Quantification forms a significant aspect of cross-linguistic research into both sentence structure and meaning. This book surveys research in quantification starting with the foundational work in the 1970s. It paints a vivid picture of generalized quantifiers and Boolean semantics. It explains how the discovery of diverse scope behavior in the 1990s transformed the view of quantification, and how the study of the internal composition of quantifiers has become central in recent years. It presents different approaches to the same problems, and links modern logic and formal semantics to advances in generative syntax. A unique feature of the book is that it systematically brings cross-linguistic data to bear on the theoretical issues, covering French, German, Dutch, Hungarian, Russian, Japanese, Telugu (Dravidian), and Shupamem (Grassfield Bantu) and points to formal semantic literature involving quantification in around thirty languages.

Quantification

ANNA SZABOLCSI
New York University
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What this book is about and how to use it

1.1 The proper treatment of quantification in ordinary Human

In The proper treatment of quantification in ordinary English Montague sets forth his goal as follows:\footnote{1}

“The aim of this paper is to present in a rigorous way the syntax and semantics of a certain fragment of a certain dialect of English. For expository purposes the fragment has been made as simple and restricted as it can be while accommodating all the more puzzling cases of quantification and reference with which I am acquainted.” (Montague 1974a: 247)

The goal of this book is to survey a good chunk of the research that has been directed at Montague’s puzzles and their natural extensions in the past 35 years. The survey has a dual focus. One is on how the understanding of “quantification” and “quantifier” has been changing over time. The way I see it, we have witnessed three main stages of research:

Grand uniformity (the 1970s and 1980s)
Foundational work that affords a uniform treatment of initially disparate-looking phenomena: generalized quantifiers for all noun phrases, a kind-based treatment of existential and generic readings of bare plurals, etc.

Diversity (the 1980s and 1990s)
Dynamic semantics for definites and indefinites, choice-functional indefinites vs. others, the differential behavior of quantifiers

Internal composition (from 2000 on)
Quantifier-phrase-internal and, most recently, quantifier-word-internal compositionality
What this book is about and how to use it

The other focus is on the core notion of scope and its implementation in several varieties of generative syntax and categorial grammar. We may disagree about what the best syntax is, but any serious attempt at compositionality must be built on a credible syntax. It is important to see that at least the core ideas can be implemented in various different ways.

Montague’s puzzles include the interaction of quantifier phrases among themselves and with intensional predicates, and the binding of pronouns by quantifiers. We will not attempt to cover the research on intensionality, save for a brief discussion in §5.7, although Chapter 3 takes up quantification over individuals vs. worlds and times. Another major self-imposed limitation has been to set aside quantificational binding (see §2.3.3).

The structure of the discussion is as follows.

Chapters 2 through 4 offer an introduction to generalized quantifiers, with an eye on the implications for scope and the syntax/semantics interface, non-nominal domains of quantification, and on semantic properties that turn out to be significant for empirical work. These chapters do not attempt to rehash what existing excellent introductions do (see some recommended readings in §2.1); they attempt to give a picture that cannot be found elsewhere.

Chapters 5 and 6 pull together some of the questions and data that led to the major transformation in how we approach “quantifiers” and “scope”. (The transformation explains why this introduction does not start with a substantial definition of “quantification” – there is no need to set up a strawman and fight with it throughout the book.)

Chapters 7 through 10 discuss some of the issues that have been in the focus of much research: existential scope, distributivity, numeral indefinites, and modified numeral expressions. Here a major limitation is that the discussion of plural noun phrases (especially of collective readings) is kept to the minimum.

Chapter 11 surveys recent approaches to the syntax of clause-internal scope, with special attention to how they account for the diversity of scopal behavior. Chapter 12 pulls together the even more recent work on the internal structure of universal quantifiers – quantifier phrases as well as quantifier words.

The last four chapters survey more controversial and more preliminary ideas than the ones preceding them. Seeing that this is a research survey, not a textbook, it hopes to stimulate further work by giving a sense of where we actually are.

Throughout the book I attempt to link up the results of serious semantics and serious syntax. Occasionally I am mainly talking to the semanticist or to the syntactician, but my hope is that many readers will put themselves in the shoes of both.

Although a great many formal semanticists are native speakers of languages other than English, the bulk of our efforts has been directed at
analyzing English or, sometimes, at disguising research on another language as work on English. This survey makes an attempt to bring multiple languages to bear on the questions under discussion, or at least to point out the existence of some high-quality literature on various languages. I am definitely not doing as good a job as I would like to, simply because I have not processed all this literature in sufficient depth.

1.2 How to use this book

This is not a textbook. Many things follow from this. It does not single out one theory and endow the reader with a working knowledge of it. It selects a story-line and shows what a relatively wide range of literature has to say about it. Although some formalization is offered, the discussion is kept as informal as possible, to maintain readability and to remain neutral as to technicalities. Sometimes it does not make sense to avoid the formalism; if the reader feels that a part is too difficult, they should breeze through it and rest assured that they will be able to pick up the thread afterwards.

