$	$[bc]$	$[ca]$
w_1	$[bc]$	$[ca]$	$[ab]$
w_2	$[ca]$	$[ab]$	$[bc]$

[9]The second condition of rule (45) is strenghtened

As stated above, the requirement seems *prima facie* doubtful if not unfulfillable: at some point in time t_j, an element $x \in A$ $[xa]$ is expected at w_0, t_j. In the next section it becomes clear under what conditions this requirement is in fact fulfilled even by asymmetric relations.

For two sets covers $\{\{\alpha_1, ...\alpha_n\}, \{\beta_1, ..., \beta_n\}\}$.

Symmetric cases.

(47)

	t_0	t_1	t_2
w_0	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$
w_1	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$

	t_0	t_1	t_2
w_0	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$
w_1	$[\beta_1, \alpha_2]$	$[\alpha_2, \beta_2]$	$[\alpha_1, \beta_1]$

If each of the covers contain one entity, the same doubts we had for two membered one-set covers araise with respect to the the following grid. We will clear these doubts in the following section.

	t_0	t_1
w_0	$[\alpha_1, \beta_1]$	$[\beta_1, \alpha_1]$
w_1	$[\beta_1, \alpha_1]$	$[\alpha_1, \beta_1]$

3.2.2 Affectedness

The generalization for triggering the use of one of the rules explains under what conditions asymmetric relation can be used while at the same time fufilling the requirements of rule (46).

(48) If $R + affectedness$ rule (45) is applied; if $R - affectedness$, rule (46) is applied.

The claim is that if the relation involves affectedness, then the action is to be reciprocated, and at least two alternatives have to be realized in the actual world, such that these two alternatives satisfy the *seo* structure together.

If the relation does not involve affection, rule (45) makes sure that the order bound to the actual world is one possibility. For *two books are lying on top of each other* it is required that if it is actually the case that book a is lying on top of book b, it could have been possible that book b had lied on top of book a (see 4.1).

A huge literature on transitivity has provided criteria for determining what affectedness is (Dowty, 1981; Testelec, 1998; and recently Beavers, 2006). It is important to note for our purposes that all criteria classify spatial geometrical relations as marked for non-affectedness.

To the nagging question as to what it means that weak reciprocal D^{seo} are to be obtained in asymmetrci configurations, the new generalization answer by appealing to the affectedness feature of the relation that crosses over the symmetric-asymmetric distinction.

Asymmetric - affectedness

(49) The plates are stacked on top of each other

(50)

	t_0	t_1	...
w_0	$[ab]$	$[bc]$	...
w_1	$[ba]$	$[cb]$	...

In other words: choose any plate to fill any position in the pile.

This requirement cannot be avoided as (51) attempts to do. It is worth noting that (51) is ruled out by the theory, since, vertically, at t_0 $\{[ab], [bc]\}$ and at t_1 $\{[bc], [ba]\}$ are not well-formed D^{seo}

(51) #

	t_0	t_1	...
w_0	$[ab]$	$[bc]$	...
w_1	$[bc]$	$[ab]$	...

Asymmetric + affectedness.

(52) The boys pushed each other down

(53)

	t_0	t_1	t_2
w_0	$[ab]$	$[bc]$	$[ca]$
w_1	$[ba]$	$[cb]$	$[ac]$

As noted first by Fiengo and Lasnik (1973), if each of the boys pushed the boy on his right in a line, one would not describe the situation by an each-other sentence.

It follows that for the asymmetric cases involving two elements, either they involve affectedneess, hence, two possibilities have to be realized in the

actual world, satisfying the each other structure as in (54); or, they do not involve affectedness as in (32) and (37), and only one of the alternatives in the sets $\{[bl_1sc_1], [sc_1bl_1]\}$ and $\{[ab], [ba]\}$ is allowed to be realized in the actual world, as pictured in (55). The speaker commits herself to the fact that other alternatives are available, which can be picked from a set which minimally satisfies, as a whole, the weak reciprocal requirement.

