3.8 Plural

In many ways plural pronouns and noun phrases behave differently from singular pronouns. Here I will give an overview of several interesting phenomena, mainly following Kamp & Reyle (1993).

3.8.1 Sum Individuals and Discourse Referents for Sum Individuals

The usual way of modeling plural NPs in model-theoretic semantics assumes sum individuals. Some examples:

(46) a. *Three children played together.*
x[CHILD*(x) |x| = 3 PLAY TOGETHER(x)]

b. *The children played together.*
PLAY TOGETHER(σx[CHILD*(x)])

c. *The three children played together.*
PLAY TOGETHER(σx[CHILD*(x) |x| = 3])

Assume that variables x can range over sum individuals. For example, let j, m, b denote the three individuals John, Mary and Bill, with child(j), child(m), child(b). Then j m b is the **sum individual** of John, Mary and Bill. In general, whenever we have two individuals x, y, then x y is an individual as well. The operation has certain mathematical properties, like being idempotent, commutative, and associative. Typically, is considered to be the join operation of a join semi-lattice.

The object denoted by j m b is in the denotation of *children*, which we represent by CHILD*. In general, a plural predicate like CHILD* is defined as the closure of the singular predicate under :

(58) a. For all x, if CHILD(x), then CHILD*(x)

b. For all x, y, if CHILD*(x) and CHILD*(y), then CHILD*(x y).

The function | | gives us the number of atomic elements a sum individual consists of. It is defined as follows:

(59) a. If x is an atomic element, then |x| = 1.

b. If x, y are two entities that don't have a common part, |x y| = |x| + |y|
(where x, y have a common part z iff x z = x and y z = y).

The expression σxΦ gives us the greatest element x that satisfies the description Φ. For example, σx[CHILD*(x)] denotes the sum individual of all the children, and σx[CHILD*(x) |x| = 3] denotes the greatest element of the extension of the predicate *three children* (it exists iff there exist exactly three children.)

(60) Def: σxΦ[x] = that a such that Φ[a] is true and for all b such that Φ[b] is true, a b = a.

We have plural pronouns, as illustrated in the following example:

(61) *Pedro bought two donkeys. They are unhappy.*

The obvious way to incorporate such phenomena into DRT is to assume a model with a sum operation for individuals, discourse referents for sum individuals, and conditions that reflect the formation of sum individuals. Using capital letters for sum DRs, we should get the following DRS:

(62)

u X
Pedro = u donkey*(X) [u bought X] |X| = 2 [X are unhappy]

The DRS construction rules for plural indefinite NPs, Ns with a number word and plural pronouns are straightforward to formulate:

CR.IND.PLUR:

- Trigger: $[_S[_{NP}[_{DET}\alpha]\ [_N\ \beta]]\ [_{VP'}\ ]]$ or $[_{VP}[_V\ ]\ [_{NP}[_{DET}\alpha]\ [_N\ \beta]]]$, as a condition of a DRS K, where α is an indefinite determiner (i.e. or *some*) and β is a plural noun.
- Introduce into universe of K a new plural discourse referent D.
- Introduce into condition set of K the condition $[_N\ \beta](D)$
- Substitute D for $[_{NP}[_{DET}\alpha]\ [_N\ \beta]]$ in the triggering configuration.

CR.N.PLUR:

- Trigger: $[_N[_{NUM}\alpha][_N\beta]](D)$ as a condition of a DRS K, where α is a number word or , and β is a plural noun.
- Replace triggering condition by the condition $[_N\beta](D)$.
- Add as a condition $|D| = \alpha$, if α is not empty; add $|D| \geq 2$ if α is empty.

CR.PRO.PLUR:

- Trigger: $[_S[_{NP}[_{PRO}\alpha][_{VP'}\ ]]$ or $[_{VP}[_V\ ][_{NP}[_{PRO}\alpha]]]$, as condition of DRS K, where α is a plural pronoun.
- Choose a suitable plural antecedent discourse referent D accessible from K.
- Substitute D for $[_{NP}[_{PRO}\alpha]]$ in the triggering configuration.

