14 Noun Phrases in English

1 Introduction

In chapter 10, we began our investigation of how the truth values of minimal English clauses are determined by the constituent structure of the clauses and values assigned to their minimal constituents. We would like to expand our investigation of the English clause to a wider range of clauses so as to show how the logical tools set out in the preceding four chapters can be applied to shed light on the central question of natural language semantics, namely, the question of how the meanings of constituent expressions contribute to the meaning of the expression of which they are constituents.

A natural next step is to investigate what we shall call *simple clauses*, which are like minimal clauses, except that the noun phrase contains at most one noun, one determiner, and one adjective. Afterward, we shall venture still further by considering noun phrases that contain modifying prepositional phrases or restrictive relative clauses. Finally, we shall revisit coordination. Previously, the coordination we investigated was that of coordinated declarative clauses. However, English permits the coordination of phrases too. We shall briefly investigate them as well.

2 Simple Noun Phrases in English

Noun phrases can be quite complex. Indeed, as we saw in chapter 3, section 3.3.3, a noun phrase may contain another noun phrase, and in some cases, there is no limit to this iteration. Here, we shall confine our attention for the most part to simple noun phrases, which we stipulate to be noun phrase containing at most two nouns, one subordinate to the other. In order to arrive at a characterization of the syntax of simple English noun phrases, let us begin by looking carefully at the core of any English noun phrase, the noun.

2.1 English Nouns

It is useful, to begin with, to recognize that English nouns fall into four classes: pronouns, proper nouns, count nouns, and mass nouns. Count nouns and mass nouns constitute what, in grammar reaching back to the Middle Ages, are known as *common nouns*. A common noun was thought to apply to more than one individual, thereby being common to the two or more individuals to which it applies. In contrast, *proper* nouns were thought to apply to just one individual and hence to be proper to the single individual to which it applies. Pronouns were so called because they were thought to stand in for (*pro-*) other nouns. The terms *count* and *mass* are recent additions to the technical vocabulary of traditional grammar. Count nouns were thought to apply to things that can be counted, whereas mass nouns were thought to apply to things that can only be measured. As we shall see, like many of the definitions of technical terms from traditional grammar, the characteristics of the definition, while applying to instances that readily come to mind, do not generalize.

2.1.1 Proper nouns

Proper nouns that fell within the ambit of chapter 10 were simple, personal first names. This was done to ease exposition by minimizing complexity. It is now time to get a more complete overview of English proper nouns. To begin with, proper nouns are not always single words, rather they range from single nouns, for example, *Montreal, Bratislava, Kigali, Pune;* to strings of words that have the form of a noun phrase, for example, *the Northwest Territories, The Dream of the Red Chamber*, *the Children's Crusade, the Age of Reason, the International Monetary Fund;* and even to simple sentences, for example, *Who Is Afraid of Virginia Woolf,* the title of a novel. There are, in fact, millions of English proper nouns: after all, each English counting numeral is a proper noun.

(1) *Two* is a prime number, but *five million three hundred forty-two thousand, eight hundred ninety-five* is not.

A proper noun, as its name is intended to suggest, denotes a unique thing. However, as is well known, for many proper nouns, so-called forenames such as *Alice*, *Burton*, *Carl*, and so on, do not denote unique individuals. Many, people share such names. Some people share both a forename and a surname: *Michael Smith,* for example, is common to many unrelated people. Still, though the same proper noun names more than one person, the presumption is that, on any occasion of use, it applies uniquely. At the same time, some proper nouns denote nothing at all. These are names of fictitious entities: fictitious persons (*Sherlock Holmes, John Doe*), fictitious places (*Xanadu, Shangrila,* or *Mount Meru*), and fictitious events (*Armageddon*). (For further details pertaining to the semantics of proper nouns, see Larson and Segal 1995, chap. 5.)

Proper nouns that comprise more than one word may exclude any determiner, require a determiner, or, rarely, permit the determiner to be optional. If a proper noun admits a determiner, the determiner is the definite article.

Though personal first names in English exclude being preceded by a determiner, many English proper nouns require the definite article (*The Hague, the Maghreb, the Crimea, the Kremlin, the Vatican, The Iliad*, *the Vedas, the Koran, the Himalayas*). Some include modifiers: *the Forbidden City, the Great Salt Lake, the Black Forest, the Grand Canyon, the Great Plains, the Rocky Mountains*). And while personal first names in English occur only in the singular and exclude the definite article, many English proper nouns occur only in the plural and require the definite article: *the Great Lakes, the Pyrennes, the Seychelles, the Andes,* to name a few.

A good first-order generalization, then, is this: proper nouns in English do not tolerate the free alternation between singular and plural nor do they admit being immediately preceded by either a possessive noun phrase or determiners other than the definite article.

As is well known, many English proper nouns also appear as common nouns, having a different but predicable shift in meaning. First, a proper noun for someone may also serve as a common noun for people with that name. Second, a proper noun for a company, an artist, or a composer may serve as a common noun for products produced by the company, the artist, or the composer, respectively. Third, a proper noun for something or someone famous may serve in addition as a common noun for other things having similar qualities.

(2.1) Each Dan at the wedding had a sarcastic remark to make.
Each person named *Dan* at the wedding had a sarcastic remark to make.

(2.2) No one can afford to buy a Rembrandt.
No one can afford to buy a painting by Rembrandt.

(2.3) Bill's wife is no Florence Nightingale.
Bill's wife does not have the qualities of Florence Nightingale.

(For further details, see Algeo 1973; Bauer 1983, chap. 3.2.3; Payne and Huddleston 2002, sec. 20.)

Exercises: Proper nouns

1. We observed that English proper nouns can also be used as common nouns. Find five more examples of the second and third usages discussed, preferably attested, and provide paraphrases of each.

2. Show that the following two sentences are not synonymous. Explain why they are not.
   (1) Bill thinks that he is Picasso.
   (2) Bill thinks that he is a Picasso.

3. Find five examples of English proper nouns used as verbs, preferably attested, and provide paraphases of each.

4. We saw in chapter 12 that CQL can be enriched by adding to its set of logic constants the symbol I, a binary relational symbol, to denote the identity relation on a structure's

universe. Suppose that one adds to its set of logical constants instead the symbol *E,* a unary relational symbol, to denote a structure's universe. Using the unary relational symbol *E* and using the individual symbol *c* as a translation of the proper noun *Santa Claus,* write out formulae for each of the following English sentences.

(1) Everything exists.
(2) Nothing exists.
(3) Santa Claus does not exist.

Do the formulae adequately render their corresponding English sentences? In each case, explain your answer.

2.1.2 Pronouns

Pronouns, which, unlike proper nouns, show a productive singular plural contrast, and which, unlike common nouns, do not admit determiners, are fairly diverse, encompassing eight subcategories.

TYPE OF PRONOUN	EXAMPLES
Quantificational pronouns	*someone, somebody, something,* *everyone, everybody, everything,* *anyone, anybody, anything*
Interrogative pronouns	*what, who*
Relative pronouns	*which, who*
Demonstrative pronouns	*this, that*
Personal pronouns	*I, we, you, he, she, it, they*
Possessive pronouns	*mine, our, your, his, her, its, their*
Reflexive pronouns	*myself, yourself, himself, herself, themselves*
Reciprocal pronouns	*each other, one another*

While the first two subcategories of pronouns, namely quantificational and interrogative pronouns, do not evince the two kinds of context dependence discussed in chapter 4, the others do. Moreover, while the reciprocal pronouns are only cotext dependent and the first- and second-person singular personal, possessive, and reflexive pronouns are only setting dependent, the remaining pronouns are liable to both forms of contextual dependence.

However, as was known already to Apollonius Dyscolus (ca. second century CE), pronouns, in particular third-person personal pronouns, can be used both endophorically and exophorically. Though we discussed the distinction between exophoric and endophoric usages in chapter 4, we said nothing about the assignment of values to such expressions. The topic is complex. Here we shall confine ourselves to brief answers to these two questions: how are the values of third-person personal pronouns determined, when used exophorically? And how are their values determined, when used endophorically, get their values?

Willard Quine (1960, sec. 28) noticed that third-person personal pronouns, used exophorically, behave in a way similar to the way free variables in a formula of CQL, or indeed expressions of English, behave. Consider the following three expressions.

(3.1) Px
(3.2) x is prime.
(3.3) It is prime.

Even if a structure assigns P a value, say the set of prime numbers, the formula Px can not be assigned a value unless x is assigned a value. However, once assigned a value by a variable assignment, the truth value of the formula is determined. It is common in writing in English on mathematical topics for variables to be used, as exemplified by the quasi-English sentence in (3.2). Here too the truth value of the expression is determined only once a value is assigned to the variable. (Readers may wish to review section 2 of chapter 11, where this point was first made.) Quine's point is that the same situation obtains for the personal pronoun *it*. Once one finds a suitable value from the context, the truth or falsity of sentence (3.3) is determined.

English pronouns have gender, while variables do not. But that just means that the gender of the third-person personal pronoun puts a restriction on the possible values the pronoun could be assigned.

The situation is more complex than Quine's brief discussion suggests. To apply the insight, one must make special provisions to distinguish the circumstances of utterance from the circumstances of evaluation. This distinction and its application to pronouns and other endophoric expressions in natural language were pioneered and developed by David Kaplan, David Lewis, and Robert Stalnaker, using ideas taken from modal logic.[1]

What about third-person personal pronouns used endophorically. As we saw in section 3.1 of chapter 4, these pronous and other proforms have their values determined by cotext. The question is how. Traditional grammarians thought of pronouns as words that stand for nouns. Early transformational linguists formalized this idea in terms of transformations. The idea is that a sentence, such as the one in (4.1), which has the proform *he* whose antecedent is *Bill,* is analyzed as having a surface structure, corresponding to the expression in (4.1), and a deep structure, corresponding to the expression in (4.2), and the two are related by the transformational rule of *pronominalization,* whereby the second occurrence of *Bill* in (4.2) is replaced by *he*.

(4.1) Bill thinks that he is smart.
(4.2) Bill thinks that Bill is smart.

(5.1) Alice put on her coat and Bill put on his coat.
(5.2) Alice put on Alice's coat and Bill put on Bill's coat.

1. See section 1 of chapter 4. For further discussion, see Larson and Segal (1995, chap. 6).

However, this account does not work for pronouns with quantified noun phrases as antecedents:

(6.1) Each woman thinks that she is brillant.
(6.2) Each woman thinks that each woman is brillant.

Here, as Quine (1960, sec. 28) observed, one turns to logic for help. Let the pronoun *she* be assigned a value that varies as the values of its antecedent noun phrase varies, just as the values of variables vary with the quantifier matrix that binds it. So widespread is this view of how to treat such cases that linguists no longer speak of a pronoun having an antecedent, but they say instead that a pronoun is bound by its antecedent, extending this talk even to cases where the antecedent is a proper noun.

2.1.3 Common nouns

As stated at the beginning of section 2.1, common nouns have come to be divided into count nouns and mass nouns. There are clear morpho syntactic criteria by which to distinguish them. (See Jespersen 1924, 198–200, where the distinction between the two kinds of nouns is made, and Bloomfield 1933, where the patterns are set out.) We shall illustrate these patterns with the minimal pair of *advice* and *suggestion* noticed by Carl Lee Baker (1989, 8–12).

Here are eight criteria, all of which were known to Bloomfield (1933). First, count nouns have both singular and plural forms; mass nouns typically having only a singular form, do not.

(7.1) Bill heeded a suggestion/suggestions by Alice.
(7.2) Bill heeded advice/*advices by Alice.

A count noun, and not a mass noun, may serve as the antecedent for the pronouns *one* and *another* (205).

(8.1) Alice made a suggestion. Bill made one as well.
(8.2) *Alice gave advice. Bill gave one as well.

The indefinite article (*a*) and the determiners *either* and *neither* are used with singular count nouns and not with either mass nouns or plural count nouns (206).

(9.1) Bill heeded a suggestion by Alice.
(9.2) *Bill heeded an advice by Alice.

Cardinal adjectives for numbers greater than one as well as quasi-cardinal adjectives such as *a few, few, several, many* are used only with plural count nouns; whereas *more, all,* and *enough* are used with mass nouns and plural count nouns (ibid.).

(10.1) Alice made more suggestions/*suggestion to Bill.
(10.2) Alice gave more advice/*advices to Bill.

Plural count nouns and mass nouns may occur with no determiner, whereas a singular count noun requires a determiner (252).

(11.1) Alice made suggestions/*suggestion to Bill.
(11.2) Alice gave advice/*advices to Bill.

Mass nouns, but not count nouns, are preceded by *less, little, a little,* and *much* the counterparts of *fewer, few, a few,* and *many,* respectively (206).[2]

(12.1) Alice made few suggestions/*suggestion to Bill.
(12.2) Alice made few advices/*advice to Bill.
(12.3) Alice gave little advice/*advices to Bill.

All this is summarized in the following table.

DISTRIBUTIONAL PROPERTIES

DISTRIBUTIONAL PROPERTIES	MASS NOUN	COUNT NOUN
Exhibits singular/plural contrast	–	+
Antecedent for *another, one*	–	+
Modifiable by indefinite article, *either,* and *neither*	–	sg+, pl–
Modifiable by *all, enough, more*	+	sg–, pl+
Modifiable by cardinal numerals other than *one*	–	sg–, pl+
Tolerates having no determiner	–	sg–, pl+
Modifiable by *few, a few, many, several*	–	sg–, pl+
Modifiable by *less, little, a little, much*	+	–

As we noted, the contrasting terms *count noun* and *mass noun* are misleading. While it is true that count nouns do indeed apply only to things that can be counted, it is not true that mass nouns apply to things that cannot be. To be sure, many mass nouns apply to things that cannot be counted, though they can be measured:

NONCOUNTABLE MASS NOUNS

bacon, beef, bleach, bronze, broth, butter, calcium, cement, cereal, chalk, champagne, charcoal, cheese, chiffon, clay, copper, coral, corn, cotton, cream, curry, denim, dew, diesel, dirt, filth, foam, garlic, granite, gravel, grease, honey, ink, ivory, ivy, jade, jam, linen, liquor, liquorice, manure, mould, mustard, oxygen, paint, parsley, plaster, pollen, porcelain, pork, powder, rhubarb, rice, salt, satin, sherry, silk, soap, soup, spaghetti, steam, succotash, sulphur, sweat, syrup, tinsel, toast, tobacco, veal, velvet, wax, wool

2. The contrast between *less* and *fewer* has eroded for many North American speakers of English. It is not unusual to hear speakers say *there are less forks than knives on the table,* instead of *there are fewer forks than knives on the table*.

However, many nouns that evince the same morpho syntactic properties as these nouns denote countable things.

MASS NOUN	COUNT NOUN (near synonym)	MASS NOUN	COUNT NOUN (near synonym)
advice	*suggestions*	*jewelry*	*jewels*
ammunition	*bullets*	*knowledge*	*beliefs*
artillery	*cannons*	*laundry*	*dirty clothes*
bedding	*sheets*	*laughter*	*laughs*
carpeting	*carpets*	*livestock*	*farm animals*
change	*coins*	*luggage*	*suitcases*
clothing	*clothes*	*machinery*	*machines*
company	*guests*	*mail*	*letters*
crockery	*pans*	*news*	*tidings*
cutlery	*knives*	*pasta*	*noodles*
damage	*injuries*	*pottery*	*pots*
dishware	*plates*	*property*	*possessions*
drapery	*drapes*	*silverware*	*spoons*
evidence	*clues*	*spaghetti*	*noodles*
foliage	*leaves*	*stuff*	*things*
footwear	*shoes*	*toiletry*	*toiletries*
furniture	*chairs*	*traffic*	*vehicles*
glassware	*glasses*	*underwear*	*undergarments*
hardware	*tools*	*weaponry*	*weapons*
infantry	*foot soldiers*	*wildlife*	*animals*

Many English common nouns appear to satisfy the criteria of both categories (Bloomfield 1933, chap. 16.1). Often, however, there is an evident difference in construal that correlates with which criteria the word satisfies. Some mass nouns, when used as count nouns, denote kinds: for example, *breads* denote kinds of bread, *cheeses* denote kinds of cheese, *wheats* kinds of wheat, and *virtues* kinds of virtue (see Quirk et al. 1985, I.53; Payne and Huddleston 2002, 336). Others, when used as count nouns, denote standard units: for example, *cakes* denote standard units of cake, as opposed to slices of cake, *pizzas* a standard unit of pizza, as opposed to slices of pizza, *hamburger* a standard unit of hamburger, that is, a hamburger paddy (see Quirk et al. 1985, I.53; Payne and Huddleston 2002, 336). Notice that *coffees, teas,* and *beers* may denote either kinds or servings. Still other mass nouns, when used as count nouns, denote instances: for example, *details* denote instances of detail, *discrepancies* instances of discrepancy, *lights* instances (sources) of light,[3] *efforts* instances where effort is exercised, *actions* instances of action, *thoughts*

3. Notice that the mass noun *darkness* has no plural counterpart.

instances of thought (cf. *ideas*), *errors* instances of error (cf. *mistakes*), and *shortages* instances of shortage (see Quirk et al. 1985, I.53; Payne and Huddleston 2002, 337). Finally, some mass nouns, when used as count nouns, may denote sources of various kinds: for example, *fears* denote things that give rise to fear, or perhaps instances of fear, *embarassments* things that give rise to embarrassment, *surprises* things that give rise to surprise, *wonders* things that give rise to wonder, *delights* things that give rise to delight, and so on. Inversely, it is well known that many count nouns, satisfying the distributional criteria for mass nouns, are then construed as denoting a subset of the parts of items in their denotation as a count noun. Just which parts are included vary from word to word and from occasion of use to occasion of use.