(54)

	t_0	t_1
w_0	$[ab]$	$[ba]$
w_1	$[ba]$	$[ab]$

(55)

	t_0
w_0	$[ab]$
w_1	$[ba]$

Summing up, *each other* is a polyadic quantifier that binds two variables, ranging over the restricted domain of quantification. It can be associated with two modal interpretations that are triggered on the basis of the affectedness feature of the relation. The common core of the two interpretations is that there has to exist a set of alternatives, which are pairs associated to world-time coordinates. Each alternative is an each-otherly structured pair. The sum of the pairs has to be an each-otherly structured set. The meaning of each-other structures for pairs and sets of pairs is given in (29). For both cases involving one-set covers and more-than-one subset covers, the criterion of maximal difference determines the well-formedness of pairs and sets of pairs. The two interpretations differ as to whether the constraint of forming an *seo* pinges over pair on the world axis or on the world-time axes. If the relation is marked for affectedness the latter option is chosen, and one has to consider what happens on the time arrow in such a way that everybody affects and is affected by somebody else. If the relation is not marked for affectedness the first option is chosen, and one has to make sure that any member is such that it can possibly be an agent or a patient. As stated above, the rule translates the intuition according to which all elements are equally eligible for affectedness. If the relation is marked for non-affectedness, then the actual order has to be chosen at random, i.e. another order could have been equally possible.

3.2.3 Restating *each other* meaning schema

Before we show the relevance and the correctness of our generalization and before showing why the traditional generalization symmetric vs. asymmetric

distinction cannot account for the data, it is worth pointing out that all meaning schema considered by Dalrymple et al. (1998) and by many of the subsequent works on reciprocity are all captured in terms of alternatives. What configuration is to be realized is entirely determined, as for Dalrymple et al. (ibid.), by the context, and if still desirable, one can order the schema by strength. This is a line of investigation entirely compatible with our approach.

In Dalrymple et al. paper cases that involve affectedness are above weak reciprocity on the entailment scale hence can be properly generated by the theory. It is important to note that in our account weak reciprocity is the minimal requirement (which, in (56) is fulfilled at t_3).

Importantly, the machinery of time allows us to add alternatives at will and to generate strong reciprocal schema. It also captures the fact that one can consider all the members even more than once, strong reciprocally, if needed.

We defer to the next section the discussion of the constraints pending over elements in order for different alternatives to be available at different worlds[10]

1. Strong reciprocity

(56)

	t_0	t_1	t_2	t_3	t_4	t_5
w_0	$[ab]$	$[bc]$	$[ca]$	$[ba]$	$[cb]$	$[ac]$
w_1	$[ba]$	$[cb]$	$[ac]$	$[ab]$	$[ba]$	$[ca]$

2. Partitioned strong reciprocity

(57)

	t_0	t_1	t_2	t_3	t_4	t_5
w_0	$[ad]$	$[da]$	$[be]$	$[eb]$	$[cf]$	$[fc]$
w_1	$[da]$	$[ad]$	$[eb]$	$[be]$	$[fc]$	$[cf]$

3. Intermediate reciprocity

(58)

	t_0	t_1	t_2	t_3	t_4	t_5
w_0	$[ab]$	$[ba]$	$[bc]$	$[cb]$	$[cd]$	$[dc]$
w_1	$[ba]$	$[ab]$	$[cb]$	$[bc]$	$[dc]$	$[cd]$

Intermediate alternative reciprocity and intermediate alternative orderings, as in the Dalrymple et al. (ibid.) study, are cases of non-affectedness which describe arrangements of stones. Consequently, rule (45) applies. In order to satisfy the rule, it is enough to make sure that, for any given time and for any well-formed pair, the reverse could have been possible.

[10]Note that the straightforward way to achieve *seq* structure is to permute the elements.

1. Intermediate alternative orderings

(59)

	t_0	t_1	t_2	t_3	t_4	t_5
w_0	$[ab]$	$[dg]$	$[be]$	$[eh]$	$[cf]$	$[fi]$
w_1	$[ba]$	$[gd]$	$[eb]$	$[he]$	$[fc]$	$[if]$

2. Intermediate alternative orderings

(60)

	t_0	t_1	t_2	t_3	t_4	t_5
w_0	$[ab]$	$[dg]$	$[be]$	$[eh]$	$[cf]$	$[fi]$
w_1	$[ba]$	$[gd]$	$[eb]$	$[he]$	$[fc]$	$[if]$

The burning question is the following: what are the criteria for determining the conditions allowing one to obtain different orders along different possible worlds?

In the following section we provide an answer to this question, while straitening out the predictions of the account.

4 Predictions

In this section we come back to the data presented in the introduction, discussing the predictions of the account. We consider in Section (4.1) the affectedness vs. non-affectedness generalization which overwrites the symmetric vs. non-symmetric distinction. From Section (4.2) on, where we discuss the problem of comparatives, and in Section (4.3), where we consider the reasons for preferring large groups with linear orderings, we discuss the issue of stating the conditions to be satisfied in order for different possible orders to be available. We also look closer at some attested data and respond to a possible couterexample (4.4). We finally mention in Sections (4.5) and (4.6) respectively, where the conditions for preferences in directionality comes from as well as those leadings to the partitioning effect, first noted by Dimitriadis (to appear).