Furthermore, we need a rule that a condition like $[_N\ \beta](D)$, where β is a plural noun, leads to the condition $\beta^*(D)$.

3.8.2 Summation

The examples we have considered so far are straightforward extensions of the singular case. One interesting difference shows up in texts like

(63) a. John and Mary went to Acapulco. They had a lousy time.

b. John took Mary to Acapulco. They had a lousy time.

c. Last month John took Mary to Acapulco. Mary insisted that Bill come along with them. On the way, they picked up a hitchhiker. Their friends Fred and Sue were already there. They had a lousy time.

Here, (63.a) illustrates that *they* can stand for a sum DR that is anaphorically related to several DRs introduced by distinct NPs introduced by a conjunction. (b) shows that the antecedent NPs don't have to form a constituent. And (c) shows that the antecedent NPs may even occur in different sen-

tences. Note also that the anaphoric possibilities of *they* depend in interesting ways on the structure of the preceding discourse. For example, in addition to referring to all persons mentioned, *they* may refer to Fred and Sue only, or to John and Mary only, but not to, say, John and Sue only.

The following rule is very tentative and doesn't take care of the influence of discourse structure:

CR.PRO.PLUR′:

- Trigger: $[_S[_{NP}[_{PRO}\alpha][_{VP'}\ ]]$ or $[_{VP}[_V\ ][_{NP}[_{PRO}\alpha]]]$, as condition of DRS K, where α is a plural pronoun.
- Choose suitable antecedent discourse referents d_1, ...d_n accessible from K. These discourse referent may be singular or plural.
- Introduce a new sum DR D in K and a condition $D = d_1 \ ... \ d_n$.
- Substitute D for $[_{NP}[_{PRO}\alpha]]$ in the triggering configuration.

Note:

- Kamp and Reyle's rule "Summation" works differently; it allows the introduction of sum DRs at arbitrary moments, without syntactic trigger. We assume here that summation is executed only when we need an antecedent for a plural pronoun.
- To limit the application of the rule, we may restrict the accessibility relation to discourse referents introduced recently, just as with other pronouns.

Example of a reading of a discourse with summation of DRs:

(64) Pedro bought two donkeys. They are unhappy.

u X Y
u = Pedro donkey*(X) |X| = 2 [u bought X] Y = u X [Y are unhappy]

Conditions that contain a summation are interpreted as follows with respect to a model M that contains a join operation , M = A, F, :

(65) A function g verifies a condition $D = d_1 \ ... \ d_n$ iff $g(D) = g(d_1) \ ... \ g(d_n)$.

Notice that the left-hand side stands for a symbol in the DRS representation language, whereas the right-hand side stands for an operation in the model structure that interprets expressions of the DRS representation languages.

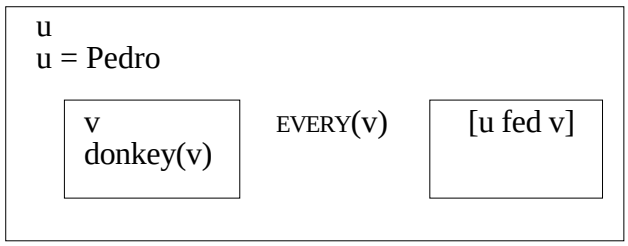
3.8.3 Abstraction

Another case in which plural pronouns behave different from singular pronouns can be illustrated with the following example:

(66) Pedro has fed every donkey. They are happy now.

Here, *they* may refer to the sum of all donkeys, although the DR introduced by *every donkey* is inaccessible: Note that after the first sentence we have the following DRS:

(67)



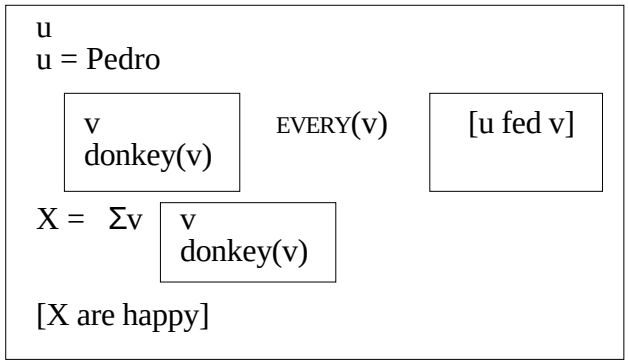
Kamp & Reyle suggest a new operation, called **abstraction**. It can be formulated as follows:

CR.PRO.PLUR.ABS:

- Trigger:
  (i) $[_S[_{NP}[_{PRO}\alpha][_{VP'}\ ]]$ or $[_{VP}[_V\ ][_{NP}[_{PRO}\alpha]]]$, as condition of DRS K, where α is a plural pronoun;
  (ii) a duplex condition K_1 Q K_2 that is immediately preceding K.
- Introduce a new sum DR D in K and a condition $D = \Sigma d[K_1]$, where d is a discourse referent introduced in K_1.
- Substitute D for $[_{NP}[_{PRO}\alpha]]$ in the triggering configuration.

The DRS above can be extended as follows:

(68)



The DRS abstraction $X = \Sigma v\ K$ is interpreted as referring to the sum individual of all v that satisfy K, in this case the sum of all donkeys. In general, we have the following verification condition:

(69) A function g verifies a condition $D = \Sigma d\ K$ in a model $M = \langle A, F \rangle$ iff
$g(D) = \sigma a\ g'[g \subseteq g' \wedge DOM(g') = DOM(g) \cup U(K) \wedge g'(d) = a \wedge g'$ verifies K in M],
where $\sigma a \Phi$ is the greatest element in A that satisfies Φ.

The DRS construction rule for abstraction formulated above is actually just one version of several rules. For non-universal quantifiers we also have to account for cases like the following:

(70) a. Many undergraduate students came to the carnival party. They like this kind of thing.
(they = the undergraduate students in general.)

b. Many undergraduate students came to the carnival party. They enjoyed it.
(they = the undergraduate students that came to the party.)

The construction rule given above accounts for case (a). For case (b) we have to assume that we can form an abstraction over the union of the antecedent box and the consequent box:

CR.PRO.PLUR.ABS′:

- Trigger:
  (i) $[_S[_{NP}[_{PRO}\alpha][_{VP'}\ ]]$ or $[_{VP}[_V\ ][_{NP}[_{PRO}\alpha]]]$, as condition of DRS K, where α is a plural pronoun;
  (ii) a duplex condition K_1 Q K_2 that is immediately preceding K.
- Introduce a new sum DR D in K and a condition D = Σd[K_1 K_2], where d is a discourse referent introduced in K_1.
- Substitute D for $[_{NP}[_{PRO}\alpha]]$ in the triggering configuration.

It also has been argued that with downward-entailing quantifiers pronouns can pick up the complement:

(71) Few undergraduate students came to the carnival party. They rather went to the beach.
(they = the undergraduate students that did not come to the party)

However, one typically can understand such sentences in a way that the pronoun refers to the entities determined by the antecedent box (here, all undergraduate students). The second sentence then is to be understood as a statement that allows for exceptions.

2. Abstraction and the Formation of Definite Plurals

We also need abstraction for the formation of definite plural NPs. The following examples show that they should be treated similar to names, that is, their discourse referent is introduced in the main DRS.

(72) a. The three donkeys protested.

b. Pedro didn't beat the three donkeys. They were happy.

We can propose the following DRS construction rules for definite plural NPs:

CR.DEF.PLUR:

- Trigger: $[_S[_{NP}[_{DET}\text{the}]\ [_N\ \beta]]\ [_{VP'}\ ]]$ or $[_{VP}[_V\ ]\ [_{NP}[_{DET}\text{the}]\ [_N\ \beta]]]$, as a condition of a DRS K, where β is a plural N.
- Introduce a new DR D in the maximal DRS that contains K.
- Introduce a new condition D = ΣD′ | D $[_N\beta](D')$ |
- Replace $[_{NP}$ the β] in the triggering condition by D.

Example (72.b), first sentence:

(73)

u X u = Pedro X = ΣYY | |Y| = 3 donkey*(Y) | ¬ | [u beat X] |

Note: This captures the absolute, non-anaphoric use of definite descriptions. It can easily be extended to the singular case, where we have the requirement |d| = 1 coming with the singular noun.

