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# Symmetric predicates and the semantics of reciprocal alternations*

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**Abstract** Reciprocal alternations appear with binary predicates that also have a collective unary form. Many of these binary predicates are *symmetric*: if A *dated* B then B *dated* A. Most symmetric predicates in English show a simple kind of reciprocity: *A and B dated* means "A dated B", or equivalently "B dated A". Similar observations hold for nouns and adjectives like *cousin* and *identical*. Non-symmetric predicates like *hug*, *fight* and *kiss* also show reciprocity, but of a more complex kind. For instance, the meaning of *A and B hugged* differs substantially from "A hugged B and/or B hugged A". Addressing a wide range of reciprocal predicates, we observe that "plain" reciprocity only appears with symmetric predicates, while other types of reciprocity only appear with non-symmetric predicates. This *Reciprocity-Symmetry Generalization* motivates a lexical operator that derives symmetric predicates from collective meanings. By contrast, reciprocity with non-symmetric predicates is analyzed using "soft" preferences of predicate concepts. Developing work by Dowty and Rappaport-Hovav & Levin, we introduce a formal semantic notion of *protopredicates*, which mediates between lexical meanings and concepts. This mechanism explains symmetry and reciprocity as two semantic aspects of one type system at the lexical-conceptual interface.

**Keywords:** symmetry, reciprocity, predicate, alternation, lexical semantics

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## 1 Introduction

A binary predicate $R$ is standardly called **symmetric** if for every $x$ and $y$, the statement $R(x,y)$ is logically equivalent to $R(y,x)$. The following equivalent sentences exemplify symmetric predication in English:

(1) a. Sue dated Dan ⇔ Dan dated Sue.
b. Shape A is identical to Shape B ⇔ Shape B is identical to Shape A.
c. Mary is John's cousin ⇔ John is Mary's cousin.

Most symmetric predicates in English have systematic morphosyntactic relations with **collective** predicates. For instance, the binary predicates in (1a-c) all have unary-collective alternates, as exemplified below:

(2) a. Sue and Dan dated.
b. Shape A and Shape B are identical.
c. Mary and John are cousins.

We say that predicates like *date*, *identical* and *cousin* show a *reciprocal diathesis alternation* (Levin 1993). Accordingly, the collective predicates in (2) are classified as **reciprocal**.

Symmetries as in (1) reflect a semantic property that may in principle appear with any binary predicate. Reciprocal alternations only concern predicates whose morphosyntax supports multiple subcategorization frames. Given this, it is remarkable that the great majority of symmetric predicates in English take part in reciprocal alternations.[1] This fact calls for an explanation: why should logical symmetry of binary predicates be such a good predictor of their morphosyntactic relations with collective predicates? This question constitutes the first major challenge of this paper.

When dealing with this challenge, we also need to look at non-symmetric predicates.[2] A considerable class of such predicates alternate with collective unary predicates, similarly to the symmetric predicates above. Consider for example the following collective sentences:

(3) Sue and Dan hugged/fought/collided.

The binary counterparts of the intransitive verbs in (3) all denote non-symmetric predicates. For instance, a person can surely *hug* someone or something without being hugged back. This lack of logical symmetry explains familiar contrasts like *the drunkard hugged the lamppost* vs. #*the lamppost hugged the drunkard* (Dong 1971,

1 Only a handful of English predicates show symmetry without having a reciprocal alternate: *near*, *far from* and *resemble* are notable examples, discussed in section 2.6.

2 *Non-symmetric* simply means "not symmetric". The term *asymmetric* is reserved for binary predicates like *taller than*, where $R(x,y)$ entails the negation of $R(y,x)$.

referring to Noam Chomsky, p.c.). The same semantic consideration also explains subject-object asymmetries in sentences like *the fireman fought the fire* or *the driver collided with the bridge*.

Previous works have proposed different analyses of reciprocal predicates like *hug*, *fight*, and *collide*, connecting them with various notions of "symmetry" (Gleitman et al. 1996, Carlson 1998, Dimitriadis 2008). However, there is no general account of the prominence of standard logical symmetry among the reciprocal forms, and its effects on the semantics of lexical reciprocity. Addressing these puzzles, we first show a distinction between the reciprocal alternations that appear with symmetric predicates and those that appear with non-symmetric predicates. Reciprocal alternations with symmetric predicates like *date* have a simple semantic description. A sentence like *Sue and Dan dated* means pretty much the same as *Sue dated Dan* or, equivalently, *Dan dated Sue*. This is summarized below:

(4) Sue and Dan dated $\Leftrightarrow$ Sue dated Dan (Dan dated Sue).

When reciprocal predicates show this equivalence, we refer to them as *plain reciprocals*. Non-symmetric verbs like *hug* show a different type of reciprocity. As has been previously observed, collective sentences like *Sue and Dan hugged* should semantically be distinguished from statements like *Sue hugged Dan and Dan hugged Sue*. To see the difference, suppose that Sue hugged Dan when he was asleep, and later, he hugged her when she was asleep. In this scenario, the sentence *Sue hugged Dan and Dan hugged Sue* is true, but the sentence *Sue and Dan hugged* is not. Thus, by contrast to equivalence (4), with the verb *hug* we observe the following non-equivalence:

(5) Sue and Dan hugged $\not\Leftrightarrow$ Sue hugged Dan (and Dan hugged Sue).

As we will see, failures of such equivalences with non-symmetric predicates occur in more semantic circumstances than what has been previously observed, further beyond what is illustrated by the separate time intervals in the example above.

The contrast in reciprocity between *date* and *hug* in (4)-(5) illustrates a general phenomenon, which we call the *Reciprocity-Symmetry Generalization*: symmetric predicates exhibit plain reciprocity, whereas non-symmetric predicates do not. This generalization supports a distinction between two different principles about reciprocal alternations:

**P1.** Meanings of symmetric predicates are *logically derived* from the collective meanings of their reciprocal alternates.

**P2.** Meanings of non-symmetric binary predicates and their collective alternates are not mutually definable, but are connected to each other by a lexical strategy of *reciprocal polysemy*.

We show that P1 leads us to expect the coupling between plain reciprocity and symmetry, whereas P2 sanctions more complex forms of reciprocity with non-symmetric predicates.

Principles P1 and P2 are implemented in a semantic system of *protopredicates*: typed predicates at an abstract level that connects lexical predicate meanings with concepts. This system allows us to formally capture the semantic distinctions that are relevant for the grammar of reciprocal predicates, and derive the Reciprocity-Symmetry Generalization as a corollary. As clarified by recent experimental results in Kruitwagen et al. 2017, the reciprocal polysemy of non-symmetric verbs like *hug*, *fight* and *collide* is profitably described using *preferential* connections between two different senses of these verbs. The general picture that emerges informs our understanding of the interface between concepts and linguistic predicates. According to this emerging view, the formal semantics of protopredicates fully encodes "hard" logical relations. By contrast, "soft" preferential connections between predicate meanings are only represented by semantic types, and the full semantic interpretation of the polysemy is obtained by systems of language use, especially those governing the use of concepts.

The paper is structured as follows. Section 2 develops principle P1 above about the lexical relations between plain reciprocity and logical symmetry. Section 3 analyzes reciprocal polysemy in the semantics of non-plain alternations with non-symmetric binary predicates, thus elaborating principle P2. Section 4 introduces the formal notion of protopredicates and uses it to account for the Reciprocity-Symmetry Generalization.

## 2 Plain reciprocity and truth-conditional symmetry

This section focuses on collective sentences like *A and B dated*, which are equivalent to *A dated B and B dated A*. It is argued that such equivalences are logically independent of symmetry, although empirically they go hand in hand with it: non-symmetric predicates like transitive *hug* show a more complex kind of reciprocity. To account for this pattern, it is proposed that the basic lexical meaning of symmetric binary predicates in English is unary-collective. Symmetry follows directly from this assumption, which explains why English symmetric predicates have collective alternates, and why they only show a simple type of reciprocity. Furthermore, this analysis suggests a potential universal about natural language lexicons: symmetry is not an accidental semantic feature of binary predicates, but appears by virtue of their underlying collectivity. Some preliminary evidence from Greek and Hebrew are shown to support this conjecture, and suggest a general method for testing it further.

## 2.1 Plain reciprocity

Many reciprocal alternations support a simple semantic relation between the two forms of the predicate, as illustrated by the following equivalences:

| | | | |
|---|---|---|---|
| (6) | A and B dated | $\Leftrightarrow$ | A dated B and B dated A |
| | A and B are cousins | $\Leftrightarrow$ | A is B's cousin and B is A's cousin |
| | A and B are similar | $\Leftrightarrow$ | A is similar to B and B is similar to A |

Thus, the reciprocal sentences *A&B dated/are cousins/are similar* only hold in situations where the relevant binary predicate — transitive *date*, *cousin of*, *similar to* — bidirectionally holds between A and B. Such observations have led previous works to employ various informal notions of "symmetry" for describing reciprocal alternations. This terminology confuses reciprocity — a linguistic phenomenon that occurs with certain collective predicates — with the standard logical notion of symmetry, which only applies to binary predicates. To avoid this terminological confusion, we refer to alternations that support equivalences as in (6) as **plain reciprocal** (plainR) alternations. The term *symmetry* is standardly used as a property of binary predicates.

To characterize plain reciprocity in general terms, let us introduce some semantic notation. Let $E \neq \varnothing$ be a domain of singular entities, and let $P$ be a unary-collective predicate ranging over *sums* of entities in $E$.[3] Let $R$ be a binary predicate alternating with $P$, ranging over pairs of entities in $E$.[4] The equivalences in (6) are formally described by the following definition:[5]

(7) **Plain reciprocity** (plainR):
*For all* $x,y \in E$ *such that* $x \neq y$: $P(x{+}y) \Leftrightarrow R(x,y) \wedge R(y,x)$

In words: the predicates $P$ and $R$ are in *plain reciprocity* if for any sum $x{+}y$ of two different singular entities, $P$ holds of $x{+}y$ if and only if $R$ holds between $x$ and $y$ in both directions. Note that this does not mean that the predicate $R$ is symmetric: it only means that $R$ holds "symmetrically" between the $x$'s and $y$'s that satisfy

3 Formally, these pluralities are assumed to come from a domain isomorphic to $\{A \subseteq E : |A| \geq 2\}$: the subsets of $E$ with cardinality 2 or more. The + operator in definition (7) is the commutative operator mapping pairs of singular/plural entities to their sums, which can be thought of as set unions. Thus, the sum $x{+}y$ of two different entities $x,y \in E$ can be thought of as the doubleton $\{x,y\}$. For further technical details see Winter & Scha 2015.

4 This should be generalized for predicates with more arguments. For instance: the verb *mix* in *Dan mixed the flour and the sugar* is a binary predicate with a collective object argument, which alternates with *mix* ... *with* in *Dan mixed the flour with the sugar* — a ternary predicate between entities. This point does not affect the generality of our proposed account.

5 Definition (7) uses event-free denotations of predicates, which are sufficient for our purposes here. The analysis in Sections 3-4 will extend this definition by using events.

$P(x+y)$. For other $x$'s and $y$'s, the predicate $R$ may hold "asymmetrically": in one direction only. Thus, from a logical point of view, the binary predicates $R$ that satisfy Definition (7) with some collective $P$ might be symmetric or non-symmetric. This point is discussed further in section 2.3.

| | |
|---|---|
| Relational verbs: | *date*, *marry*, *get married* (*to*) |
| Verbs of interaction: | *meet* (*with*), *fight* (*with*), *talk* (*with*), *make love* (*with*)* |
| Sharing: | *share NP* (*with*) |
| Connections: | *cross*,† *match*, *rhyme*, *connected* (*to*), *united* (*with*), *differ* (*from*) |
| Relational nouns: | *sister,*‡ *brother, sibling, twin, cousin, friend, lover, neighbour, colleague, compatriot, penpal, synonym, antonym* |
| Relational adjectives: | (*dis*)*similar, identical, parallel, complementary, equivalent, equal, adjacent, synonymous, antonymous* |

*these verbs also show non-plain alternations with binary predicates (transitive *fight*, *talk to*, *make love to* and possibly transitive *meet*) — see sections 3 and 4
†on the verb *cross*, see note 11
‡on gender-sensitive relational nouns like *sister* and *brother*, see section 2.2

**Table 1** Plain reciprocal predicates

Definition (7) together with the equivalences in (6) characterize the predicates *date*, *cousin* and *similar* as plain reciprocals. Table 1 gives more plain alternations of this type. When considering these alternations, it is useful to keep in mind the following points:

i. Definition (7) assumes a standard semantics of plurals, where a conjunction like *Sue and Dan* denotes a sum of entities $\mathbf{s}+\mathbf{d}$. The commutativity of the sum-formation operator means that collective sentences like *Sue and Dan dated* are standardly analyzed as equivalent to *Dan and Sue dated*.

ii. Definition (7) makes use of collective predication over duos like *Sue and Dan*, ignoring reciprocal sentences with trios or bigger collections, as in *Sue, Dan and Sam are cousins*. The semantic relation between such sentences and binary predicates like *cousin of* will be addressed in more detail in subsection 2.5.

iii. The predicate $P$ in Definition (7) is the collective-reciprocal meaning of the unary form. With intransitive *hug* there is no distributive interpretation, as witnessed by the unacceptability of strings like ?*Sue hugged*. However, many other reciprocal predicates also have a distributive reading. For instance, *Dan* *and Sue talked* can be interpreted reciprocally, but also distributively: "Dan talked, and Sue talked as well". We assume that such distributive uses are distinct from the reciprocal-collective use, and ignore them in Definition (7) and the rest of this paper.[6]

iv. Some reciprocal predicates have two or more binary forms. In such cases, each of these forms may show a different kind of alternation with the unary entry. For instance, the construction *talk with* is arguably in a plain alternation with intransitive *talk*, although the construction *talk to* is not (see below).

