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The Logic of Reflexivity and Reciprocity

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1. Introduction

In this paper, we account for the logical properties of a variety of simple reflexive and reciprocal sentences, including those with reflexive or reciprocal anaphors such as (1), and those without anaphors, such as (2).*

(1) Reflexive and reciprocal sentences with anaphors

a. Anna and Bob are in love with themselves

b. Anna and Bob are looking at each other

c. Anna and Bob are lying on top of each other

(2) Reflexive and reciprocal sentences without anaphors

a. Anna and Bob are shaving

b. Anna and Bob disagree

We show that these properties result from the interaction of the following three factors:

- the 'plural properties' of the predicate of which the antecedent is the subject, and the anaphor (if present) is the object;

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- the core meanings of reflexivity and reciprocity, which we call the 'criteria' for reflexivity and reciprocity;
- whether reflexivity or reciprocity is expressed overtly by an anaphor, so that the predicate remains two-place, or covertly by incorporation into a corresponding one-place predicate.

What we are calling the plural properties of predicates was first systematically investigated by the philosopher Nelson Goodman in *The Structure of Appearance* (Goodman, 1951), who observed that if a member of a certain class of one-place predicates holds for an 'individual' (the denotation of its subject), then it holds for every part of that individual down to some atomic level.[1] Goodman called this type of predicate 'dissective.' Another class of predicates has the property that if any of its members holds for all the atomic parts of an individual, then it holds for the entire individual. Goodman called this type of predicate 'collective.' In section 2, we review Goodman's analysis of the plural properties of one-place predicates, limiting ourselves to 'singular' and 'plural' individuals denoted by count noun phrases.[2] This review provides the foundation for our extension of Goodman's analysis to the plural properties of two-place predicates in section 3.[3]

In section 4, we consider certain logical properties of sentences in which a plural object noun phrase is coreferential with the subject but not bound by it, as in (3). Specifically we examine the entailment relations between these sentences and other sentences in which the singular terms that comprise the plurality are distributed between the subject and the object, as in (4). We show that these relations are determined simply by the plural properties of the predicate. Depending on those properties, the original sentence either entails the corresponding reflexive and reciprocal sentences with overt anaphors as in (1)a and (1)b, or is entailed by them.

(3) Sentences in which the object is coreferential with the subject but not bound by it

a. Anna and Bob are in love with Anna and Bob

b. Anna and Bob are looking at Anna and Bob

(4) Sentences in which the parts of the object of the two-place predicates in (3) are distributed between their subject and object

a. Anna is in love with Anna

b. Anna is looking at Bob

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[1] Goodman's analysis of the denotation of noun phrases as structured individuals subject to the logic of part-whole relations (mereology) did not begin to catch on in linguistic semantics until the late 1970s with the work of Massey (1976) and Wald (1977), and was not firmly established until after Link (1983), perhaps because of its association with nominalist empiricism. See Ojeda (1993) for discussion.

[2] This limitation is not necessary, but simplifies the presentation of our analysis.

[3] According to Goodman, a plural individual is the 'sum' of its singular parts. Koslow (1992) shows that when the whole-part relation for individuals is considered an entailment relation, Goodman's sum operator is simply logical conjunction. This explains why English *and* (and similar expressions in other languages) expresses both summation for individuals and conjunction for sentences.

Sections 5 through 9 deal in turn with the properties of reflexive two-place predicates with anaphors, as in (1)a; reflexive one-place predicates without anaphors, as in (2)a; reciprocal two-place predicates with anaphors, as in (1)b; 'hyporeciprocal' two-place predicates (also with anaphors, as in (1)c, and reciprocal one-place predicates without anaphors, as in (2)b.The criterion for reflexivity is stated in section 5, and for reciprocity in section 7. Section 7 also provides an account of reciproreflexive two-place predicates as in (5), in which the distinction between two-place reflexivity and reciprocity is neutralized.

(5) Reciproreflexive sentences with anaphors

a. Ana y Pepe se quieren 'Ana and Pepe like themselves or each other' (Spanish)

b. Ume yoemem emo waata 'The people like themselves or each other' (Yaqui)

2. Plural properties of one-place predicates

Let P be a one-place predicate over the variable individual X serving as its subject, which we represent schematically as $P\langle X\rangle$. If X is a plural individual made up of the singular individuals $x_1, \ldots, x_n$ (e.g. if X = *Anna and Bob*, then x_1 = *Anna* and x_2 = *Bob*), then, as was first demonstrated by Goodman (1951), the interpretation of the resulting sentence depends on what we call the 'plural properties' of P. Goodman distinguished the following four plural properties for one-place predicates, which we illustrate using the predicates and sentences in (6) through (9). The classification of those predicates appears in Table 1.

- P is **dissective** (D) if for all i such that x_i is a singular part of X, $P\langle X\rangle$ entails $P\langle x_i\rangle$.[4]

  Predicates (6)) and (7)) are D, since (6)a entails both (6)b and (6)c, and similarly for (7). On the other hand, (8) and (9) are **nondissective** (-D), since (8)a (on its collective, or nondistributive, reading) entails neither (8)b nor (8)c, and similarly for (9).[5]

- P is **nucleative** (N) if for some i, $P\langle X\rangle$ entails $P\langle x_i\rangle$.[6]

  Any predicate which is D is also N; hence (6) and (7), being D, are also N. However, a -D predicate may or may not be N. For example, the -D predicate (8) is N, since (8)a entails (8)d, whereas (9) is **nonnucleative** (-N), since (9)a (on its collective reading) does not entail (9)d.

[4] The dissective property is called 'divisible' by Moltmann (1997) and others.

[5] Sentence (8)a entails both (8)b and (8)c on its distributive reading, but that fact is irrelevant to the classification of the predicate (8) as -D. Similarly for (9). If a one-place predicate is -D, then the distributive reading of a sentence in which that predicate holds of a plural subject entails its collective reading, but not conversely. On the other hand, if such a sentence contains a D predicate, then its distributive and collective readings are equivalent.

[6] For convenience, we omit expressions like 'such that x_i is a singular part of X' in this and the remaining definitions of plural properties.

- *P* is **expansive** (E) if for some *i*, $P\langle x_i \rangle$ entails $P\langle X \rangle$.

  Predicates (8) and (9) are E, since (8)d entails (8)a (on its collective reading), and similarly for (9). On the other hand, (6) and (7) are **nonexpansive** (-E), since (6)d does not entail (6)a, and similarly for (7).[7]

- *P* is **cumulative** (C) if for all *i*, the $P\langle x_i \rangle$s together entail $P\langle X \rangle$.[8]

  Any predicate which is E is also C; hence (8) and (9), being E, are also C. However, a -E predicate may or may not be C. For example, the -E predicate (6) is C, since (6)b and (6)c together entail (6)a (on its collective reading), whereas (7) is **noncumulative** (-C), since (7)b and (7)c together do not entail (7)a.

(6) *be healthy*

a. Anna and Bob are healthy

b. Anna is healthy

c. Bob is healthy

d. Anna is healthy or Bob is healthy

(7) *be quiet*

a. Anna and Bob are quiet

b. Anna is quiet

c. Bob is quiet

d. Anna is quiet or Bob is quiet

(8) *be infected*

a. Anna and Bob are infected

b. Anna is infected

c. Bob is infected

d. Anna is infected or Bob is infected

(9) *be noisy*

a. Anna and Bob are noisy

b. Anna is noisy

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[7] Moreover, lexical one-place predicates which are E are -D, and those which are D are -E, since otherwise there would be an *i* such that $P\langle x_i \rangle$ is equivalent to $P\langle X \rangle$. But such predicates apparently are not lexicalized in natural languages.