3.8.4 Collective and Distributive Readings

There are two modes how a predicate can be applied to a sum individual: The predicate may be applied collectively to the whole sum, or distributively to the atomic elements.

(74) a. The farmers gathered in the market place. [collective]

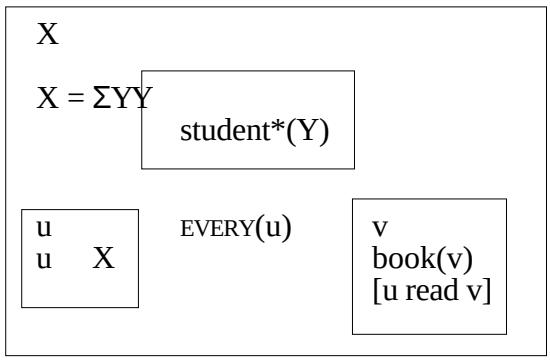
b. The men carried the piano upstairs. [probably collective]

c. The students read a book. [probably distributive]

d. The children ate one apple each.
The children each ate one apple. [distributive]

Distributive readings are generated by a universal quantification over the atomic parts of a sum individual. For example, for (74.c) we should get the following DRS:

(75)



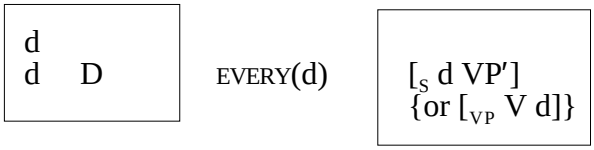
Here, is a condition that expresses that u is an atomic part of X. We assume the following verification condition:

(76) A function g verifies a condition "d D" in a model M = A, F, iff
g(d) g(D) = g(D) and there is no a A, a ≠ g(d), such that a g(d) = g(d).

That is, d D holds if the entity d is anchored to is atomic and a part of the entity D is anchored to. The general DRS construction rule for distribution can be given as follows:

CR.DISTRIBUTION:

- Triggering configuration: [$_S$D VP′] {or [$_{VP}$ V D]} as a condition of a DRS K, where K is a plural discourse referent.
- Replace the triggering configuration by the duplex condition



3.8.5 Syntactic Plural Agreement

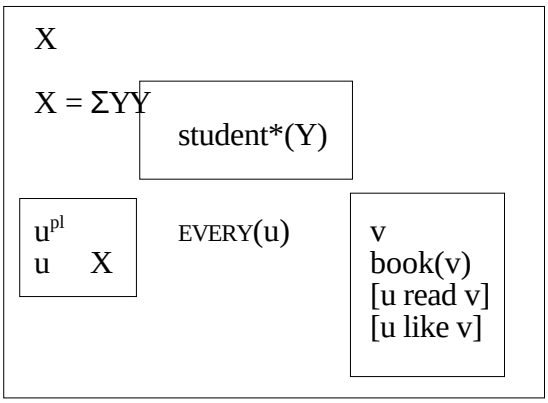
So far we have treated the plural pronoun *they* as involving sum DRs. But this is problematic in cases like the following:

(77) a. The students read a book which they liked. [distributive]

b. Most students read a book which they liked.

It seems that *they* can pick up a singular DR as well, and that its plural form is solely motivated by the fact that the antecedent NP is plural in form. Kamp & Reyle 1993 suggest that this is a purely syntactic rule of anaphoric agreement, related to gender agreement. The introduce superscripts "pl" on individual DRs to indicate that these DRs were introduced by a plural NP. For example, the new distribution condition should lead to the following representation of (77.a):

(78)



3.8.6 Dependent Plurals

Another interesting phenomenon of plural reference can be illustrated with the following examples:

(79) a. Unicycles have wheels.

b. Most of my friends own cars.

c. The women bought cars which had automatic transmissions.

Take (b); this doesn't necessarily mean that most of my friends have more than one car, but that most of my friends have a car (and perhaps more than one). Note that we could replace *cars* by *a car* without change of meaning. This illustrates so-called **dependent plurals**; the selection of a bare plural NP depends on the fact that some other NP (here, *friends*) is plural. This NP must be in the same clause, witness the following example, which only has the reading that the car had more than one automatic transmission.