COUNT NOUN	DENOTATION OF ITS MASS VERSION
turnip	the edible parts of turnips
potato	the edible parts of potatoes
apple	the edible parts of apples
carrot	the edible parts of carrots
duck	the edible parts of ducks
turkey	the edible parts of turkeys
chicken	the edible parts of chickens
lamb	the edible parts of lamb
crab	the edible parts of crabs
oak	the usable parts of oak trees
birch	the usable parts of birch trees
maple	the usable parts of maple trees
pine	the usable parts of pine trees
rabbit	the usable fur of rabbits
	the edible parts of rabbits

Moreover, as noted in descriptive grammars and demonstrated in psycholinguistic studies going back to Clark and Clark (1979), common nouns usually used as count nouns can be used, on the fly, as it were, as mass nouns.

(13.1) The termite was living on a diet of book.
(Payne and Huddleston 2002, p. 337, ex. 14 i)

(13.2) There was cat all over the driveway.
(ex. 14 ii)

(13.3) Bill got a lot of house for $100,000.

(13.4) How much floor did you lay today?

These four classes of English noun are easily distinguished on the basis of two criteria: first, whether the noun in question occurs equally freely in the singular and in the plural, and second, whether the noun in question tolerates a variety of determiners. On the one hand, proper nouns and pronouns do not tolerate determiners, though admittedly the definite article occurs in some proper nouns, while mass nouns and count nouns do. On the other hand, pronouns and count nouns evince the alternation between singular and plural, whereas proper nouns and mass nouns do not evince such an alternation.

DISTRIBUTIONAL PROPERTIES OF NOUNS	Occurs with a determiner	Admits the contrast of singular and plural
Proper noun	−	−
Pronoun	−	+
Mass noun	+	−
Count noun	+	+

Exercises: Common nouns

1. Here are three lists of words. For each list, state in what way the words in the list are exceptional with respect to the criteria set out in this section, find at least five similar words and explain how you think the exceptionality of these words should be treated.

(a) *hair, rock, rope*

(b) *antelope, deer, swine*

(c) *brains, dues, effects, goods*

2.2 Adjectives

We discussed English adjectives briefly in chapter 10. There, we pointed out that English adjectives may be used both predicatively and attributively. While many adjectives may be used either way, some are used exclusively predicatively and others exclusively attributively. Indeed, some languages, such as Slave, an indigenous North American language of the Dene (Athabaskan) language family, require all adjectives to be predicative, that is, to occur as a complement to a copular verb (Rice 1989, chap. 21; cited in Baker 2003, 194); others, such as Vata and Gbadi, West African languages, require that all adjectives occur attributively (Koopman 1984, 64–66; cited in Baker 2003, 206); still other languages, such as Russian, impose special morphology on the adjective, depending on whether it is used attributively, having a so-called short form, or predicatively, having a so-called long form (Baker 2003, 206).

Here we shall turn our attention to English attributive adjectives. When one thinks of attributive adjectives, one usually thinks of adjectives that may also occur predicatively. We shall call such adjectives *predictive* attributive adjectives. Predictive attributive adjectives are not, however, the only attributive adjectives. There are also *cardinal* adjectives and *thematic* adjectives.[4] A cardinal adjective is one that says something about the size of the denotation of the noun it modifies; in other words, they are the cardinal numerals (*one, two, three,* etc.) used as adjectives. A thematic adjective is one that restricts the set denoted by the noun it modifies by dint of a thematic relation the members of the set bear to other things.[5] These adjectives are typically obtained from nouns by the addition of a suitable suffix.

PARAPHRASAL PROPERTIES OF THEMATIC ADJECTIVES		
THEMATIC RELATION	PHRASE	PARAPHRASE
AGENT	presidential lies	lies told by a president
PATIENT	mental stimulation	stimulation of the mind
BENEFICIARY	avian sanctuaries	sanctuaries for birds
INSTRUMENT	solar generators	generators using the sun
LOCATION	marine life	life in the sea
MATERIAL	molecular chains	chains made out of molecules
POSSESSOR	musical comedies	comedy which have music
POSSESSEE	reptilian scales	scales had by reptiles
CAUSE	malarial mosquitoes	mosquitoes causing malaria
EFFECT	thermal stress	stress caused by heat

Notice that the phrase and the paraphrase observe similar restrictions on the relata of the thematic relation. For example, a lie requires an animate agent. Hence the oddity both of the phrase *reptilian lies* and of its paraphrase *lies by reptiles*.

When they modify a noun, the resulting constituent is often susceptible of a number of construals.

(14) atmospheric testing:
CONSTRUAL 1: testing of the atmosphere (patient)
CONSTRUAL 2: testing in the atmosphere (location)
CONSTRUAL 3: testing by the atmosphere (instrument)

Let us turn to the patterns whereby these three classes of attributive adjectives distinguish themselves from one another. First, as already mentioned, predictive adjectives may occur as complements to copular verbs. Cardinal and thematic adjectives either do not so occur at all or do so with less ease or with a shift in construal.

(15.1) The expensive sofa
The sofa is expensive.

4. The basic patterns were first identified in Levi (1978). Many of the examples pertaining to thematic adjectives are drawn from her work.

5. What are called *thematic roles* include agent, patient, beneficiary, instrument, and location. Since these adjectives are construed with such roles, or relations, we call them *thematic adjectives*.

(15.2) These two beliefs
*These beliefs are two.

(15.3) The solar panel
*The panel is solar.
The panel is a solar one.

Second, coordinators may coordinate predictive adjectives, but may not coordinate thematic adjectives. Cardinal adjectives are only coordinated by the coordinator *or*.

(16.1) a rich and surly tourist

(16.2) those six or seven tourists
*those six and seven tourists

(16.3) *solar but lunar module

Third, however, an adjective from one class may not coordinate with an adjective from another.

(17.1) *which five and governmental subsidies

(17.2) *those handsome and two friends

(17.3) *each departmental and large meeting

Fourth, though predictive adjectives may occur one after another, cardinal adjectives may not, and thematic adjectives do so only exceptionally.

(18.1) a short, ugly dog
an obnoxious old man

(18.2) *six, seven stones

(18.3) *a dental, malarial infection

Fifth, cardinal adjectives precede predictive ones and predictive ones precede thematic ones.

(19.1) thirteen, expensive pencils
*expensive, thirteen pencils

(19.2) large, malarial mosquito
*malarial, large mosquito

(19.3) arrogant, criminal lawyer
*criminal, arrogant lawyer

(19.4) eight, logical fallacies
*logical, eight fallacies

(19.5) three, large, ugly reptilian scales
*large, ugly, reptilian, three scales
*reptilian, three, large, ugly scales
*three, reptilian, large, ugly scales

Finally, many predictive adjectives have acceptable comparative and superlative forms and admit modification by words of degree, such as *quite, rather, so,* and *very;* neither cardinal adjectives nor thematic adjectives have either comparative or superlative forms and do not admit modification by degree words, unless they shift their construal.

(20.1) rich, richer, richest
expensive, more expensive, most expensive

(20.2) five, *fiver, *fivest
five, *more five, *most five

(20.3) macular, *macularer, *macularest
macular, *more macular, *most macular

(21.1) very richer

(21.2) *so three

(21.3) *rather malarial

The foregoing criteria are summarized in this table.

	CARDINAL	PREDICTIVE	THEMATIC
LINEAR ORDER	1	2	3
FOLLOW A COPULAR VERB	No	Yes	No
COORDINATION WITHIN	No	Yes	No
COORDINATION ACROSS	No	No	No
ITERATION	No	Yes	No
COMPARATIVE/SUPERLATIVE	No	Many	No
DEGREE WORD MODIFICATION	No	Many	No

We stated that though many predictive adjectives have comparative and superlative forms, many do not. Those that do also admit of modification by degree words, and those that do not do not. The former predictive adjectives are known as *gradable* adjectives. Typical examples are *tall, short, good, bad, erroneous, accurate, beautiful, ugly, expensive,* and *gaudy*. The latter are known as *nongradable* adjectives. *Alive, dead, foreign,* and *pregnant* are examples of these adjectives.

Finally, there are seven other adjectives that behave like cardinal adjectives. They are: *few, a few, little, a little, many, much,* and *several*. They sound stilted when placed after a copular verb. They must precede predictive and thematic adjectives. They may not iterate or coordinate with themselves or cardinal adjectives. The first two, like cardinal adjectives, do not have comparative and superlative forms and they do admit modification by degree words; the last four do have comparative and superlative forms and do admit modification by degree words.

(22.1) many, more, most
(22.2) much, more, most
(22.3) few, fewer, fewest
(22.4) little, less, least

2.3 Determiners

As we noted in chapter 3, English noun phrases sometimes include words such as the definite article (*the*) and the indefinite article (*a*). These words form a substitution class with the demonstrative adjectives (*this* and *that*) and the interrogative adjectives (*which* and *what*). The substitution class, called *determiners* (Dt), also include such words as the indefinite article, *all, any, each, every, no,* and *some*. These are called *quantificational* determiners, because of their evident similarity to the quantifiers of CQL.

Determiners have three properties distinguishing them within noun phrases. First, though they do not occur in every noun phrase, if one does occur in a noun phrase, it occurs initially.

(23.1) We enjoyed [NP that very tasty dish].
(23.2) *We enjoyed [NP very tasty that dish].

Second, determiners do not iterate with one another.

(24)	*that a car	*a that car
	*this which tie	*which this tie
	*the each election	*each the election
	*what the friends	*the what friends
	*which what lawyer	*what which lawyer
	*what some guard	*some what guard
	*some these cars	*these some cars
	*no which contrivance	*which no contrivance
	*any no essay	*no any essay

And third, while some do coordinate with one another,

(25.1) Each and every person must attend.
(25.2) You must do this and that exercise.

they do not do so freely.

(26.1) *Every and each person must attend.
(26.2) *You must do this and some exercise.

Exercises: Determiners

1. In what way, if at all, does the fact that such English expressions as *What the hell!* and *That a boy!* are acceptable bear on the claim that English determiners do not iterate? Provide evidence to support your answer to this question.

2. Cardinal and quasi-cardinal adjectives may occur initially in a noun phrase. Does this fact warrant treating them as determiners? Provide evidence to support your answer to this question.

3 Putting Things Together

The Lambek typed Lambda calculus can be used to provide a grammar for the expressions of a natural language. Formulae, or types, of the Lambek calculus are assigned to the basic expressions of a natural language. These formulae, or types, are the syntactic categories of the basic expressions. The deduction rules are used to assign formulae, or types, to the composite expressions. In other words, they are the syntactic rules whereby the syntactic categories of composite expressions are obtained from the syntactic categories of their immediate subexpressions. At the same time, a basic expression is assigned a lambda term of the same type as the expression and a composite expression is assigned a lambda term of the same type as the composite expression that arises from the lambda terms assigned to the composite expression's immediate subexpressions. The Lambek typed Lambda calculus used to treat the syntax and semantics of a natural language is often known as a *type logical grammar*. We shall call such a grammar a *Lambek typed grammar*.

In the remainder of this chapter, we shall introduce a Lambek typed grammar for English by showing how the Lambek typed Lambda calculus can be applied to a range of patterns in English. For comparison, we shall also show how the same range of patterns can be handled by an enriched constituency grammar supplemented with a transformational rule. To simplify the exposition and to facilitate the comparison, we shall alter a few of assumptions adopted earlier in chapters 3, 8, and 10.

Notice that a Lambek typed grammar does not assign values to the expressions of the language for which it is a grammar, rather it assigns lambda terms. These lambda terms may be assigned values through a structure for the lambda terms. In this way, a structure for the lambda terms of a Lambek typed grammar is indirectly a structure for the expressions of the language for which the Lambek typed grammar is a grammar. The interposition of lambda terms between the expressions of natural language and their values in a structure provides for an elegant and compact formulation of the semantic rules corresponding to the Lambek calculus rules, though, as we shall see in section 3.6, it also has its drawbacks.

In section 3.2 of chapter 10, we formulated semantic rules, one for the constituency formation rule that forms a clause and one for each of the constituency formation rules that forms a phrase. These rules stated the value of an expression in terms of the values assigned to the expression's immediate constituents. However, the values to be assigned, though mathematically equivalent, are nonetheless different. In particular, a phrase is assigned, not a set, but its mathematically equivalent characteristic function, and a noun phrase comprising a proper noun is assigned, not a singleton set, but its member. At the same time, we add a category, commonly used by many syntacticians, known as a *determiner phrase*. We redesignate all proper nouns as determiner phrases (DP) and redesignate complements previously designated as noun phrases also as determiner phrases.[6] We shall also modify a few of the constituency formation rules found in section 3.1 of chapter 3. We shall indicate these changes when the first occasion to use one presents itself. These changes permit us to use lambda terms in the formulation of the corresponding semantic rules, thereby making the rules easier to state and comparison with the rules of Lambek typed grammar easier to see.

The expressions of English to be investigated here are not only simple clauses but also clauses whose noun phrases include as modifiers not just adjectives but also prepositional phrases and relative clauses. We shall also revisit coordination, first discussed in chapter 8, adverting to coordination of nonclausal constituents. We end the chapter by seeing how some of the patterns pertaining to complements discussed in chapter 10 and requiring an extension of constituency grammar with enriched categories can be handled in Lambek typed grammar.

3.1 Simple Clauses with Quantified Noun Phrases

We begin our discussion by showing how Lambek typed grammar can be applied to minimal clauses whose verbs are either intransitive, transitive, or ditransitive, as illustrated by the following sentences. We shall also show how the corresponding constituency formation rules and their accompanying semantic rules can be recast in the deductive format used in Lambek typed grammars.

(27.1) Alice slept.
(27.2) Alice greeted Bill.
(27.3) Alice showed Bill Fido.

A Lambek typed grammar follows the customary practice of assigning to clauses truth values and proper nouns members of a structure's universe. This means that a clause has type t and is assigned a lambda constant of type t, and hence assigned a truth value when the lambda terms are interpreted in a structure, and all proper nouns are of type e and are

6. We shall continued to use *noun phrase* in our description of English expressions and use DP only in connection with the enriched constituency grammar analysis of this chapter.

assigned constants of type *e,* and hence assigned an individual in the universe of a structure for lambda terms. Sentence (27.1) comprises a proper noun and an intransitive verb. Since the intransitive verb *slept* occurs to the right of the proper noun *Alice,* the intransitive verb must be assigned the type $e\backslash t$. In our altered constituency grammar, the proper noun *Alice* is assigned the category DP, the intransitive verb *slept* is still assigned the category V:$\langle\,\rangle$, or VP, and a clause is still assigned S. Since we have changed the category NP to DP, the clause formation rule, NP VP $\rightarrow$ S changes to the rule, DP VP $\rightarrow$ S. To make clear the close analogy between the clause formation rule and the elimination rule of the Lambek calculus, we recast the clause formation rule in the form of an elimination rule.

$$\frac{\text{DP} \qquad \text{VP}}{\text{S}}\ \text{S1} \qquad\qquad \frac{e \qquad e\backslash t}{\text{t}}\ \backslash\text{E}$$

We now apply these rules to sentence (25.1).

$$\begin{array}{cc} \textit{Alice} & \textit{slept} \end{array} \qquad\qquad \begin{array}{cc} \textit{Alice} & \textit{slept} \end{array}$$

$$\frac{\text{DP} \qquad \text{VP}}{\text{S}}\ \text{S1} \qquad\qquad \frac{e \qquad e\backslash t}{\text{t}}\ \backslash\text{E}$$

We shall call *derivations* not only constituency trees of constituency grammar recast in the format of a deduction but also deductions in the Lambek calculus insofar as they are applied to the syntactic analysis of natural language expressions, as just illustrated.