4.1 Shortcomings for the asymmetric vs. symmetric distinction and the new generalization

The symmetric-asymmetric distinction has been commonly recognized as the source of allowance or rejection of different meaning schema. Typically, non-asymmetric relations have been associated with (at least) weak reciprocity and asymmetric ones have been considered as exclusively allowing linear orderings. In particular, for sets of cardinality 2, the commonly assumed generalization is presented in (61):

(61) a. if R is nonasymmetric then $Rab \wedge Rba$

b. if R is asymmetric then $Rab \vee Rba$

The generalization in (61) together with the neglection of the temporal component leads us to incorrect predictions.

The first one is illustrated in (62). Asymmetric predicates such as *push down* require, contrary to expectation that, preferably at the same time, $Rab \wedge Rba$.

Similarly, *delouse*, for $A = 2$, requires, contrary to expectation, that $Rab \wedge Rba$[11].

(62) a. The two men push each other down

b. The two men delouse each other

The second problem for the asymmetric vs. symmetric generalization is that it leaves us without a solution for the contrast in (7a) vs. (9), repeated in (63).

(63) a. The two books are lying on top of each other

b. *The two men are father of each other

The two cases present the same kind of configuration: both involve states, one entity being the actor, the second the theme.

Assuming that the generalization correctly predicts that (63a) is possible, the reason for the ungrammaticality of (63b) is obscure.

These problems lead us to revise the generalization and to evaluate the new one provided in (48).

For the data in (62), since Rs involve affection, the new generalization requires that there be at least two (possibly overlapping) times at which different pairs of entities stand in the given relation.[12]

Schema (54) applies, that we repeat in (65), where [ab] stand for [a delouse b] or [a delouse b])[13]

[11] Possibly in turn, or at the same time, if they use sprays, for instance.

[12] It is worth noting that the granularity of the moments is determined lexically or contextually: it can correspond to the fiscal year (64a), to a contextually variable period (64b)- (64a).

(64) a. The men have been passing the shop to each other for taxation purposes

b. They have been cheating on each other for years

c. The boys have been hitting each other for one hour

[13] As noted by Evans (2005), even the spatio-temporal relation *to follow* for sets of cardinality 2 (*the two men followed each other*) can require that each of the elements follow the other in turn if the scenario involves a chase. In our terms, if the relation is marked for affectedness, the action has to be weakly reciprocated.

(65)

	t_0	t_1
w_0	$[ab]$	$[ba]$
w_1	$[ba]$	$[ab]$

The data in (63) is also correctly captured. Intuitively, (639) is ungrammatical since for all possible times, for all possible worlds, for two *given* entities, the relation *being father of* imposes exactely one possible order[14].

The model we have proposed allows us to sharpen the intuition and to set a framework for more complex cases to come.

We have stated that alternatives are epistemic. That requires in turns that all pairs are in the denotation of the predicate and that the speaker commits herself to the fact that any pair is a candidate for the actual history. The relational predicate *be father of* establishes an intrinsic asymmetry between the entities, such that, even without knowing which entity is the father and which is the son, the speaker knows that one pair is not in the denotation of the predicate in some world that is a candidate for the actual history.

(66)

	t_0
w_0	$[ab]$
w_1	$[ba]$

For (63a) the result is different. First of all, since geometrical relations do not involve affection, the account requires that there exists an alternative order, a requirement that in sufficiently similar worlds is taken to be fulfilled. In that case, (55) holds, repeated in (67).

(67)

	t_0
w_0	$[ab]$
w_1	$[ba]$

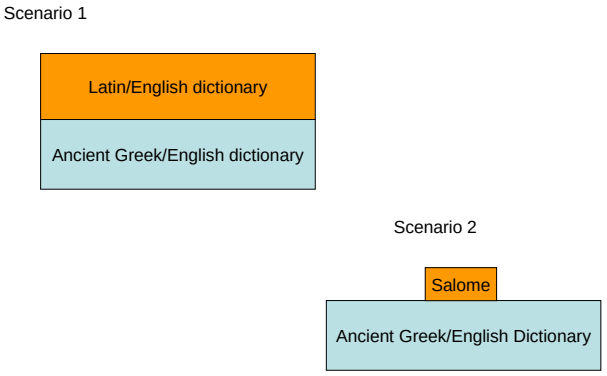
This case differs from the father example in that, if it is *actually* the case that one book is on top of the other, different options are available to choose from: any pair is in the denotation of the predicate in a world, which is a candidate for being the actual one.