As mentioned in the introduction, previous work on lexical reciprocity has made it clear that equivalences as in (6) do not hold with all reciprocal alternations. For instance, let us reconsider the the verb *hug*. We look at a scenario where Sue hugged Dan in his sleep, and then Dan hugged Sue in her sleep. In such a scenario, the collective sentence *Sue and Dan hugged* may be false when the two transitive sentences are true in different time coordinates. This fact is summarized in the following non-equivalence:

(8) Sue and Dan hugged $\not\Leftrightarrow$ Sue hugged Dan and Dan hugged Sue

A considerable class of predicates behave like *hug* in this respect. This includes pairs of verbal forms like *collide* (*with*), *talk* (*to*), in/transitive *kiss* and *fight*, as well as stative constructions like *be in love* (*with*). In Section 3 we will get back to reciprocal alternations that show this behavior.

### 2.2 Truth-conditional symmetry and presuppositional non-symmetry

When considering binary forms of plainR predicates as in Table 1, we see that symmetric predicates are highly prominent among them. For example, if Sue *dated* Dan, then he dated her as well; if Sue's skirt *matches* her jacket, then her jacket also matches her skirt; if Sue is Dan's *cousin*, then he is her cousin too. When characterizing such binary predicates as "symmetric", we rely on equivalences like the following (=(1a)):

(9) Sue dated Dan $\Leftrightarrow$ Dan dated Sue

The claim that such pairs of sentences are "equivalences" invites some elaboration. The sentences in (9) are not equivalent in their implications about Sue's

6 Teasing apart reciprocal readings from distributive readings requires some semantic tests. For instance, *Dan and Sue haven't talked for ages* can be true when the two people haven't talked to each other, but each of them has constantly talked to other people. Here the reciprocal reading is true while the distributive reading is false, which is evidence for ambiguity (or polysemy) of *talk* between two senses.

and Dan's capacities or statures from the point of view of the speaker. However, these sentences have the same truth-conditions: they are both true in situations where Sue and Dan went out on dates with each other, and false otherwise. Similarly, *Podolsky collaborated with Einstein* is a natural way to highlight the contribution of the physicist Boris Podolsky for work on the EPR paradox. *Einstein collaborated with Podolsky* may sound stylistically odd in such contexts, but both sentences are factually true and are classified as truth-conditionally equivalent. The same holds for familiar examples like *North Korea is similar to China* and *China is similar to North Korea* (Tversky 1977). Such apparent "asymmetries" are commonly related to Figure-Ground effects, or other non-truth-conditional phenomena (Talmy 1975, 2000). Accordingly, we stick to the standard classification of predicates like *date*, *collaborate with* and *similar to* as truth-conditionally symmetric (Dowty 1991, Gleitman et al. 1996).

Most plainR alternations in English involve this kind of truth-conditional symmetry. However, with one type of of English predicates, plain alternations appear without symmetry. These are relational nouns like *sister* and *brother*, which are sensitive to the gender of their referent. Reciprocity with these predicates is characterized as plain due to equivalences like the following:

(10) Kim and Hillary are sisters
⇔ Kim is Hillary's sister and Hillary is Kim's sister

However, the relational noun *sister* (*of*) is not symmetric. Consider for instance the following sentences:

(11) a. Kim is Hillary's sister.
b. Hillary is Kim's sister.

Sentence (11a) requires that Kim is a female whereas (11b) does not. Conversely, (11b) requires that Hillary is a female but (11a) does not. What can we make of this non-symmetry?

Among the relational nouns that have a reciprocal alternate, gender-sensitivity is the only recognized factor that leads to non-symmetry.[7] This exceptional status of nouns like *sister* and *brother* led Schwarz (2006) and Partee (2008) to look in some

7 For instance: (i) Gender-insensitive relational nouns like *friend* and *neighbor* have reciprocal variants and are symmetric; (ii) Other gender-insensitive relational nouns like *ancestor* or *boss* are non-symmetric, but do not have a reciprocal alternate (wit. the absence of a reciprocal reading in *we are ancestors/bosses*). Besides *sister* and *brother*, the only cases of non-symmetric reciprocal nouns that I know in English are the compounds *sister-in-law* and *brother-in-law*, as well as *girlfriend*, *boyfriend*, *wife* and *husband*, when the latter are also adapted to gay couples. Like *sister*, the plural uses of these nouns all show plain reciprocity, while their binary forms are not symmetric. For instance, *H&K are girlfriends* shows plainR, but *H is K's girlfriend* does not show symmetry: it requires H to be a female but doesn't have this requirement for K.

detail into their semantics. Schwarz and Partee propose that the non-symmetry of such nouns is not truth-conditional, but results from a *gender presupposition*. Thus, sentences (11a-b) are analyzed as follows:

(12) a. Kim is Hillary's sister
*Asserted*: Kim is Hillary's sibling
*Presupposed*: Kim is a female

b. Hillary is Kim's sister
*Asserted*: Hillary is Kim's sibling
*Presupposed*: Hillary is a female

Under this analysis, the truth-conditions of sentences like (12a) and (12b) are assumed to be the same. Accordingly, we refer to the nouns *sister* and *brother* as *truth-conditionally symmetric*.[8] The non-symmetry exhibited by (12a) and (12b) is analyzed as a result of a presupposition that targets one argument but not the other. We say that in the construction *Kim's sister*, the gender presupposition concerns the "referential argument": the entity that the complex NP's denotes. This presupposition does not concern the "possessor" *Kim*. In sum:

(13) **Gender presupposition of relational nouns**: Gender sensitive reciprocal nouns like *sister* and *brother* are truth-conditionally symmetric. Their non-symmetry follows from a gender presupposition on the referential argument.

Schwarz and Partee do not analyze collective sentences like *Kim and Hillary are sisters* (10). However, the analysis in (13) also applies to such sentences. The only difference from the case of *sister of* is that the referential argument of a plural noun like *sisters* is now a sum rather than a singular entity. We get the following analysis:

(14) Kim and Hillary are sisters

*Asserted*: Kim and Hillary are siblings
*Presupposed*: Kim and Hillary are females

Under this analysis, sentence (14) is truth-conditionally equivalent to the conjunction of the two sentences in (12a-b). The truth-conditional import of the noun *sister*(*s*) is assumed to be identical to the gender-neutral noun *sibling*(*s*), which supports the following plainR equivalence:

(15) Kim and Hillary are siblings

$\Leftrightarrow$ Kim is Hillary's sibling and Hillary is Kim's sibling

8 Schwarz calls this kind of symmetry *Strawson symmetry*, adopting von Fintel's (1999) terminology of "Strawson entailments": entailments that hold between sentences provided that their presuppositions are satisfied.

When we factor out gender presuppositions in this way, the reciprocity of the *sister* alternation is analyzed as plain like the alternation with the noun *sibling*.

Moving away from English to languages with grammatical gender, we see that principle (13) is also suitable as a general principle describing the behavior of gender-marked relational expressions. In Hebrew, a language with grammatical gender, all relational predicates (verbs, nouns and adjectives) must be gender-marked according to the grammatical gender of their referential argument. When a predicate refers to an animate object, gender marking has the expected semantic implications for the gender of the referent. For example, let us consider the following Hebrew sentences:

(16) a. yuval doma le tal
Yuval similar-*fem*. to Tal
"Yuval (female) is similar to Tal (gender unspecified)"
*Asserted*: Yuval is similar to Tal
*Presupposed*: Yuval is a female

b. tal dome le yuval
Tal similar-*masc*. to Yuval
"Tal (male) is similar to Yuval (gender unspecified)"
*Asserted*: Tal is similar to Yuval
*Presupposed*: Tal is a male

The names *Yuval* and *Tal* are contemporarily given to both males and females. A feminine/masculine agreement on the adjective as in sentences (16a/b) specifies *Yuval*/*Tal* as a female/male, respectively. The analyses in (16) illustrate how principle (13) accounts for the semantic effects of gender in these sentences. When using this principle, gender as in *doma*/*dome* is not treated as part of the core meaning of the word, which is just gender-neutral "similar". In this way, the truth-conditions of sentences (16a) and (16b) are assumed to be the same. However, the morphology of the predicate induces a gender presupposition, which leads to a different semantic import in each sentence despite the identical core meaning of the main predicate.

Using this analysis we treat both the feminine and the masculine forms of the adjective in (16a-b) as truth-conditionally symmetric, similar to *sister* and *brother* in English. Grammatical gender in Hebrew leads to many other cases of presuppositional non-symmetry with binary predicates that are otherwise symmetric. Similarly to English, the overwhelming majority of such truth-conditionally symmetric predicates have a reciprocal form, which is analyzed as a plain reciprocal. For instance, consider the following sentence:

(17) tal ve-yuval domot
Tal and-Yuval similar-*fem.pl*.
"Tal and Yuval (both of them female) are similar"

*Asserted*: Tal and Yuval are similar
*Presupposed*: Tal and Yuval are females

The assertion in sentence (17) is analyzed as an equivalent to the assertions in (16a) and (16b). Accordingly, the reciprocal alternation of the adjective *doma/dome* ("similar-*fem./masc*.") is analyzed as plain despite the semantic effects of gender.[9]

In sum, following Schwarz and Partee, I propose that the non-symmetry of gender-sensitive reciprocal predicates like *sister/brother* is presuppositional, although truth-conditionally, these predicates are symmetric. This explains the exceptional non-symmetry of gender-sensitive nouns among the reciprocal nouns in English, and offers a clear division of labor between gender agreement and the truth-conditional semantics of predicates in languages with grammatical gender.[10]

### 2.3 The Reciprocity-Symmetry Generalization

Among the binary predicates in English that are intuitively symmetric, the great majority have reciprocal alternates. This observation has constantly fascinated theoretical linguists since the 1960s. With our notions of *truth-conditional* symmetry and *plain* reciprocity, we can now be more precise about the connection between the two. The characterization of plain alternations in Section 2.1 reveals that symmetric predicates only alternate with plain reciprocals. Furthermore, Section 2.2 argued that from a truth-conditional perspective, the opposite is true as well: plain reciprocal alternations only appear with symmetric predicates. This generalization is formally stated below:

(18) **Reciprocity-Symmetry Generalization (RSG):** *A reciprocal alternation between a unary-collective predicate P and a binary predicate R is* **plain** *if and only if R is truth-conditionally* **symmetric**.

According to the RSG, truth-conditionally symmetric predicates like the verb *date* or the noun *sister* show plain reciprocity with their collective alternates. Conversely, non-symmetric binary predicates like *hug* fail to show plain reciprocity with their

9 Some further intricacies affect the semantics of gender-marked plurals in Hebrew. Notably, if one of the conjuncts is masculine, Hebrew speakers tend to use masculine plural agreement, e.g. *domim* (similar-*masc.pl.*) or *axim* (brother-*masc.pl.*). This makes a sentence like *Yuval ve-Tal domim/axim* ("Yuval and-Tal are similar/brother-*masc.pl.*") mean: "Yuval and Tal are similar/siblings, and at least one of them is a male". We analyze the gender-marked predicate *domim/axim* as truth-conditionally identical to "similar/siblings". The implication "at least one of them is a male" is analyzed as a gender presupposition.

10 See Schwarz 2006 for further arguments regarding the gender presupposition of *sister/brother* in English. For the more general issue, see Zamparelli 2008, Percus 2011, Sudo 2012. Despite their different proposals, the main conclusions of these works are consistent with the non-truth-conditional analysis of gender that is advocated by Schwarz.

collective alternates. Indeed, as we saw in (8), the *hug* alternation is not plain. As we will see in Section 3, this is the case with virtually all other non-symmetric predicates that have reciprocal alternates.[11]

What principles can help us to account for the RSG? Before addressing this question, the first thing to note is that the RSG is by no means a logical necessity. Thus, we can construct hypothetical languages where symmetric predicates show non-plain alternations, or where non-symmetric predicates participate in plain alternations. Let us demonstrate the latter scenario by considering a simple example in natural language.[12] In this example we use the reciprocal expression *each other*. This kind of reciprocals involves quantification in complex constructions, hence it is largely orthogonal to our current study of lexical predicates.[13] However, for the purpose of the current discussion, *each other* helps us observe a logical point about symmetry and plain reciprocity. Suppose that $R$ is a non-symmetric binary predicate without any reciprocal alternate in the lexicon. The complex expression "$R$ each other" is usually in a plain alternation with $R$. For instance, consider the transitive verb *thank*. This verb has no intransitive form, let alone one with a reciprocal interpretation.