[8] We have replaced Goodman's term 'collective' by 'cumulative,' reserving the term 'collective' as the antonym of 'distributive,' as in note 5. Goodman used the term 'cumulative' for a plural property of two-place predicates; our usage follows Krifka (1992). Another term for 'cumulative' is 'fully additive' (Eilenberg, 1974). For further discussion of terminology for plural properties, see Langendoen (1998).

c. Bob is noisy

d. Anna is noisy or Bob is noisy

Predicate	Plural property	E	C	D	N
(6)	*be healthy*	–	+	+	+
(7)	*be quiet*	–	–	+	+
(8)	*be infected*	+	+	–	+
(9)	*be noisy*	+	+	–	–

Table 1. Classification of one-place predicates according to their plural properties[9]

Of special interest are predicates like (6), which are both C and D (CD). For CD predicates, the equivalence in (10) holds, where & represents sentential conjunction. Since & also represents the sum operator for individuals (i.e., $X = x_1 \,\&\, \ldots \,\&\, x_n$), (10) can be expressed as (11), which is a special case of 'conjunction reduction' as exemplified in (12).

(10) $P\langle x_1\rangle \,\&\, \ldots \,\& P\langle x_n\rangle \leftrightarrow P\langle X\rangle$

(11) $P\langle x_1\rangle \,\&\, \ldots \,\& P\langle x_n\rangle \leftrightarrow P\langle x_1 \,\&\, \ldots \,\& x_n\rangle$

(12) Anna is healthy and Bob is healthy ↔ Anna and Bob are healthy (=(6)a)

The equivalence in (12) holds whether or not sentence (6)a is understood distributively. Similar equivalences obtain for sentences (7)a, (8)a, and (9)a, if they are understood distributively, but not otherwise.

3. Plural properties of two-place predicates

Next, let *R* be a two-place predicate over the variable individuals *X* and *Y* serving as its subject and object, schematically $R\langle X, Y\rangle$. If *X* and *Y* are plural individuals made up of the singular individuals $x_1, \ldots, x_n$ and $y_1, \ldots, y_m$ (e.g. X = *Anna and Bob*, where x_1 = *Anna* and x_2 = *Bob*; and Y = *Otto and Nan*, where y_1 = *Otto* and y_2 = *Nan*), then the interpretation of the resulting sentence again depends on the plural properties of *R*. Goodman did not provide a systematic analysis of the plural properties of two-place predicates,[10] nor to our knowl-

[9] This classification is not exhaustive for natural languages such as English, but covers all the plural properties of one-place predicates that are expressed lexically. Note that the complex (nonlexical) one-place predicate *neither noisy nor quiet* is nondissective, nonnucleative, nonexpansive, and noncumulative.

[10] Goodman (1951: 49) wrote: "As the number of places increases, so does the number of such differences among predicates as we have been considering; but there is no need for burdening ourselves with terms for all the possible variations."

edge has any been offered since. For lexical two-place predicates in English, we find that the following six plural properties are required.[11] We illustrate these properties using the predicates and sentences in (13) through (17). The classification of those predicates appears in Table 2.

- *R* is **doubly dissective** (DD) if for all *i* and *j*, $R\langle X, Y\rangle$ entails $Rx_i, y_j\rangle$.[12]

  The two-place predicate (13) is DD, since (13)a entails (13)b through (13)e. However, none of the predicates in (14)-(17) is DD.

- *R* is **dissective-nucleative** (DN) if for all *i* there is some *j*, and for all *k* there is some *h* such that $R\langle X, Y\rangle$ entails $Rx_i, y_j\rangle$ and $Rx_h, y_k\rangle$.

  Any predicate which is DD is also DN, hence (13) is DN. Moreover, (14) is DN, since (14)a entails (14)f. However, none of the predicates in (15)-(17) is DN.

- *R* is **2-dissective** (2D) if for all *j*, $R\langle X, Y\rangle$ entails $R\langle X, y_j\rangle$.

  Any predicate which is DN is also 2D, hence (13) and (14) are 2D. Moreover, (15) is 2D, since (15)a entails both (15)g and (15)h. However, neither (16) nor (17) is 2D.

- *R* is **doubly nucleative** (NN) if for some *i* and *j*, $R\langle X, Y\rangle$ entails $Rx_i, y_j\rangle$.

  Any predicate which is 2D is also NN, hence (13)-(15) are 2D. Moreover, (16) is NN since (16)a entails (16)i. However (17) is not NN, since (17)a does not entail (17)e.

- *R* is **expansive-cumulative** (EC) if for all *i* there is some *j*, and for all *k* there is some *h* such that the $Rx_i, y_j\rangle$s and $Rx_h, y_k\rangle$s together entail $R\langle X, Y\rangle$.

  The predicates in (14)-(16) are EC. For example, (14)f entails (14)a, and similarly for (15) and (16). On the other hand, (13) and (17) are not EC, since (13)f does not entail (13)a, and (17)c does not entail (17)a.[13]

- *R* is **doubly cumulative** (CC) if for all *i* and *j*, the $Rx_i, y_j\rangle$s together entail $R\langle X, Y\rangle$.

  Any predicate which is EC is also CC, hence (14)-(16) are CC. Moreover (13) is CC, since (13)b-(13)e together entail (13)a. However, (17) is not CC, since (17)b does not entail (17)a.[14]

(13) *be in love with*

a. Anna and Bob are in love with Otto and Nan

b. Anna is in love with Otto

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[11] The plural property that Goodman called 'cumulative' would be called, in our terminology, '2-cumulative' (2C); similarly Krifka's 'summative' would be called '1-cumulative' (1C). These and their dissective counterparts are properties of certain comparative adjectives; for example, *be quieter than* is 1-dissective (1D) and 2C, and *be noisier than* is 2D and 1C. If a two-place predicate is either 1C or 2C then it is CC, but not conversely.

[12] DD is similar to but not the same as Goodman's 'pervasive.'

[13] Lexical two-place predicates which are DD are -EC and conversely. This is comparable to the restriction on lexical one-place predicates pointed out in note 7.

[14] Examples (17)a and (17)b are true together if the number of women and men is the same, but not if the number of women is different from the number of men.

c. Anna is in love with Nan

d. Bob is in love with Otto

e. Bob is in love with Nan

f. Anna is in love with Otto and Bob is in love with Nan, or Anna is in love with Nan and Bob is in love with Otto

g. Anna and Bob are in love with Otto

h. Anna and Bob are in love with Nan

i. Anna or Bob is in love with Otto or Nan

(14) *be looking at*

a. Anna and Bob are looking at Otto and Nan

b. Anna is looking at Otto

c. Anna is looking at Nan

d. Bob is looking at Otto

e. Bob is looking at Nan

f. Anna is looking at Otto and Bob is looking at Nan, or Anna is looking at Nan and Bob is looking at Otto

g. Anna and Bob are looking at Otto

h. Anna and Bob are looking at Nan

i. Anna or Bob is looking at Otto or Nan

(15) *be defending*

a. Anna and Bob are defending Otto and Nan

b. Anna is defending Otto

c. Anna is defending Nan

d. Bob is defending Otto

e. Bob is defending Nan

f. Anna is defending Otto and Bob is defending Nan, or Anna is defending Nan and Bob is defending Otto