Using lambda terms, we can state the syntactico-semantic version of DP, the clause formation, in a fashion as compact as that of the Lambek typed grammar. A proper noun, such as *Alice,* is assigned a member of a structure's universe. Let a be a lambda constant of type e. An intransitive verb, such as *slept,* denotes a subset of a structure's universe. Let it be assigned a lambda constant for the characteristic function of such as set. Call it s. The term a can be assigned to the proper noun, regardless of whether it is categorized as DP or as of type e. Similarly, the term s can be assigned to an intransitive verb, regardless of whether it is categorized as VP or as of type $e\backslash t$. We use these terms of the Lambda calculus to write down the syntactico-semantic version of the DP rule and the corresponding rule in a Lambek typed grammar.

$$\frac{\text{DP} \mapsto a \qquad \text{VP} \mapsto s}{\text{S} \mapsto sa}\ \text{DP} \qquad\qquad \frac{e \mapsto a \qquad e\backslash t \mapsto s}{t \mapsto sa}\ \backslash\text{E}$$

As readers might recall from the paragraph following the definition of the formation of Lambek typed terms (definition 27) chapter 13, the lambda term of type $e\backslash t$ is written to the left of the term of type e when the two terms are combined into a composite term.[7]

7. The assignment of the type $e\backslash t$ to an English verb phrase reflects a fact about English: sometimes argument expressions occur to the left of the function expressions. Though as we noticed in chapter 13, this is also true of informal mathematical notation, it is avoided in the notation of the Lambda calculus, as to do otherwise brings about needless notational complexity.

Next comes sentence (27.2). Its analysis in constituency grammar is just the way it was before, with one further alteration: what was previously specified as a noun phrase in a specification of a word's complement is now specified as a determiner phrase. Turning now to the Lambek typed analysis, we ask: what is the type of the transitive verb *greeted*? Since *Bill,* a proper noun, has type e and *greeted Bill,* the verb phrase, has type $e\backslash t$, *greeted* has the type $(e\backslash t)/e$. Here then are the derivations.[8]

$$\dfrac{\begin{array}{c}\textit{Alice}\\ \text{DP}\end{array} \quad \dfrac{\begin{array}{c}\textit{greeted}\\ \text{V:}\langle\text{DP}\rangle\end{array} \quad \begin{array}{c}\textit{Bill}\\ \text{DP}\end{array}}{\text{VP}}}{\text{S}} \qquad\qquad \dfrac{\begin{array}{c}\textit{Alice}\\ e\end{array} \quad \dfrac{\begin{array}{c}\textit{greeted}\\ (e\backslash t)/e\end{array} \quad \begin{array}{c}\textit{Bill}\\ e\end{array}}{e\backslash t}}{t}$$

The values associated with the expressions *Alice, Bill,* and *greeted* are those of the values of Lambda calculus terms of type e for the first two and of type $(e\backslash t)/e$ for the last. Let those terms be a, b, and g, respectively, which we take to be terms of the appropriate type in the Lambda calculus.

$$\dfrac{\begin{array}{c}\textit{Alice}\\ \text{DP}\mapsto a\end{array} \quad \dfrac{\begin{array}{c}\textit{greeted}\\ \text{V:}\langle\text{DP}\rangle\mapsto g\end{array} \quad \begin{array}{c}\textit{Bill}\\ \text{DP}\mapsto b\end{array}}{\text{VP}\mapsto gb}}{\text{S}\mapsto gba} \qquad \dfrac{\begin{array}{c}\textit{Alice}\\ e\mapsto a\end{array} \quad \dfrac{\begin{array}{c}\textit{greeted}\\ (e\backslash t)/e\mapsto g\end{array} \quad \begin{array}{c}\textit{Bill}\\ e\mapsto b\end{array}}{e\backslash t\mapsto gb}}{t\mapsto gba}$$

(Recall that gba is an abbreviation of the lambda term $\big((gb)a\big)$.)

The very same values assigned in the Lambek typed derivation provide appropriate values for the constituency grammar derivation. To see this, let us pause to consider what the function denoted by g is. Let G be the set of ordered pairs formed from members of a structure's universe. Corresponding to this set is a function that assigns to each member of the universe x the set of those things in the universe that G pairs with x. The function denoted by g assigns to each member of the universe x, the characteristic function of the set of members of the universe that G pairs with x. This is just a restatement in terms of the Lambda calculus of the semantic rule stated in section 3.3.1 of chapter 10 for the formation of verb phrases from a transitive verb and its complement noun phrase. We can easily see the equivalence of the rule for the formation of a verb phrase from a transitive verb and its complement in a constituency grammar and the rule of \E where the terms are $(e\backslash t)/e$ and e, in that order.

$$\dfrac{\text{V:}\langle\text{DP}\rangle\mapsto g \qquad \text{DP}\mapsto b}{\text{VP}\mapsto gb} \qquad\qquad \dfrac{(e\backslash t)/e\mapsto g \qquad e\mapsto b}{e\backslash t\mapsto gb}$$

8. The labels for the rules applied in the derivations are omitted, lest the derivations become too cluttered with notation. In each case, it is evident which rule has been applied.

We now come to the last example, sentence (27.3). Following the reasoning used thus far, the type of *showed Bill Fido,* the verb phrase, is $e\backslash t$ and the type of *Bill* and *Fido* is e. There are two prima facie plausible type assignments for *showed:* $((e\backslash t)/e)/e$ and $(e\backslash t)/(e \cdot e)$. Within the context of our exposition here, the assignments are empirically equivalent. We choose the latter to emphasize the parallel with the constituency grammar analysis.

$$\cfrac{\begin{array}{c}\textit{Alice}\\ e \mapsto a\end{array} \qquad \cfrac{\begin{array}{c}\textit{showed}\\ (e\backslash t)/(e\cdot e)\mapsto s\end{array}\qquad \cfrac{\begin{array}{cc}\textit{Bill} & \textit{Fido}\\ e\mapsto b & e\mapsto f\end{array}}{e\cdot e\mapsto \mathrm{pr}(b, f)}}{e\backslash t \mapsto s\big(\mathrm{pr}(b, f)\big)}}{t\mapsto \big(s\big(\mathrm{pr}(b, f)\big)\big)a}$$

(Recall that pr is an expression in the Lambda calculus that denotes the pairing function. For example, pr(3, 7) is an expression that denotes the ordered pair $\langle 3, 7\rangle$.)

The constituency derivation tree is just like the Lambek typed derivation tree, except that the two proper nouns, *Bill* and *Fido,* do not form a constituent. The values assigned are the same.

$$\cfrac{\begin{array}{c}\textit{Alice}\\ \mathrm{DP} \mapsto a\end{array} \qquad \cfrac{\begin{array}{ccc}\textit{showed} & \textit{Bill} & \textit{Fido}\\ \mathrm{V}{:}\langle \mathrm{DP}, \mathrm{DP}\rangle \mapsto s & \mathrm{DP}\mapsto b & \mathrm{DP}\mapsto f\end{array}}{\mathrm{V}{:}\langle\,\rangle \mapsto s\big(\mathrm{pr}(b, f)\big)}}{\mathrm{S}\mapsto (s(\mathrm{pr}(b, f)))a}$$

Again, it is easy to see the equivalence of the rule for the formation of a verb phrase from a ditransitive verb and its two complements in a constituency grammar and the rule of \ elimination where the terms are $(e\backslash t)/(e \cdot e)$ and $e \cdot e$, in that order.

$$\cfrac{\mathrm{V}{:}\langle \mathrm{DP}, \mathrm{DP}\rangle \mapsto s \qquad \mathrm{DP}\mapsto b \qquad \mathrm{DP}\mapsto f}{\mathrm{V}{:}\langle\,\rangle \mapsto s\big(\mathrm{pr}(b, f)\big)}$$

$$\cfrac{(e\backslash t)/(e\cdot e)\mapsto s \qquad e\cdot e\mapsto \mathrm{pr}(b, f)}{e\backslash t \mapsto s\big(\mathrm{pr}(b, f)\big)}$$

We now venture beyond English minimal clauses and explore how to treat clauses whose subject noun phrases are quantified noun phrases. There are four kinds of quantificational English noun phrases, depending on whether the head noun is singular or plural, count or noncount. We shall confined ourselves to singular quantified noun phrases with count nouns.

Right at the inception of the development of CQL, the great Italian mathematician, Giuseppe Peano (1858–1932) noted that sentences, such as the in (28), have paraphrases by sentences, such as those in (29), that are themselves readily put into logical notation, such as the formulae in (30).

(28.1) Each boy sleeps.
(28.2) Some girl sleeps.

(29.1) For each x, if x is a boy, then x sleeps.
(29.2) There is some x such that x is a girl and x sleeps.

(30.1) $\forall x(Bx \rightarrow Sx)$
(30.2) $\exists x(Gx \wedge Sx)$

While each of the sentences in (28) are monoclausal, comprising a subject noun phrase and a verb phrase with a single intransitive verb, the sentences in (29), paraphrases of the sentences in (28), are biclausal. Similarly, the formulae in (30), which render the sentences in (28) into the notation of CQL, are composite formulae, whereas formula (31.2), which renders the monoclausal sentence in (31.1), is an atomic formula.

(31.1) Alice slept.
(31.2) Sa.

This shows that the model theory of CQL cannot be adapted to the constituency of simple English clauses with quantified noun phrases. However, the model theory of the second presentation of MQL^2, set out in section 3.2.2 of chapter 12, provides values suited to the syntactic structure of such clauses. In fact, simple quantified noun phrases, such as those in (28), have the same syntactic structure as the restrictors of the second presentation of MQL^2.

Let us state the constituency formation rule for constituents comprising a quantificational determiner and a singular common noun, or a minimal quantified noun phrase. The relevant constituency formation rule given in chapter 3 is restated first and its reformulation using DP in lieu of NP is stated second.

NP2 Dt $N_c \rightarrow$ NP
DP Dt $N_c \rightarrow$ DP

These rules can be recast as follows.

$$\frac{\text{Dt} \qquad N_c}{\text{NP}}\ \text{NP2} \qquad\qquad \frac{\text{Dt} \qquad N_c}{\text{DP}}\ \text{DP}$$

Now a quantificational determiner is assigned a suitable function from the functions assigned to the quantifiers of the second presentation of MQL^2. For example, if the determiner is *each,* we assign it $o_{\forall^2}$, and if it is *some* or the indefinite article (*a*), we assign it $o_{\exists^2_{\geq 1}}$. A common noun is assigned a subset of the universe. The resulting determiner phrase is assigned a set of subsets of the universe, namely the family of sets that results from applying the function assigned to the determiner to the set assigned to the common noun. To use the Lambda calculus, all this has to be recast in terms of functions. We shall use the symbols ∀ and ∃ as the lambda constants for the functions $o_{\forall^2}$ and $o_{\exists^2_{\geq 1}}$, adapted to serve in structures for the Lambda calculus. Such functions are of the type $\big(t/(e\backslash t)\big)/(e\backslash t)$, since they are functions from characteristic functions for sets, which have type $e\backslash t$, into characteristic functions for sets of sets, which have type $t/(e\backslash t)$. Letting o be the lambda constant for functions of this type, we state the syntactico-semantic versions of the constituency formation rule DP and its corresponding Lambek typed grammar rule.

$$\frac{\text{Dt} \mapsto o \qquad \text{N}_c \mapsto b}{\text{DP} \mapsto ob}\,\text{DP} \qquad\qquad \frac{\big(t/(e\backslash t)\big)/(e\backslash t) \mapsto o \qquad e\backslash t \mapsto b}{t/(e\backslash t) \mapsto ob}\,\backslash\text{E}$$

We first apply the constituency formation rules with their semantic pairs to sentence (28.1), letting b denote the characteristic function for the set of boys and s the characteristic function for the set of sleepers.

$$\cfrac{\cfrac{\overset{\textit{each}}{\text{Dt} \mapsto \forall} \qquad \overset{\textit{boy}}{\text{N}_c \mapsto b}}{\text{DP} \mapsto \forall b} \qquad \overset{\textit{sleeps}}{\text{VP} \mapsto s}}{\text{S} \mapsto \forall bs}$$

To analyze the sentences in (28) using Lambek typed grammar, we must assign a type to common nouns. Since they denote subsets of a structure's universe, they must have either the type $e\backslash t$ or t/e. For the time being, we shall assign them the former type. As readers are asked to show in the exercises, neither of these choices is empirically correct. We shall show how this empirical inadequacy can be addressed in section 3.5.

$$\cfrac{\cfrac{\overset{\textit{each}}{(t/(e\backslash t))/(e\backslash t) \mapsto \forall} \qquad \overset{\textit{boy}}{e\backslash t \mapsto b}}{t/(e\backslash t) \mapsto \forall b} \qquad \overset{\textit{sleeps}}{e\backslash t \mapsto s}}{t \mapsto \forall bs}$$

We close this section by bringing to readers' attention a contrast between the constituency grammar and the Lambek typed grammar set out here. Recall that in a Lambek typed grammar, the Lambek types are the syntactic categories of a language's (grammatical) expressions. An expression's Lambek type determines the kind of lambda term to be assigned to it, which, in turn, determines the kind of semantic value it has in a structure. As we noted in chapter 10, section 1, the syntactic categories of constituency grammars are silent about the kind of semantic value a grammatical expression might have. This shortcoming was partially addressed in chapter 10, section 3. There we enriched the syntactic categories of constituency grammars to include complement lists, which themselves determined the kind of semantic value to be assigned. The syntactic category of determiner, as introduced in this chapter, is a simple syntactic category, not having any complement list. As a consequence, nothing about a determiner's syntactic category requires that it be assigned functions of the type $(t/(e\backslash t))/(e\backslash t)$.

Exercises: Simple clauses with quantified noun phrases

1. Recast the constituency trees in section 3.3 of chapter 10 as derivations.
2. Find evidence to show that common nouns cannot have either the type $e\backslash t$ or the type t/e.

3.2 Adjectives Again

We saw in section 2.2 that there are various subcategories of attributive adjectives, the main categories being cardinal, predicative, and thematic. In general, little, if any, attention has been given to how thematic adjectives might be treated semantically. Most attention has been devoted to cardinal adjectives and to predicative adjectives. Since we shall discuss cardinal adjectives when we revisit quantified noun phrases (section 3.5), we shall discuss only predicative adjectives here.

Predicative adjectives do not form a uniform semantic class; rather, they comprise three principal classes, two of which restrict the denotations of the nouns they modify and one of which excludes the denotations of the nouns they modify. Predicative adjectives which, when occurring attributively, can be paraphrased by a pair of coordinated restrictive relative clauses are called *intersective* (predicative) adjectives. Color adjectives furnish ready examples.

(32.1) A pink elephant is in the cage.
(32.2) Something which is pink and which is an elephant is in the cage.

Another criterion for such adjectives is that they give rise to judgments of entailment of the sort shown below. The first sentence is judged to entail the second and the third.

(33.0) This is a pink elephant.
(33.1) This is pink.
(33.2) This is an elephant.

The second kind of predicative adjective does not admit the kind of paraphrase illustrated in (32): the sentence in (34.2) is not a paraphrase of the one in (34.1).

(34.1) A small elephant is in the cage.
(34.2) Something which is small and which is an elephant is in the cage.

However, such adjectives, called *subsective* adjectives, are judged to have entailments which contrast with those for intersective adjectives. In particular, though the sentence in (35.0) is judged to entail the sentence in (35.2), it is not judged to entail the one in (35.1).

(35.0) This is a small elephant.

(35.1) This is small.

(35.2) This is an elephant.

In general, what is judged to be a small elephant is need not be judged as small.

Finally, we come to what one might call *exclusive* adjectives. Like subsective adjectives, and unlike intersective adjectives, the noun phrases in which they occur are judged not to be paraphrased properly by a noun phrase with a pair of coordinated restrictive relative clauses, one for the adjective and one for the noun.

(36.1) A plastic flower is in the vase.

(36.2) Something which is plastic and which is a flower is in the vase.

The sentence in (36.2) is not judged to be a correct paraphrase of the one in (36.1). These adjectives are judged to have entailments which contrast both with intersective and with subsective adjectives. In particular, such adjectives give rise to noun phrases whose denotations are disjoint from the denotations of the nouns they modify. For example, the sentence in (37.0) is judged to entail the sentence in (37.1) and is judged to entail the falsity of the sentence in (37.2).

(37.0) This is a plastic flower.

(37.1) This is plastic.

(37.2) This is a flower.

In a constituency grammar, predicative adjectives are assigned the same category regardless of whether they are used predicatively, that is, as complements to copular verbs, or attributely, that is, as modifiers of common nouns.