11 In English, the only potential exception I know to the RSG is the verb *cross* (and in some dialects, *intersect*). The sentence *the road crosses the town* does not entail #*the town crosses the road*, hence transitive *cross* is not symmetric. Yet, *A and B cross* means the same as *A crosses B and B crosses A*, hence the *cross* alternation is plain. Whether this one case challenges the RSG is unclear, however, since *x crosses y* may involve two different meanings: "*x* passes across *y*" and "*x* forms a crossing with *y*". Only the latter meaning has a reciprocal alternate (wit. the unacceptability of *the road and the town cross*). In Hebrew, these two senses are expressed by different binary verbal constructions: a non-symmetric *xacah* ('divide, cut, halve, cross, bisect') vs. a symmetric *hictalev im* 'form a cross with'. Only the latter verb has a reciprocal entry, which is in a plain alternation with the binary use. I hypothesize that the non-symmetric use of English *cross* in *the road crosses the town* reflects a separate sense, which does not have any reciprocal alternate. If correct, this hypothesis removes the challenge for the RSG.

12 Using artificial examples we can illustrate both scenarios. For instance, let us use $\mathbf{hug_1}$ and $\mathbf{hug_2}$ to denote the unary/binary meanings of the verb *hug*. Assuming a hypothetical verb **Xhug*, we make up the following artificial unary/binary meanings:

$$\mathbf{Xhug_1}(x{+}y) \;=\; \mathbf{hug_2}(x,y) \wedge \mathbf{hug_2}(y,x)$$
$$\mathbf{Xhug_2}(x,y) \;=\; \mathbf{Xhug_2}(y,x) \;=\; \mathbf{hug_1}(x{+}y)$$

By definition, intransitive **Xhug* is now in plainR with the *non*-symmetric transitive *hug*. Further, as we saw, *Sue and Dan hugged* means something different than *Sue hugged Dan and Dan hugged Sue*. Consequently, although transitive **Xhug* is by definition symmetric, it is *not* in plainR with intransitive **Xhug*.

13 Expressions like *each other* appear as arguments of virtually all binary predicates. For some works that study such reciprocals, see Dalrymple et al. 1998, Kerem et al. 2011, Sabato & Winter 2012, Mari 2014, Poortman et al. 2018. The possible relations between lexical reciprocity as in *they hugged* and quantificational reciprocity as in *they hugged each other* is a complex topic that is still poorly understood. Studying this problem is supplementary to, and partly dependent on, the main issues of the present paper.

However, like all transitive verbs, it combines well with *each other*. Now let us consider the following two sentences:

(19) a. Yesterday, Sue and Dan thanked each other.
 b. Yesterday, Sue thanked Dan and Dan thanked Sue.

These sentences are equivalent. This means that the complex predicate *thank each other* is in a plain alternation with transitive *thank*. Transitive *thank* is not symmetric, hence the equivalence in (19a-b) refutes the RSG for the complex predicate *thank each other*. From a logical perspective, we might expect English to develop a reciprocal alternation refuting the RSG in the same way. However, as we saw, this is not the case. Many non-symmetric binary predicates like *thank* have no lexical reciprocal alternate whatsoever. Furthermore, arguably, all the non-symmetric binary predicates that do have reciprocal alternates (e.g. *hug*) do not support plain alternations.

The discussion above (and note 12) shows that the RSG, if correct, must be viewed as a semantic generalization about the lexicon, rather than a logical consequence of some standard notion of reciprocity. To account for the observed linkage between symmetry and plain reciprocity, we need to study the general principles that regulate predicate meanings in the lexicon. We will get back to this question in Section 4, after analyzing more facts about reciprocal alternations.

### 2.4 Deriving symmetric predicates from collective meanings

In her pioneering transformational account of conjunction and plurality, Gleitman (1965) proposed that sentences with lexically reciprocal predicates are derived from sentences with their binary alternates. For instance, Gleitman derives the intransitive sentence *Oxygen and hydrogen combine* from the sentence *Oxygen and hydrogen combine with each other*. Thus, in Gleitman's account, binary entries like *combine with* are more basic than collective intransitive entries like *combine*. While such transformational treatments are no longer in fashion, the idea that binary entries are semantically more basic than reciprocal entries has persisted. Most works on the topic assume that the meanings of lexical reciprocals are derived from meanings of binary predicates in one way or another.[14]

In the current analysis of plain reciprocity, I follow an alternative approach by Lakoff & Peters (1969), who proposed a syntactic transformation that derives binary forms of predicates from unary-collective forms. Similarly, according to the semantic analysis developed here, predicates that support plain alternations are inherently

14 Dimitriadis (2008), Rubinstein (2009), Siloni (2012) and Bar-Asher Siegal (2015) all propose mappings from meanings of transitive verbs to meanings of reciprocal verbs. Hackl (2002) is a similar account of reciprocal nouns.

collective. Thus, the basic meaning of predicates like *combine*, *date*, *sister* and *similar* is assumed to categorize pluralities. For instance, sentence (20a) below is analyzed as in (20b), where $F$ is the relevant plurality.

(20) a. These films are similar.

b. $\textbf{similar}(F)$

Works following Gleitman 1965 treat unary lexical entries like *similar* as having complex meanings, which are syntactically or semantically derived from the meanings of binary forms like *similar to*. By contrast, in (20b), as in Lakoff & Peters's approach, we treat the collective-reciprocal entry as primary. Thus, the representation in (20b) has no logical entailments about similarity relations between pairs of individual films. We will get back to this point about collectivity in Section 2.5.

With plain reciprocals like *similar*, we logically derive the meaning of the binary construction from the collective meaning. For instance, the meaning of the binary predicate *similar to* is defined as follows:

(21) $\textbf{similar\_to} = \lambda x.\lambda y.\textbf{similar}(x{+}y)$

In words: an entity $x$ is considered *similar to* an entity $y$ if the sum of $x$ and $y$ is in the extension of the collective predicate **similar**. More generally, we adopt the following formal definition for all binary predicates in plain alternations:

(22) **Symmetric image of a collective predicate**: *Let $P$ be a unary-collective predicate meaning. The* symmetric image *of $P$ is the binary predicate $R$ that is defined as follows:*

$R \stackrel{def}{=} \lambda x.\lambda y.P(x{+}y)$

Definition (22) accounts for the symmetry of the predicate $R$ as well as for the semantics of plain alternations. For instance, with the predicate *similar*, we obtain the following equivalences for all $a$ and $b$:

Symmetry:

$$\textbf{similar\_to}(a,b) \stackrel{def}{\Leftrightarrow} \textbf{similar}(a{+}b) \Leftrightarrow \textbf{similar}(b{+}a) \stackrel{def}{\Leftrightarrow} \textbf{similar\_to}(b,a)$$

Plain reciprocity:

$$\textbf{similar}(a{+}b) \Leftrightarrow \textbf{similar\_to}(a,b) \wedge \textbf{similar\_to}(b,a)$$

The same holds for all binary predicates that are derived by (22).

Lakoff & Peters's original rule only targeted specific forms of binary predicates, especially verbal *with* and adjectival *to*. The semantic rule in (22) is both less general and more general than L&P's transformational rule. On the one hand, symmetric images are assumed to be derived only for a subset of the collective predicates in the lexicon, and are not necessarily related to prepositions like *with* and *to*. This explains why predicates like *collide with* or *be in love with* are not symmetric, and do not stand in a plain alternation with their collective counterparts. In Section 3 we treat such constructions using a different reciprocity principle than the rule in (22).[15] Further, because the semantic strategy in (22) is lexical, it applies to binary predicates without *with* or *to*. This includes transitive verbs like *date* and *match* and relational nouns like *cousin of* and *sister of*. As will be proposed in Section 4, the semantics of reciprocal alternations is regulated by lexical features in the representation of protopredicates, and is not fully specified by overt items like the prepositions *with* and *to*.

### 2.5 The linguistic irreducibility of plain reciprocals

By taking collective predicates to be primitive, the semantic strategy above is in line with theories of plurality where predication over collections has an equal status to other kinds of predication. One advantage of this view comes from examples like the following (Lasersohn 1995: p.29):

(23) John, Mary and Bill are similar.

Lasersohn points out a remark by Goodman (1951), showing that the collective sentence (23) is not equivalent to the following conjunction of transitive sentences:

(24) John is similar to Mary, Mary is similar to Bill, and Bill is similar to John.

Sentence (23) strongly favors situations where John, Mary and Bill share the same feature (or features). By contrast, sentence (24) is also true if the members of each of the three pairs share different features. For instance, consider a situation where John and Mary have the same hobbies, Mary and Bill have the same cultural background, and Bill and John have the same look. Such a situation supports (24) but not (23). We conclude that sentence (23) involves a collective predication over the sum **j**+**m**+**b**, with the predicate *similar* having the meaning of *sharing a feature*.[16]

This "sharing" is a rather general phenomenon with collective predicates. For example, the collective sentences in (25a) below require that A, B and C share

15 Lakoff & Peters also treat sentences like *John left with Bill* as derived from *John and Bill left together*. This captures the intuition that when comitative *with* combines with distributive predicates like *leave*, its analysis involves collectivity. One complication in L&P's analysis is that it incorrectly predicts sentences like *Sue jogged with her baby* (e.g. using a jogging stroller) to mean "Sue and her baby jogged together". For relevant discussion, see Lasersohn 1990, Mari 2003. Further research of comitative *with* in relation to the semantics of reciprocal alternations is left for future work.

16 Theories of plurals that rely on pragmatic covers allow readings of sentences like (23) that are equivalent to (24) (Schwarzschild 1996). These theories have a problem with observations like the ones above (see also Winter 2000).

one opinion, one pair of grandparents, and one (material or non-material) asset, respectively. In contrast, the sentences in (25b) allow different opinions, grandparents and assets to be associated with each of the three pairs.

(25) a. A, B and C agreed/are cousins/are partners.
b. A agreed with/is cousin of/is partner of B, and
B agreed with/is cousin of/is partner of C, and
C agreed with/is cousin of/is partner of A.

We see that the collective predicates *similar, agree, cousin* and *partner* make stronger claims than pairwise applications of their binary forms. Such collective predicates support the following "sharing" implications, which are not easily respected if we try to express collective statements using binary predicates:[17]

| | | |
|---|---|---|
| *be similar* | → | "share feature(s)" |
| *agree* | → | "share opinion(s)" |
| *be cousins* | → | "share grandparent(s)" |
| *be partners* | → | "share asset(s)" |

This is evidence that meanings of collective predicates are basic, and cannot be logically analyzed in terms of simpler meanings.

## 2.6 The RSG as a language universal

As we have seen, the symmetry of binary predicates in plain alternations is naturally explained when their meanings are logically derived from their collective alternates. However, some symmetric predicates in English do not have such alternates. Consider for instance the following examples:

(26) A { resembles / borders on / is near / is far from } B

17 Formally, suppose that $P$ is a collective predicate s.t. for any sum $A$: $P(A) \Leftrightarrow \exists u.\mathbf{share}(A,u)$. Let the binary predicate $R$ be defined for all $x$ and $y$ by: $R(x,y) \Leftrightarrow P(x{+}y)$. The statements $R(a,b) \wedge R(b,c) \wedge R(c,a)$ and $P(x{+}y{+}z)$ are equivalent to (i) and (ii), respectively:

(i) $\exists u_1.\mathbf{share}(a{+}b,u_1) \wedge \exists u_2.\mathbf{share}(b{+}c,u_2) \wedge \exists u_3.\mathbf{share}(a{+}c,u_3)$

(ii) $\exists u.\mathbf{share}(a{+}b{+}c,u)$

Unless we make implausible assumptions on the predicate **share**, (i) does not entail (ii). Consequently, it is hard to rely on (i) when analyzing the meaning of (ii).

(27) A and B $\left\{\begin{array}{l}\text{#resemble}\\ \text{#border}\\ \text{are near}\\ \text{are far}\end{array}\right\}$

The binary predicates in (26) are symmetric, but their unary usages in (27) cannot be interpreted reciprocally, if they are interpretable at all. For instance, *A&B are near* does not mean that A and B are near each other, and *A&B resemble* is furthermore unacceptable. Thus, these unary predicates have no reciprocal sense.[18] The RSG in (18) deals with pairs of predicates where one predicate ("*P*") has a reciprocal interpretation. Therefore, strictly speaking, predicates as in (26) do not challenge our statement of the RSG. However, the examples in (26) raise an important question: why does English have only a small class of symmetric predicates without reciprocal alternates?