g. Anna and Bob are defending Otto

h. Anna and Bob are defending Nan

i. Anna or Bob is defending Otto or Nan

(16) *be next to*

a. Anna and Bob are next to Otto and Nan

b. Anna is next to Otto

c. Anna is next to Nan

d. Bob is next to Otto

e. Bob is next to Nan

f. Anna is next to Otto and Bob is next to Nan, or Anna is next to Nan and Bob is next to Otto

g. Anna and Bob are next to Otto

h. Anna and Bob are next to Nan

i. Anna or Bob is next to Otto or Nan

(17) *be the same weight as*[15]

a. The women are the same weight as the men

b. Each woman is the same weight as each man

c. Each woman is the same weight as one of the men and each man is the same weight as one of the women

d. The women are the same weight as one of the men

e. One of the women is the same weight as one of the men

Conjunction reduction for sentences containing a two-place predicate is the equivalence in (18) (where $X = x_1, ..., x_n$ and $Y = y_1, ..., y_m$). If a predicate, like (13), is both CC and DD (CCDD), then any sentence in which it occurs as the main predicate with plural subject and object, such as (13)a, exhibits the equivalence in (18) on both its collective and distributive readings (these readings being themselves equivalent), as shown in (19). On the other hand, any sentence whose main two-place predicate is not CCDD exhibits conjunction reduction only on its distributive reading.

(18) $P\langle x_1, y_1\rangle \,\&\, ... \,\&\, P\langle x_1, y_m\rangle \,\&\, ... \,\&\, P\langle x_n, y_1\rangle \,\&\, ... \,\&\, P\langle x_n, y_m\rangle \leftrightarrow P\langle x_1 \,\&\, ... \,\&\, x_n, y_1 \,\&\, ... \,\&\, y_m\rangle$

(19) Anna is in love with Otto and Anna is in love with Nan and Bob is in love with Otto and Bob is in love with Nan ↔ Anna and Bob are in love with Otto and Nan (=(13)a)

We do not investigate here the very interesting question of the correlation of the plural properties of predicates with their other semantic properties. For example, the CCDD predicates largely, if not entirely, denote mental states, whereas the ECDN predicates denote actions carried out by singular, animate individuals.

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[15] The predicate *be the same weight as* is lexically complex. A lexically simpler example with the same plural properties is *be in equilibrium with*.

Predicate	Plural property	EC	CC	DD	DN	2D	NN
(13)	*be in love with*	–	+	+	+	+	+
(14)	*be looking at*	+	+	–	+	+	+
(15)	*be defending*	+	+	–	–	+	+
(16)	*be next to*	+	+	–	–	–	+
(17)	*be the same weight as*	–	–	–	–	–	–

Table 2. Classification of two-place predicates according to their plural properties

4. Coreference without binding of the object of two-place predicates

Next, let the object of a two-place predicate be the same as its subject, but without being bound by it, schematically $R\langle X, Y\rangle$, where $Y = X$.[16] If X is instantiated by a plural individual made up of the singular individuals $x_1, \ldots, x_n$ (e.g., X = *Anna and Bob*, where x_1 = *Anna* and x_2 = *Bob*), then the resulting sentences are interpreted as in (13) through (17), with *Anna* substituted for *Otto*, and *Bob* for *Nan*. In particular, consider (20) and (21), which are the counterparts to (13) and (14) (omitting the counterparts to the original (b), (c), (d), (e), (g), (h), and (i) examples, so that the original (f) examples correspond to (b), and adding new (c) examples, which are the conjunctions of the counterparts to the original (b), (c), (d), and (e) examples). Because the predicate *be in love with* is CCDD, (20)a is equivalent to (20)c, and because *be looking at* is EC and DN (ECDN), (21)a is equivalent to (21)b.

(20) *be in love with*

a. Anna and Bob are in love with Anna and Bob

b. Anna is in love with Anna and Bob is in love with Bob, or Anna is in love with Bob and Bob is in love with Anna

c. Anna is in love with Anna and Bob is in love with Bob and Anna is in love with Bob and Bob is in love with Anna

(21) *be looking at*

a. Anna and Bob are looking at Anna and Bob

b. Anna is looking at Anna and Bob is looking at Bob, or Anna is looking at Bob and Bob is looking at Anna

[16] Here we follow Fiengo & May (1994), but without adopting their notation. The resulting examples, which involve coreference between subject and object but without the object being bound by the subject, do not violate Principle C of the Binding Theory (Chomsky, 1981), because the object R-expression, although coreferential with the subject, is free, not bound.

c. Anna is looking at Anna and Bob is looking at Bob and Anna is looking at Bob and Bob is looking at Anna

Making use of the logical equivalences in (22) and (23), we restate these results in (26) and (27). In general, if a CCDD predicate has an identical, coreferential plural subject and object, the resulting sentence **entails** the corresponding reflexive and reciprocal sentences, whereas if an ECDN predicate has an identical, coreferential plural subject and object, the resulting sentence **is entailed by** the corresponding reflexive and reciprocal sentences.

(22) Anna is {in love with, is looking at} Anna, and Bob {is in love with, is looking at} Bob ↔ Anna and Bob {are in love with, are looking at} themselves

(23) Anna is {in love with, is looking at} Bob, and Bob {is in love with, is looking at} Anna ↔ Anna and Bob {are in love with, are looking at} each other

(24) Anna and Bob are in love with Anna and Bob (= (20)a)

a. Anna and Bob are in love with themselves

b. Anna and Bob are in love with each other

(25) Anna and Bob are looking at Anna and Bob (= (21)a)

a. Anna and Bob are looking at themselves

b. Anna and Bob are looking at each other

(26) Example (24) is understood as the **conjunction** of the reflexive sentence (24)a and the reciprocal sentence (24)b; i.e., as entailing each of those sentences.

(27) Example (25) is understood as the **disjunction** of the reflexive sentence (25)a and the reciprocal sentence (25)b; i.e., as being entailed by each of those sentences.

The situation with the EC and 2D (EC2D) predicate *be defending* is a little harder to analyze, as the examples in (28) illustrate.

(28) *be defending*

a. Anna and Bob are defending Anna and Bob

b. Anna and Bob are defending Anna

c. Anna and Bob are defending Bob

d. Anna is defending Anna and Bob is defending Bob, or Anna is defending Bob and Bob is defending Anna

e. Anna and Bob are defending themselves

f. Anna and Bob are defending each other

Since (28) is EC, (28)d entails (28)a; it also entails the disjunction of (28)e and (28)f. However, since (28) is also 2D, (28)a entails both (28)b and (28)c, and consultants disagree as to the logical relation between (28)b and (28)c on the one hand, and reflexive and reciprocal sentences (28)e and (28)f on the other. Some consultants, including the first author, consider (28)b and (28)c together to entail the reflexive sentence (28)e; oth-

ers, including the second author, consider them to entail the reciprocal sentence (28)f. This uncertainty leads us to suspect that (28)b and (28)c together (and consequently (28)a by itself) entail the disjunction of (28)e and (28)f. If that is correct, then (28)a is equivalent to the disjunction of the reflexive sentence (28)e and the reciprocal sentence (28)f, just as (25) is equivalent to the disjunction of the reflexive sentence (25)a and the reciprocal sentence (25)b.

Thus the interpretation of a sentence with a two-place predicate with an identical, coreferential plural subject and object in which the object is free differs from those of the corresponding sentences in which bound reflexive or reciprocal anaphors occur as the object. Depending on the plural properties of the predicate, the former sentence is either logically stronger or weaker than the corresponding sentences with bound anaphors. We turn next to an investigation of the interpretations of sentences in which bound reflexive anaphors occur, and show that these too depend in part on the plural properties of two-place predicates.