The constituency rule NP3 in chapter 3, restated first below, forms a noun phrase from a determiner, an adjective phrase, and a common noun. We shall form the same constituent, now called a determiner phrase, using the constituency rule DP and another constituency rule N3, given second.

NP3 $\quad$ Dt AP $N_c \rightarrow$ NP
N3 $\quad$ AP $N_c \rightarrow N_c$

Using the derivational format, we can easily see that the constituents formed by NP3 are also formed by a combination of N3 and DP.

$$\frac{\text{Dt} \qquad \text{AP} \qquad \text{N}_\text{c}}{\text{NP}}\ \text{NP3} \qquad\qquad \frac{\text{Dt} \qquad \dfrac{\text{AP} \qquad \text{N}_\text{c}}{\text{N}_\text{c}}\ \text{N3}}{\text{DP}}\ \text{DP}$$

The question we wish to address is: what value is to be assigned to intersective (predicative) adjectives? If one is used predicatively, the obvious value to assign to it is the set of things of which it is true. If one is used attributively, the value restricts the denotation of the common noun it modifies. It does so by intersecting the value of the adjective with the value, or denotation, of the common noun it modifies.

In light of the fact that we are using lambda terms to express the semantic value of constituents, we must have a lambda term which expresses this kind of restriction. The constant term we adopt is $\cap_{e\backslash t}$. We now explain what it is intended to denote. Recall that $\cap$ is a set theoretic operation which, for each pair of sets, yields their intersection. Now consider some fixed set A. We can define a function which assigns to each set its intersection with A. Let f_A be the function which assigns the set $A \cap X$ to the set X: in other words, $f_A(X) = A \cap X$. $\cap_{e\backslash t}$ is the lambda constant which denotes the function which assigns to the characteristic function of X the characteristic function of $X \cap A$.

We use the lambda constant $\cap_{e\backslash t}$ to state the syntactico-semantic version of the constituency rule N3.

$$\frac{\text{AP} \mapsto a \qquad \text{N}_\text{c} \mapsto b}{\text{N}_\text{c} \mapsto \cap_{e\backslash t}ab}\ \text{N3}$$

Let us now turn to the Lambek typed grammar. We stated above that the value of a predicative adjective used predicatively is the set of things of which it is true. This means that a predicative adjective, used predicatively, has the type $e\backslash t$. However, an adjective used attributively must be assigned the type $(e\backslash t)/(e\backslash t)$, since it modifies a common noun, which has the type $e\backslash t$ to yield an expression of the same type. This, in turn, means that the type of the lambda term assigned to a predicative adjective used predicatively and the type of the same predicative adjective used attributively must be different; so they are assigned different values. In particular, if an intersective adjective, used predicatively, is assigned the lambda term a, which is of type $e\backslash t$, then used attributively it must be assigned $\cap_{e\backslash t}a$, which is of type $(e\backslash t)/(e\backslash t)/(e\backslash t)$.

The rule in the Lambek typed grammar corresponding to the one in the constituency grammar is therefore this.

$$\frac{(e\backslash t)/(e\backslash t) \mapsto \cap_{e\backslash t}a \qquad e\backslash t \mapsto b}{e\backslash t \mapsto \cap_{e\backslash t}ab}$$

3.3 Prepositional Phrases

In chapter 10, we saw that a prepositional phrase may occur as a complement to a verb.

(38.1) Dan is on the bus.
(38.2) Dan relies on Beverly.

But prepositional phrases may also occur as modifiers, modifying either a common noun or a verb, as illustrated by the second two sentences below.

(39.1) A man is in Calgary.
(39.2) A man in Calgary sleeps.
(39.3) A man sleeps in Calgary.

The constituency rules used to treat prepositional phrases which are modifiers are the rules VP4 and NP4 (Chapter 10, section 3.1). We shall adopt the former rule as well as N4, a revision of NP4, similar to the revision of NP3 as N3 in the previous section.

VP4 VP PP $\rightarrow$ VP
NP4 Dt N_c PP $\rightarrow$ NP
N4 N_c PP $\rightarrow$ N_c

Again, we use the derivational format to show that the constituents formed by NP4 are also formed by a combination of N4 and DP.

$$\frac{\text{Dt} \quad N_c \quad \text{PP}}{\text{NP}}\ \text{NP4} \qquad\qquad \frac{\text{Dt} \quad \dfrac{N_c \quad \text{PP}}{N_c}\ \text{N4}}{\text{DP}}\ \text{DP}$$

As readers can easily check, these constituency rules can be used to obtain syntactic derivations of the sentences in (39) as well as to show the structural ambiguity of the sentence in (40.0).

(40.0) A book on the table near the lamp
(40.1) A [NP [N_c [N_c book [PP on the table]] [PP near the lamp]]]
(40.2) A [NP [N_c book [PP on the [NP [N_c table [PP near the lamp]]]]]]

We now turn to the question of what lambda terms to assign to the various constituents as found in the rules above. Recall from chapter 10 (section 3.3) that a preposition denotes a binary relation, the identity relation when it occurs in the complement of a non-copular verb (section 3.3.3), as in (38.2), and a non-identity relation when it occurs in the complement of the copular verb *to be* (section 3.3.2), as in (38.1) and (39.1). When a prepositional phrase occurs as a complement to a copular verb, it is assigned the set of members of the domain which bear the binary relation of the preposition to some or other member of the denotation of the noun phrase serving as a complement to its preposition. Thus, the lamba term to be assigned to a prepositional phrase is of type $e\backslash t$. It follows, then, that the term to be assigned to the preposition is of type $(e\backslash t)/e$. For example, if l is the lambda term denoting the characteristic function for the relation *in* and c is the lambda term for *Calgary*, then lc, the characteristic function for the set of things in Calgary, is the lambda term both for *in Calgary* and for *is in Calgary*.

As we just saw, prepositional phrases may modify common nouns. The customary view is that, when they do, their values restrict the value of the common nouns they modify in the same way the values of predicative (intersective) adjectives do. Using the lambda constant $\cap_{e\backslash t}$, introduced earlier, we obtain the following syntactico-semantic version of N4.

$$\frac{\mathrm{N_c} \mapsto a \qquad \mathrm{PP} \mapsto b}{\mathrm{N_c} \mapsto \cap_{e\backslash t} ba}\ \mathrm{N4}$$

Assuming for the sake of simplicity that the situation with prepositional phrases restrictively modifying verb phrases is essentially the same as for their restrictively modifying common nouns, we turn VP4 into the following syntactico-semantic constituency rule:

$$\frac{\mathrm{VP} \mapsto v \qquad \mathrm{PP} \mapsto m}{\mathrm{VP} \mapsto \cap_{e\backslash t} mv}\ \mathrm{VP4}$$

A Lambek typed grammar assigns the same types to the prepositional phrases serving as complements to copular verbs and their prepositions as the types assigned to the lambda terms in the constituency rules above: namely, the types $e\backslash t$ and $(e\backslash t)/e$ respectively. However, if a prepositional phrase occurs as a modifier, either of a verb phrase or of a common noun, the prepositional phrase must have the type $(e\backslash t)\backslash(e\backslash t)$, since in a Lambek typed grammar verb phrases have type $e\backslash t$ and common nouns do, too. Therefore, the preposition in these modifying prepositional phrases must have the type $((e\backslash t)\backslash(e\backslash t))/e$. The situation here is like the situation with predicative adjectives, except there is one small complication: a predicative adjective is a modifier on its own, and although a prepositional phrase is a modifier on its own, the preposition it contains is not. So, the lambda term to be assigned to, say, the preposition *in*, is $\lambda x . \cap_{e\backslash t} (lx)$.

$$\dfrac{\begin{array}{c} \textit{man} \\ e\backslash t \mapsto m \end{array} \qquad \dfrac{\dfrac{\begin{array}{cc} \textit{in} & \textit{Calgary} \\ ((e\backslash t)\backslash(e\backslash t))/e \mapsto \lambda x . \cap_{e\backslash t} (lx) & e \mapsto c \end{array}}{(e\backslash t)\backslash(e\backslash t) \mapsto (\lambda x . \cap_{e\backslash t} (lx))c}}{(e\backslash t)\backslash(e\backslash t) \mapsto \cap_{e\backslash t}(lc)}\ \text{Beta conversion}}{e\backslash t \mapsto \cap_{e\backslash t}(lc)m}$$

Exercises: Prepositional phrases

1. Show that the noun phrase in (40.0) has more than one derivation in the Lambek typed grammar. Assume that *the* has the type $e/(e\backslash t)$. Omit lambda terms from the derivation, as no lambda term for *the* has been given.

2. Provide a constituency grammar derivation for the sentences in (39.2) and (39.3). Are the lambda terms in the last line of each derivation the same? If they are not the same, do you think that they are nonetheless equivalent?

3. Provide a Lambek typed grammar derivation for the sentences in (39.2) and (39.3). Are the lambda terms in the last line of each derivation in Lambek typed grammar the same as those in the last line of the derivations in the constituency grammar?

3.4 Restrictive Relative Clauses

We shall investigate the syntax and semantics of relative clauses. As we remarked in section 3.4.3 of chapter 3, typically a relative clause begins with either a relative pronoun or a prepositional phrase that has a relative pronoun as an immediate constituent. Moreover, the initial relative pronoun or prepositional phrase corresponds to a noun phrase that could serve either as the subject or as the complement of the verb or to a prepositional phrase that could serve either as a complement to, or a modifier of, the verb. We indicate this correspondence in the sentences that follow.

(41.1) A man [RC [DP who] __ bought a yacht] was found dead in the marina.
(41.2) A guest [RC [PP to whom] Don gave the key __] is in the lobby.
(41.3) The woman [RC [DP whose dog] Alice fed __] is waiting for Colleen.
(41.4) The country [RC [PP in which] the president declared martial law __] is suffering from food shortages.

This observation that a relative clause is a clause with a missing element suggests, as noted by Willard Quine (1960, sec. 22 and 23), that a restrictive relative clause corresponds to a formula of CQL which has one free variable in it.

Not all relative clauses have relative pronouns. Some begin with the word *that* instead of starting with a relative pronoun or a phrase one of whose immediate constituents is a relative pronoun.

(42.1) A man [RC that __ bought a yacht] was found dead in the marina.
(42.2) A guest [RC that Don gave the key to __] is in the lobby.
(42.3) The country [RC that the president declared martial law in __] is suffering from food shortages.

Others have no special word to signal the beginning of the clause.

(43.1) A guest [RC Don gave the key to __] is in the lobby.
(43.2) The country [RC the president declared martial law in __] is suffering from food shortages.

Finally, the verb of the relative clause need not be finite, it may be infinitival.

(44) A book [RC for Don to give __ to Carol] is on the table.

Relative clauses may be either appositive or restrictive. These two relative clauses are distinguished in written English by the use of commas: an appositive relative clause is put between commas, as in (45.1), a restrictive relative clause is not, as in (45.2). This convention of punctuation reflects the fact that, when a relative clause is used appositively, the clause is uttered with a special intonation in which the voice drops. This intonation is not used when the relative clause is used restrictively.

(45.0) Each book [RC which Beverly bought __] has a red dust jacket.
(45.1) Each book, which Beverly bought, has a red dust jacket.
(45.2) Each book which Beverly bought has a red dust jacket.

A sentence with a relative clause, such as the one in (45.0), has different truth conditions. Consider the following circumstances. There are five books that are being talked about. Beverly had bought precisely three of them. The three that Beverly bought have red dust jackets; the other two, which she did not buy, do not. The sentences in (45) may be true or false. It is true that each book Beverly bought has a red dust jacket, but it is false that she bought each book. On the restrictive use of the relative clause, it *restricts* the denotation of *book* to the three Beverly bought and the sentence says of those three that they have red dust jackets. On the appositive use of the relative clause, rather than restricting the denotation of *book,* the sentence says that each of the five books has a red dust jacket and that Beverly had bought all five.

Let us now consider restrictive relative finite clauses with relative pronouns. Here are three examples.

(46.1) a dog which __ slept
(46.2) a city which Beverly likes __
(46.3) a toy which Alice gave __ to Bill.

We begin with the example in (46.1). In light of the type assignments made earlier to the indefinite article (*a*) to common nouns, such as *dog,* and the intransitive verb, *slept,* the relative pronoun, *which,* must be assigned the type, $\big((e\backslash t)\backslash(e\backslash t)\big)/(e\backslash t)$. Since the denotation of *dog which slept* is the set of things that are dogs and which slept, the value assigned to *which* is the function whose term in the Lambda calculus is $\cap_{e\backslash t}$, which denotes the function corresponding to set intersection and which we have now encountered twice in connection with modification.

$$\dfrac{\overset{\textit{dog}}{e\backslash t \mapsto d} \qquad \dfrac{\overset{\textit{which}}{\big((e\backslash t)\backslash(e\backslash t)\big)/(e\backslash t) \mapsto \cap_{e\backslash t}} \qquad \overset{\textit{slept}}{e\backslash t \mapsto s}}{(e\backslash t)\backslash(e\backslash t) \mapsto \cap_{e\backslash t} s}}{t/e\backslash t \mapsto \cap_{e\backslash t} sd}$$

We turn to the example in (46.2). Under the type assignments made to its various words, there is no type that can be assigned to the entire expression. One possibility is to assign *likes,* not the type $(e\backslash t)/e$, but the mathematically equivalent type $e\backslash(e\backslash t)$.

$$\dfrac{\overset{\textit{city}}{e\backslash t \mapsto c} \qquad \dfrac{\overset{\textit{which}}{\big((e\backslash t)\backslash(e\backslash t)\big)/(e\backslash t) \mapsto \cap_{e\backslash t}} \qquad \dfrac{\overset{\textit{Beverly}}{e \mapsto b} \qquad \overset{\textit{likes}}{e\backslash(e\backslash t) \mapsto l}}{e\backslash t \mapsto bl}}{(e\backslash t)\backslash(e\backslash t) \mapsto \cap_{e\backslash t}(lb)}}{e\backslash t \mapsto \cap_{e\backslash t}(lb)c}$$

Though the type assignments determine Lambda terms whose interpretation guarantees that the expression denotes (the characteristic function for) the set of things that are cities and which Beverly likes, it does so at the expense of assigning *likes* in (46.2) the type $e\backslash(e\backslash t)$, while *likes* in the sentence *Beverly likes Calgary* is assigned the type $(e\backslash t)/e$. Because of the different type assignments, it is possible for sentences like the following to be jointly satisfiable,

(47.1) a city which Beverly likes is Calgary.
(47.2) Beverly does not like Calgary.

for *like* can be assigned one relation in the first sentence and another in the second.

Fortunately, there is an alternative. It is possible to assign *likes* the usual type assigned to transitive verbs, namely, $(e\backslash t)/e$. To do so, though, we must avail ourselves of one of the rules of which we have not availed ourselves so far, the rule of / Introduction.

$$\dfrac{\overset{\textit{city}}{e\backslash t \mapsto c} \qquad \dfrac{\overset{\textit{which}}{\big((e\backslash t)\backslash(e\backslash t)\big)/(e\backslash t) \mapsto \cap_{e\backslash t}} \qquad \dfrac{\dfrac{\overset{\textit{Beverly}}{e \mapsto b} \qquad \dfrac{\overset{\textit{likes}}{(e\backslash t)/e \mapsto l} \qquad [e \mapsto x]}{e\backslash t \mapsto lx}}{t \mapsto lxb}}{e\backslash t \mapsto \lambda x.lxb}}{(e\backslash t)\backslash(e\backslash t) \mapsto \cap_{e\backslash t}(\lambda x.lxb)}}{t/e \mapsto \cap_{e\backslash t}(\lambda x.lxb)c}$$

However, a problem remains. Moreover, the types we have do not permit us to handle relative clauses where the relative pronoun gap is not at the edge of the clause, as for example in (46.3).

There are a number of ways to address this problem. We turn to one due to Michael Moortgat (1988, 1996). He introduces a new connective to the expanded Lambek calculus, together with the following introduction rule.