(80) The women bought a car which had automatic transmissions.

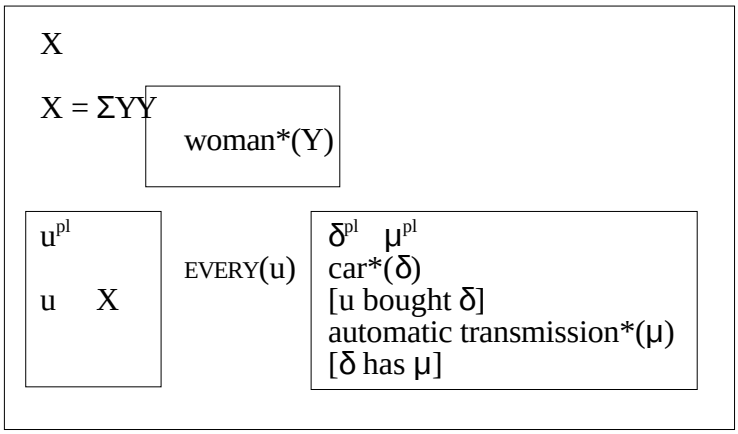
Kamp & Reyle (1993) treat dependent plurals by a DRS construction rules that allows to relate a plural NP (like *cars*) to a neutral DR that ranges over both atomic individuals and sum individuals in case the condition in which the plural NP occurs contains another discourse referent that is marked as plural, by superscript pl:

CR.NP (Dep):

- Triggering configurations:
  (i) $[_S[_{NP}[_{DET}\ ][_N\beta]][_{VP'}\ ]]$ or $[_{VP}[_V\ ][_{NP}[_{DET}\ ][_N\beta]]]$, as (part of) a condition of a DRS K, where β is a plural noun,
  (ii) and there is a DR marked *pl* which is contained in this condition.
- Introduce into the universe of K a neutral DR δ^{pl},
- Add the condition β(δ) to K.
- Add the condition obtained by replacing $[_{NP}[_{DET}\ ][_N\beta]]$ in the triggering condition by δ.

Example for (79.c):

(81)



The rule for dependent plurals should be actually more complex. Kamp & Reyle argue that the topic/comment articulation plays a role:

(82) a. Weak men tend to drive strong cars. [*strong cars* dependent on *weak men*]

b. WEAK MEN tend to drive strong cars. [*weak men* dependent on *strong cars*]

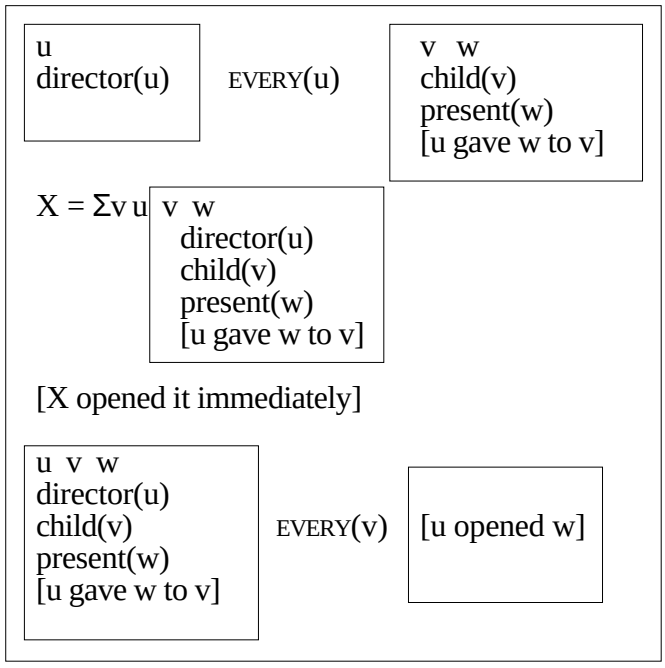
c. It is WEAK MEN who tend to drive strong cars.

Kamp & Reyle also discuss rather complicated cases of dependent plural pronouns, as in the following example:

(83) Every director gave a present to a child from the orphanage. They opened it right away.