As a possible answer to this question, I hypothesize that in fact, all denotations of symmetric predicates are derived from collective meanings, even when those meanings are not lexically realized. Specifically, binary predicates like *resemble*, *far from* and *near* are symmetric due to underlying unary-collective meanings that are not realized in English as intransitive predicates, but are nevertheless operational at the semantic analysis. For instance, to deduce the symmetry of the verb *resemble*, an English speaker has to have a collective predicate meaning that categorizes a group of objects as being similar. A transitive sentence like *A resembles B* is understood as applying this collective predicate to the sum *A+B* despite the absence of an intransitive entry for *resemble*.

This line of analysis entails that even though English does not have collective usages for symmetric predicates like *resemble* and *near*, other languages might. To substantiate this "universalist" approach to the RSG, we should examine the following conjecture:

(28) **The Symmetry-Collectivity Conjecture**: *If a language $L_1$ has a symmetric binary predicate R without any collective alternate, then there exists another language, $L_2$, where the near translation of R does have a collective alternate, with a plain reciprocal meaning.*

18 Like *near*, the adjective *close* rejects reciprocity in its spatial use, but *close* has an additional sense of social proximity (*a close friend*), where it does have a reciprocal counterpart (*we have been close since childhood*). Other symmetric relations in English that do not have reciprocal counterparts are *remote of* and *within reach of* (Ginzburg 1990).

To test this conjecture with the English predicates in (26), let us look at some of their near translations in other languages. First, let us consider the following usages of the near translations of *far*, *resemble* and *border on* in Greek:[19]

(29) a. i Thessaloniki apexi apo tin Athina
the Thessaloniki-*nom.sg.* be-far-*pres*.3.*sg.* from the Athens-*acc.sg*.
"Thessaloniki is far from Athens"

b. i Thessaloniki ke i Athina apexun
the Thessaloniki-*nom.sg.* and the Athens-*acc.sg.* be-far-*pres.3.pl.*
(poli/arketa)
(somewhat/very)
"Thessaloniki and Athens are (somewhat/very) far from each other"

(30) a. o Janis mjazi ston Kosta
the Janis-*nom.sg.* resemble-*pres.3.sg.* to.the-*acc.sg.* Kostas-*acc.sg.*
"Janis resembles Kostas"

b. o Janis ke o Kostas miázun
the Janis-*nom.sg.* and the Kostas-*nom.sg.* resemble-*pres.3.pl.*
"Janis and Kostas are similar/look alike"

(31) a. i Rosia sinorevi me i Kina
the Russia border-*sg.* with the China
"Russia has a border in common with China"

b. i Rosia kje i Kina sinorevun
the Russia and the China border-*pl.*
"Russia and China have a border in common"

Sentences (29b), (30b) and (31b) all have reciprocal meanings. A similar collective-reciprocal reading appears in (32b) with the parallel of *near* in Hebrew:

(32) a. nekuda 1 krova le-nekuda 2
point 1 near-*fem*. to-point 2
"Point 1 is near Point 2"

b. nekudot 1 ve-2 krovot
points 1 and-2 near-*fem.pl*.
"Points 1 and 2 are near each other"

19 In (29b), the adverbials *poli/arketa* 'somewhat/very' may help to boost the reciprocal interpretation, but apparently they are not obligatory. I thank Eleni Tsouloucha for pointing out to me (29) and (30). Example (31) is from Dimitriadis 2004.

Such data may be used for supporting the conjecture in (28). Any substantial attempt to test this conjecture would require comparing many reciprocal and symmetric predicates in different languages. At present, despite the extensive typological knowledge on reciprocals that has accumulated over the last 20 years (Frajzyngier & Walker 2000, Nedjalkov 2007, König & Gast 2008, Evans et al. 2011), there is no cross-linguistic database that could help to test such cross-linguistic conjectures as in (28). This challenge must be left for further research.

## 3 Preferential reciprocity and non-symmetric predicates

In the previous section we treated symmetric predicates and their plain reciprocal alternations. This section studies the semantics of verbs like *hug*, *fight* and *collide*, whose binary uses are non-symmetric and fail to show plain reciprocity. This supports the RSG of Section 2 but raises further questions about the semantics of reciprocal alternations. After reviewing some central semantic phenomena with non-plain reciprocals, this section proposes that such alternations are based on a polysemy relation that lacks a complete logical definition. We characterize two semantic postulates that restrict the meanings of non-plain reciprocals like the verb *hug*: (i) a verbal postulate — if A and B *hug* then A hugs B or vice versa; (ii) a nominal postulate — a *hug* between A and B is either unidirectional or collective. The latter postulate explains the special properties of reciprocal events (Carlson 1998). Following Kruitwagen et al. 2017, we propose that further specifications of the semantics of non-plain alternations rely on "soft", preferential connections, rather than logical rules. One of these preferences explains the "maximal reciprocity" inference that speakers often draw when interpreting non-plain reciprocals.

### 3.1 Non-symmetry and reciprocal alternations

As we have seen, the verb *hug* shows a reciprocal alternation but fails to show symmetry. Similar phenomena were observed by Dong (1971), who mentions the following non-equivalences:

(33) The drunk embraced the lamppost
$\not\Leftrightarrow$ #The lamppost embraced the drunk

The truck collided with the lamppost
$\not\Leftrightarrow$ #The lamppost collided with the truck

Examples as in (33) support the classification of transitive *embrace* and *collide with* as non-symmetric relations. At the same time, in sentences like *Dan and Sue embraced* or *the two cars collided*, the same verbs exhibit a reciprocal interpretation. Some more English predicates of this type are given in Table 2.

| | |
|---|---|
| Transitive/intransitive alternations: | *hug, embrace, kiss, fuck, fight, divorce* |
| *With*/intransitive alternations: | *break up, collide, fall/be in love* |
| *To*/intransitive alternations: | *talk, speak, chat, make love* |

**Table 2** Reciprocal alternations with non-symmetric binary predicates

The non-symmetry of *embrace* and *collide* is easily observed in (33) due to the different selectional restrictions of the two arguments. As a result, an assertion of the form $R(x,y)$ can be true while $R(y,x)$ is unacceptable or patently false. We find similar non-symmetries with other verbs that have collective intransitive entries:[20]

(34) Sue *kissed* the doll $\not\Leftrightarrow$ #The doll kissed Sue
Dan *fought* the fire $\not\Leftrightarrow$ #The fire fought Dan
Ann *fell in love* with the book $\not\Leftrightarrow$ #The book fell in love with Ann
Pete *talked* to the wind $\not\Leftrightarrow$ #The wind talked to Pete

The non-symmetry of the verbs in Table 2 also surfaces when the two arguments of the binary form satisfy the selectional restrictions of both positions. For instance:

(35) a. Sue embraced Dan $\not\Leftrightarrow$ Dan embraced Sue
b. The truck collided with the bicycle $\not\Leftrightarrow$ The bicycle collided with the truck

In (35a) Sue may have embraced Dan without Dan reciprocating. Similarly, in (35b) the truck may have been the cause of the collision while the bicycle was not. In such cases, the first sentence in each pair is true while the second sentence is acceptable but false. Similar effects can be observed with other predicates from Table 2:

(36) a. The chihuahua dog fought the postman (but the postman ignored it).
b. Sue broke up with/divorced Dan (though Dan wished they would stay together).
c. Dan fell in love with the actress (but she wasn't interested in him).
d. Ann talked to the clerk (but the clerk didn't answer).

These examples and similar ones decisively demonstrate that the binary guises of the predicates in Table 2 are not truth-conditionally symmetric.

### 3.2 The logical irreducibility of non-plain reciprocals

The non-symmetry of the predicates in Table 2 leads the RSG to expect that these predicates do not support plain alternations. With respect to the verb *hug*, we have already seen that in relation to the following sentence:

20 For similar examples see also Rákosi 2008 on Hungarian and Bar-Asher Siegal 2015 on Hebrew.

(37) Sue and Dan hugged.

As we saw, the truth-conditions of sentence (37) are different than those of the following conjunction:

(38) Sue hugged Dan and Dan hugged Sue.

This was exemplified in the following scenario:

(39) Sue hugged Dan while he was sleeping; then, Dan woke up, Sue fell asleep, and he hugged her while she was sleeping.

Under scenario (39), sentence (38) is true but (37) does not follow. We concluded that sentence (38) does not logically entail (37), hence the *hug* alternation is not plain. Using similar tests, we will show below that the alternations with the other verbs in Table 2 are not plain either.

This absence of plain reciprocity has been previously observed in Carlson 1998, Siloni 2002, 2012, Dimitriadis 2008 and Rubinstein 2009, among others.[21] These works all use event semantics, where sentence (37) is analyzed according to the following formula, in a Davidsonian setup:[22]

(40) $\exists e.\mathbf{hug}_1(e,\mathbf{s}{+}\mathbf{d})$

In words: there is an event $e$ where the collective predicate *hug* holds of the sum $\mathbf{s}{+}\mathbf{d}$. Dimitriadis (2008) further analyzes statements like (40) by decomposing the event $e$ into sub-events with unidirectional hugs between singular entities. In this approach, the collective predicate $\mathbf{hug}_1$ in (40) is analyzed using the denotation $\mathbf{hug}_2$ of transitive *hug*:

(41) $\exists e.\exists e_1 \prec e.\exists e_2 \prec e.\mathbf{hug}_2(e_1,\mathbf{s},\mathbf{d}) \wedge \mathbf{hug}_2(e_2,\mathbf{d},\mathbf{s})$

In words: an event $e$ is a collective hug of Sue and Dan if $e$ contains a more specified event $e_1$ where Sue hugged Dan, and a more specified event $e_2$ where Dan hugged Sue. This analysis intuitively explains why there is no entailment from (38) to (37): sentence (38) requires two events $e_1$ and $e_2$ with the corresponding

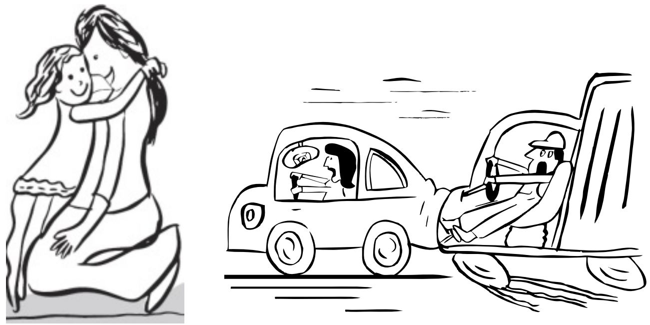
21 These works do not distinguish intransitive verbs like *hug* or *fight* from plain reciprocals like *date* or *marry*, and the symmetry of the latter is not their main concern. The focus in these works is on non-entailments like the following:

(i) Sue and Dan kissed each other five times $\not\Rightarrow$ Sue and Dan kissed five times.

(ii) Sue and Dan said that they kissed each other $\not\Rightarrow$ Sue and Dan said that they kissed.

A full semantic analysis of cases like (i) and (ii) requires a detailed theory of *each other*, time adverbials (i), and propositional attitudes (ii), and is beyond the scope of this paper. However, our main conclusions here are fully consistent with previous analyses of cases like (i) and (ii).

22 The works mentioned above all rely on a neo-Davidsonian setting, but their analyses are very similar to the Davidsonian presentation in (40) and (41).



(a) (b)

**Figure 1** *Kruitwagen et al.'s experiment* — in (a), 48% of the participants judged the Dutch translation of "the girl and the woman hug" as true and "the woman hugs the girl" as false; in (b), 96% of the participants judged the Dutch translation of "the car and the truck collide" as true and "the car collides against the truck" as false.

unidirectional hugs, but such events are not necessarily more specified than any event $e$. This leaves room for models where (38) is true but (37) is false.[23] More generally, Dimitriadis proposes a rule that connects any reciprocal entry $P$ to its binary alternate $R$. According to this rule, for all events $e$ and entities $x$ and $y$ such that $x \neq y$, we have:

(42) $P(e, x{+}y) \Leftrightarrow \exists e_1 \prec e. \exists e_2 \prec e. R(e_1, x, y) \wedge R(e_2, y, x)$

Dimitriadis's account relies on the event-specification relation '$\prec$', whose semantics is not formally defined. Thus, his proposal gives no formal criterion for deciding which pairs $e_1$ and $e_2$ of "unidirectional events" support a collective event $e$ and which ones do not. This leads to some empirical weaknesses. For instance, although speakers reject scenarios like (39) as supporting a collective hug, Dimitriadis's analysis does not: it does not rule out the possibility that in models that support (39), the two "unidirectional" hug events are more specified than some event $e$, describing a "collective" hug. Therefore, although rule (42) correctly predicts that (39) does not entail the sentence *Sue and Dan hugged*, it does not expect any inconsistency between the two.

23 (41) uses the "$\prec$" symbol for what Dimitriadis, following Link 1987, calls the *specification* relation between events. The gist of Dimitriadis's account of the non-entailment (38)$\not\Rightarrow$(37) is the assumption that the domain of events is not necessarily *complete* under specification: for some domains $\varepsilon$ of events, we have $e_1, e_2 \in \varepsilon$ but no $e \in \varepsilon$ s.t. $e_1 \prec e$ and $e_2 \prec e$. Rubinstein (2009) similarly avoids completeness in the algebra of events, but she treats reciprocals using "group" events.