We have pointed to the fact that relational predicates suspend this possibility. There are some constraints on objects, which prevent them from occupying any position in the order, a point we will return to later in the discussion.

Let us for the time being mention that, for the book case, one is typically going to assume that the two books are of a similar size. Scenario 1 in (68) is more felicitous than scenario 2.

[14] We would prefer considering *be father of* as a geometrical relation over entities[15]. However, no matter whether marked for plus or minus affectedness, (639) si predicted to be ungrammatical.

(68)



We come back to this question in section (4.4) once we have considered linguistic constraints pending on comparatives (4.2) and "normal linear orderings" (4.3).

4.2 Comparatives

As stated in the introduction, comparatives are incompatible with *each other*. Data in (4) are repeated in (69).

(69) a. #The two trees are taller than each other

b. #The two sets outnumber each other

c. #The skyscrapers are taller than each other for miles

d. #These sets outnumber each other

The account captures the ill-formedness of these sentences as follows. Assume $A = \{j, r, a\}$. Also, assume that the speaker does not know who is taller than whom. She will form the following hypothesis.

(70)

	t_0	t_1
w_0	$[jr]$	$[ra]$
w_1	$[ra]$	$[jr]$
w_2	$[aj]$	$[ar]$

As for cases discussed above, stating that the set of pairs at time-world coordinates are epistemic alternatives means to recognize: (1) that no particular one can be chosen to set the actual history, and (2) that each of the pairs

satisfy the relation, in this case "be taller than". In the case of comparatives, the speaker is aware of the fact that there is at least one pair in a world w' at every time t', which does not satisfies the relation and is not eligible for being chosen as the actual pair.

This claim is strengthen by showing under what circumstances comparative statements can be made compatible with *each other*.

First, some cases can be rescued if for any time, the speaker can truthfully admit that any pair is in the denotation of the predicate in a world that is eligible for being the actual one.

(71) They look *alternately* taller than each other in different scenes (http://p081.ezbo

(72)

	t_0	t_1	$[t_2]$
w_0	$[jr]$	$[ra]$	$[aj]$
w_1	$[rj]$	$[ar]$	$[ja]$

Second, as expected, all comparatives do not behave the same. The following attested example in (73) is particularly relevant.

(73) I try to have several varieties blooming throughout the growing season by *either* choosing ones that bloom progressively at certain times of the season *or* by planting them a few weeks *later than each other* in stages.

The speaker states that (i) if the plants have different blooming times (i.e. they are of a different sort) they are planted all together and will bloom at different moments; if they have the same blooming time, then they get planted at different times. For three seeds $\{a, b, c\}$, which, when planted, need the same amount of time to bloom any possible planting order can be chosen, *salva veritate*.

(74)

	t_0	t_1
w_0	$[ab]$	$[bc]$
w_1	$[bc]$	$[ca]$
w_2	$[ca]$	$[ab]$

The speaker can faithfully commit herself to the fact that any pair is in the denotation of the predicate in a world that is eligible for being the actual one.

4.3 The descriptive content of the NP and conditions for the availability of any possible order

One can restate the lesson from comparatives and cases in (83) by claiming that intrinsic properties of an object do not have to force an ordering. In order to have different orders associated with different alternatives, the elements must be such that they can enter any position in the order.

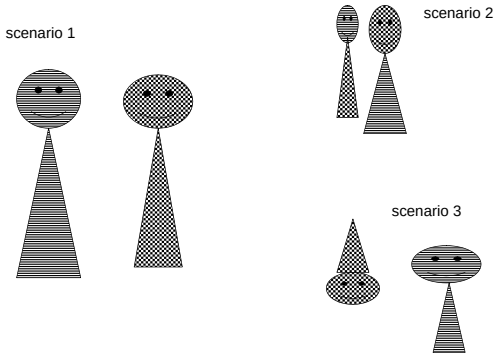
A first consequence of this requirement is that the *description* of the individuals in the denotation set of A must allow the assignment of different places in the order to any element. Some examples illustrate this.

The judgment of ungrammaticality for (75) is related to the availability of a linear order interpretation according to which each head is on a different body. In other words, the sentence cannot describe a set of *natural* pairs "head+body" as in Scenario 1.