In the most natural interpretation, each child opened his or her present. The treatment of such cases involves a combination of plural reference and modal subordination.

(84)



We construct a plural discourse referent X that is anchored to the children that got presents from a director. But for the second sentence, we have to "unfold" this discourse referent by replacing it by the box by which it was constructed, otherwise the pronoun *it* could not be properly interpreted. The second sentence is interpreted distributively.

3.8.7 Kinds and ‘one’ Anaphora

Another type of discourse referents appears in examples like the following:

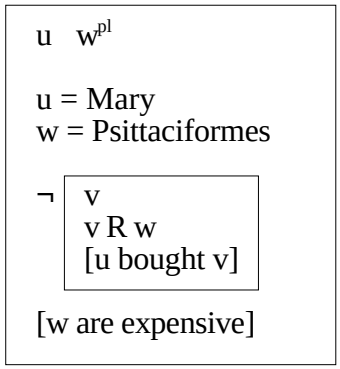
(85) a. Mary did not buy a parrot. They are so expensive.

b. Mary did not buy Chanel No. 5. It is so expensive.

The pronouns *they* and *it* obviously do not refer to a particular parrot or a particular quantity of Chanel No.5, but to the kind of *Psittaciformes* or Chanel No. 5. In order to explain the anaphoric relations in (85) we have to assume that NPs based on a noun introduce a kind discourse referent in the maximal box.

For (85.a) we should get the following DRS. Note that the kind individual w is marked plural; it is picked up by a plural pronoun. In general, count nouns introduce plural kind DRs, and mass nouns introduce singular kind DRs. I use a capitalized noun as name of the corresponding kind. Obviously, *parrot* and *Parrot* should be semantically related. We can follow Greg Carlson (1977), who assumed a realization relation R that holds between kinds and their specimens; we have that x is a parrot iff x R *Psittaciformes.* I will be silent about what it means that a kind is expensive; obviously, this will be true iff typical specimens of the kind are expensive.

(86)



We have to change the DRS construction rule for indefinites accordingly. Essentially, an indefinite NP with head noun N should introduce a kind discourse referent x and the condition $x = k_N$ (where k_N stands for the kind related to N) in the main DRS, and a regular discourse referent d and the condition d R x in its local DRS.

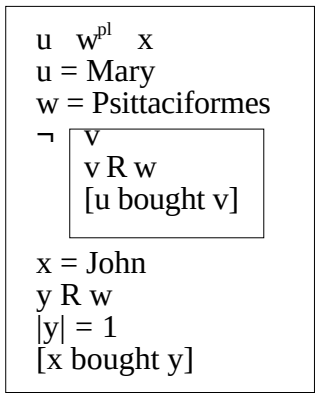
An important type of pronoun are partitive pronouns like *one* or *some*. They are related to a discourse referent that is already introduced and introduce a new discourse referent in their local box that refers to a part of the entity the antecedent refers to. These pronouns can be related to sum individuals or to kind individuals:

(87) a. Mary bought three parrots. One was sick.

b. Mary didn’t buy a parrot. But John bought one.

Take as an example (b). The pronoun *one*, being a singular pronoun for count nouns, introduces a DR that refers to an atomic object. Let us assume a relation R between kinds and their specimens. Then our construction rules should provide for the following DRS:

(88)



Exercises:

1. a. Construct a DRS for the following text;
notice that you will have to assume a distributive interpretation for the second sentence.

Every farmer (of the village) owns a donkey. They like it.

b. Is the resulting DRS true or false with respect to the model M = U, F ,
where U = {f1, f2, f3, f4, f5, d1, d2, d3, d4, d5},
F(*farmer*) = {f1, f2, f3, f4, f5}, F(*donkey*) = {d1, d2, d3, d4, d5},
F(*own*) = { f1, d1 , f2, d2 , f3, d3 , f4, d4 , f5, d5 }
F(*like*) = { f1, d1 , f2, d2 , f3, d3 , f4, d4 }.

2. Specify a DRS construction rule for reciprocal pronouns, in the format we have used so far, and show how it works with the example *The farmers hate each other*.