This unintuitive result may seem disappointing if we expect a logical definition for the meaning of intransitive *hug* in terms of transitive *hug*. However, I believe that the indeterminacy in Dimitriadis's analysis is actually welcome: lexical concepts like collective *hug* are notoriously vague. As with other concepts, specifying sufficient and necessary conditions for categorization of events using such lexical concepts is often hard, or even impossible (Laurence & Margolis 1999). Dimitriadis's account and similar proposals give a clear explanation of why sentences like (38) do not entail collective sentences like (37). Such formal semantic proposals do not aim to explain which of the situations that support (38) support (37) as well. I believe that this is as it should be: analyzing lexical concepts like collective *hug* requires different principles than standard logical techniques of formal semantics.

Yet, in another respect all previous accounts of non-plain reciprocals are logically pregnant. The analysis in (42) expects all sentences like (37) to entail conjunctions like (38). Similarly, virtually all other previous works assume entailments like the following as a core property of reciprocal alternations:[24]

(43) **Assumption of previous approaches**:

A and B hugged (collided/fought) ⇒
A hugged (collided with/fought) B, and B hugged (collided with/fought) A.

Recent experimental results in Kruitwagen et al. 2017 cast doubt on this assumption. Kruitwagen et al. show that speakers often judge sentences like the antecedent in (43) as true in situations where they consider one of the conjuncts in the consequent to be false. For example, in the situation of Figure 1a, 48% of the participants in Kruitwagen et al.'s experiment judged the Dutch translation of "the girl and the woman are hugging" as true, while judging "the woman is hugging the girl" as false. Similar "asymmetric" illustrations and video clips were used by Kruitwagen et al. to study Dutch verbs of physical contact like *botsen* "collide" (Figure 1b), *knuffelen* "hug", and *vechten* "fight", as well as verbs of communication like *praten* "talk", *roddelen* "gossip", and *appen* "send WhatsApp messages". In all those cases, substantial percentages of speakers accepted the collective statement but rejected one of the corresponding binary statements. The conclusion is that rules like (42), although partly underspecified, are still too strong as a general description of non-plain reciprocals. We will get back to this problem in section 3.4.

24 The only potential exception I know is Dowty (1991: n.29), who expresses doubts that "rule-based approaches" could answer the "deeper question" about acquisition of reciprocal verb meanings. Dowty mentions the fact that collective predicates normally do not require full participation in an event (wit. *the Americans elected Trump*). However, like other previous works, Dowty assumes that reciprocal predicates as in *A and B hugged/kissed* are special among the collective predicates, and do require "full participation" of A and B.

### 3.3 Non-plain reciprocals: a variety of lexical relations

The discussion above concentrated on the verb *hug* as one example for non-plain reciprocity. To get an impression of the semantic diversity of non-plain reciprocals, this section considers some more examples for such verbs. As for the verb *hug*, we saw that we cannot infer a collective hug from two unidirectional hugs, and conversely: events with a single unidirectional hug may be classified as collective hugs. In general notation, neither ($\mathrm{Pr}_1$) nor ($\mathrm{Pr}_2$) below holds for *hug*, where $R$ is the binary entry and $P$ is the corresponding reciprocal verb:

($\mathrm{Pr}_1$) $[R(x,y) \wedge R(y,x)] \Rightarrow P(x{+}y)$

($\mathrm{Pr}_2$) $P(x{+}y) \Rightarrow R(x,y)$

The non-entailment (37)$\not\Rightarrow$(38) demonstrated the lack of property ($\mathrm{Pr}_1$). The non-entailment (38)$\not\Rightarrow$(37) in Kruitwagen et al.'s experiments demonstrated the lack of ($\mathrm{Pr}_2$).

A weaker logical property than ($\mathrm{Pr}_1$) may still hold for *hug*. Suppose that Sue hugged Dan and that Dan hugged Sue *at the same time*. In such a case is very hard to imagine how Sue and Dan could not have hugged. Thus, we may reasonably accept the following entailment:

(44) Sue hugged Dan and Dan hugged Sue simultaneously
$\Rightarrow$ Sue and Dan hugged

In more general terms, with *Sim* as an informal notation for the simultaneity requirement, we denote:

($\mathrm{Pr}_3$) $[R(x,y) \wedge R(y,x) \wedge Sim] \Rightarrow P(x{+}y)$

Examining the inferential properties ($\mathrm{Pr}_1$)-($\mathrm{Pr}_3$) has shown us in which ways the lexical meaning of the verb *hug* fails to show plain reciprocity. Other verbs that show a similar behavior are *embrace* and *make love to*, as well as the verb *fuck* and its variants (Dong 1971). We now move on to other examples of non-plain reciprocals and their inferential properties.

**kiss:** This is another non-symmetric predicate whose alternation is similar to *hug*, though counterexamples for ($\mathrm{Pr}_2$) are not easily found. If Sue and Dan are kissing, it is hard to imagine how Dan could not be kissing Sue. Presumably, however, this difference is smaller than it seems: if Dan is extremely cooperative while Sue is kissing him, without kissing her back, I speculate that speakers might accept the collective scenario as they did for *hug* in Kruitwagen et al.'s experiments. Showing this point experimentally would require a more specific study of this verb.

**fight:** Transitive *fight* is a non-symmetric predicate, which alternates with collective *fight* similarly to the *hug* alternation:[25] like *hug*, the verb *fight* satisfies ($Pr_3$) but does not satisfy ($Pr_1$). Kruitwagen et al. show that a parallel verb in Dutch — *vechten* (*tegen*), 'fight (against)' — does not satisfy ($Pr_2$) either.

**break up, divorce:** Examples like (36b) above show that the predicate *break up with* is not symmetric. Expectedly, the *break up* (*with*) alternation is not plain. For instance, the following example shows that *break up* fails to show property ($Pr_2$):

(45) Sue and Dan broke up $\not\Rightarrow$ Sue broke up with Dan

If the instigator of the breakup was Dan, then the antecedent in (45) is true but the consequent may be false (e.g. if the breakup was against Sue's will). Interestingly, however, the *break up* alternation shows the following property:

(46) Sue broke up with Dan $\Rightarrow$ Sue and Dan broke up

In general notation:

($Pr_4$) $R(x,y) \Rightarrow P(x{+}y)$

Property ($Pr_4$) is logically stronger than ($Pr_1$), hence predicates like *break up* trivially satisfy ($Pr_1$) as well. For instance, if Sue broke up with Dan and Dan broke up with Sue, then Sue and Dan broke up: once (if both Dan and Sue were the instigators of one breakup), or twice (with a different instigator reported for each breakup).

A similar behavior is observed with the non-symmetric predicate *divorce*. If Sue and Dan divorced, the sentence *Sue divorced Dan* may still be false (failure of ($Pr_2$)), but if one of the two people divorced the other, it necessarily follows that they divorced ($Pr_4$).

**collide:** As we saw, *collide with* is a non-symmetric predicate. As Kruitwagen et al. show, the Dutch parallel of *collide* — *botsen* (*tegen*), 'collide (against)' — fails to show ($Pr_2$). Further, the alternation between collective *collide* and *collide with* fails to show property ($Pr_4$): if Sue's car collided with a bridge, it does not follow that #*Sue's car and the bridge collided*. Whether ($Pr_1$) holds with *collide* is hard to test, since the test would have to involve unlikely situations like car 1 colliding with car 2 and car 2 colliding with car 1 in different occasions. By contrast, ($Pr_3$) surely holds: if two cars simultaneously collided with each other, then they undoubtedly collided.

25 Unlike *hug*, the English verb *fight* also has a comitative use (e.g. *Sue fought with Dan*, see Section 4.3) as well as an intransitive use with an implicit object reading (e.g. *Sue fought hard*).

**in love:** The predicate *be in love with* is not symmetric. However, if A and B are in love, then A is in love with B and B is in love with A. Thus, the *in love* alternation satisfies property ($Pr_2$). On the other hand, if A is in love with B and B is in love with A, neither of them has to be aware of the other's feelings, or even know that the other one knows her. In this situation, the love relations between the two people are not accompanied by "collective intentionality" (a term due to Searle 1990). Accordingly, the situation misses a critical ingredient of the collective interpretation of *A&B are in love*. In such a situation, this sentence can only be considered true under a distributive reading: "A is in love (with someone) and B is in love (with someone)". According to this observation, the construction *be in love*, and its eventive variant *fall in love*, fail to show ($Pr_1$) and hence are non-plain reciprocals. Note that these constructions do not even satisfy the weaker property ($Pr_3$): even if each of A and B is in love or falls in love with the other at the same time, the sentence *A&B are* (*fell*) *in love* may remain false under its collective reading.

**talk:** Similar observations hold for the *talk* (*to*) alternation. If A is talking to B and B is talking to A, the collective interpretation of sentence *A&B are talking* may be false. This collective interpretation requires that A and B are intentionally engaged in a talk. However, if the two people do not hear each other or are not listening to each other, the collective interpretation of sentence *A&B are talking* may be considered false. Since the collective reading of intransitive *talk* and the binary form *talk to* do not satisfy property ($Pr_3$), they are not in a plain alternation.[26] Furthermore, Kruitwagen et al. experimentally show that in Dutch, a parallel alternation — *praten* (*tegen*), 'talk (against, to)' — does not satisfy ($Pr_2$) either: if one person is talking to the other while the other person is quiet but looks collaborative, many speakers accept collective sentences like "the two people are talking".

**Hebrew *makir* ('know'):** Another example for a non-plain alternation is the Hebrew verb *makir* ("knows", "is familiar with", "has heard of"). Like its English translations, the transitive use of this verb is non-symmetric. Now let us consider the following sentence:

(47) morrissey *makir* et hod-ma'alata, ve-hi *makira*
Morrissey know-*masc.sg.* ACC her-majesty and-she know-*fem.sg.*
oto
him

26 Like the reciprocal *fight*, the verb *talk* also allows a comitative *with*, which plausibly supports a plain alternation. A similar but subtler distinction between the comitative and the transitive entry is found between transitive *meet* and *meet with*: witness the contrast in *A met (with) B at the station* (Dixon 2005: 361-2).

"Morrissey knows Her Majesty, and she knows him"

Sentence (47) is most probably true of the two celebrities, at least when *makir* is interpreted in the sense of "has heard of".[27] However, this does not yet support the truth of the following sentence:

(48) morrissey ve-hod-ma'alata *makirim*
Morrissey and-her-majesty know-*masc.pl.*

"Morrissey and Her Majesty are acquainted with each other"

Sentence (48) entails a personal acquaintance between Morrissey and Her Majesty, whereas (47) does not: if Morrissey and the queen have never met or talked, (48) is false while (47) is still likely to be true. Note that unlike what we saw with the English predicates *be in love* and *talk*, the intransitive use of *makir* in (48) only has a collective interpretation and no distributive interpretation. This intransitive form does not tolerate singular subjects (wit. **morrissey makir* "Morrissey knows"). Therefore, the intransitive sentence (48) is unambiguously collective, and only has the sense "be in an acquaintance relation with each other".

The facts reviewed above are summarized in Table 3. As we see, there are different ways in which non-symmetric predicates fail to show the plain reciprocity equivalence in (7). Yet, one weak logical pattern is shared by all the predicates in Table 3. For all entities $x$ and $y$ such that $x \neq y$, we have:

($\mathrm{Pr}_5$) $P(x+y) \Rightarrow R(x,y) \vee R(y,x)$

Thus, when two people *hug*, *fight*, *collide*, or *break up*, then at least one of them must be hugging/fighting/etc. the other. This weak disjunctive entailment is found with all non-plain reciprocals (and of course, with all plain reciprocals). Yet, property ($\mathrm{Pr}_5$) gives little insight into the general semantics of non-plain alternations. As Table 3 summarizes, other logical properties are often found in such alternations. Property ($\mathrm{Pr}_5$) is only a necessary requirement from reciprocal predicates, but the intuitive notion of "reciprocity" is often much stronger. In fact, the only reciprocal predicates I know where the entailment ($\mathrm{Pr}_5$) may reasonably be strengthened into an equivalence are *break up* and *divorce*. Is there something more general than ($\mathrm{Pr}_5$) that can be said about non-plain alternations? The following two sections answer this question positively, from two different perspectives: the counting properties of event nominals, and the preferential properties of reciprocal concepts.