$\uparrow$	Introduction
	$\dfrac{\dfrac{\begin{matrix}\vdots & [x \mapsto v] & \vdots \\ \vdots & \vdots & \vdots\end{matrix}}{y \mapsto f}}{y \uparrow x \mapsto \lambda v.f}$ v fresh

The semantic value associated with expressions of the type $x \uparrow y$ is $\mathrm{Fnc}(D_y, D_x)$. In other words, $D_{x\uparrow y} = D_x^{D_y}$, which is the same as $D_{x/y}$ and $D_{y\backslash x}$. The relative pronouns *which, who,* and *whom* are assigned the type $\big((t/e)\backslash(t/e)\big)/(t\uparrow e)$. Using this new type assignment, one arrives at the following derivation for the example in (46.1).

$$\dfrac{\overset{\textit{dog}}{e\backslash t \mapsto d} \qquad \dfrac{\overset{\textit{which}}{\big((e\backslash t)\backslash(e\backslash t)\big)/(t\uparrow e) \mapsto \cap_{e\backslash t}} \qquad \dfrac{\dfrac{[e \mapsto x] \qquad \overset{\textit{slept}}{e\backslash t \mapsto s}}{t \mapsto sx}}{t \uparrow e \mapsto \lambda x.sx}}{(e\backslash t)\backslash(e\backslash t) \mapsto \cap_{e\backslash t}(\lambda x.sx)}}{e\backslash t \mapsto \cap_{e\backslash t}(\lambda x.sx)d}$$

We note that eta conversion permits the last Lambda term to be reduced to $\cap_{e\backslash t} sd$.[9] Readers are encouraged to carry out the derivations for the other two sentences in (46).

We noted in chapter 3, section 3.4.3, that relative clauses are just one of a number of patterns exhibiting discontiguity. We alluded to a number of syntactic approaches to discontiguity and sketched how it can be handled by a constituency grammar supplemented with transformational rules. A relative clause, such as the one in (47.1), repeated in (48.0), is analyzed as having a deep structure, shown in (48.1) and a surface structure, shown in

9. Though this might look like a case of beta conversion, it is not. Look carefully at the types of x and d.

(48.2), the latter arising from the former by a transformation rule that moves, so to speak, the noun phrase containing the relative pronoun *which* from its object position to a position at the beginning of the clause containing it.

(48.0) A city which Beverly likes __ is Calgary.

(48.1) A city [S Beverly [VP likes [DP which]]] is Calgary.

(48.2) A city [RC [DP,i which] [S Beverly [VP likes [DP,i t]]]] is Calgary.

To analyze sentence (48.0), we require a constituency formation rule for modification by a restrictive relative clause. To simplify the discussion, we shall take the category of relative clause to be primitive. We adopt the constituency formation rule N5: N_c RC $\rightarrow \mathrm{N}_c$. We now state its syntactico-semantic version, using the familiar Lambda term for intersection.

$$\frac{\mathrm{N}_c \mapsto a \qquad \mathrm{RC} \mapsto b}{\mathrm{N}_c \mapsto \cap_{e\backslash t} ba}\ \mathrm{N5}$$

Next is the derivation for the expression *city which Beverly likes* in sentence (48.0). It illustrates the point made by Quine (1960) that the part of the relative clause that excludes the relative pronoun, here *Beverly likes,* corresponds to an open formula with just one free variable, here the Lambda term lxb, instead of a formula.

$$\frac{\overset{\textit{city}}{\mathrm{N_c} \mapsto c} \qquad \dfrac{\overset{\textit{which}}{\mathrm{DP,i} \mapsto \lambda x} \qquad \dfrac{\overset{\textit{Beverly}}{\mathrm{DP} \mapsto b} \qquad \dfrac{\overset{\textit{likes}}{\mathrm{V}{:}\langle \mathrm{DP}\rangle \mapsto l} \qquad \mathrm{DP,i} \mapsto x}{\mathrm{VP} \mapsto lx}}{\mathrm{S} \mapsto lxb}}{\mathrm{RC} \mapsto \lambda x.lxb}}{\mathrm{N_c} \mapsto \cap_{e\backslash t}(\lambda x.lxb)c}$$

As we observed in section 3.4.3 of chapter 3, some discontiguous constituents are, as it were, local, confined to a clause or a phrase; others are unbounded, the two parts being separated by what seems to be an unbounded number of clauses. It was soon recognized that whether an unbounded dislocation is allowed depends in part on the nature of the constituents intervening between the gap and the dislocated constituent. The first person to investigate this in a systematic fashion was John R. (Haj) Ross (1967). Ross identified constituents that would block, as it were, unbounded dislocations, dubbing them *islands*. Though we shall illustrate some islands with unbounded dislocations involving relative clauses, these islands apply to other forms of discontiguity as well.

In the pair of sentences in (47), the dislocated constituent and the gap are separated by a clause. However, in the first sentence the clause is a complement to a verb, in the second the clause is a clause in apposition to a noun.

(49.1) Carl read a book on a topic [PP on which] Dan said [S that Beverly wrote a paper ___].
(49.2) *Carl read a book on a topic [PP on which] Dan repeated the rumor [S that Beverly wrote a paper ___].

Another contrast depends on whether the gap occurs in an uncoordinated clause or only one of a pair of coordinated clauses.

(50.1) Colleen knows the person [DP whom] Bill greeted ___ .
(50.2) *Colleen knows the person [DP whom] Alice saw Carl and Bill greeted ___ .

Stating constituency formation rules that respect such islands is a central empirical challenge to grammatical theories of English. Indeed, it constitutes an area of research unto itself. Needless to say, we shall not pursue the problem further here.

3.5 Quantified Noun Phrases Again

We now return to the treatment of quantified noun phrases. Earlier we saw how to treat quantified noun phrases that occur in subject position both with an enriched constituency grammar and with a Lambek typed grammar. Though we used a sentence with an intransitive verb to illustrate the analyses, sentences where the verbs are either transitive or ditransitive could have been used as well to illustrate the point, provided that the complements of the verbs are proper nouns. However, should a position other than the subject position contain a quantified noun phrase, a problem arises.

Consider sentence (51), whose direct object is a quantified noun phrase.

(51) Alice greeted each boy.

Whereas a constituency grammar permits a syntactic derivation of the verb phrase, indeed the entire sentence, the semantic rules associated with the constituency formation rules do not assign any value to the verb phrase, as shown here.

$$\cfrac{\begin{array}{c}\textit{greeted}\\ \mathrm{V}{:}\langle \mathrm{DP}\rangle \mapsto g\end{array} \qquad \cfrac{\begin{array}{c}\textit{each}\\ \mathrm{Dt}\mapsto\forall\end{array}\qquad \begin{array}{c}\textit{boy}\\ \mathrm{N}_c\mapsto b\end{array}}{\mathrm{DP}\mapsto\forall b}}{\mathrm{VP}\mapsto\ ?}$$

To see why this is so, recall what the function g is. Let G be the set of ordered pairs formed from members of a structure's universe. Corresponding to this set is a function that assigns to each member of the universe x the set of those things in the universe that G pairs with x. The function denoted by g assigns to each member of the universe x the characteristic function of the set of members of the universe that G pairs with x. Thus, the domain of g is a structure's universe. However, $\forall b$ is not a subset of a structure's universe, or more accurately, a characteristic function for a subset of a structure's universe, rather it is a family of its subsets, or more accurately, a characteristic function for a set of characteristic functions for its subsets. Thus, the function denoted by g is undefined for the value assigned to the quantified noun phrase *each boy*.

A Lambek typed grammar also does not permit a syntactic derivation of the verb phrase, let alone the clause containing the verb phrase. If there is no syntactic derivation, there can be no assignment of values either.

$$\dfrac{\overset{\textit{greeted}}{(e\backslash t)/e \mapsto g} \qquad \dfrac{\overset{\textit{each}}{\big(t/(e\backslash t)\big)/(e\backslash t) \mapsto \forall} \qquad \overset{\textit{boy}}{e\backslash t \mapsto b}}{t/(e\backslash t) \mapsto \forall b}}{e\backslash t \mapsto ?}$$

The problem of quantified noun phrases in nonsubject position can be handled both in Lambek typed grammar and in transformational grammar. We shall present one solution for each. We start with Lambek typed grammar and show how Michael Moortgat (1990) proposed a variation of his idea of how to handle restrictive relative clauses to handle the problem posed by quantified noun phrases in nonsubject position. He introduces still another connective to the expanded Lambek calculus, whose introduction rule is this:

$\Uparrow$	Introduction
	$\begin{array}{c} \vdots \quad\quad \vdots \quad\quad \vdots \\ \vdots \quad \dfrac{y \Uparrow x \mapsto f}{} \quad \vdots \\ \vdots \quad \dfrac{y \mapsto v}{} \quad \vdots \\ \vdots \quad\quad \vdots \quad\quad \vdots \\ \hline x \mapsto h \\ \hline x \mapsto f(\lambda v.h) \\ (v \text{ fresh}) \end{array}$

$D_{x\Uparrow y} = D_y^{\left(D_y^{D_x}\right)}$, that is, Fnc(Fnc($D_x$, D_y), D_y), where the determiners of quantified noun phrases are assigned values from $D_{e\Uparrow t}$, precisely the type that corresponds to the quantifiers of the second presentation of MQL^2.

$$\dfrac{\dfrac{\overset{\textit{Alice}}{e\mapsto a}\qquad \dfrac{\overset{\textit{greeted}}{(e\backslash t)/e\mapsto g}\qquad \dfrac{\dfrac{\overset{\textit{each}}{(e\Uparrow t)/(e\backslash t)\mapsto\forall}\qquad\overset{\textit{boy}}{e\backslash t\mapsto b}}{(e\Uparrow t)\mapsto\forall b}}{e\mapsto x}}{e\backslash t\mapsto gx}}{t\mapsto gxa}}{t\mapsto \forall b(\lambda x.gxa)}$$

Treatment here can be applied to single clauses with more than one quantified noun phrase, as readers will see.

One way to handle the problem posed by clauses with quantified noun phrases in non-subject positions in a transformational grammar, as observed and developed by Robert May (1977), is to suppose that, in addition to deep structure and surface structure, there is what he called *logical form*. Moreover, just as a transformational rule of wh-movement moves, as it were, a constituent containing a wh word to a clause initial position, so a rule of quantifier raising, or QR, moves a quantified noun phrase to an initial position in its clause. For example, sentence (51), repeated as (52.0), has, on this account, a deep structure and a surface structure corresponding to the analysis in (52.1) and a logical form corresponding to the analysis in (52.2).

(52.0) Alice greeted each boy.

(52.1) [S [DP Alice] [VP [V:⟨DP⟩ greeted] [DP each boy]]].

(52.2) [DP,i each boy] [S Alice greeted [DP,i t]].

The assignment of values is done with respect to the sentence's logical form.

$$\dfrac{\dfrac{\overset{\textit{each}}{\text{Dt}\mapsto\forall}\qquad\overset{\textit{boy}}{\text{N}_{\text{c}}\mapsto b}}{\text{DP,i}\mapsto\forall b}\qquad\dfrac{\overset{\textit{Alice}}{\text{DP}\mapsto a}\qquad\dfrac{\overset{\textit{greeted}}{\text{V:}\langle\text{DP}\rangle\mapsto g}\qquad\text{DP,i}\mapsto x}{\text{VP}\mapsto gx}}{\text{S}\mapsto gxa}}{\text{S}\mapsto\forall b(\lambda x.gxa)}$$

These two ways to treat the syntax and semantics of English quantified noun phrases raise two questions: first, which words are to be treated as quantificational determiners? and second, how well do these treatments accord with how speakers judge such sentences? We shall begin with the second question. To avoid distracting complexities, we shall confine the words to be regarded as quantificational determiners to a proper subset of those discussed earlier, namely, those which have a use with singular count nouns, namely, *each* and *every*, assigning them the lambda term ∀, whose value is $o_{\forall 2}$, but adapted to the Lambda calculus, the indefinite article (*a*) and *some*, assigning them the lambda term

$\exists$, whose value is $o_{\exists^2_{\geq 1}}$, again adapted to the Lambda calculus, and *no*, assigning it the lambda term N, whose value o_{N^2} is adapted to the Lambda calculus.

We now turn to four open problems pertaining to the syntax and semantics of quantified noun phrases. The first two pertain to sentences in which more than one quantified noun phrase occurs, the third pertains to sentences in which occur not only a quantified noun phrase but also the adverb *not* and the fourth pertains to what value is to be assigned to cardinal and quasi-cardinal adjectives. However, before turning to these problems, we say something about the sort of evidence used to assess the empirical adequacy of the semantics of quantified noun phrases.

3.5.1 Scope judgments

The principal kind of judgment used to investigate the semantics of quantified noun phrases are what are often called *scope judgments*. Before explaining what such judgments are, let us be clear about what the term *scope* means. The point that we are about to make, though subtle, is important.

In earlier chapters, we were introduced to the notion of the scope of a logical constant. This notion is a technical one, defined for a formal notation. In logic, the scope of an occurrence of a logical constant is the smallest subformula containing the occurrence of the logical constant. Quantifiers and the negation symbol of CQL are logical constants and therefore their occurrences in a formula have scope. In the Lambda calculus, the scope of an occurrence of a constant term is the smallest subterm containing the constant term's occurrence. Scope, then, is a purely syntactic notion. It has semantic consequences. The values assigned to two formulae that are alike except that the relative scopes of two logical constants may well be different. Thus, for example, we know that in CQL the following pair of formulae may very well have different values assigned to them in the very same structure: $\forall x \exists y Rxy$ and $\exists y \forall x Rxy$. This difference arises from the difference in the order, and hence scope, of the quantifier prefixes. To determine the truth of the formula $\forall x \exists y Rxy$ in a structure, one first chooses a value for x and then hunts for a suitable value for y so that Rxy is true with respect to those choices and one proceeds in that way for each possible assignment of a value to x. It might turn out that, for different choices of values for x, one must choose different values for y so that Rxy is true for each choice of a value for x. In this way, it is said that the choice of value for y might depend on the choice of value for x. But in the case of the formula $\exists y \forall x Rxy$, the choice of a value for y does not depend on choice of any value for x. It should be noted that not every transposition of quantifier prefixes in a formula results in inequivalent formulae: $\forall x \forall y Rxy$ is equivalent to $\forall y \forall x Rxy$, just as $\exists x \exists y Rxy$ is equivalent to $\exists y \exists x Rxy$.

By analogy with formal notation, scope can be defined for expressions of a natural language, once the expressions are given a syntactic analysis. There is no universally accepted definition of scope for constituency grammars and their enrichments, though the various definitions used bear a close resemblance to the definition scope for formal notation. For constituency grammar and its transformational enrichment set out here, we adopt the following definition: the scope of an occurrence of a quantified noun phrase is the constituent of which the quantified noun phrase is an immediate constituent. We then say that an occurrence of constituent A falls within the scope of an occurrence of constituent B just in case the latter occurrence is a constituent of the scope of the former occurrence. For example, in sentence (53.1), the quantified noun phrase *some guest* falls within the scope of the quantified noun phrase *each host,* since the scope of the latter is the entire sentence and the former constituent is an immediate constituent of the entire sentence, whereas in sentence (53.2), the quantified noun phrase *each host* falls within the scope of the quantified noun phrase *some guest*.

(53.1) Each host thinks some guest is tired.
[S [NP Each host] thinks [S [NP some guest] is tired]].

(53.2) Some guest greeted each host.
[NP Some guest] [VP greeted [NP each host]].

The converse holds for the quantified noun phrases in the second sentence.

We observe that, just as the transposition of quantifier prefixes in a formula of CQL may result in inequivalent formulae, so the transposition of quantified noun phrases in a natural language sentence may result in sentences judged to be inequivalent, as are the sentences in (53).

Besides its use as a technical term for syntax, the word *scope* is also used to describe speaker judgments regarding how sentences with more than one quantified noun phrase are construed. Consider the English sentence in (54).

(54) Each investigator believes some tourist is a spy.

CONSTRUAL 1
Each investigator believes some tourist is a spy, where different investigators may have different tourists in mind.

CONSTRUAL 2
There is a tourist that each investigator believes to be a spy.

Contemporary scholars, linguists, and philosophers alike, say that the sentence has two construals, one where the quantified noun phrase *each investigator* has scope of the quantified noun phrase *a tourist,* which happens to correspond to the scope relation as defined with respect to the constituency of the sentence, and one in which the quantified noun phrase *a tourist* has scope of the quantified noun phrase *each investigator,* which does not correspond to the constituency of the sentence. The idea that is the basis for this descriptive usage is that, should we symbolize sentence (54) in some notation of logic, the quantifier prefix corresponding to *each investigator* would have scope over the quantifier prefix corresponding to *some tourist,* on the first construal, whereas the converse relation describes the second construal. This description then reflects the fact that, on the first construal, the choice of tourist might depend on the choice of investigator, whereas on the second construal, there is no such dependence.

Such judgments of choice dependence, described in terms of which quantified noun phrase falls within the scope of which quantified noun phrase, regardless of the constituency of an expression's surface structure, is the principal source of data for the assessment of the syntax and semantics of quantified noun phrases.