(75) #The heads and the bodies are on top of each other

The sentence, however, is interpretable if the heads have been decapitated and there is a bunch of heads and bodies (Scenario 2), or if there are pairs of heads and bodies which are not the natural ones as in Scenario 3. In other terms, this requires that heads are no longer categorized *qua* heads of particular bodies and bodies *qua* bodies of particular heads.

(76)



In other terms, if Scenarios 2 and 3 are alternatives for Scenario 1, then scenario 1 happens to be a possible order (which can be the case only if heads and bodies have been separated from each other). If individuals in Scenario

1 are taken to represent human living beings, then there are no alternatives for it[16].

The behavior of linear orderings with large groups can now be better understood.

As noted by Beck (2001) large group better support the reciprocal linear order interpretation than small groups. Data in (5) are repeated in (78).

(78) a. ??The two men buried each other on this hillside

b. The members of this family have inherited the shop from each other for generations

c. The settlers have buried each other on this hillside for centuries

As expected, since the relation involves affectedness, (78a) is interpretable only if the two men buried each other at the same time.

For large groups, the two requirements of rule (46) are satisfied. In view of the facts that (78c) becomes ungrammatical if "for centuries" is deleted, it can be claimed that unboundedness allows the interpretation according to which there is, *eventually* a different settler who will burn the last one that has burned the others, restoring a hidden weak reciprocal interpretation.

However, this is not the whole story. If unboundedness leads to grammaticality, the impossibility of rescuing comparative statements would remain mysterious (79).

(79) a. *The skyscrapers were taller than each other

b. *The skyscrapers were taller than each other for miles

The case of (78b) is to be compared to (73): given the description provided by the NP, the members of the set A are presented as equally eligible for occupying any position in the ordered pair. This is to be contrasted with the impossibility of (80).

(80) *The grandfather and grandchildren have inherited the shop from each other for centuries

[16]In a similar vein, and for a more controversial example, though, Evans (2005) has shown that even (77) can be rescued if one overwrites the assumption that policemen chase thefts and not the other way around. In our terms, if the policeman ceases acting as a policeman and the theft as a theft, speakers tend to better accept the sentence.

(77) (*)The policeman and the theft chase each other

In spite of the fact that "for centuries" makes available new slots for family members, the description of the entities does not allow *seo* neither with respect to times, nor with respect to worlds. Assuming that $Grandfathers = \{gf_1, ..., gd_n\}$ and $Grandchildren = \{gc_1, ..., gd_n\}$ the following schema results. It is not felicitous, since the speaker cannot commits herself to the truth of all the alternatives.

(81)

	t_0	t_1
$*w_0$	$[gf_1, gc_1]$	$[gf_1, gc_2]$
$*w_1$	$[gc_1, gf_1]$	$[gc_1, gf_2]$

This allows us to capture the difference with comparatives. Recall that stating that the set of pairs at time-world coordinates are epistemic alternatives means to recognize: (1) that particular one can be chosen to set the actual history, and (2) that each of the pairs satisfies the relation, in this case "inherit the shop from".

Also, recall that in the case of comparatives, the speaker is aware of the fact that there is at least one pair at a certain time, which does not satisfy the relation and is not eligible for being chosen as the actual pair. This is not the case for the family members.

Assuming a set A of family members, it is true from the speaker's perspective, that any pair, given the description provided by the predicate, satisfies the predicate, and can be bound to a world-time coordinate that is eligible for being a portion of the actual history.

(82)

	t_0	t_1
w_0	$[ab]$	$[bc]$
w_1	$[bc]$	$[ca]$
w_2	$[ca]$	$[ab]$

4.4 Some constraints on objects

The case of comparatives and the constraints pending on the descriptive content of the NP, have lead us to suggest that the elements have to such that they can enter any position in the ordered pairs.

As suggested by Scenario 2 in (68), for (63a) the entities have to be similar. This also strongly suggested by the attested data. The speaker insists on two facts: (i) the entities have to be similar; (ii) their geometrical relation preferably has to result in a merge relation.

(83) a. Once the two photos land on top of each other your eye will focus on the *merged* image. www.dpreview.com

b. Repeat for the remaining corners until the two sheets are *perfectly* aligned on top of each other robotroom.com/PCB2.html

c. Place the *two* heart shapes *on top of each other*, and then punch holes all the way around the perimeter of *the* heart www.world.org/reuse/inst

d. It is widely known that when two *identical random* dot. screens, or any two identical two-dimensional random structures, are superposed on top of each other ... www.epfl.ch/w3lsp/publications/moire/gpa

The notion of merging, allows us to see under a new perspective a piece of data that seems *prima facie* problematic for our account (84). The problem is represented by the fact that, for "nesting into each other", the two bowls have to be of different sizes, and that the order is imposed, and is unique, by the sizes of the bowls, as in (9). Yet, the sentence is grammatical.