27 Morrissey used this sense of *know* in a song from 1986: "So I broke into the Palace/With a sponge and a rusty spanner/She said: 'Eh, I know you, and you cannot sing'/I said: 'that's nothing — you should hear me play piano'" (The Smiths, The Queen is Dead).

| | *hug* | *kiss* | *fight* | *break up* | *divorce* | *collide* | *be/fall in love* | *talk* | *makir* (Hebrew 'know') |
|---|---|---|---|---|---|---|---|---|---|
| | in/tr | in/tr | in/tr | in/w | in/tr | in/w | in/w | in/to | in/tr |
| $Pr_1$ | – | – | – | + | + | ? | – | – | – |
| $Pr_2$ | – | ? | – | – | – | – | + | – | + |
| $Pr_3$ | + | + | + | + | + | + | – | – | – |
| $Pr_4$ | – | – | – | + | + | – | – | – | – |
| $Pr_5$ | + | + | + | + | + | + | + | + | + |

in/tr: intransitive/transitive alternation
in/w: intransitive/*with* alternation
in/to: intransitive/*to* alternation

$Pr_1$: $[R(x,y) \wedge R(y,x)] \Rightarrow P(x{+}y)$
$Pr_2$: $P(x{+}y) \Rightarrow R(x,y)$
$Pr_3$: $[R(x,y) \wedge R(y,x) \wedge Sim] \Rightarrow P(x{+}y)$
$Pr_4$: $R(x,y) \Rightarrow P(x{+}y)$
$Pr_5$: $P(x{+}y) \Rightarrow [R(x,y) \vee R(y,x)]$

**Table 3** Logical patterns with non-plain reciprocals

### 3.4 On counting events

Following Carlson 1998 and Siloni 2002, previous works have addressed some questions about the way events are counted with reciprocal predicates (see note 21). Here we focus on one of these questions, which Carlson calls the *individuation* of events. If Sue hugged Dan and Dan hugged Sue, how many hug events were there? Answering "two" would be too hasty, since the given conjunction may also be true when the two acts are considered parts of one collective hug event. In that case we might as well answer "one hug". It is impossible to decide a priori that one of these two counting strategies is the "correct" one. Thus, the following entailment fails:

(49) Sue hugged Dan and Dan hugged Sue $\not\Rightarrow$ There were two hugs.

This failure is due to the ambiguity (or polysemy) of the noun *hug*: like the corresponding verb, this noun describes unidirectional as well as bidirectional events.

After observing this ambiguity of reciprocal event nominals, it is also useful to observe their disambiguation strategies. Suppose that Sue hugged Dan and Dan hugged Sue, and we choose to count it as one *hug*. Under this reading of the noun *hug*, we intuitively assume that the sentence *Sue and Dan hugged* is true. Formally, this intuition is described as the following entailment:

(50) Sue hugged Dan and Dan hugged Sue, and there was only one hug between Sue and Dan $\Rightarrow$ Sue and Dan hugged.

These observations extend to the other eventive verbs in Table 3: if Sue *fought*, *kissed* or *collided with* Dan, and Dan did the same to Sue, we may count it as one collective *fight*, *kiss* or *collision*, or as two unidirectional events. Additionally, if in such a case we only count one event, then this event is a collective event, which supports the sentences *Sue and Dan fought* (*kissed*, *collided*).[28] Note that (non-)entailments similar to (49) and (50) also trivially hold with plain reciprocals like *marry*:

(51) Sue married Dan and Dan married Sue $\nRightarrow$ There were two marriages.

(52) Sue married Dan and Dan married Sue, and there was only one marriage between Sue and Dan $\Rightarrow$ Sue and Dan married.

To account for these counting effects, we adopt one direction of Dimitriadis's proposal in (42):

(53) $\exists e_1 \prec e. \exists e_2 \prec e. R(e_1, x, y) \wedge R(e_2, y, x) \Rightarrow P(e, x{+}y)$

Thus, when two unidirectional $R$ events ($e_1$ and $e_2$) are considered part of an event $e$, then that event is a collective $P$ event. In such cases, Dimitriadis (2008) stipulates that "events specifying some superior eventuality are obscured by it; when we count events, we only count eventualities that [ . . . ] do not themselves specify some 'larger' eventuality". This means that in cases where the antecedent of (53) holds for an event $e$, we only count one event: a mutual hug, fight etc. Consequently, we account for the non-entailment (49) as follows: if the hugs in the antecedent are viewed as two parts of another event, then we only count that event as a hug event. That event also supports the entailment in (50).[29]

By contrast to these counting effects with reciprocals, transitive verbs without reciprocal alternates individuate single events. For instance, in contrast to (49), the parallel entailment below does hold with the verb *push* and the corresponding noun:

(54) Sue pushed Dan and Dan pushed Sue $\Rightarrow$ There were two pushes.

28 The same also holds for stative expressions like *be in love* or Hebrew *makir* ("know"). If Dan is in love with Sue and Sue is in love with Dan, we may count it as one state of *love* or as two states. If we count only one state, then the sentence *Sue and Dan are in love* is true under the collective reading.

29 A formal system of event "specification" should derive these results without stipulations like Dimitriadis's. The challenge is similar to other cases of counting of events and individuals (Krifka 1990, Rothstein 2010, 2017). For instance, Rothstein points out a contrast between count nouns like *cat* and count nouns like *fence*: while cats are "naturally countable", fences are not. Thus, for any two separate entities A and B:

(i) A is a cat and B is a cat $\Rightarrow$ A and B together are two cats.

(ii) A is a fence and B is a fence $\nRightarrow$ A and B together are two fences (A and B may be different parts of one fence).

This contrast is remarkably similar to the contrast between *hug* and *push* events in (49) vs. (54).

Even if the antecedent in (54) is true because Sue and Dan pushed each other simultaneously, we must count two pushes and not one "mutual push". We conclude that the unambiguous transitivity of the verb *push* correlates with the unambiguous directionality of the event nominal *push*. According to Dimitriadis's line, the entailment (54) is accounted for by assuming that for any two *push* events $e_1$ and $e_2$, the antecedent of (53) fails for any possible event $e$: there is no way of having two *push* events that specify a larger event. Thus, the contrast between (53) and (49) is a candidate for a semantic property distinguishing possibly reciprocal verbs from other verbs. Informally, we state this distinction as follows:

(55) **Event individuation with (non-)reciprocal verbs**:

- Binary verbs that have a reciprocal alternate (e.g. *hug*, *marry*) do **not** individuate events described by the corresponding event nominal.
- Binary verbs that do **not** have a reciprocal alternate (e.g. *push*) individuate events described by the event nominal.

This property characterizes binary verbs that have a reciprocal alternate on the basis of their semantic relation with the corresponding event nominal. Events described by these verbs do not stand in a one-to-one correspondence with the events that the nominal individuates. By contrast, the events specified by transitive verbs like *push* specify events in a one-to-one relation to the corresponding nominal. As a result, any use of such a verb is counted as one event. This property, like property ($Pr_5$) above, is a logical regularity that distinguishes reciprocal verbs from other verbs.

### 3.5 Preferential reciprocity

The semantic properties that we have considered so far do not define completely how a non-plain reciprocal verb is logically related to its binary counterpart. No matter how hard we try, it seems impossible to specify necessary and sufficient conditions that fully define the semantics of non-plain alternations. This kind of difficulty is quite common in lexical semantics (Laurence & Margolis 1999). A familiar reaction to this challenge has been to replace logical analyses of concepts by theories based on *typicality*. In such theories, key features in a concept's representation determine how typical different entities are considered as instances of that concept. For example, most speakers consider tennis as a more typical instance of the concept *sport* than chess. This judgement is based on certain key features of the concept *sport* that characterize tennis, but not chess: physical activity, played outdoors, carried out in stadiums etc. Such features are assumed to be part of the concept representation for *sport*. This does not define the concept yet, but it explains the preference of tennis to chess as a sport, while still leaving room for speakers to consider chess as a sport (e.g. due to its competitive nature).

What is common to many typicality-based accounts is their specification of predicate extensions using what Hampton (2007) calls the *threshold model* of categorization. For example, suppose that **sport** is the lexical predicate associated with the concept *sport*. When determining the truth-value of a statement $\mathbf{sport}(x)$, speakers rely on the typicality value for $x$ in relation to *sport*, and check if it is above their threshold value. The way this typicality value is determined depends on the most salient features of the concept. In this approach, the important challenge is not so much to define the "real" truth-conditions of sentences like *X is a sport*, *fruit*, *pet* etc., but to recognize speakers' strategies of using typical features of concepts when making truth-value judgements on such sentences. The features of concepts like *sport* do not change dramatically from one speaker to another, but the factors that determine their use, including the categorization threshold, vary from speaker to speaker and from situation to situation. When speakers try to categorize chess as an instance of *sport*, the partial matching between the features of chess and the features of the concept *sport* leads to a boundary typicality value. This explains the divergences in truth-value judgements on contingent sentences like *chess is a sport*.

I propose that something quite similar is happening with reciprocal verbs like *hug*. To analyze the meaning of such lexical items, the challenge is not so much to determine necessary and sufficient truth-conditions for sentences like *A&B are hugging*, but to characterize the systemic variables that affect truth-value judgements on such sentences. As with other concepts, this can be achieved by characterizing typical properties of the concept's instances. I propose that one property that is common to all collective predicates that partake in reciprocity alternations is what I call *preferential reciprocity*. When trying to categorize an event as a collective *hug*, we look for as many as possible pairs of agents that perform unidirectional hugs in that event. In this typicality-based account of *hug*, we still use the Davidsonian predicates like $\mathbf{hug}_1$ and $\mathbf{hug}_2$ as above, which range over entities and events.[30] When a reciprocal predicate $\mathbf{hug}_1$ applies to an event $e$ and a sum $A$, we rely on the typicality value of $e$ and $A$ for the concept "collective hug". This typicality value is proportional to the number of non-identical pairs $\langle x,y\rangle$ over $A$, such that $x$ is hugging $y$ in $e$. In formula:

(56) $\mathrm{Typ}_{\mathbf{hug}_1}(e,A) \propto |\{\langle x,y\rangle \in A^2 : x \neq y \wedge \mathbf{hug}_2(e,x,y)\}|$

Definition (56) leads us to expect the non-entailments between sentences (37) and (38). When (38) is true, there is an event $e_1$ where $\mathbf{hug}_2(e_1,x,y)$ holds and another event $e_2$ where $\mathbf{hug}_2(e_2,y,x)$ holds. This does not mean that we found any

30 Here, the term "event" is meant to also include states, which is useful for stative predicates like *be in love* and Hebrew *makir*, discussed above.

event $e$ where $\text{Typ}_{\mathbf{hug}_1}(e,x{+}y)$ passes the speaker's threshold for collective *hug*. Furthermore, (56) also explains why (37) does not entail (38): an event $e$ where $\text{Typ}_{\mathbf{hug}_1}(e,x{+}y)$ passes the speaker's threshold does not guarantee that within $e$, the relation $\mathbf{hug}_2$ holds in both directions.

The analysis in (56) embodies a weak, non-logical relation between collective events and directional events: it guarantees that having many unidirectional hugs in an event boosts its typicality as a collective *hug*. More formally:

(57) Let $e$ be an event with a set of agents $A$ such that $\text{Typ}_{\mathbf{hug}_1}(e,A)$ passes the speaker's threshold. Then any event $e'$ that contains more $\mathbf{hug}_2$ relations than $e$ but is otherwise minimally different from $e$, passes the speaker's threshold as well.

Thus, changing a unidirectional hug as in Figure 1a to an event where the woman hugs the girl as well can only boost the categorization of the event as a collective hug. This prediction is supported by Kruitwagen et al.'s (2017) findings.[31]

Generalizing the principle in (56), let us consider the Davidsonian meaning $P$ of a unary-collective predicate, and the Davidsonian meaning $R$ of an alternate binary predicate. The following condition characterizes $P$ as *preferentially reciprocal* with respect to $R$:

(58) **Preferential reciprocity**: For every event $e$ with a sum argument $A$, the typicality value $\text{Typ}_P(e,A)$ of that event with respect to $A$ satisfies:

$$\text{Typ}_P(e,A) \propto |\{\langle x,y\rangle \in A^2 : x \neq y \wedge R(e,x,y)\}|$$

This condition explains how reciprocal interpretations surface in the absence of plain reciprocity. According to (58), preferential reciprocity is a typicality effect with collective verbs like *hug*, *fight* and *collide*, which relates them to their binary alternates. This helps to explain two inferential effects:

i. *Default inferences*: In many situations, speakers infer plain reciprocity as a default with non-plain reciprocals. For instance, upon hearing the sentence *Sue and Dan hugged*, most people would infer that each of them hugged the other. However, upon being shown weird scenarios like Figure 1a, speakers often accept the collective sentence despite the absence of a bidirectional hug. This kind of "defeasible" reasoning characterizes inferences with many natural concepts. Famously, speakers tend to accept inferences like *Tweety*

31 Kruitwagen et al. also identify effects that are extraneous to the meaning of transitive *hug*, but boost the categorization of an event as a collective hug. One such factor is what they call the *collective intentionality* of the group (Searle 1990): the degree to which its members show a joint attention, a shared belief, or a collective emotion. With respect to the verb *hug*, for instance, Kruitwagen et al. show the relevance of this factor by comparing the categorization of Figure 1a to a similar drawing where the depicted woman has a less collaborative look.

*is a bird, therefore she flies*, and only start questioning them after being reminded about penguins, ostriches and the like.

ii. *Disjunctive inferences*: As mentioned above, the disjunctive property ($Pr_5$) characterizes all reciprocal verbs. This is easily explained by principle (58). For a sentence like *Sue and Dan hugged* to be judged as true, all speakers require a non-zero typicality threshold. If neither Dan nor Sue hugged the other person, typicality is zero (or close to zero), and the sentence is unanimously judged as false in all situations.