5. Reflexive two-place predicates

Let R be a two-place predicate. Then Rf is a **reflexive two-place predicate** obtained from R by replacing the object variable with a reflexive anaphor f (e.g. in English *herself*, *himself*, *themselves*) bound by the subject, schematically $R\langle X, f\rangle$. The plural properties of reflexive two-place predicates are as follows; examples appear in (29) through (31), and the classification of reflexive two-place predicates appears in Table 3.[17]

- Rf is **reflexively doubly dissective** (DDf) if for all i, $R\langle X, f\rangle$ entails $R\langle x_i, x_i\rangle$.

  The distinction between DD and DN is neutralized for reflexive two-place predicates. If R is either DD or DN, then its Rf counterpart is DDf. For example, (29) is DDf, since (29)a entails both (29)b and (29)c; similarly for (30). On the other hand, (31) is not DDf, since (31)a (on its collective reading) entails neither (31)b nor (31)c.

- Rf is **reflexively 2-dissective** (2Df) if for all i, $R\langle X, f\rangle$ entails $R\langle X, x_i\rangle$.

  All DDf predicates are 2Df. Moreover if R is 2D, then its Rf counterpart is 2Df. For example, (31) is 2Df, since (31)a entails both (31)d and (31)e.

- Rf is **reflexively doubly cumulative** (CCf) if for all i, the $R\langle x_i, x_i\rangle$s together entail $R\langle X, f\rangle$.

  The distinction between EC and CC is also neutralized for reflexive two-place predicates. All such predicates are CCf; for example, (29) is DDf, since (29)b and (29)c together entail (29)a; similarly for (30) and (31).

[17] Since all strictly NN and -NN predicates are either logically reflexive (*be the same weight as*) or irreflexive (*be next to*), the reflexive predicates derived from them are of no particular interest, resulting either in tautologies or contradictions.

(29) *be in love with f*

a. Anna and Bob are in love with themselves

b. Anna is in love with herself

c. Bob is in love with himself

(30) *be looking at f*

a. Anna and Bob are looking at themselves

b. Anna is looking at herself

c. Bob is looking at himself

(31) *be defending f*

a. Anna and Bob are defending themselves

b. Anna is defending herself

c. Bob is defending himself

d. Anna and Bob are defending Anna

e. Anna and Bob are defending Bob

Predicate	Plural property	CCf	DDf	2Df
(29), (30)	*be in love with f; be looking at f*	+	+	+
(31)	*be defending f*	+	–	+

Table 3. Classification of reflexive two-place predicates according to their plural properties

At this point the question arises as to what contribution is made by the reflexive anaphor *f* to the meaning of the reflexive predicate *Rf*. First, $R\langle X, f\rangle$ is not equivalent to $R\langle X, X\rangle$, unless *X* itself is singular. Second, $R\langle X, f\rangle$ does not in general entail $Rx_i, x_i\rangle$ (for all *i* such that x_i is a singular part of *X*); that entailment holds only if *Rf* is DDf. The criterion for two-place reflexivity is best stated in terms of 'possibly intermediate individuals' as follows.

- **Criterion for two-place reflexivity**: For all *R* and for all *i* such that x_i is a singular part of *X*, there is an X_i such that x_i is part of X_i, and X_i is part of *X*, and $R\langle X, f\rangle$ entails $R\langle X_i, X_i\rangle$.

If *Rf* is DDf, X_i may be taken to be x_i itself for all *i*. Otherwise, X_i may have to be larger than x_i, possibly even *X* as a whole, as in the case of (31)a when understood collectively.

6. Reflexive one-place predicates

Certain one-place predicates in natural languages are also understood reflexively (see for example Reinhart & Reuland, 1994); we represent them schematically as *Pf* or $Pf\langle X\rangle$. Their plural properties appear below; an example is (32), which corresponds to the

two-place predicate *R* (33), and the reflexive two-place predicate *Rf* (34). Its plural properties are summarized in Table 4.

- *Pf* is **reflexively dissective** (Df) if for all *i*, $Pf\langle X\rangle$ entails $Pf\langle x_i\rangle$ (which is equivalent to $R\langle x_i, x_i\rangle$, where *R* is the two-place predicate that corresponds to *Pf*).

  All reflexive one-place predicates are Df. In particular, (32) is Df, since (32)a entails both (32)b and (32)c.

- *Pf* is **reflexively cumulative** (Cf) if for all *i*, the $Pf\langle x_i\rangle$s together entail $Pf\langle X\rangle$.

  All reflexive one-place predicates are Cf. In particular, (32) is Cf, since (32)a is entailed by (32)b and (32)c together.

(32) *be shaving* (one-place)

a. Anna and Bob are shaving

b. Anna is shaving ↔ Anna is shaving herself

c. Bob is shaving ↔ Bob is shaving himself

(33) *be shaving* (two-place)

a. Anna and Bob are shaving Otto and Nan

b. Anna is shaving Otto and Bob is shaving Nan, or Anna is shaving Nan and Bob is shaving Otto

c. Anna and Bob are shaving Otto

d. Anna and Bob are shaving Nan

(34) *be shaving f* (two-place)

a. Anna and Bob are shaving themselves

b. Anna is shaving herself

c. Bob is shaving himself

d. Anna and Bob are shaving Anna

e. Anna and Bob are shaving Bob

Plural property / **Predicate**	**Cf**	**Df**
(32) *be shaving*	+	+

Table 4. Classification of reflexive one-place predicates according to their plural properties

Thus all reflexive one-place predicates such as (32) are both Cf and Df (CDf). On the other hand, (33) (like (15)) is 2D, and consequently (34), like (31), is 2Df, but not DDf. As a result, any *Pf* is at least as strong as its *Rf* counterpart. For example, (32) is stronger than (34): (32)a entails (34)a, but not conversely. If (34)d and (34)e are true, then so is (34)a, but (32)a may be false.

In general, in languages like English in which reflexivity is normally expressed using reflexive anaphors, inherently reflexive predicates correspond to two-place predicates which are 2D (with which the subject can act as a group as well as singularly), since only with such predicates is there a possibility of semantic contrast.

7. Reciprocal two-place predicates

Again let R be a two-place predicate. Then R_{p} is a **reciprocal two-place predicate** obtained from R by replacing the object variable with a reciprocal anaphor p (e.g. in English *each other* or *one another*) bound by a plural subject, schematically $R\langle X, p\rangle$ if the subject is plural but not conjunctive (e.g. *the people*, *the Scandinavians*), and $R\langle X_1 \& \ldots X_n, p\rangle$ if it is conjunctive and its members are disjoint (e.g. *Anna and Bob*; *Anna and the children*; *the children and the adults*; *Anna, Bob, Otto, and Nan*; *the Danes, Finns, Norwegians, and Swedes*). A partial listing of the plural properties of reciprocal two-place predicates is as follows. Relevant examples appear in (35) through (37), and a partial classification of reciprocal predicates in Table 5.[18]

- R_{p} is **reciprocally doubly dissective** (DDp) if (1) for all i, j such that x_i and x_j are distinct singular parts of X, $R\langle X, p\rangle$ entails $R\langle x_i, x_j\rangle$; and (2) for all $n > 1$ and distinct $i, j \leq n$ such that x_i and y_j are singular parts of X_i and X_j respectively, $R\langle X_1 \& \ldots X_n, p\rangle$ entails $R\langle x_i, x_j\rangle$.[19]

  If R is DD, then its R_{p} counterpart is DDp. For example, (35) is DDp, since (35)a entails (35)b , and (35)d entails (35)e.