3.5.2 The scope of quantified noun phrases

What, then, are the facts pertaining to sentences with more than one occurrence of quantified noun phrases? We shall confine our discussion to sentences comprising a single clause with more than one quantified noun phrase. We shall first consider cases where no quantified noun phrase is a constituent of any other quantified noun phrase and then cases where one quantified noun phrase is a constituent of another.

QUANTIFIED NOUN PHRASES: NO ONE A CONSTITUENT OF THE OTHERS

We begin by considering sentence (55). Even though it comprises a single clause, like the biclausal sentence in (54), it is liable to two construals.

(55) Each pilot inspected some airplane.

CONSTRUAL 1: $\forall\ \exists$
For each pilot, there is an airplane that he or she inspected.

CONSTRUAL 2: $\exists\ \forall$
There is an airplane that each pilot inspected.

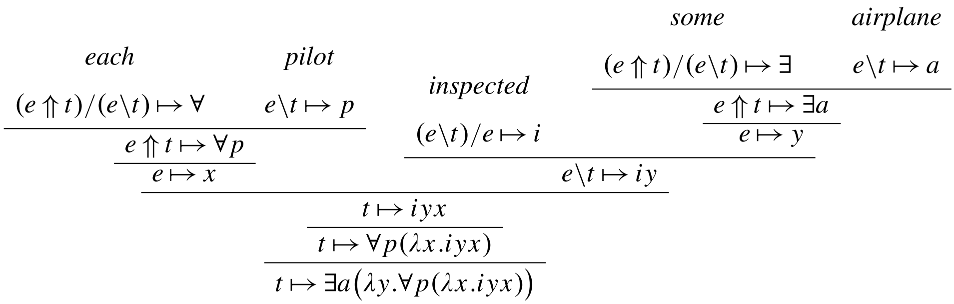
In other words, though syntactically the quantified noun phrase *some airplane* falls within the scope of the quantified noun phrase *each pilot,* at least in terms of the sentence's surface structure, the sentence is liable to two construals, the first where the former quantified noun phrase is described as falling within the scope of the latter, annotated with $\forall\ \exists$, and the second where the latter is described as falling within the scope of the former, annotated with $\exists\ \forall$.

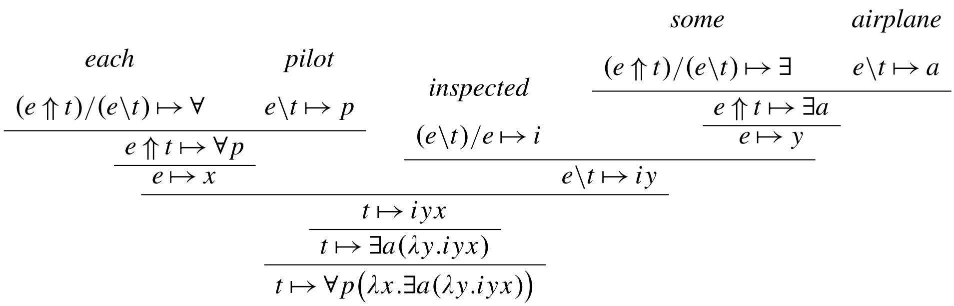
In a transformational grammar with the rule of QR, the existence of these two construals is treated as a matter of amphiboly, where the very same string of sounds accommodates two constituent structures, not with respect to the so-called surface structure, but with respect to its logical form. In other words, associated with sentence (55) are two triples of constituent structure, which are the same with respect to deep structure and surface structure but different with respect to logical form. The two logical forms for sentence (55) and their corresponding Lambda terms are shown in (56).

(56.1) LOGICAL FORM 1
[S [DP,i some airplane] [S [DP each pilot] inspected [DP,i t]]]
$\exists a\big(\lambda y.\forall p(\lambda x.iyx)\big)$

(56.2) LOGICAL FORM 2
[S [DP,j each pilot] [S [DP,i some airplane] [S [DP,j t] inspected [DP,i t]]]]
$\forall p(\lambda x.\exists a(\lambda y.iyx))$

Lambek typed grammar also furnishes two analyses of sentence (55), whose associated lambda terms are the same.





In case of transformational grammar, these two construals are reflected in the scopal relations of the quantified noun phrases, not in the sentence's surface structure, but in its logical form. In the Lambek typed grammar, the construals are reflected in the order of the discharge of the assumptions introduced by the quantified expressions, which, in turn, is reflected in the accompanying lambda terms by the scope of the subterms corresponding to the natural language quantified expressions.

In a single-clause sentence with two quantified noun phrases, neither of which is a constituent of the other, a consequence of both transformational grammar and the Lambek typed grammar treatments is that each such sentence is liable to two distinct syntactic analyses, which, for a suitable choice of quantifier noun phrases, means that the sentence has two distinguishable construals. In fact, more generally, for n quantified noun phrases in a single-clause sentence no two occurrences of which are such that one is a constituent of the other, the sentence has $n!$, that is, $n \cdot (n-1) \cdot \ldots \cdot 1$, syntactic analyses, and with perhaps as many distinguishable construals. However, this is not always the case. Exceptions may arise from the choice of verb, from the choice of quantificational determiner and from difference in syntactic structure.

We begin with the pair of verbs, *to grow out of* and *to grow into* that express converse relations. We wish to compare the range of construals that minimal sentences having these verbs and the same quantified noun phrases admit. The first sentence in (57) is liable to two construals, the first consistent with common sense beliefs and the second inconsistent. The second sentence is just like the first, except that the quantificational determiners have been transposed. It, however, is liable to only one construal. Moreover, the available construal is not the one that is consistent with common sense beliefs, but rather the one that is not.

(57.1) Each oak tree grew out of some acorn.

CONSTRUAL 1: ∀ ∃
For each oak tree, there is some acorn out of which it grew.

CONSTRUAL 2: ∃ ∀
There is an acorn out of which each oak tree grew.

(57.2) Some oak tree grew out of each acorn.
CONSTRUAL 1: ∀ ∃ (unavailable)
For each oak tree, there is some acorn out of which it grew.

CONSTRUAL 2: ∃ ∀
There is an oak tree which grew out of each acorn.

The same disparity obtains when the verb *to grow out of* is replaced by its converse *to grow into*.

(58.1) Each acorn grew into some oak tree.

CONSTRUAL 1: ∀ ∃
For each acorn, there is some oak tree into which it grew.

CONSTRUAL 2: ∃ ∀
There is an oak tree into which each acorn grew.

(58.2) Some acorn grew into each oak tree.

CONSTRUAL 1: ∀ ∃ (unavailable)
For each oak tree, there is some acorn into which it grew.

CONSTRUAL 2: ∃ ∀
There is an oak tree into which each acorn grew.

This important observation is reported by Ray Jackendoff (1983, 207), who ascribes it to Jeffrey Gruber (1965).

Another kind of exception arises from the presence of the quantificational determiner *no*. Quantified noun phrases that have *no* as a determiner often fail to evince both scopal construals.

(59.1) Each girl greeted no boy.

CONSTRUAL 1: ∀ N
For each girl, there is no boy she greeted.

CONSTRUAL 2: N ∀
There is no boy whom each girl greeted.

(59.2) No boy was greeted by each girl.

CONSTRUAL 1: ∀ N (unavailable)
For each girl, there is no boy she greeted.

CONSTRUAL 2: N ∀
There is no boy whom each girl greeted.

Finally, verbs with double complements also do not evince both scope construals.[10]

(60.1) Alice told each lie to a boy.

CONSTRUAL 1: ∀ ∃
For each lie, there is a boy to whom Alice told it.

CONSTRUAL 2: ∃ ∀
There is a boy to whom Alice told each lie.

(60.2) Alice told a boy each lie.

CONSTRUAL 1: ∃ ∀
There is a boy to whom Alice told each lie.

CONSTRUAL 2: ∀ ∃ (unavailable)
For each lie, there is a boy to whom Alice told it.

QUANTIFIED NOUN PHRASES: ONE A CONSTITUENT OF ANOTHER

So far we have been considering monoclausal sentences in which no quantified noun phrase is a constituent of another. Let us now consider monoclausal sentences in which one quantified noun phrase is a constituent of another.

(61) Each pupil in some class slept.

Both Lambek typed grammar and a transformation grammar with quantifier raising give rise to two derivations. Let us examine the Lambek typed derivation first. There are two derivations that are the same up to the point of the formation of the subject noun phrase, as shown here.

10. See Larson (1990, sec. 3.1), where he credits the initial observation to an unpublished manuscript by Patricia Schneider-Zioga and to personal communication from David Lebeaux. For a systematic treatment, see Bruening (2001).

$$\dfrac{\genfrac{}{}{0pt}{}{\textit{each}}{(e\Uparrow t)/(e\backslash t)\mapsto\forall}\quad \dfrac{\genfrac{}{}{0pt}{}{\textit{pupil}}{e\backslash t\mapsto p}\quad \dfrac{\genfrac{}{}{0pt}{}{\textit{in}}{((e\backslash t)\backslash(e\backslash t))/e\mapsto\lambda x.\cap_{e\backslash t}(lx)} \quad \dfrac{\dfrac{\genfrac{}{}{0pt}{}{\textit{some}}{(e\Uparrow t)/(e\backslash t)\mapsto\exists}\quad\genfrac{}{}{0pt}{}{\textit{class}}{e\backslash t\mapsto c}}{e\Uparrow t\mapsto\exists c}}{e\mapsto y}}{(e\backslash t)\backslash(e\backslash t)\mapsto\cap_{e\backslash t}(ly)}}{e\backslash t\mapsto\cap_{e\backslash t}(ly)p}}{\dfrac{e\Uparrow t\mapsto\forall(\cap_{e\backslash t}(ly)p)}{e\mapsto x}}$$

Once the next step is taken, the derivation may proceed in either of two ways, depending on which assumption is discharged first. In the first continuation of the derivation, it is the last assumption introduced, the one that corresponds to the *each pupil,* which is discharged first, whereas in the second continuation, it is the first assumption introduced, the one that corresponds to *some class,* which is discharged first.

$$\genfrac{}{}{0pt}{}{\textit{each pupil in some class}\qquad\qquad \textit{slept}}{\dfrac{\dfrac{\dfrac{e\mapsto x\qquad\qquad e\backslash t\mapsto s}{t\mapsto sx}}{t\mapsto\forall(\cap_{e\backslash t}(ly)p)(\lambda x.sx)}}{t\mapsto\exists c\big(\lambda y.\forall(\cap_{e\backslash t}(ly)p)(\lambda x.sx)\big)}}$$

$$\genfrac{}{}{0pt}{}{\textit{each pupil in some class}\qquad\qquad \textit{slept}}{\dfrac{\dfrac{\dfrac{e\mapsto x\qquad\qquad e\backslash t\mapsto s}{t\mapsto sx}}{t\mapsto\exists c(\lambda y.sx)}}{t\mapsto\forall(\cap_{e\backslash t}(ly)p)\big(\lambda x.\exists c(\lambda y.sx)\big)}}$$

Look carefully at the lambda terms at the end of each derivation. In the first case, there are no occurrences of free variables, and in the second case, the variable *y,* introduced in connection with the quantified noun phrase *some class,* has a free occurrence. The first derivation yields a closed lambda term, which means that any structure for lambda terms assigns a truth value to it, while the second yields an open lambda term, which means that, without a variable assignment, no structure for lambda terms assigns a truth value to it.

A similar result obtains when the sentence is analyzed by a transformational grammar with quantifier raising, at least when the rule is formulated as we have done. The surface structure constituency of sentence (61) is given in (62.1), while the two constituent structures of the logical forms are given in (62.2) and (62.3). The logical form in (62.2) arises from quantifier raising applying first to the subject noun phrase *each pupil in some class*, then to the noun phrase *some class* in its dislocated position. The logical form in (62.3) arises from quantifier raising applying first to the noun phrase *some class* within the noun phrase *each pupil in some class*, still in the subject position, then applying to what remains in the subject noun phrase, [DP each pupil [PP in [DP,i t]]. In the first logical form, the dislocated determiner phrase *some class,* which carries the index i, has within its scope the gap with which it is coindexed; however, it does not in the second logical form.

(62.1) SURFACE STRUCTURE
[S [DP [DP each pupil] [PP in [DP some class]]] slept].

(62.2) LOGICAL FORM 1
[S [DP,i some class] [S [DP,j each pupil in [DP,i t]] [S [DP,j t] [VP slept]]]]
$\exists c\big(\lambda y.\forall(\cap_{e\backslash t}(ly)p)(\lambda x.sx)\big)$

(62.3) LOGICAL FORM 2
[S [DP,j each pupil [PP in [DP,i t]]] [S [DP,i some class] [S [DP,j t] [VP slept]]]]
$\forall(\cap_{e\backslash t}(ly)p)\big(\lambda x.\exists c(\lambda y.sx)\big)$

In other words, the transformational analysis and the Lambek typed analysis arrive at precisely the same results: each assigns only one closed lambda term to sentence (61), which corresponds to the construal where the second quantified noun phrase, which is a proper constituent of the first, is construed as having the first within its scope, that is, the construal to the effect that there is some class in which each pupil slept. Construals such as these are often called the *inverse linked* ones. This is because the left to right order of the quantified noun phrases in the surface structure receives a construal in which the order is, as it were, *inverted*.

In recent work, Robert May and Alan Bale (2006), developing earlier work by Robert May (1977), point out that the pattern pertaining to the possible scope construals of quantified noun phrases within the same clause and none a constituent of the other is similar to the possible scopes construals of quantified noun phrases where one is the constituent of the other.

3.5.3 Quantified noun phrases and *not*

We have followed linguistic custom and extended the use of the word *scope* so as to describe different construals to which sentences containing quantified noun phrases are susceptible. This custom is extended to other words that are the natural language counterparts of other logical constants, for example, the English adverb *not,* which, in the presence of quantified noun phrases, gives rise to different construals. Consider the following minimal pair of monoclausal sentences, both containing the adverb *not* and a quantified noun phrase, the first of which admits only one construal, the second two.

(63.1) Some guest did not sleep.

CONSTRUAL 1: $\exists\ \neg$
There is some guest who did not sleep.

(63.2) Each guest did not sleep.

CONSTRUAL 1: $\forall \neg$
Each guest is such that he or she did not sleep.

CONSTRUAL 2: $\neg \forall$
Not every guest slept.

Such different construals are well established (see Horn 1989, chap. 4.3 and 7.3). Moreover, such different construals arise with quantified noun phrases whose determiner is *no,* as pointed out by Horn with respect to an advertising slogan from the 1960s:

(64) Everybody doesn't like something; but nobody doesn't like Sara Lee.

Further complications arise in cases where the adverb *not* occurs in a clause with two quantified noun phrases. Particularly challenging here is to distinguish just what the various construals are.

(65) Each pilot did not inspect some airplane.

This sentence accommodates six orders for the two quantified noun phrases and the one adverb.

(66.1) CONSTRUAL 1: $\neg \forall \exists$
There is a man who admires no women.

(66.2) CONSTRUAL 2: $\neg \exists \forall$
There is no woman whom each man admires.

(66.3) CONSTRUAL 3: $\forall \neg \exists$
Each man admires no women.

(66.4) CONSTRUAL 4: $\exists \neg \forall$
There is a woman whom some man does not admire.

(66.5) CONSTRUAL 5: $\forall \exists \neg$
Each man is such that there is a woman whom he does not admire.

(66.6) CONSTRUAL 6: $\exists \forall \neg$
There is a woman whom no man admires.

They, in turn, give rise to four logically distinct construals.

Another complication, as noted in chapter 8 (section 7.2), is that the adverb *not* may occur at the beginning of a finite clause, provided it is followed by a noun phrase whose determiner is a universal one.

(67.1) Not every bird flies.
(67.2) *Not some bird flies.

Moreover, when the adverb *not* does occur initially, rather than in its usual position of being to the immediate right of an auxiliary verb, there are fewer construals.

(68.1) Not every bird flies.
CONSTRUAL: $\neg \forall$
It is not the case that every bird flies.

(68.2) Not every man admires some woman.
CONSTRUAL: $\neg \forall \exists$
There is a man who admires no women.

These complications, which have yet to receive a satisfactory treatment, will not be pursued further here.

3.5.4 The quantificational determiners of English

Words of quantity include not only determiners called quantificational but also adjectives, which we previously called *cardinal adjectives* and *quasi-cardinal adjectives*. With the advent of the application of generalized quantifiers to the study of the semantics of natural language, many linguists took to treating these adjectives as denoting generalized quantifiers. One fact about cardinal and quasi-cardinal adjectives is that, with the exception of the cardinal numeral *one,* they must modify plural count nouns.

One important feature of plural noun phrases is that they are often liable to two construals: a collective one and a distributive one. It has been long recognized that, in English, plural noun phrases in subject position give rise to so-called collective and distributive construals. An example of this is found in the sentence given in (69), which is, in fact, true on both a distributive and a collective construal.