Recognizing these predictions from (58), we are justified to refer to collective verbs like *hug* as "reciprocal". However, as we saw, empirically we must distinguish preferential reciprocity from the logical, plain reciprocity that was addressed in Section 2. With preferential alternations, I propose that binary predicate meanings are not logically derived from their reciprocal alternates, or vice versa. This aspect of the proposal is made explicit in the type system of the next section.

## 4 The RSG and the formal semantics of protopredicates

The previous two sections analyzed the behavior of reciprocal predicates and introduced the Reciprocity-Symmetry Generalization. As we saw, the link that the RSG makes between plain reciprocity and symmetry is not a logical necessity, but a contingent fact about language. In theory, we might expect languages with symmetric predicates in non-plain alternations, or non-symmetric predicates in plain alternations. How can we account for the apparent absence of such cases in English and other languages? Would such an account be plausible as a language universal? Would it follow from other established properties of natural language?

Answering these general questions requires more knowledge than what is currently available. In this paper I will only deal with one preliminary issue: the lexical properties that are necessary for deriving the RSG as a corollary. Thus, the challenge of this section is to develop a formal account that explicitly describes the semantic relations between unary predicates and binary predicates in reciprocal alternations according to the RSG. This is done by defining a notion of *protopredicate*, which forms an intermediate level between concepts and lexical predicates. I will develop this notion as a formal semantic correlate of previous accounts — especially by Dowty and Rappaport-Hovav & Levin — and show how the new mechanism naturally accounts for the RSG.

## 4.1 Dowty's and Rappaport-Hovav & Levin's accounts of verb alternations

In traditional Transformational Grammar and Montague Grammar, the only means for encoding semantic relations between lexical entries is using syntactic transformations or logical meaning postulates. Indeed, all previous formal analyses of reciprocal predicates postulate some syntactic or semantic rules that link their meanings to their binary alternates. Dimitriadis's semantic rule in (42) is representative of recent approaches to reciprocal alternations. An opposing view to such rule-based accounts of predicate alternations is introduced by Dowty (1991: pp.584-5), who does not rely on formal principles connecting between predicate meanings. Instead, according to Dowty's account, the realization of a participant in an eventuality as argument in a certain syntactic position (subject, object etc.) is based on *prototypical roles*. A participant that shows prototypical properties of an agent (volition, activity, movability, etc.) is more likely to appear in subject position than a participant that has prototypical properties of a patient (affected, stationary, etc.). Although Dowty does not analyze reciprocal predicates in detail, two of his remarks are especially illuminating for our purposes:

1. "*Marrying*, *playing chess*, *debating* [ . . . ] are actions that by their nature require the volitional involvement of two parties. [ . . . ] By the same token, volition is irrelevant to whether stative relations [like *rhyme, intersect*, and *be similar*] obtain."

2. [*Hugging, kissing, making love* etc. are] "actions that differ from both of the types [mentioned in 1] in that [ . . . ] the relation may involve volition on the part of either one or of both parties, without the language, as it were, feeling the need for [ . . . ] 'unrelated' lexemes to distinguish such subcases."

Dowty's first remark concerns verbs that — in the terminology of Section 2 — show plain reciprocity. What is common to these verbs is that volition, a prototypical property of agents, does not distinguish the different participants. More generally: plain reciprocals like *marry* or *similar* only refer to eventualities where different participants have the same roles. As a result, such plain reciprocals show no difference in meaning between the unary entry and the binary entry. By contrast, with non-plain predicates like *hug*, events may have only one participant that exhibits volition. This kind of hug is exclusively described by the binary entry, hence the semantic difference between that entry and the unary use of the verb.

The aim here is to capture the RSG by relying on these intuitive distinctions. To do that, we define what Rappaport Hovav & Levin (1998) call a "structural component of meaning": those aspects of lexical semantics that are responsible for the relations between meanings of a predicate's alternates. RH&L's proposal makes use of *verb templates*: structural descriptions that involve concepts like *ACT*, *CAUSE* and *BECOME*, and describe semantic relations between different verbal entries. For instance, for describing the relations between the intransitive and transitive forms of the verb *break* (“the vase *broke*”, “Sue *broke* the vase”) RH&L use the following templates:

(59) Intransitive *break*: [ *BECOME* [ *x* ⟨ BROKEN ⟩ ]]
Transitive *break*: [[ *x ACT*] *CAUSE* [ *BECOME* [ *y* ⟨ BROKEN ⟩ ]]]

The predicate symbol “BROKEN” in (59) stands for the abstract concept associated with the verb *break*. The templates in (59) are general representations of the meanings of intransitive *break* and transitive *break* in terms of this (unanalyzed) concept. Generalizing this template, RH&L obtain a meaning representation for all verbs that participate in this *inchoative-causative* alternation like the verb *break*.

Other alternations are treated using different templates. For instance, the alternation between transitive *sweep* (“Dan swept the floor”) and resultative *sweep* (“Dan swept the floor *clean*”) is described as follows:

(60) Transitive *sweep*: [ *x ACT* ⟨SWEEP⟩ *y* ]
Resultative *sweep*: [[ *x ACT* ⟨SWEEP⟩ *y* ] *CAUSE* [ *BECOME* [ *y* ⟨ STATE ⟩ ]]]

Importantly, while the template in (60) is used with *sweep* and other resultatives, it is ruled out with verbs like *break*. This is observed in the ungrammaticality of strings like **Dan broke the dishes valueless*.

## 4.2 Protopredicates

Templates as in (59) and (60) are the “structural components” that Rappaport-Hovav & Levin use for describing meanings of lexical verbs in terms of abstract predicate concepts. In more semantic terms, we restate these representational descriptions as follows:

(i) Each predicate concept is associated with an abstract *type*, which describes properties of this concept’s denotations that are constant across models. For instance: the predicate BROKEN only applies to states with one participant, whereas SWEEP only applies to events with two participants.

(ii) When a template matches a concept’s type, it derives denotations for the lexical predicates associated with that concept. For instance: the rules in (59) derive denotations for the intransitive and transitive entries of the verb *break*, based on a type of the concept BROKEN that classifies it as suitable for this template.

In this way, a concept's type and the templates it is associated with encode a *class of lexical predicates*: "sets of semantically-related verbs [or other predicates — Y.W.] sharing a range of linguistic properties, such as possible realizations of arguments, and interpretation associated with each possible argument realization." (Levin 2009)

Rappaport-Hovav & Levin's paper does not deal with reciprocal predicates. However, their use of templates is consistent with Dowty's conception. Similarly to RH&L's reliance on a distinction between concepts like BROKEN and SWEEP, the quotes above from Dowty 1991 specify a difference between concepts like MARRY and concepts like HUG. Information that encodes this distinction must be available to any linguistic analysis that seeks to model the difference between verbs like *marry* and *hug*. According to Dowty, events that are categorized using the concept MARRY must have two participants that are not thematically distinguished. By contrast, participants in events that are categorized by the concept HUG may be thematically distinguished, in that there may be only one participant showing volition. To formalize this distinction between the concepts MARRY and HUG, we analyze MARRY as a collective predicate concept that has *unordered sums* in its extension. By contrast, the concept HUG is analyzed using an abstract predicate that categorizes sums as well as *ordered pairs*. Concepts like MARRY are assigned the type *c* (collective), whereas concepts like HUG are given the type *bc* (binary-collective). In other cases, as with the transitive verb *push*, we have "purely binary" concepts. Such predicates only have a binary form that distinguishes a participant showing volition from another participant. Thus, we assume that the concept PUSH only categorizes events with ordered pairs of participants. Such concepts are assigned the type *b*, for *binary*.

The *b*, *c* and *bc* types describe the aggregation of participants in the eventualities that a concept categorizes. By doing that, they also restrict the semantic rules, or templates, that are applicable to a concept. Let us first address the first aspect: the possible *denotations* for concepts of different types. When we concentrate on verbs, these denotations are representable as standard *n-ary Davidsonian predicates*: relations between an event or a state and participants in that eventuality.[32] Since these relations are the basis for deriving denotations of lexical predicates, we refer to them

32 While this analysis can be easily extended to nouns and adjectives, there is a reason to focus here on verbs: (i) apparently, all reciprocal nouns and adjectives in English show plain reciprocity, which makes them a less general test case; (ii) our account is neutral on the question whether (some) nouns or adjectives have an event argument (Larson 1998). The first point is quite remarkable, and may be related to the latter point: presumably, non-plain reciprocity stems from the special role of events in the semantics of verbs. Interesting as they are, these issues do not bear too much on the analysis here: treating nouns and adjectives using protopredicates can be similar to the treatment of verbs (if we use events), or even simpler (if we do not).

as *protopredicates*.[33] A protopredicate is an abstract description of a predicate meaning, where the class of the predicate is encoded as the protopredicate's type. Here we focus on the protopredicates of the three types discussed above: $n$-ary relations of type $b$, $c$ or $bc$ that range over eventualities and (sums of) other individuals.

To see what kind of relations these protopredicates denote, let us first consider the $c$-type protopredicate for the concept MARRY in a model that describes the following marriages:

(61) Marriage 1: A and B are collectively involved.

Marriage 2: C and D are collectively involved.

This is the only kind of eventualities that the concept of monogamic marriage allows: ones where two participants are collectively involved. The marriages in (61) are described by the following sentences:

(62) a. A&B married (alternatively: *A married B*, or *B married A*).

b. C&D married (alternatively: *C married D*, or *C married D*).

In a model of these two marriages, the protopredicate $\mathbf{marry}^c$ holds of the sums corresponding to A&B and C&D as the respective participants of two different events. Formally:

(63) $\mathbf{marry}^c = \{\langle e_1, a{+}b\rangle, \langle e_2, c{+}d\rangle\}$

This protopredicate is responsible for deriving both the intransitive and the transitive guises of the verb *marry*. Following Dowty, and ultimately Lakoff & Peters 1969, we view this as the origin for the symmetry of the latter. The same holds for all predicates that we classified as plain reciprocals. They are derived from $c$-type protopredicates whose denotations hold of sums, hence the binary forms of such predicates are symmetric.

Protopredicates of non-plain reciprocals like *hug* are assigned the type $bc$. Such protopredicates hold of pairs as well as sums. To see how such protopredicates are used, let us consider the following hug events:

(64) Hug 1: A is active and B is passive.

Hug 2: B is active and A is passive.

Hug 3: C and D are collectively involved, and both of them are active.

Hug 4: E and F are collectively involved, but only E is active.

33 Dowty used the term "protorole" to describe prototypical properties that participants have in an eventuality. Protopredicates relate to this notion as follows: let $C$ be a concept that categorizes an event $e$ with participants $x$ and $y$; then these participants occupy the same (collective) argument of the *protopredicate associated with* $C$ if and only if $x$ and $y$ have the same protorole, i.e. the same prototypical properties in the eventualities that $C$ categorizes.

Hugs 1 and 2 are prototypical directional hugs. Hug 3 is a prototypical "collective hug": the two participants are collectively engaged, and they are both actively engaged. Hug 4 is a "collective non-symmetric hug": the two participants are collectively involved, but only one of them is actively hugging the other one (see e.g. Figure 1a). These four events support the following sentences, respectively.

(65) a. A hugged B.
b. B hugged A.
c. C&D hugged; C hugged D; D hugged C.
d. E&F hugged; E hugged F.

Thus, in models that describe the events in (64), we construct the protopredicate $\mathbf{hug}^{bc}$ as follows:

Hug 1 corresponds to the ordered pair $\langle a,b\rangle$.

Hug 2 corresponds to the ordered pair $\langle b,a\rangle$.

Hug 3 corresponds to the sum $c{+}d$ and the ordered pairs $\langle c,d\rangle$ and $\langle d,c\rangle$.

Hug 4 corresponds to the sum $e{+}f$ and the ordered pair $\langle e,f\rangle$.

In sum, we get the following denotation for the protopredicate **hug**:

(66) $\mathbf{hug}^{bc} = \{\langle e_1,a,b\rangle,\langle e_2,b,a\rangle,\langle e_3,c{+}d\rangle,\langle e_3,c,d\rangle,\langle e_3,d,c\rangle,\langle e_4,e{+}f\rangle,\langle e_4,e,f\rangle\}$

In addition to *c* and *bc* protopredicates such as **marry** and **hug**, we also use binary protopredicates of type *b*. For example, (67) and (68) below describe the way we model different *push* events using the protopredicate **push** of type *b*:

(67) Push 1: A is active and B is passive.
Push 2: B is active and A is passive.
Push 3: C is pushing herself.

(68) $\mathbf{push}^{b} = \{\langle e_1,a,b\rangle,\langle e_2,b,a\rangle,\langle e_3,c,c\rangle\}$

The entailment observed in (54) means that unlike Hug 3 above, we do not have push events with two participants where both participants are active.