- R_{p} is **reciprocally dissective-nucleative** (DNp) if (1) for all i there is a j, and for all k there is an h such that $R\langle X, p\rangle$ entails $R\langle x_i, x_j\rangle$ and $R\langle x_h, x_k\rangle$; and (2) for all $n > 1$ and distinct $i, k \leq n$ there are $j, h \leq n$ ($j \neq i$ and $k \neq h$) such that $R\langle X_1 \& \ldots X_n, p\rangle$ entails $R\langle x_i, x_j\rangle$ and $R\langle x_h, x_k\rangle$.

  If R_{p} is DDp (e.g. (35)), then it is also DNp. Moreover, if R is DN, then its R_{p} counterpart is DNp. For example (36) is DNp, since (36)a entails (36)c, and (36)d entails (36)f. However, it is not DDp, since (36)a does not entail (36)b, and (36)d does not entail (36)e.

- R_{p} is **reciprocally 2-dissective** (2Dp) if (1) for all j, $R\langle X, p\rangle$ entails $R\langle X\text{-}x_j, x_j\rangle$; and (2) for all $n > 1$ and $j \leq n$, $R\langle X_1 \& \ldots X_n, p\rangle$ entails $R\langle X_1 \& \ldots X_{j-1} \& X_{j+1} \ldots X_n, x_j\rangle$.

  If R_{p} is DNp (e.g. (35) and (36)), then it is also 2Dp. Moreover, if R is 2D, then its R_{p} counterpart is 2Dp. For example, (37) is 2Dp, since (37)a entails (37)b, and (37)d entails (37)e.

- R_{p} is **reciprocally expansive-cumulative** (ECp) if (1) for all i there is a j, and for all k there is an h such that the $R\langle x_i, x_j\rangle$s and $R\langle x_h, x_k\rangle$s together entail $R\langle X, p\rangle$; and (2) for all

[18] Our analysis is adequate for English and many other languages, but not for the *otagai* construction in Japanese (Ikawa 1999).

[19] Again henceforth, we omit for convenience expressions like 'such that x_i and x_j are distinct singular parts of X_i and X_j respectively.'

$n > 1$ and distinct $i, k \leq n$ there are $j, h \leq n$ ($j \neq i$ and $k \neq h$) such that $R\langle x_i, x_j\rangle$ and $R\langle x_h, x_k\rangle$ together entail $R\langle X_1 \& \ldots X_n, p\rangle$.

If R is EC, then its R_{p} counterpart is ECp. For example, (36) is ECp, since (36)c entails (36)a, and (36)f entails (36)d; and similarly for (37). If R_{p} is both ECp and DNp (ECDNp), as in (36), it is **reciprocally weak** (Langendoen, 1978).[20]

- R_{p} is **reciprocally doubly cumulative** (CCp) if (1) for all i, j, the $R\langle x_i, x_j\rangle$s and $R\langle x_j, x_i\rangle$s together entail $R\langle X, p\rangle$; and (2) for all $n > 1$ and distinct $i, j \leq n$, $R\langle x_i, x_j\rangle$ and $R\langle x_j, x_i\rangle$ together entail $R\langle X_1 \& \ldots X_n, p\rangle$.

  If R_{p} is ECp (e.g. (36) and (37)), then it is also CCp. Moreover, if R is CC, then its R_{p} counterpart is CCp. For example, (35) is CCp, since (35)b entails (35)a, and (35)e entails (35)d. If R_{p} is both CCp and DDp (CCDDp), as in (35), it is **reciprocally strong** (Langendoen, 1978), i.e. satisfies the **each-the-other** property of Fiengo & Lasnik (1973).[21]

(35) *be in love with p*

a. These people are in love with each other

b. Each of these people is in love with each other one

c. Each of these people is in love with some other one, and each of these people has some other one in love with him or her

d. These men and women are in love with each other

e. Each of these men is in love with each of these women, and each of these women is in love with each of these men

f. Each of these men is in love with one of these women, each of these women is in love with one of these men, each of these men has one of these women in love with him, and each of these women has one of these men in love with her

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[20] Following Langendoen (1978), the definition of ECDNp (reciprocally weak) can be expressed as follows.

- R_{p} is ECDNp if (1) for all $n > 1$ and all $i \leq n$, there are j, h, and for all k there are g, q such that the $R\langle x_i, y_j\rangle$s, $R\langle y_h, x_i\rangle$s, $R\langle x_g, y_k\rangle$s, and $R\langle y_k, x_q\rangle$s together entail $R\langle X_1 \& \ldots X_n, p\rangle$, and $R\langle X_1 \& \ldots X_n, p\rangle$ entails each $R\langle x_i, x_j\rangle$, $R\langle x_h, x_i\rangle$, $R\langle x_g, x_k\rangle$, and $R\langle x_k, x_q\rangle$; and (2) for all i there are j, h (not necessarily distinct) such that the $R\langle x_i, x_j\rangle$s and $R\langle x_h, x_i\rangle$s together entail $R\langle X, p\rangle$, and $R\langle X, p\rangle$ entails both $R\langle x_i, x_j\rangle$ and $R\langle x_h, x_i\rangle$.

[21] The distinction between ECDNp (reciprocally weak) and CCDDp (reciprocally strong) two-place predicates is apparently well understood by the age of four years (Matsuo, 1997).

(36) *be looking at p*[22]

a. These people are looking at each other

b. Each of these people is looking at each other one

c. Each of these people is looking at one other one, and each of these people is being looked at by some other one

d. These women and men are looking at each other

e. Each of these women is looking at each of these men, and each of these men is looking at each of these women

f. Each of these women is looking at one of these men, each of these men is looking at one of these women, each of these women is being looked at by one of these men, and each of these men is being looked at by one of these women

(37) *be defending p*

a. These people are defending each other

b. Each of these people is being defended by all the others of these people (as a group)

c. Each of these people is defending some other one, and each of these people is being defended by some other one

d. These women and men are defending each other

e. These women (as a group) are defending each of these men and these men (as a group) are defending each of these women

f. Each of these women is defending one of these men, each of these men is defending one of these women, each of these women is being defended by one of these men, and each of these men is being defended by one of these women

From Table 5, we see that the reciprocal two-place predicate *be in love with p* is CCDDp (reciprocally strong), *be looking at* is ECDNp (reciprocally weak), and *be defending* is ECp and 2Dp (EC2Dp; reciprocally neither strong nor weak, but more nearly reciprocally weak than strong). Just as for reflexivity, the particular type of reciprocity exemplified by a reciprocal two-place predicate follows from the plural properties of its nonreciprocal two-place counterpart. None of these types constitutes the fundamental criterion for reciprocity from which the other types can be derived. However, before we

[22] Kim & Peters (1998) and Dalrymple et al. (1998) impose a weaker 'one-way weak reciprocity' condition for predicates like *be staring at p*, which requires that every singular individual which is part of the subject noun phrase be staring at someone else, but does not require that every such individual be being stared at. We disagree with this judgment, believing that either every such individual must both be staring at someone else and be being stared at by someone else, or that the predicate is understood hyporeciprocally (see section 8), in which case every individual must either be staring at someone else or be being stared at by someone else.

take up the question of the criterion for two-place reciprocity, we need to define another plural property of reciprocal two-place predicates, and consider two additional types.