(69) Whitehead and Russell wrote a book.

CONSTRUAL 1: collective
Whitehead and Russell wrote a book *together*.

CONSTRUAL 2: distributive
Whitehead and Russell *each* wrote a book.

It is true on the collective construal, since *Principia Mathematica* was written as a collaborative effort of Whitehead and Russell. This construal can be forced by the use of the adverb *together*. The sentence is also true on the distributive construal, since Russell wrote at least one book on his own, for example, *An Inquiry into Meaning and Truth*, and Whitehead also wrote a book on his own, for example, *A Treatise on Universal Algebra*. This construal can be enforced by the use of the adverb *each*.

It is important to stress that collective and distributive construals are not confined to sentences with plural subject noun phrases and verb phrases with verbs denoting actions that can, but need not be, undertaken collaboratively. Sentence (70) has both collective and distributive construals but the verb does not denote an action that can be undertaken collaboratively.

(70) These two suitcases weigh 50 kilograms.

CONSTRUAL 1: collective
These two suitcases weigh 50 kilograms *together*.

CONSTRUAL 2: distributive
These suitcases weigh 50 kilograms *each*.

Though we shall not show it here, a plural noun phrase in any complement position is liable to collective and distributive construals, depending on the choice of word to which the noun phrase is a complement. (See Gillon 1999 for a survey of the data.) Finally, we note that many plural noun phrases are liable to construals intermediate, as it were, between collective and distributive construals. (See Gillon 1987 for discussion.)

The point is that the distributive construal of plural noun phrases exhibits construals reminiscent of those construals described in terms of scope judgments. For example, on the distributive construals of sentence (69), the choice of book depends on the choice of man. This dependence is evinced in the following paraphrases of sentence (69), where the relevant men are Whitehead and Russell.

(71.1) These men wrote a book.
(71.2) These two men wrote a book.
(71.3) Two men wrote a book.

The first sentence is devoid of any quantified noun phrase, yet each of the sentences evinces the same possible dependence of choice of book upon the choice of man.

Finally, recall sentence (55), which has two construals, one on which the subject noun phrase is construed as having scope over the object noun phrase, the other on which the object noun phrase is construed as having scope over the subject noun phrase. In the case of the sentences in (72), there is no construal of the object noun phrase having scope over the subject noun phrase.

(72.1) Two men wrote two books.
(72.2) Two books were written by two men.

In particular, we do not construe the first sentence, for example, as one in which, for each choice of book, there is a choice of two men, distinct pairs of men for each choice of book; whereas, we do construe it in such a way that for each choice of man there is a choice of two books, distinct pairs of books for each choice of man. In other words, *two books* distributes with respect to *two men,* but *two men* does not distribute with respect to *two books*. The opposite holds for the second sentence. The sentence permits the construal that one book has been written by two men and the other has been written by two other men;

however, the sentence does not permit the construal that one man wrote two books and the other man wrote two other books.

These facts suggest that the choice dependence evinced by noun phrases with cardinal and quasi-cardinal adjectives may not arise from these adjectives having the values of generalized quantifiers but may arise instead from the distributivity to which plural noun phrases are liable and that the value of cardinal and quasi-cardinal adjectives may be simply the imposition of a cardinality on the denotation of the noun phrase.

Exercises: The quantificational determiners of English

1. For each of the following sentences, write out the logical forms that QR assigns to it. Provide the derivations that type logical grammar assigns it. Make sure that each is accompanied by a lambda term.

(a) No pilot slept.

(b) Each host greeted some guest.

(c) Each oak tree grew out of some acorn.

(d) Some oak tree grew out of each acorn.

(e) Some host greeted no guest.

(f) No guest was greeted by each host.

(g) Bill carved each figurine from a stick.

(h) Bill carved each stick into some figurine.

(i) Bill carved some figurine from each stick.

(j) Bill carved some stick into each figurine.

2. Briefly describe the circumstances in which the adverb *not* may occur initially in a clause.

3.6 Nonclausal Coordination

In chapter 8, we investigated the coordination of clauses in English in great detail. However, coordination in English is not confined to clauses: almost any pair of constituents of the same category may be coordinated in English. However, as we shall see, it is also possible to coordinate constituents of different categories. Indeed, it is possible to coordinate two expressions one of which is not even a constituent. In this section, we shall review the basic patterns.[11] We shall then consider various ways in which some of the patterns pertaining to coordination have been analyzed, both by constituency grammar and by a Lambek typed grammar.

11. Interested readers should consult the thorough presentation of the patterns found in Quirk et al. (1985, chap. 13), as well as in Huddleston, Payne, and Peterson (2002).

BASIC PATTERNS

The best known pattern is this: except for coordinators themselves and determiners, two constituents of the same category may be coordinated. Moreover, the resulting clause is often well paraphrased by a corresponding pair of coordinated clauses. We shall call this pattern *homogeneous constituent coordination*. Here are a few examples.

(73.1) Carla [VP hit the ball] [CNJ but] [VP did not run to first base].
PARAPHRASE
Carla hit the ball but Carla did not run to first base.

(73.2) Adam [V met] [CNJ and] [V hugged] Beverly.
PARAPHRASE
Adam met Beverly and Adam hugged Beverly.

(73.3) My friend seemed [AP rather tired] [CNJ and] [AP somewhat peevish].
PARAPHRASE
My friend seemed rather tired and my friend seemed somewhat peevish.

(73.4) [NP A man in a jacket a box] [CNJ or] [NP a woman in a dress] left the store.
PARAPHRASE
A man in a jacket left the store or a woman in a dress left the store.

(73.5) [NP [NP Alice's] [CNJ or] [NP Bill's] house] burned down.
PARAPHRASE
Alice's house burned down or Bill's house burned down.

(73.6) Bill remained [PP in the house] [CNJ and] [PP on the telephone]
PARAPHRASE
Bill remained in the house and Bill remained on the telephone.

(73.7) Bill remained [P in] [CNJ or] [P near] the house.
PARAPHRASE
Bill remained in the house or Bill remained near the house.

(73.8) Bill walked [Adv quietly] [CNJ and] [Adv deliberately].
PARAPHRASE
Bill walked quietly and Bill walked deliberately].

However, while being constituents of the same category is close to a sufficient condition for coordination, it is not a necessary one. One pattern involves the coordination of prepositional phrases with adverbial phrases or the coordination of prepositional phrases with temporal noun phrases.

(74.1) The enemy attacked *very quickly* and *with great force*.

(74.2) Bill works *Sunday afternoons* or *on weekdays*.

Another pattern of the coordination of constituents of different categories arise from appended coordination, a form of ellipsis discussed in chapter 4. This occurs when a nonclausal constituent, often introduced by a coordinator such as *and* or *but,* is appended to a clause.

(75.1) [NP Alice] has been charged with perjury, and [NP her secretary] __ too.
PARAPHRASE
Alice has been charged with perjury, and her secretary had been charged with perjury too.

(75.2) The judge found [NP Beverly] guilty, but not __ [NP Fred].
PARAPHRASE
The judge found Beverly guilty, but the judge did not find Fred guilty.

(75.3) The speaker lectured about the periodic table, but __ only briefly.
PARAPHRASE
The speaker lectured about the periodic table, but the speaker lectured about the periodic table only briefly.

(75.4) Fred goes to the cinema, but __ seldom with his friends.
PARAPHRASE
Fred goes to the cinema, but Fred seldom goes to the cinema with his friends.

In some cases, the appended constituent corresponds to a constituent in the preceding clause. In that case, what the appended constituent conveys is what would be conveyed by a clause just like the preceding clause, except that the appended phrase replaces its counterpart in the preceding clause. This is seen in the first two sentences in (75). In other cases, the preceding clause may contain no counterpart to the appended constituent. In that case, what is conveyed is what is conveyed by the same clause with the appended constituent. This is exemplified in the last two sentences in (75).

A fourth pattern, known as gapping, arises when a series of phrases that do not themselves form a constituent is coordinated with a clause. Gapping, a form of ellipsis discussed in chapter 4, occurs, roughly, under the following circumstances: an independent clause is followed by an expression that, though not itself a constituent, comprises two constituents, neither of which is a constituent of the other; the first of these latter two constituents, corresponds to the initial constituent in the preceding clause and the second to the clause's final constituent; the point of ellipsis, or gap, is the point between the two constituents that follow the clause; and the expression between the initial and final constituent of the clause is the antecedent for the gap.

(76.1) On Monday <u>Alice had been</u> in Paris and on Tuesday __ in Bonn.
PARAPHRASE
On Monday Alice had been in Paris and on Tuesday Alice had been in Bonn.

(76.2) Bill came to Fiji in 1967 and Evan __ the following year.
PARAPHRASE
Bill came to Fiji in 1967 and Evan came to Fiji the following year.

(76.3) Max had not finished the assignment, nor (had) Jill __ hers.
PARAPHRASE
Max had not finished the assignment, nor (had) Jill finished hers.

In the first sentence of (76), for example, the prepositional phrases, *on Tuesday* and *in Bonn*, do not form a constituent; however, the noun phrase *on Tuesday* corresponds to the first phrase in the preceding clause, *on Monday*, and the phrase *in Bonn* to the last phrase in the preceding clause, *in Berlin*.

Not only may a series of phrases be coordinated with a clause, a series of phrases may be coordinated with a second series of phrases, as we see in the sentences that follow.

(77.1) The mother gave [NP a cookie] [PP to one of her children] [PP on Wednesday] [CNJ and] [NP a piece of cake] [PP to the other] [PP on Thursday].
(77.2) Colleen painted [NP the bedroom] [AP blue] [CNJ but] [NP the kitchen] [AP purple].

In the first sentence of (77), for example, the pair of phrases *a cookie* and *to one of her children* is coordinated with the pair of phrases *a piece of cake* and *to the other*.

The last pattern, sometimes called *delayed right constituent coordination* and known in transformational linguistics as *right node raising,* occurs where two expressions neither of which need be constituents are coordinated and followed by a constituent which, if taken with the two coordinated nonconstituents, would make them constituents; it is as if one common constituent has been factored out, as it were, of the coordinated expressions, thereby rendering them nonconstituents. In the first sentence of (74), neither the expression *Dan may accept* nor the expression *Bill will certainly reject* are constituents, yet they are coordinated by *but*. Moreover, as we see from the paraphrase, these expressions, when supplemented by the expression *the management's new proposal,* each form a constituent.

(78.1) [S Dan may accept __] but [S Bill will certainly reject __] [NP the management's new proposal]].
PARAPHRASE
Dan may accept the management's new proposal but Bill will certainly reject the management's new proposal.
(78.2) [S I enjoyed __] but [S everyone else seemed to find fault with __] [NP her new novel]].

PARAPHRASE
I enjoyed her new novel but everyone else seemed to find fault with her new novel.

(78.3) Alice [VP knew of __] but [VP never mentioned __] [NP Bill's other work]].
PARAPHRASE
Alice knew of Bill's other work but Alice never mentioned Bill's other work.

SOME ANALYSES

Reviewed above are six patterns pertaining to coordination, including homogeneous coordination, appended coordination, gapping, and delayed right constituent coordination. As readers will have noticed, each example of coordination is paired with a paraphrase comprising a pair of sentences coordinated with the same coordinator. In early transformational grammar, the analysis was evident: posit a transformational rule to connect the constituency analysis of the paraphrasing sentence with the coordinated clauses, the paraphrased sentence's so-called deep structure, with the constituency analysis of the paraphrased sentence, the paraphrase sentence's so-called surface structure. The pattern of homogeneous constituent coordination was treated by a rule called *conjunction reduction,* now generally abandonned. Appended coordination, gapping and delayed right constituent coordination were treated by the transformational rules of *stripping, gapping,* and *right node raising,* respectively.

Since this is a book on semantics, we shall not divert our attention to the various transformational treatments of these patterns. Rather, we shall confine our attention to semantic analyses of just two patterns, homogeneous constituent coordination and delayed right constituent coordination, based on the apparent syntactic structure of the two patterns.

We begin with the analysis of the pattern of homogeneous constituent coordination provided by a Lambek typed grammar. To enhance the readability of the notation in the exposition to follow, we adopt the following abbreviation for types. Any type expression of the form $x\backslash x/x$ is an abbreviation for a type expression of the form $(x\backslash x)/x$. For example, $t\backslash t/t$ is an abbreviation for $(t\backslash t)/t$. Similarly, any derivation of the form on the left abbreviates a derivation of the form on the right:

$$\frac{x \qquad x\backslash x/x \qquad x}{x} \qquad\qquad \dfrac{x \qquad \dfrac{(x\backslash x)/x \qquad x}{x\backslash x}}{x}$$

We first present derivations for the three sentences in (79), without values,

(79.1) Don jogged and Carol swam.
(79.2) Don jogged and swam.
(79.3) Don accompanied and hosted Carol.

and then we shall discuss the derivations and their associated values.

$$\dfrac{\dfrac{\substack{\textit{Don}\\ e}\qquad \substack{\textit{jogged}\\ e\backslash t}}{t}\qquad \substack{\textit{and}\\ t\backslash t/t}\qquad \dfrac{\substack{\textit{Carol}\\ e}\qquad \substack{\textit{swam}\\ e\backslash t}}{t}}{t}$$

$$\dfrac{\substack{\textit{Don}\\ e}\qquad \dfrac{\substack{\textit{jogged}\\ e\backslash t}\qquad \substack{\textit{and}\\ (e\backslash t)\backslash(e\backslash t)/(e\backslash t)}\qquad \substack{\textit{swam}\\ e\backslash t}}{e\backslash t}}{t}$$

$$\dfrac{\substack{\textit{Don}\\ e}\qquad \dfrac{\dfrac{\substack{\textit{accompanied}\\ (e\backslash t)/e}\qquad \substack{\textit{and}\\ x\backslash x/x}\qquad \substack{\textit{hosted}\\ (e\backslash t)/e}}{(e\backslash t)/e}\qquad \substack{\textit{Carol}\\ e}}{e\backslash t}}{t}$$

(where, in the last case, x is $(e\backslash t)/e$).

If we look at the derivations closely, we see that the coordinator *and* is assigned a different type in each derivation. In the first derivation, the coordinator coordinates two expressions of type t. This means that *and* in that context must have type $t\backslash t/t$. In the second sentence, the coordinator coordinates two expressions of type $e\backslash t$, so it has the type $(e\backslash t)\backslash(e\backslash t)/(e\backslash t)$. And in the third derivation, it has type $\big((e\backslash t)/e\big)\backslash\big((e\backslash t)/e\big)/\big((e\backslash t)/e\big)$, since it coordinates expressions of type $(e\backslash t)/e$. In fact, in general, as the type of the coordinated expressions vary, so does the type of the coordinator, even though it appears to be the very same word. In other words, a coordinator is assigned as many different types as there are types for the expressions which it coordinates. Moreover, different types correspond to different values, the very same word is assigned as many different values as it has types of expressions it coordinates.

To incorporate this into a Lambek typed grammar, we must first define a subset of the set of types, which we shall call *Boolean types*.

Definition 1 Set of Boolean types

(1) $t \in$ Btp;

(2) if $x \in$ Typ and $y \in$ Btp, then so are $x\backslash y$ and y/x;

(3) Nothing else is in Btp.

In fact, since we are interested in coordination, we shall confine our attention to a proper subset of the Boolean types, the set we call the *binary Boolean types*. These are types of the form $x\backslash x/x$, where x is a Boolean type.

Definition 2 Set of binary Boolean types
$z \in$ Bbt iff, for some $x \in$ Btp, $z = x\backslash x/x$.

Next we define two sets of Boolean constant terms, one set for those to be assigned to *and,* depending on its type, and another set for those to be assigned to *or,* depending on its type. We shall designate the former set of constant terms as CN_I and the latter as CN_U.

The family CN_I comprises as many constant terms as there are binary Boolean types. It is therefore convenient to use the binary Boolean types to distinguish the various intersective constant terms. If x is a binary Boolean type, then $\cap_{(x\backslash y)\backslash(x\backslash y)/(x\backslash y)}$ and $\cap_{(y/x)\backslash(y/x)/(y/x)}$ are intersective constant terms. While the indexation is mnemonically convenient, it is graphically cumbersome. So, we abbreviate $\cap_{(x\backslash y)\backslash(x\backslash y)/(x\backslash y)}$ as $\cap_{x\backslash y}$ and $\cap_{(y/x)\backslash(y/x)/(y/x)}$ as $\cap_{y/x}$.

Finally, we must state what values are to be assigned to the terms in CN_I. We stipulate that $o_\wedge$ be assigned to $\cap_t$, an abbreviation of $\cap_{t\backslash t/t}$. We shall treat all the other intersective constant terms as abbreviations. We state the definition as follows.