### 4.3 Deriving denotations of lexical predicates from protopredicates

To formalize the three types of protopredicates, we use $E$ as the domain of entities and $\varepsilon$ as the domain of events (possibly a sub-domain of $E$). The notation $E^2$ is standardly for the cartesian product $E \times E$: the set of ordered pairs from $E$. In addition, we also use the notation $\wp^2(E)$ for the set of all duo sums in $E$. Formally:[34]

34 For simplicity, here we only treat *c* and *bc* protopredicates ranging over *duo* sums. Extending this definition for sums with more than two members is straightforward.

$$\wp^2(E) = \{x+y \mid x,y \in E \text{ and } x \neq y\}.$$

We use this notation for generalizing the treatment of protopredicates in (63), (66) and (68) above. With the protopredicate $\mathbf{push}^b$, the denotation in (68) associates events with pairs in $E^2$, but not with sums. With $\mathbf{marry}^c$, the denotation (63) associates events with sums in $\wp^2(E)$, but not with pairs. With $\mathbf{hug}^{bc}$, the denotation (66) associates events with sums as well as pairs. These three types of protopredicates are generally defined as follows:

(69) **Protopredicate denotations**: Let $E$ and $\varepsilon$ be non-empty sets of entities and events, respectively. The denotation $[\![\mathbf{P}]\!]$ of a protopredicate $\mathbf{P}$ over $E$ and $\varepsilon$ is made of two parts: a binary part $[\![\mathbf{P}]\!]^B$ and a collective part $[\![\mathbf{P}]\!]^C$. For protopredicates of types $b$, $c$ and $bc$, these parts are:

| | | |
|---|---|---|
| $\mathbf{P}^b$: | $[\![\mathbf{P}^b]\!]^B \subseteq \varepsilon \times E^2$ | $[\![\mathbf{P}^b]\!]^C$ is undefined |
| $\mathbf{P}^c$: | $[\![\mathbf{P}^c]\!]^B$ is undefined | $[\![\mathbf{P}^c]\!]^C \subseteq \varepsilon \times \wp^2(E)$ |
| $\mathbf{P}^{bc}$: | $[\![\mathbf{P}^{bc}]\!]^B \subseteq \varepsilon \times E^2$ | $[\![\mathbf{P}^{bc}]\!]^C \subseteq \varepsilon \times \wp^2(E)$ |

From these protopredicates we derive collective and binary lexical predicates as follow:

- *Collective* lexical predicates hold of the sums in the $C$ part of protopredicates. For instance, the intransitive entries for *marry* and *hug* denote the following functions over events $e$ and sums $z$:

  $$[\![marry_{\text{iv}}]\!] = \lambda e.\lambda z.\langle e,z\rangle \in [\![\mathbf{marry}^c]\!]^C$$
  $$[\![hug_{\text{iv}}]\!] = \lambda e.\lambda z.\langle e,z\rangle \in [\![\mathbf{hug}^c]\!]^C$$

- *Binary* lexical predicates are derived using two strategies:

  (i) One strategy derives binary predicates directly from the ordered pairs in the $B$ part of protopredicates. For instance, the denotations of the transitive entries for *push* and *hug* are:

  $$[\![push_{\text{tv}}]\!] = \lambda e.\lambda x.\lambda y.\langle e,x,y\rangle \in [\![\mathbf{push}^b]\!]^B$$
  $$[\![hug_{\text{tv}}]\!] = \lambda e.\lambda x.\lambda y.\langle e,x,y\rangle \in [\![\mathbf{hug}^{bc}]\!]^B$$

  (ii) Another strategy uses the rule in (22) to derive binary predicates from the *sums* in the $C$ part of protopredicates. For instance, the denotation of transitive *marry* is:

  $$[\![marry_{\text{tv}}]\!] = \lambda e.\lambda x.\lambda y.\langle e,x+y\rangle \in [\![\mathbf{marry}^c]\!]^C$$

The last example above illustrates how a plain alternation is derived from the $c$-type protopredicate **marry**. With the $bc$-type protopredicate **hug**, English does not support such a plain strategy. However, other languages also have a comitative meaning "hug with", in addition to transitive *hug*. English has similar cases. For instance, collective *fight* alternates both with transitive *fight* and with the binary construction *fight with*. Other examples where the same collective verb shows two reciprocal alternations are transitive *meet/meet with*, *talk* (*to/with*) and *make love* (*to/with*).

As we saw, transitive *hug* and *fight* support preferential reciprocity with their collective entry. Evidence for the plain reciprocity of "hug with" and *fight with* comes from contrasts like *Sue fought* (?*with*) *the disease*, where the infelicity of the *with* construction is evidence for its symmetry. Based on such cases, we have assumed that constructions like *fight with* support plain alternations.[35]

Under the assumption that *fight with* supports plain reciprocity, we derive the following meanings for the *bc* protopredicate **fight**:

| | | | |
|---|---|---|---|
| $[\![fight_{\text{iv}}]\!]$ | $=$ | $\lambda e.\lambda z.\langle e,z\rangle \in [\![\textbf{fight}^{bc}]\!]^C$ | collective |
| $[\![fight_{\text{tv}}]\!]$ | $=$ | $\lambda e.\lambda x.\lambda y.\langle e,x,y\rangle \in [\![\textbf{fight}^{bc}]\!]^B$ | binary, non-symmetric |
| $[\![fight\_with]\!]$ | $=$ | $\lambda e.\lambda x.\lambda y.\langle e,x+y\rangle \in [\![\textbf{fight}^{bc}]\!]^C$ | binary, symmetric |

Summarizing, we have three general derivational strategies:

(70) **Deriving lexical denotations from protopredicates**: Let **P** be a protopredicate of type *b*, *c* or *bc*. From **P** we derive a unary collective predicate $P^{uc}_{\mathbf{P}}$, a non-symmetric binary predicate $R^{ns}_{\mathbf{P}}$ and a symmetric binary predicate $R^{s}_{\mathbf{P}}$, which are defined as follows:

| | | | |
|---|---|---|---|
| $P^{uc}_{\mathbf{P}}$ | $=$ | $\lambda e.\lambda z.\langle e,z\rangle \in [\![\mathbf{P}]\!]^C$ | the collective part of **P**, if defined |
| $R^{ns}_{\mathbf{P}}$ | $=$ | $\lambda e.\lambda x.\lambda y.\langle e,x,y\rangle \in [\![\mathbf{P}]\!]^B$ | the binary part of **P**, if defined |
| $R^{s}_{\mathbf{P}}$ | $=$ | $\lambda e.\lambda x.\lambda y.\langle e,x+y\rangle \in [\![\mathbf{P}]\!]^C$ | the binary predicate based on the collective part of **P**, if defined |

An important feature of this system concerns protopredicates of type *bc*. As discussed in Section 3.5, for such protopredicates we have not presupposed any logical connection between the "*B*-part" and the "*C*-part". The connection between these parts is regulated by the preference that is formulated in (58). For instance, for the protopredicate **hug**, this preference is stated as follows (cf. (56)):

35 This tentative assumption requires more evidence. However, further analysis of symmetry/plain reciprocity with "with" constructions would go beyond the scope of the present study. Dimitriadis (2008) and Siloni (2012) treat "with" constructions in Greek and Hebrew as cases of plain reciprocity ("discontinuous reciprocity"). By contrast, Rákosi (2008) proposes that predicates like *fight with* in Hungarian are not symmetric, hence, in our terms, they might not support plain alternations. Kruitwagen et al.'s experiments show that in Dutch *vechten tegen* ("fight against") is not in plain alternation with collective *vechten* ("fight"), but they do not study constructions like *vechten met* ("fight with").

(71) $\text{Typ}_{\mathbf{hug}_1}(e,x{+}y) \propto |\{\langle u,v\rangle \in \{x,y\}^2 \colon u \neq v \text{ and } \mathbf{hug}_2(e,u,v)\}|$
where $\mathbf{hug}_1 = P^{uc}_{\mathbf{hug}}$ and $\mathbf{hug}_2 = R^{ns}_{\mathbf{hug}}$

Thus, for a given sum $x{+}y$ and an event $e$, we check how many of the pairs among $\langle x,y\rangle$ and $\langle y,x\rangle$ are in the $B$ part of **hug** in $e$. The larger this number is, the stronger the tendency of speakers is to have the sum $x{+}y$ in the $C$ part of **hug** in the same event. This tendency, rather than being logically or grammatically derived, is assumed to be encoded as a preferential property of the concepts associated with *bc* protopredicates.

The system above specifies protopredicate denotations (69) and three ways in which they derive denotations of lexical predicates (70). To verify that our system derives the Reciprocity-Symmetry Generalization as a corollary, we formally restate the RSG in (18) as follows:

(72) **Reciprocity-Symmetry Generalization (RSG, formal):** Let **P** be a protopredicate of one of types *c* or *bc*, with $P$ and $R$ the corresponding predicates s.t. $P = P^{uc}_{\mathbf{P}}$, and $R$ is either $R^{ns}_{\mathbf{P}}$ or $R^{s}_{\mathbf{P}}$. The following conditions are equivalent:

(i) **Symmetry** — for every model, for all $e$, $x$ and $y$:
$[\![R]\!](e,x,y) \Leftrightarrow [\![R]\!](e,y,x)$.

(ii) **Plain reciprocity** — for every model, for all $e$, $x$ and $y$:
$[\![P]\!](e,x{+}y) \Leftrightarrow [\![R]\!](e,x,y) \wedge [\![R]\!](e,y,x)$.

**Proof**: For simplicity, we abbreviate $R^{ns} = R^{ns}_{\mathbf{P}}$ and $R^{s} = R^{s}_{\mathbf{P}}$. There are two cases to consider:

1. The protopredicate **P** is of type *c*. In this case $R = R^s$ by definition, since $R^{ns}$ is undefined. And any $R^s$ satisfies (i) and (ii) by definition (70).
2. The protopredicate **P** is of type *bc*. If $R = R^s$, then again, (i) and (ii) are both satisfied by definition. Otherwise $R = R^{ns}$. In this case, we show that neither (i) nor (ii) holds. For instance, in a model where $[\![\mathbf{P}^{bc}]\!] = \{\langle e,c{+}d\rangle, \langle e,c,d\rangle\}$, we have $[\![R^{ns}]\!](e,c,d)$ but not $[\![R^{ns}]\!](e,d,c)$, hence (i) fails. Further, $[\![P^{uc}]\!](e,c{+}d)$ holds but $[\![R^{ns}]\!](e,d,c)$ does not, hence (ii) also fails.

We conclude that (i) and (ii) are equivalent. Thus, the RSG is supported by the system of protopredicates that we have defined. Specifically, in this system, lexical predicates with meanings like "thank each other" or *Xhug* (section 2.3) cannot be derived:

i. Transitive *thank* is non-symmetric. To derive this non-symmetric predicate in alternation with a unary-collective entry, the protopredicate **thank** would have to be of type *bc*. However, as we saw, models for *bc* protopredicates allow denotations like $\{\langle e, c{+}d\rangle, \langle e, c, d\rangle\}$, ruling out plain reciprocity. As a result, a unary *thank* would not mean "thank each other", which as we saw is in plain alternation with transitive *thank*.

ii. The binary entry of the hypothetical verb *Xhug* was postulated to be symmetric similarly to "hug with" ($\mathbf{Xhug}_2$, note 12). For this to be the case, we would need to derive this binary meaning from the $C$ part of a protopredicate. This would entail that the unary entry of *Xhug* shows plain reciprocity with its binary entry, contrary to the assumption.

A sophisticated question here is why some *bc* protopredicates should not still be restricted by additional meaning postulates, which might create plain reciprocity relations or symmetry effects that do not follow from the type system of protopredicates. The current approach and the proof above rely on the assumption that such meaning postulates are not available. Languages are assumed to own a type system that encodes the conceptual property of "collectivity" by the label $c$, but encoding of plain reciprocity or symmetry by predicate-specific meaning postulates is assumed to be impossible.

## 5 Conclusion

In a new analysis of lexical reciprocity and its relations with symmetry, this paper elucidated the notion of *truth-conditionally* symmetric predicates. As we observed, these predicates are connected to their reciprocal alternates in a logical relation that was referred to as *plain reciprocity*. This was contrasted with non-symmetric predicates, which show weaker relations with their reciprocal counterparts. The emerging *Reciprocity-Symmetry Generalization* (RSG) led us to treat symmetric predicates as semantic images of collective predicate meanings. This treatment is conjectured to reflect a language universal that accounts for all cases of predicate symmetry. By focusing on plain alternations, the RSG also specifies a complementary domain of reciprocal alternations where formal semantics plays a weaker role. It was proposed that non-plain reciprocal alternations are all *preferential*: the meanings of the unary and the binary entries are only connected by typicality principles, similar to those that characterize the connections between other concepts. Preferential reciprocals are not logically expressible by their non-symmetric counterparts, and their logical features are tied to meanings of specific entries or to the individuation of collective events.

At a more general level, I believe that this paper has a hopeful message for theories of lexical meaning and formal semantics. When paying close attention to the underlying mathematical properties of intuitive linguistic notions like "reciprocity" or "symmetry", we have a better chance to tease apart grammatical principles from other cognitive principles governing language use for expressing concepts.

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