Predicate	Plural property	ECp	CCp	DDp	DNp	2Dp
(35)	*be in love with p*	–	+	+	+	+
(36)	*be looking at p*	+	+	–	+	+
(37)	*be defending p*	+	+	–	–	+

Table 5. Partial classification of reciprocal two-place predicates according to their plural properties

Given that *be next to* is EC and NN (ECNN) and *be the same weight as* is -CC and -NN (-CCNN), we expect *be next to p* to be ECNNp (and neither DDp, DNp nor 2Dp) and *be the same weight as p* to be -CCNNp, where NNp is **reciprocally doubly nucleative** defined as follows.

- *Rp* is reciprocally doubly nucleative (NNp) if (1) for some distinct i, j, $R\langle X, p\rangle$ entails $R\langle x_i, x_j\rangle$ and $R\langle x_j, x_i\rangle$; and (2) for all $n > 1$, there are $x_{i_1}, x_{j_2}, \ldots, x_{i_{n-1}}, x_{j_n}$, such that $R\langle X_1 \,\&\, \ldots\, X_n, p\rangle$ entails $R\langle x_{i_1}, x_{j_2}\rangle$, $R\langle x_{j_2}, x_{i_1}\rangle$, …, $R\langle x_{i_{n-1}}, x_{j_n}\rangle$ and $R\langle x_{j_n}, x_{i_{n-1}}\rangle$.

This expectation is borne out if we consider sentences with subjects made up of conjoined plural phrases as in (38) and (39). Example (38)c entails (38)a, showing that *be next to p* is ECp, and (38)a entails neither (38)b nor (38)c, but does entail (38)d, showing that *be next to p* is strictly NNp. Similarly, (39)b does not entail (39)a, showing that *be the same weight as p* is -CCp, and (39)a entails none of the other propositions in (39), showing that *be the same weight as p* is -NNp. However, if we consider sentences with simple plural subjects as in (40) and (41), a different picture emerges. Example (40)c entails (40)a, again showing that *be next to p* is EC, but (40)a also entails (40)c, as if *be next to p* were DNp. Similarly, (41)c entails (41)a, as if *be the same weight as p* were ECp, and (41)a entails (41)c, as if *be the same weight as p* were DNp.[23] What we observe in these cases is the effect of the criterion for reciprocity together with the logical symmetry (and transitivity, in the case of *be the same weight as*) of these predicates.

(38) *be next to p*

a. These men and women are next to each other

b. Each of these men is next to each of these women[24]

[23] It may be felt that (41)b has a stronger reading; that it entails (41)a and that (41)a entails (41)b, so that *be the same weight as p* behaves as if it is CCDDp in this case. We return to this question in section 9.

[24] We have taken advantage of the symmetry of *be next to* and *be the same weight as* to simplify the sentences in (38)b through (38)d, (39)b through (39)d, (40)b and (40)c, and (41)b and (41)c; e.g., in (38)b, we have omitted *and each woman is next to each man.*

c. Each of these men is next to one of these women and each of these women is next to one of these men

d. One of these men is next to one of these women

(39) *be the same weight as p*

a. These men and women are the same weight as each other

b. Each of these men is the same weight as each of these women

c. Each of these men is the same weight as one of these women and each of these women is the same weight as one of these men

d. One of these men is the same weight as one of these women

(40) *be next to p* (2)

a. These people are next to each other

b. Each one of these people is next to each other one

c. Each one of these people is next to some other one, and each of these people has some other one next to him or her

(41) *be the same weight as p* (2)

a. These people are the same weight as each other

b. Each one of these people is the same weight as each other one

c. Each one of these people is the same weight as some other one

To assist in formulating the correct criterion for two-place reciprocity, we first repeat the criterion for two-place reflexivity from section 5.

- For all R and for all i such that x_i is a singular part of X, there is an X_i such that x_i is part of X_i, and X_i is part of X, and $R\langle X, f\rangle$ entails $R\langle X_i, X_i\rangle$.

Next we define the notion of reciprocal connectedness, as follows.

- X is **reciprocally connected** by R ($R^*\langle X, X\rangle$) if and only if there are one or more possibly plural individuals $X_1, \ldots X_p$ each disjoint from X and from each other such that $R\langle X, X_1\rangle$ & ... & $R\langle X_p, X\rangle$.

Finally we obtain the criterion for two-place reciprocity by substituting $R^*\langle X_i, X_i\rangle$ for $R\langle X_i, X_i\rangle$ in the criterion for two-place reflexivity.

- **Criterion for two-place reciprocity:** For all R and for all i such that x_i is a singular part of X, there is an X_i such that x_i is part of X_i, and X_i is part of X, and $R\langle X, p\rangle$ entails $R^*\langle X_i, X_i\rangle$.[25]

[25] Intermediate-size individuals may be needed to show that DNp (reciprocally weak) predicates satisfy the reciprocal criterion when the subject consists of at least five singular individuals. For example, let Rp be the DNp predicate *be tickling p*, with the subject X = *Ana, Bob, Otto, Nan, and Lil,*

Footnote continues on next page.

It is reciprocal connectedness that primarily accounts for the differences in entailment we have observed between (38) and (40) on the one hand, and (39) and (41) on the other. In (38), R = *be next to* and X = *these men and these women*. Taking x_i to be one of these men, we may take X_i to be *these men*, and X_{i_1} to be *these women*. This immediately satisfies the reciprocal connectedness condition, since *be next to*these men, these men⟩* = *be next to⟨these men, these women⟩* & *be next to⟨these women, these men⟩*. A similar result is obtained if we take x_i to be *one of these women*. In (40), on the other hand, X = *these people*. Taking x_i to be *one of these people*, we may take $X_i = x_i$, and X_{i_1} to be x_j for $j \neq i$. (The form of the sentence gives us no other choice for X_i, and though we may choose X_{i_1} to be X-x_i, the fact that *be next to p* is NNp allows us to select a singular individual.) This satisfies the reciprocal connectedness condition for x_i, since (by the symmetry of *be next to*) *be next to*x_i, x_i⟩* = *be next to⟨x_i, x_j⟩* & *be next to⟨x_j, x_i⟩*. Since this argument holds for any choice of x_i, we have established that (40)a entails (40)c, without having to suppose that *be next to p* is DNp. In a similar fashion, we can establish the equivalence of (41)a and (41)c, without having to suppose that *be the same weight as p* is ECDNp.[26]

The complete classification of reciprocal two-place predicates according to their plural properties appears in Table 6. It is isomorphic to the classification of two-place predicates in Table 2.

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and suppose Anna is tickling Bob and Otto, Bob is tickling Anna and Otto, Otto is tickling Nan and Lil, Nan is tickling Lil, and Lil is tickling Anna. Then the sentence *Anna, Bob, Otto, Nan, and Lil are tickling each other* is true, even though Otto, as an individual, is not reciprocally connected to himself by the *be tickling p* relation. However, the reciprocal criterion is satisfied if we take X_{Otto} = *Anna, Otto, and Nan*, and X_{Otto_1} = *Bob and Lil*.

However, if the subject of a DNp predicate is infinite, then the reciprocal criterion may not be satisfied. Imagine an infinite chain of people unbounded at both ends in which each person is tickling the person to his or her right, and no other tickling is going on. Such a situation satisfies DNp, but not the reciprocal criterion, and accordingly the sentence *The people are tickling each other* is false (unless *be tickling p* is understood hyporeciprocally; see section 8). This shows that the reciprocal criterion when applied to singular individuals is stronger than DNp.