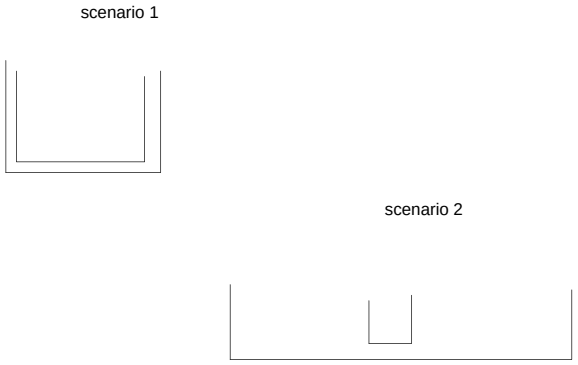
(84) The two bowls nest into each other

Close attention to the data shows that the account is on the right track.

It is worth mentioning first that the objects have to be of a similar nature. A bird and a nest cannot be said of "nesting into each other," even though the formal structure is common of that of two bowls nesting into each other.

Second, the entities have to be of a comparable size. Scenario 1 is felicitous, whereas scenario 2 below is less usual.

(85)



Attested pieces of data go in the same direction; (86) is one of those. The remark "hampers nest inside each other for storage" would be totally irrelevant if the sizes of the two hampers were not comparable.

(86) Handy two hamper set gives you one for the nursery and one for the bathroom. . . . or use both in the nursery to pre-sort clothes for wash day! Hampers nest inside each other for storage. Hampers measure 18Wx13Lx22H and 15Wx10.5Lx18.5H and each includ.. www.walmart.com/catalog

Finally, and crucially, speaker's remarks can be interpreted as amounting to the statement that the entities fit each other in a certain way. The way is a nesting configuration. The fit component of nesting allows the strong reciprocal interpretation: if $R = \mathit{fit}$, then $\{[ab], [ba]\}$ is a set of well formed alternatives.

4.5 A note on directionality

Resting on the idea that alternatives can be added through time, we capture differences related to directionality.

(87) a. #The plates are stacked underneath each other

b. The plates are stacked on top of each other

(88) a. #They preceded each other into the elevator

b. They followed each other into the elevator

(89) a. #The settlers have procreated each other on this hillside for centuries

b. The settlers have buried each other on this hillside for centuries

An observation put forward by (Kennedy and McNally, 1999) in relation with deverbal adjectives, is that time is represented as bounded for its starting point[17]. The idea is that, in a scale or a sequence, it is obligatory to know the beginning element, but not necessarily the ending one. Upper unboundednees is allowed, whereas lower unboundedness is not.

For the interpretation of reciprocal sentences, adding alternatives through time has to remain an available option. This option is blocked if the relation is

[17] This is usually represented by events of increasing size, which requires the existence of a minimal event (e.g. Link, 1983)

bottom bounded, as *underneath*, *precede*, and *procreate* are, in the default scenarios for the sentences above (e.g. for (87a) the plates are stacked in a pile).

The conditions determining in what direction a relation is bounded vary lexically and contextually. Naïve physics also provides an important contribution. That *underneath* is lower bounded derives for a simple schema according to which the soil is bounded whereas the upper direction is open (Vandeloise, 1996)[18]. An investigation of the constraints on boundedness and unboundedness is outside the scope of this paper.

4.6 Partitioning effect

In a recent work, Dimitriadis (to appear) has shown that some predicates are irreducibly symmetric, i.e. they require an equal participation of the individuals they denote, in the same event. *Meet* is one of these. *Each other*, as argued by the author, is responsible for creating a cumulativity effect[19]. This is correctly captured by our account.

(90a) preferably enhances a scenario in which the boys meet all in the same place. (90b) better accommodates a scenario in which there are different meeting points or times.

(90) a. The boys met

b. The boys met each other

It is worth noting that if Cov were introduced by the verb, this would be equally plausible for (90a) and (90b) sentences.

Our account considers covers that are explicitly provided by the NP and are neither transversal nor covered (i.e. for (90), we assume that in both of the cases above there is one-subset cover). *Each other* selects a subset of possible pairs that it associates with different alternatives (enhancing the interpretation according to which all boys are not meeting all together). The sum of these alternatives amounts to the the strong reciprocal interpretation obtained for (90a), as expected[20].