Definition 3 Values for CN_I
(1) $\cap_t$ denotes $o_\wedge$;
(2.1) if $\sigma, \tau \in \mathrm{TM}_{y/x}$, $\cap_y \in \mathrm{CN}_I$ and $\upsilon \in \mathrm{VR}_x$, then $\sigma \cap_{y/x} \tau = \lambda\upsilon.\sigma\upsilon \cap_y \tau\upsilon$;
(2.2) if $\sigma, \tau \in \mathrm{TM}_{x\backslash y}$, $\cap_y \in \mathrm{CN}_I$ and $\upsilon \in \mathrm{VR}_x$, then $\sigma \cap_{x\backslash y} \tau = \lambda\upsilon.\upsilon\sigma \cap_y \upsilon\tau$.

Using the Lambek typed grammar, we analyze the first two sentences in (75). To do so, we assign the expressions *jogged* and *swam* the lambda constants j and s, each of type $e\backslash t$, and the expressions *Don* and *Carol* the lambda constants d and c, each of type e.

$$\dfrac{\dfrac{\begin{array}{c} \textit{Don} \\ e \mapsto d \end{array} \quad \begin{array}{c} \textit{jogged} \\ e\backslash t \mapsto j \end{array}}{t \mapsto jd} \qquad \begin{array}{c} \textit{and} \\ t\backslash t/t \mapsto \cap_t \end{array} \qquad \dfrac{\begin{array}{c} \textit{Carol} \\ e \mapsto c \end{array} \quad \begin{array}{c} \textit{swam} \\ e\backslash t \mapsto s \end{array}}{t \mapsto sc}}{t \mapsto jd \cap_t sc}$$

$$\dfrac{\dfrac{\begin{array}{c} \textit{Don} \\ e \mapsto d \end{array} \qquad \dfrac{\dfrac{\begin{array}{c} \textit{jogged} \\ e\backslash t \mapsto j \end{array} \quad \begin{array}{c} \textit{and} \\ (e\backslash t)\backslash(e\backslash t)/(e\backslash t) \mapsto \cap_{e\backslash t} \end{array} \quad \begin{array}{c} \textit{swam} \\ e\backslash t \mapsto s \end{array}}{e\backslash t \mapsto j \cap_{e\backslash t} s}}{e\backslash t \mapsto \lambda\upsilon.j\upsilon \cap_t s\upsilon}}{t \mapsto (\lambda\upsilon.j\upsilon \cap_t s\upsilon)d}}{t \mapsto jd \cap_t sd}$$

To analyze the last sentence in (79), we assign the expressions *accompanied* and *hosted* the lambda constants a and h, each of type $(e\backslash t)/e$. (Note that x in the following derivation stands for the type $(e\backslash t)/e$.)

$$\dfrac{\dfrac{\begin{matrix}\textit{Don}\\ e\mapsto d\end{matrix}\qquad \dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\begin{matrix}\textit{accompanied}\\ (e\backslash t)/e\mapsto a\end{matrix}\quad\begin{matrix}\textit{and}\\ x\backslash x/x\mapsto \cap_x\end{matrix}\quad\begin{matrix}\textit{hosted}\\ (e\backslash t)/e\mapsto h\end{matrix}}{(e\backslash t)/e\mapsto a\cap_x h}}{(e\backslash t)/e\mapsto \lambda v.av\cap_{e\backslash t} hv}\qquad\begin{matrix}\textit{Carol}\\ e\mapsto c\end{matrix}}{e\backslash t\mapsto (\lambda v.av\cap_{e\backslash t} hv)c}}{e\backslash t\mapsto ac\cap_{e\backslash t} hc}}{e\backslash t\mapsto \lambda w.acw\cap_t hcw}}{t\mapsto (\lambda w.acw\cap_t hcw)d}}{t\mapsto acd\cap_t hcd}$$

As we remarked previously, a coordinator is assigned as many different types as the types of the constituents it coordinates and, accordingly, is assigned as many different values. But this apparent ambiguity is a fact about the notation we have chosen, not about the language we are analyzing. Nothing in the patterns described suggest there is any such ambiguity.[12]

It is possible to achieve the same coverage of homogenous constituent coordination as is achieved by a Lambek typed grammar, but without treating the coordinators as ambiguous. To do so in an enriched constituency grammar,[13] we require, to begin with, constituency formation rules for the various categories of constituents that may be coordinated: $X\ C_c\ X \rightarrow X$, where X is a lexical category, a phrasal category, or S. And we assign $\cap$, intersection, to *and*$|C_c$, and $\cup$, union, to *or*$|c_c$. We stress that here the symbols $\cap$ and $\cup$ are not terms of the Lambda calculus, but the usual symbols for intersection and union. We illustrate this analysis with derivations for the last two sentences in (79), where *jogged* and *swam* are assigned J and S, subsets of the universe, respectively, and *accompanied* and *hosted* A and H, sets of ordered pairs of members of the universe, *Don* the singleton set $\{d\}$, and *Carol* the singleton set $\{c\}$.

$$\dfrac{\begin{matrix}\textit{Carol}\\ \mathrm{NP}\mapsto \{c\}\end{matrix}\qquad\dfrac{\begin{matrix}\textit{jogged}\\ \mathrm{V}{:}\langle\,\rangle\mapsto \mathrm{J}\end{matrix}\quad\begin{matrix}\textit{and}\\ \mathrm{C_c}\mapsto \cap\end{matrix}\quad\begin{matrix}\textit{swam}\\ \mathrm{V}{:}\langle\,\rangle\mapsto \mathrm{S}\end{matrix}}{\mathrm{V}{:}\langle\,\rangle\mapsto \mathrm{J}\cap\mathrm{S}}}{\mathrm{S}\mapsto \mathrm{T}\ (\text{iff } \{c\}\subseteq \mathrm{J}\cap\mathrm{S})}$$

12. This point was made to me a number of years ago by Ed Keenan.

13. This is essentially a constituency grammar adaptation of the treatment of this pattern in Keenan and Faltz (1985).

accompanied	*or*	*hosted*	
V:⟨NP⟩ $\mapsto$ A	$C_c \mapsto \cup$	V:⟨NP⟩ $\mapsto$ H	*Carol*

Don

V:⟨NP⟩ $\mapsto$ A $\cup$ H   NP $\mapsto \{c\}$

NP $\mapsto \{d\}$ V:⟨ ⟩ $\mapsto \{x : \langle x, c\rangle \in A \cup H\}$

S $\mapsto$ T (iff $\{d\} \subseteq \{x : \langle x, c\rangle \in A \cup H\}$)

Now one problem, which is easily handled, is this. The semantic values assigned to declarative clauses are the truth values T and F. But it makes no sense to speak of the union or intersection of a pair of truth values. It appears, therefore, that this assignment of values to *and* and *or* does not permit an assignment of truth values to coordinated declarative clauses, such as sentence (79.1). However, it is easy to find sets that behave with respect to union, intersection, and complementation just as T and F behave with respect to $o_\vee$, $o_\wedge$, and $o_\neg$. They are the sets {∅} and ∅, and as readers can see from inspecting the following tables, the functions are isomorphic.

$\wedge$	T	F
T	T	F
F	F	F

$\cap$	{∅}	∅
{∅}	{∅}	∅
∅	∅	∅

$\vee$	T	F
T	T	T
F	T	F

$\cup$	{∅}	∅
{∅}	{∅}	{∅}
∅	{∅}	∅

$\neg$	T	F
	F	T

$-$	{∅}	∅
	∅	{∅}

(where $-$ is complementation over the set {∅, {∅}}.)

While many instances of the patterns in (73) are successfully treated by conjunction reduction, important problems remained. It was quickly realized in the early days of transformational grammar that conjunction reduction failed to handle a variety of cases of homogeneous constituent coordination. We now detail these.

To begin with, coordinated constituents that have a quantified noun phrase either as a subject or as a complement do not always have the requisite paraphase, as the pair of sentences in (80.2) shows.

(80.1) Each attendee smokes and drinks.
Each attendee smokes and each attendee drinks.

(80.2) Some attendee smokes and drinks.
Some attendee smokes and some attendee drinks.

The second sentence in (80.2) is true even if the smokers and the drinkers form disjoint sets; the first sentence is not true with respect to those circumstances. Another kind of sentence that lacks the requisite paraphrase are those that have coordinated noun phrases serving as the antecedents of reciprocal pronouns. Indeed, the required paraphrases of such sentences are judged unacceptable.

(81.1) Alice and Alexis admire each other.
NONPARAPHRASE
*Alice admires each other and Alexis admires each other.
PARAPHRASE
Alice admires Alexis and Alexis admires Alice.

(81.2) Bill introduced Jules and Jim to each other.
NONPARAPHRASE
*Bill introduced Jules to each other and Bill introduced Jim to each other.
PARAPHRASE
Bill introduced Jules to Jim and Bill introduced Jim to Jules.

Sentences in which reciprocal polyadic words are predicated of coordinated noun phrases also lack the requisite paraphrase.

(82.1) Alice and Alexis are friends.
NONPARAPHRASE
Alice is a friend and Alexis is a friend.
PARAPHRASE
Alice is a friend of Alexis and Alexis is a friend of Alice.

(82.2) Audrey and Alexis are alike.
NONPARAPHRASE
*Audrey is alike and Alexis is alike.
PARAPHRASE
Audrey is like Alexis and Alexis is like Audrey

Finally, the conjunction reduction rule entails that noun phrases coordinated by *and* have only distributive construals. But as we saw earlier, such coordinated noun phrases often also have collective construals.

These patterns, except the one illustrated by sentence (80.2), also pose a problem both for the Lambek typed grammar analysis and the enriched constituency grammar analysis of homogeneous constituent coordination.

We close this treatment of nonclausal coordination by showing how a Lambek typed grammar can nicely handle the pattern of delayed right constituent coordination right, as evinced in the two sentences in (83).

(83.1) Bill likes and Carol dislikes Atlanta.
(83.2) Alexie showed Colleen Banff and Don Fresno.

In the first derivation that follows, x below stands for the type t/e. In order to fit the entire derivation on the page, we break it up into two parts.

$$\dfrac{\dfrac{\dfrac{\underset{\textit{Bill}}{e \mapsto b} \quad \dfrac{\underset{\textit{likes}}{(e\backslash t)/e \mapsto l} \quad e \mapsto v}{e\backslash t \mapsto lv}}{t \mapsto lvb}}{t/e \mapsto \lambda v.lvb} \quad \underset{\textit{and}}{x\backslash x/x \mapsto \cap_x} \quad \dfrac{\dfrac{\underset{\textit{Carol}}{e \mapsto c} \quad \dfrac{\underset{\textit{dislikes}}{(e\backslash t)/e \mapsto d} \quad e \mapsto w}{e\backslash t \mapsto dw}}{t \mapsto lvc}}{t/e \mapsto \lambda w.dwc}}{\dfrac{\dfrac{t/e \mapsto \lambda v.lvb \cap_x \lambda w.dwc}{t/e \mapsto \lambda u.(\lambda v.lvb)u \cap_t (\lambda w.dwc)u}}{t/e \mapsto \lambda u.lub \cap_t duc}}$$

$$\dfrac{\dfrac{\underset{\textit{Bill likes and Carol dislikes}}{t/e \mapsto \lambda u.lub \cap_t duc} \quad \underset{\textit{Atlanta}}{e \mapsto a}}{t \mapsto (\lambda w.lub \cap_t duc)a}}{e \mapsto lab \cap_t dac}$$

Exercises: Nonclausal coordination

1. Find an example where the quantified noun phrase is not a subject noun phrase and fails to give rise to an equivalent paraphrase.

2. Identify which of the following types are Boolean types and, of the Boolean types, which are binary Boolean types. Recall that $x\backslash x/x$ abbreviates $(x\backslash x)/x$.

(a) t	(f) $e\backslash e/e$	(k) $(e\backslash t)\backslash(t\backslash e)$
(b) e	(g) $(e\backslash e)\backslash t$	(l) $t\backslash e/t$
(c) $t\backslash e$	(h) $(t/e)\backslash(t/e)/(t/e)$	(m) $e/\big(e/(e\backslash t)\big)$
(d) $t\backslash t/t$	(i) $(t/t)\backslash e$	(n) $(t/e)\backslash(t\backslash e)/(t/e)$
(e) $e\backslash t$	(j) $(e\backslash t)\backslash(e\backslash t)$	(o) $e\backslash\big(e\backslash(e\backslash t)\big)$

4 Conclusion

In this chapter, we have expanded both our empirical and theoretical horizons. In chapter 10, we confined our attention to minimal clauses, declarative clauses whose noun phrases are all proper nouns and whose verb phrases contain the verb and its complements. In this chapter, we considered first simple clauses, clauses with noun phrases having at most one determiner and one adjective. We then ventured further to consider simple clauses whose nouns are modified either by prepositional phrases or by restrictive relative clauses. And we ended the chapter by considering monoclausal declarative sentences with various coordinated phrasal constituents. Nonetheless, we avoided much detail. While we described the various kinds of English nouns, we confined our theoretical treatment to singular count nouns. Although we reported on the different kinds of English determiners, we only gave a theoretical treatment for quantificational determiners. In addition, we choose to assign values only to intersective, predictive adjectives, though we had noted the existence of various other kinds. And while distinguishing two kinds of relative clauses, we analyzed only restrictive ones.

In chapter 3, we introduced the notion of a constituency grammar. We showed that, while immediate constituency analysis brought to light many patterns in English syntax, constituency grammar failed to do justice to many of the patterns. In chapter 10, we set out to address two of the problems brought to light in chapter 3, namely the projection problem and the subcategorization problem, as well as a new problem, namely the problem of defining a structure of an English lexicon. However, the new patterns, pertaining to modification, homogeneous constituent coordination, and different ways of construing choice dependence in clauses with quantified noun phrases, required further modifications of constituency grammar. At the same time, these new patterns afforded us the opportunity to see how Lambek typed grammars, also known as type logical grammars, can be applied to the study of the same patterns. We saw that each kind of grammar has advantages and disadvantages.

SOLUTIONS TO SOME OF THE EXERCISES

2.1.1 Proper nouns

2. We can show that the two sentences are not synonymous by finding a circumstance of evaluation where one is true and the other is false. Consider the situation in which Bill knows that he is not the artist, Picasso, but he believes that he has the same artistic genius as Picasso. In this situation, the first sentence of the pair is false and the second is true.

(1) Bill thinks that he is Picasso.

(2) Bill thinks that he is a Picasso.

4. *Everything exists*:

This sentence can be rendered as $\forall x Ex$. The formula is a tautology and the sentence is judged true, no matter what.

Nothing exists:

This sentence can be rendered as $\neg\exists x Ex$. Depending on the circumstance of evaluation, the sentence may be true or false. The formula, however, is a contradiction, since the definition of a structure requires that its universe be nonempty. Should this requirement be omitted, then the formula is a contingency.

Santa Claus does not exist:

This sentence is true, though it could have been false. Yet the formula Ec is a tautology, since a structure requires that its universe is nonempty and its interpretation function assign a value from the universe for each individual symbol.

2.1.3 Common nouns

1.(a) These words satisfy the criteria both for count nouns and for mass nouns.
1.(b) These words satisfy the criteria for count nouns, except that the plural suffix -*s* cannot be added to them.
1.(c) In omitting the suffix -*s* from these words, the result either has a different meaning or it is not an English word.

2.3 Determiners

1. English expressions such as *What the hell!* and *That a boy!* are idioms. Each word fails to be intersubstitutable with other words of the same word class.

3.1 Simple clauses with quantified noun phrases

2. It cannot be that proper nouns are assigned the type e and common nouns either the type $e \setminus t$ t or the type t/e, since neither *Alice person* nor *person Alice* are expressions of English, let alone expressions which can be judged either true or false.

3.3 Prepositional phrases

1. The syntactic derivations in the Lambek typed grammar correspond to the constituency given in (40.1) and (40.2), respectively.
2. Under the assumption that the lambda terms for *a*, *Calgary*, *in*, *man*, and *sleeps* are $\exists$, c, l, m, and s, respectively, the lambda terms for the sentences in (39.2) and (39.3) are $\exists(\cap_{e\setminus t}(lc)m)s$ and $\exists m(\cap_{e\setminus t}(lc)s)$, respectively. These terms are not equivalent; but under the intended interpretation of the terms, they denote the same value. They both say that the intersection of the set of men with the set of things in Calgary and the set of sleepers is non-empty.

3.6 Nonclausal coordination

2.(a) Btp: a, d, e, g, h, j, n, o
Bbt: d, h