[26] Since *be the same weight as p* is -NNp, we must use the logical transitivity of the predicate to obtain the result. In addition, the -NNp predicate *be in equilibrium with p* gives the impression of being both 1Dp and 2Dp when its subject is simply plural. This result, too, can be accounted for by the reciprocal criterion, since *be in equilibrium with* is neither NN nor logically transitive. A similar observation holds for the predicate *cancel out p* discussed by Dalrymple et al. (1998), as in the sentence *The libration point is where the gravitational fields of the sun, the moon, and the earth cancel each other out*. As they observe, the libration point is understood to be where the gravitational field of the sun cancels out those of the moon and the earth together, the gravitational field of the moon cancels out those of the sun and the earth together, and the gravitational field of the earth cancels out those of the sun and the moon together.

Predicate	Plural property	ECp	CCp	DDp	DNp	2Dp	NNp
(35)	*be in love with p*	–	+	+	+	+	+
(36)	*be looking at p*	+	+	–	+	+	+
(37)	*be defending p*	+	+	–	–	+	+
(38)/(40)	*be next to p*	+	+	–	–	–	+
(39)/(41)	*be the same weight as p*	–	–	–	–	–	–

Table 6. Complete classification of reciprocal two-place predicates according to their plural properties

Finally, the definitions of reflexivity and reciprocity can be unified by generalizing the notion of reciprocal connectedness to include reflexive connectedness ($R^{*}\langle X, X\rangle$) as follows.

- X is reciproreflexively connected by R ($R^{**}\langle X, X\rangle$) if and only if there are zero or more possibly plural individuals $X_1, \ldots X_q$ each disjoint from X and from each other such that $R^{*}\langle X, X_1\rangle$ & ... & $R^{*}\langle X_q, X\rangle$.[27]

Letting *pf* represent a reciproreflexive anaphor (e.g. *se* in the various Romance languages and *emo* in some Uto-Aztecan languages such as Yaqui), a general criterion for reciproreflexivity can be stated as follows; examples appear in (42). The reciproreflexive criterion predicts correctly that (42)b can be used to describe a situation in which two out of three or more people like each other and the rest of them like themselves.

- For all R and for all i such that x_i is a singular part of X, there is an X_i such that x_i is part of X_i, and X_i is part of X, and $R^{*}\langle X, pf\rangle$ entails $R^{**}\langle X_i, X_i\rangle$.

(42) Reciproreflexive sentences with anaphors (= (5))

a. Ana y Pepe se quieren 'Ana and Pepe like themselves or each other'

b. Ume yoemem emo waata 'The people like themselves or each other'

8. Hyporeciprocal two-place predicates

Fiengo & Lasnik (1973) first pointed out cases of apparent reciprocity, such as (1)c and the examples in (43), in which the reciprocity criterion fails. We call such sentences and the two-place predicates they contain 'hyporeciprocal.'

[27] $R^{**}\langle X, X\rangle$ reduces to $R^{*}\langle X, X\rangle$ if $q = 0$.

(43) Hyporeciprocal sentences

a. The plates are stacked on top of each other

b. The natural numbers succeed each other

c. he children caught measles from each other

Hyporeciprocity arises when the two-place predicate is either logically asymmetric (*be stacked on top of, succeed*), or pragmatically so (*caught measles from*), and in English, at least, only certain asymmetric predicates tolerate this apparent failure (e.g., *be outside of* does not).[28] Kim & Peters (1998) and Dalrymple et al. (1998) account for hyporeciprocity by means of their 'Strongest Meaning Hypothesis.' For example, any interpretation of the sentences in (43) which honors the reciprocal criterion results in a semantic or pragmatic contradiction (e.g. in (43)c, each of the children would have to be a member of a closed loop along which measles was transmitted from one child to the next, which contradicts our beliefs about how such contagions are spread). Consequently, they argue, the strongest meaning which does not lead to contradiction is made available, which, in the case of (43)c, is one in which each of the children is linked to every other child through a chain in which the paired children either caught measles from the other child, or infected the other child with measles).

We do not adopt Kim & Peters' and Dalrymple et al.'s solution, first because we do not see how it explains the failure of some asymmetric predicates to be used hyporeciprocally,[29] and second because the reciprocity criterion does not accommodate itself readily to the Strongest Meaning Hypothesis. Instead we adopt a solution like that proposed by Dixon (1988) for cases of hyporeciprocity in Fijian. Dixon points out that the prefix *vei-* in Fijian not only forms ordinary reciprocal predicates from two-place predicates in Fijian, but also hyporeciprocal ones, for example *vei'eve* from *vei-* plus *'eve* 'nurse.' A sentence containing this predicate and plural subject understood as 'the baby and its grandmother' is invariably construed as 'the baby is nursing its grandmother,' not as 'the baby and its grandmother are nursing each other.' Dixon proposes that the literal meaning of the sentence is 'the baby and its grandmother enter into a nursing relation with each other,' with the actual interpretation derived from the implicature that if a baby and its grandmother are in a nursing relation, then the baby is nursing its grandmother, and not vice versa.

Dixon's account of Fijian hyporeciprocity can be formalized as follows. Let R be a semantically or pragmatically asymmetric two-place predicate, and let R be the symmetric two-place predicate meaning 'enter into the relation R with,' which when combined with p has the same phonological form as R. Then $R\langle X, p\rangle$ is a reciprocal two-place predicate with respect to R (inasmuch as it satisfies the reciprocity condition), but a hypore-

[28] Bolinger (1987) points out a number of predicates for which the reciprocal criterion can be violated in English, which Langendoen (1978) contends require that the criterion be honored, notably *precede*.

[29] Kim & Peters (1998: 244, n. 13) acknowledge this problem and suggest a revision to the Strongest Meaning Hypothesis to deal with it.

ciprocal two-place predicate with respect to *R*. Moreover, this account appears to work for hyporeciprocity in English (and in any other natural language) as well as in Fijian.[30]

Additional support for our view of hyporeciprocity is provided by the results of experiments carried out by William Philip, who found that children tend to interpret ECDNp (weakly reciprocal) two-place predicates such as *be tickling p* hyporeciprocally (e.g. as 'be entering into a tickling relation with each other,' instead of as 'be tickling each other'), and that even a small, but nonnegligible, percentage of adults do. This suggests that hyporeciprocal interpretations do not simply arise as a result of a strategy to avoid contradictions, and may even be the 'initial state' of the representations which typically develop into ECDN reciprocal ones.

9. Reciprocal one-place predicates

In addition to reflexive one-place predicates, natural languages also contain reciprocal one-place predicates, which we represent schematically as *Pp* (or $Pp\langle X\rangle$).[31] The plural properties of reciprocal one-place predicates are as follows; examples appear in (44)–(46), and the classification of the predicates in Table 7.

- *Pp* is **reciprocally dissective** (Dp) if for all distinct *i* and *j*, $Pp\langle X\rangle$ entails $Pp\langle x_i \,\&\, x_j\rangle$ (which is equivalent to $R\langle x_i, x_j\rangle \,\&\, R\langle x_j, x_i\rangle$, where *R* is the two-place predicate corresponding to *Pp*).

  (44) and (45) are Dp, since (44)a entails (44)b through (44)d, (45)a entails (45)b through (45)d, and (45)e entails (45)f. However, (46) is -Dp, since (46)a does not entail (46)b through (46)g.[32]

- *Pp* is **reciprocally cumulative** (Cp) if for all distinct *i* and *j*, the $Pp\langle x_i \,\&\, x_j\rangle$s together entail $P\langle X\rangle$.