[18]However, if one changes the reference point, and the upper bound is given as closed, the downward direction can be seen as unbounded.

[19]This prediction that is not borne out if one considers that cumulativity stands on the side of weak reciprocity, since *meet* is by nature strong reciprocal

[20]The reader will have already concluded that adding all alternatives leads to a strong reicprocal schema.

5 Conclusion

The aim of the paper has been to propose a new account of *each other* that tries to reconcile linear orderings with other interpretation schema, while shedding new light on a variety of unexplained data. We have considered in particular the problem of two-membered pluralities, the question of comparatives, the reasons for preferring large groups with non-comparative linear orderings, and directionality preferences.

We have claimed that *each other* is a polyadic quantifier along the lines of Dalrymple et al. (1998) without assuming any parametric variation.

We have made the hypothesis that *each other* requires that structured pairs be associated with world-time coordinates.

The first task has consisted in identifying the constraints that pairs and sets of pairs have to satisfy. We have proposed a restatement of the weak reciprocity condition of Langedoen (1978) using the distinctenss condition of Heim, Lasnik, and May (1992), for both cases involving one-set covers and more-than-one-subset covers (following the suggestion proposed by Schwarzschild (1996) of considering individual contributions to collections). For the latter we have assumed that entities belonging to different subsets of the same partition have less in common than do two any elements belonging to the same subset. One of the novelties of our account consists in encapsulating this condition in an alternative-based framework.

The second task has consisted in stating the role of times and worlds, following up on Schein's (2003) insight of binding individuals to events.

Previous accounts identified the cutting edge criteria for teasing apart strong and weak reciprocity from linear orderings in the symmetric asymmetric distinction, assuming in particular that, for two-membered sets, asymmetric relations require that $aRb \vee bRa$, while nonsymmetrical predicates require $aRb \wedge bRa$.

In view of the fact that some asymmetric relations also require that $aRb \wedge bRa$ (91), we have proposed a new criterion.

(91) John and Mary pushed each other down

The newly proposed criterion for choosing between the two schemas has been identified with the affectedness vs. non affectedness feature of the relation.

In modal terms, the - affectedness feature triggers possible worlds, it allows that only one alternative be instantiated in the actual world (ie it is compatible with the fact that there is one moment in time only, t), but it requires that

(i) different alternatives be available in accessible worlds at t, and (ii) that they together form an each-other structure (D^{seo}). To this requirement, the + affectedness feature adds that more than one alternative (each involving one pair of each-otherly structured entities) be realized in the actual world at different (possibly overlapping) times and that these alternatives together also form an an each-other structure.

The account based on orders bound to alternatives has allowed us to grasp the difference between:

(92) a. The two tables are stacked on top of each other

b. *The two men are father of each other

Similarly, we have shown that some comparative statements are not compatible with *each other* unless the context provide us with the possibility of considering all alternative ordered pairs that can be bound to worlds eligible for being the actual history.

(93) a. *The men are taller than each other

b. The men look alternately taller than each other

This has brought us to the third task of identifying the conditions that the elements of the reference set have to satisfy in order for more than one alternative be available. Speakers have a preference for homogeneous groups, for both cases involving two members and large groups. Non-comparative linear orderings are preferred with homogeneous large groups, since this allows the speaker to assume that, from her point of view, insofar as one of the elements satisfies the description provided by the NP, it is entitled to occupy any position in the order (under the assumption that elements do not come with an intrinsic temporal order). As soon as the NP provides descriptions that constrain the possibilities of assigning one member a position, the sentence becomes ungrammatical.

This has explained the difference between (acceptabilities concern the linear order interpretation):

(94) a. The settlers buried each other on the hillside for centuries

b. *The grandfathers and the grandchildren have buried each other on the hillside for centuries

We have claimed that unbinding the sequence allow us to restore a hidden weak reciprocal relation, satisfying the other requirement of the rule for + affectedness.

We have claimed that unbounded relations are preferred over bounded ones since adding alternatives has to remain an available option. The bounded direction depends on lexical and contextual elements, and can vary according to principles of folk physics. Finally, associating *each other* with sets of alternatives allows us tocapture the partitioning effect for irreducibly symmetric predicates.

Our alternative-based account suggests a promising research direction: reciprocity amounts to a causal chain of actions. The intuition is that the requirement on relations involving affectedness can be generalized by weakening to cases of non-affectedness, once we introduce possible worlds in the account. In that case, one can see that the existence of an actual order brings with it the possibility of the existence of a different one. As in the +affectedness case, reciprocity is a fair insofar as anyone can be chosen for occupying the actor or experiencer role, everyone being equally eligible for affecting and being affected.