  (45) and (46) are Cp, since (45)b through (45)d together entail (45)a, and (46)b through (46)g together entail (46)a. However, (44) is -Cp, since (44)b through (44)d together do not entail (44)a.[33]

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[30] Kim & Peters (1998) and Dalrymple et al. (1998) distinguish two types of hyporeciprocity (in addition to 'one-way weak reciprocity' discussed in note 22), which they call 'intermediate alternating reciprocity,' manifested by example (43)c, and 'inclusive alternative ordering,' manifested by (43)a. We are not convinced of the need for this distinction. For example, suppose there are six children, three of whom infect the other three with measles. Then we consider (43)c true, even though this is an instance of the weaker condition of inclusive alternative ordering. It is the latter interpretation that generally arises under our account of hyporeciprocity.

[31] Reciprocal one-place predicates are also known, somewhat misleadingly, as 'symmetric predicates'; see Lakoff & Peters (1969), Langendoen (1992).

[32] Examples (44)a, (45)a, and (46)a are all ambiguous, admitting of non-reciprocal interpretations containing a covert indefinite object in addition to their reciprocal interpretations. The former interpretations are to be ignored.

[33] Almerindo Ojeda (personal communication) points out that the three-way distinction among reciprocal one-place predicates is also manifested in reciprocal one-place predicate nouns. For example, *be friends* is -Cp and Dp (like *agree*); *be sisters* is Cp and Dp (CDp, like *disagree*); and *be neighbors* is Cp and -Dp (like *be side-by-side*).

(44) *agree*

a. Anna, Bob, and Otto agree

b. Anna and Bob agree ↔ Anna agrees with Bob and Bob agrees with Anna

c. Anna and Otto agree ↔ Anna agrees with Otto and Otto agrees with Anna

d. Bob and Otto agree ↔ Bob agrees with Otto and Otto agrees with Bob

(45) *disagree*

a. Anna, Bob, and Otto disagree

b. Anna and Bob disagree ↔ Anna disagrees with Bob and Bob disagrees with Anna

c. Anna and Otto disagree ↔ Anna disagrees with Otto and Otto disagrees with Anna

d. Bob and Otto disagree ↔ Bob disagrees with Otto and Otto disagrees with Bob

e. These men and these women disagree

f. Each of these men and these women disagrees with each of the other of these men and these women

(46) *be side-by-side*[34]

a. Anna, Bob, Otto, and Nan are side-by-side

b. Anna and Bob are side-by-side ↔ Anna is beside Bob and Bob is beside Anna

c. Anna and Otto are side-by-side ↔ Anna is beside Otto and Otto is beside Anna

d. Anna and Nan are side-by-side ↔ Anna is beside Nan and Nan is beside Anna

e. Bob and Otto are side-by-side ↔ Bob is beside Otto and Otto is beside Bob

f. Bob and Nan are side-by-side ↔ Bob is beside Nan and Nan is beside Bob

g. Otto and Nan are side-by-side ↔ Otto is beside Nan and Nan is beside Otto

[34] Example (46) shows that a reciprocal one-place predicate need not be morphologically identical to its two-place counterpart; the same is true for reflexive one-place predicates (e.g. *commit suicide* is a one-place reflexive predicate whose two-place counterpart is *kill*).

Predicate	Plural property	Cp	Dp
(44)	*agree*	–	+
(45)	*disagree*	+	+
(46)	*be side-by-side*	+	–

Table 7. Classification of reciprocal one-place predicates according to their plural properties

Each of the reciprocal one-place predicates (44)–(46) is stronger than its two-place counterpart (47)–(49). First, (44) is stronger than (47), because (44)a entails (47)a, but not conversely. For (44)a to be true, Ana, Bob, and Otto must agree as a threesome about the same thing, whereas for (47)a to be true, they merely have to agree pairwise, as in (47)b through (47)d. This difference results from the fact that (47) is CCp, whereas (44) is -Cp.[35] Second, (45) is stronger than (48), since although (45)a and (48)a are logically equivalent, (45)e entails (48)e, but not conversely.[36] This difference results from the fact that the Dp property of (45) is stronger than the DDp property of (48), since it applies both within and across the members of a conjoined subject. Finally, (46) is stronger than (49), since (46)a entails (49)a, but not conversely. Example (46)a is entailed by any three of the propositions in (46)b through (46)g which involve all four of the singular individuals which comprise the subject of (46)a (e.g. (46)b, (46)e, and (46)g together), whereas (49)a is entailed by any two of the propositions in(49)b through (49)g which involve all four of those individuals (e.g. (49)b and (49)g together). This difference results from the fact that the Cp property of (46) is stronger than the ECp property of (49).

(47) *agree with p*

a. Anna, Bob, and Otto agree with each other

b. Anna and Bob agree with each other ↔ Anna agrees with Bob and Bob agrees with Anna

c. Anna and Otto agree with each other ↔ Anna agrees with Otto and Otto agrees with Anna

d. Bob and Otto agree with each other ↔ Bob agrees with Otto and Otto agrees with Bob

[35] For discussion of this cumulativity difference between the reciprocal one-place predicate *be similar* and the reciprocal two-place predicate *be similar to p*, see Langendoen (1978). Leonard & Goodman (1940) were the first to observe and describe the difference in cumulativity between these two kinds of reciprocal predicates.

[36] Note that (45)e entails (45)f, but (48)e does not entail (48)f, which repeats (45)f.

(48) *disagree with p*

a. Anna, Bob, and Otto disagree with each other

b. Anna and Bob disagree with each other ↔ Anna disagrees with Bob and Bob disagrees with Anna

c. Anna and Otto disagree with each other ↔ Anna disagrees with Otto and Otto disagrees with Anna

d. Bob and Otto disagree with each other ↔ Bob disagrees with Otto and Otto disagrees with Bob

e. These men and these women disagree with each other

f. Each of these men and these women disagrees with each of the other of these men and these women (= (45)f)

(49) *be beside p*

a. Anna, Bob, Otto, and Nan are beside each other

b. Anna and Bob are beside each other ↔ Anna is beside Bob and Bob is beside Anna

c. Anna and Otto are beside each other ↔ Anna is beside Otto and Otto is beside Anna

d. Anna and Nan are beside each other ↔ Anna is beside Nan and Nan is beside Anna

e. Bob and Otto are beside each other ↔ Bob is beside Otto and Otto is beside Bob

f. Bob and Nan are beside each other ↔ Bob is beside Nan and Nan is beside Bob

g. Otto and Nan are side-by-side ↔ Otto is beside Nan and Nan is beside Otto

Among the Cp and Dp (CDp) reciprocal one-place predicates are those, like (50), that are related to two-place predicates which are reflexive (in the traditional logical sense), symmetric, and transitive. Example (50) is CDp because (50)a and (50)b are equivalent.

(50) *be the same weight*

a. These people are the same weight

b. Each pair of these people is the same weight ↔ Each of these people is the same weight as each other one

As a reciprocal one-place predicate, (50) is stronger than its reciprocal two-place counterpart (39)/(41), which, as we showed in section 7, is ECp and -NNp. In note 23, we observed that a sentence like (41)a may be felt to have a CCDDp, rather than an

ECDNp interpretation (which it receives as a result of the criterion for reciprocity). We attribute that perception to a tendency to understand (41)a as equivalent to (50)a, like the tendency noted by Leonard & Goodman (1940) to interpret sentences like (44)a as equivalent to those like (47)a. However, suppose the referent of *these people* is a group of identical twins and that each person is the same weight as his or her twin, but a different weight from everyone else in the group. Then (50)a is false, but (41)a is true, and likely to be judged so, despite the general tendency to interpret it as (50)a.

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