References

Beavers, J. (2006). *Argument Oblique Alternations and the Structure of Lexical Meaning*. Ph.D. thesis, Stanford University.

Beck, S. (2001). "Reciprocals are definites." *Natural Language Semantics 9*: 69-138.

Brisson, C. (1998). *Distributivity, Maximality, and Floating Quantifiers*. PhD Dissertation, Rutgers University.

Dalrymple, M., Makoto, K., Yookyung, K., Sam, M., and Stanley, P. (1998). "Reciprocal expressions and the concept of reciprocity." *Linguistics and Philosophy 21*:159-210.

Dimitriadis, A. (forthcoming), "Irreducible symmetry in recirpocal constructions" in König & Gast eds. Reciprocals and Reflexives – Theoretical and Cross-linguistic Explorations. Current Trends in Linguistics. Berlin: Mouton de Gruyter.

Dowty, D. (1981). "Thematic proto-roles and argument selection." *Language 67*: 547-619.

Evans, N. and Gaby, A. (University of Melbourne) Demo of video elicitation clips for Reciprocals Project, Elicitation Protocol, Workshop *Reciprocity and reflexivity - description, typology and theory*, Berlin.

Fiengo, R. and Lasnik, H. (1973). "The logical structure of reciprocal sentences in English." *Foundations of Language 9*: 447-468.

Gillon, B. (2003). "The plurality and reciprocity in French and in English". Zentrum fur allgemeine Sprachwissenschaft, Berlin, Germany, October 2003.

Heim, I., Lasnik, H. and May, R. (1991). "Reciprocity and plurality." *Linguistic Inquiry 22*:63-101.

Higginbotham, J. (1980). "Reciprocal interpretation." *Journal of Linguistic Research 1(3)*: 97-117.

Kennedy, C. and McNally, L. (1999). "From event structure to scale structure: Degree modification in deverbal adjectives." In *Proceedings of SALT IX*, Ithaca, New York. Cornell University.

Keenan, E.L. (1987). "Unreducible n-ary quantifiers in natural language." In Gardenfors, P. (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*. Dordrecht: D.Reidel, pp.109-150.

Landman, F. (2000). *Events and Plurality*. Dordrecht: Kluwer Academic Publishers.

Langendoen, D.T. (1978). "The logic of reciprocity." *Linguistic Inquiry 9*:177-197.

Link, G. (1983). "The logical analysis of plural and mass terms: a lattice theoretic approach". In R. Bauerle, Ch. Schwarze and A. von Stechow (eds.). *Meaning, Use and Interpretation of Language*. Berlin: de Gruyter.

Moltmann, F. (1992). "Reciprocals and same/different: toward a semantic analysis." *Linguistics and Philosophy 15*: 411-462.

Roberts, C. (1987). *Modal Subordination, Anaphora and Distributivity*. PhD dissertation, University of Massachusetts at Amherst.

Sauerland, U. (1998). "Plurals, derived predicates and reciprocals." In U. Sauerland and O. Pecus (eds.). *The interpretative tract. MIT Working Papers in Linguistics 25*, pp. 177-204.

Schwarzschild, R. (1996). *Pluralities*. Dordrecht: Kluwer Academic Publishers.

Schein, B. (2003). *Plurals and Events*. Cambridge: MIT Press.

Schein, B. (2003). "Adverbial, Descriptive Reciprocals," *Philossophical Perspectives 17, Language and Philososphical Linguistics*: 334-367.

Talmy, L. (2000). *Toward a Cognitive Semantics: Typology and Process in Concept Structuring*. Cambridge, Mass.: MIT Press.

Testelec, Y.G. (1998). "On two parameters of transitivity." In L. Kulikov and H. Vater, (eds.), *Typolgy of Verbal Categories*, Tuebingen: Niemeyer, 29-45.

Thomason, R. (1984). "Combinations of tense and modality." In D. M. Gabbay and F. Guenthner (eds.), *Handbook of Philosophical Logic: Exten-*

sions of Classical Logic, vol. II, 135-165. Dordrecht, Reidel.

van Benthem, J. (1989). "Polyadic Quantifiers." *Linguistics and Philosophy 12*: 437-464. Vandeloise, C. (1986). *L'espace en Français*. Paris: Seuil. Winter, Y. (2001)."Plural Predication and the Strongest Meaning Hypothesis." *Journal of Semantics 18*: 333-365.