The endnotes typically supply further important empirical or formal detail. Their contents are an integral part of the text, at least for some readers. They are relegated to note status to avoid disrupting the train of thought in the main text. The best thing is to keep a bookmark at the notes and consult them systematically.

The chapters and sections address theoretical issues, rather than descriptive topics, whenever possible. For this reason the discussion is somewhat fragmented and repetitive: a particular descriptive topic and a particular piece of work may be relevant for various different questions. So one descriptive topic may be discussed in many places in the book, and different claims made in one and the same piece of work may be brought to bear on various different issues. Usually there are pointers to the other relevant sections and occasionally brief summaries are given of what has already been said; the reader is encouraged to also make good use of the index. A certain amount of repetition is necessary in any case, because not every reader will want to go through the whole book. No issue or piece of work is discussed completely. It is assumed that the reader will go on to consult some of the literature surveyed herein.

The publisher and the author were unanimous in wanting a slender volume, so a certain amount of background is presupposed. For the basics I recommend the syntax and semantics chapters of the twelve-author textbook Fromkin (2000). A good thorough introduction to syntax is Koopman, Sportiche and Stabler (to appear). For formal foundations, the ideal background is a combination of Gamut (1991) and Chapters 2, 6, and 7 of Landman (1991). For lighter fare, use Allwood et al. (1977) and Szabolcsi (1997d). It will be extremely helpful if the reader is comfortable with
What this book is about and how to use it

\(\lambda\)'s. For a boost I recommend Chris Barker’s famed Lambda Tutorial, http://homepages.nyu.edu/~cb125/Lambda/.

Where appropriate the text will point to handbook articles or textbooks, or to original works that have acquired comparable status, for background on the topic under discussion. To draw the reader’s attention to these items the authors’ names appear in small capitals.

1.3 Notation and terminology

As Montague (1974a, b) points out, the syntax of the object language may be directly interpreted in models, or translation into a suitably rich logical language may induce a model-theoretic interpretation for the object-language syntax. Montague uses the translation strategy; Heim and Kratzer (1998) use direct interpretation. The present book follows the translation strategy, because it makes it much easier to calculate with somewhat complex expressions. The reader should be aware of the following: (i) Expressions are translated into a logical language; the \(\lambda\)-operator for example is not used as part of the English meta-language; (ii) Square brackets indicating scope are not abandoned in favor of right-unbounded dots; (iii) The domain of quantification is either not indicated or its type appears as an index on the prefix. For example:

Heim and Kratzer: \(\lambda x \in D. P(x) = 1\)

this book: \(\lambda x_e[P(x)]\)

Following current syntactic practice we refer to syntactic units like every dragon as “quantifier phrases”, “noun phrases”, “DPs”, or “QPs”. The label “NP” is reserved for the complement of the determiner, as in the schematic form every NP. Notice that “NP” is not short for “noun phrase”: every dragon is a noun phrase but dragon is a NP.

Plain italics, as in every dragon, indicate a mention of a natural-language expression. Adding a prime (in the text or in numbered examples), as in every dragon’ signifies both the counterpart of a natural-language expression in the syntax of some logical language, and the interpretation (denotation, meaning) of the expression. This convention allows us to avoid clumsy things like \([every\\ dragon]^{M,s}\). Although the convention is obviously sloppy and can be seen as complicit in promoting the confusion of logical syntax with model theoretic semantics, if the reader bears the distinction in mind it will always be clear which of the two things we are talking about in a given context.

Sometimes the interpretation of a linguistic example is prefixed with \textit{OK} or \#\. Such annotation indicates that the example is acceptable or unacceptable on the given interpretation, and that no claim is being made as to whether the example has other interpretations.
Towards a compositional semantics of quantifier words

In the past decade different lines of research have been converging on the claim that there is no sharp demarcation line in grammar corresponding to word boundaries. One such line is Distributed Morphology, which argues for “syntactic hierarchical structure all the way down” (see Halle and Marantz 1994, and a more recent overview in Harley and Noyer 2003). Another line leading to similar results was initiated in Kayne (2000, 2005a). This expansive view of syntax also converges with recent work at the syntax/semantics interface that has been busy dissecting items that traditional generalized quantifier theory took to be unanalyzed primitives; much of the second half of this book has surveyed such work. The closely related literature on polarity items and free-choice items, not reviewed here, is another rich source of decompositional analyses. Higginbotham (1991) is one of the early examples, with an analysis of whether as the wh-counterpart of either.

It seems useful to formulate the general thrust of this work, even though it is very programmatic at the moment:

(1) Compositional analysis cannot stop at the word level.

This contrasts with the more traditional strategy, which does not shy away from postulating fairly complex semantics for lexical items, but does not systematically strive to link their ingredients to morpho-syntactic components of the lexical items or to account for all the morphemes in evidence. A striking example is the determiner most, because its being the superlative of many and more is uncontroversial. Yet, the first attempt to derive the well-known truth-conditional content in a compositional fashion is Hackl (2009); see §5.6 and §10.4.

The present chapter will survey some further very recent research in this spirit, directed specifically at universal quantifiers. Some of the work
Towards a compositional semantics of quantifier words

is primarily syntactic, but of course compositional semantics must interpret what is there in the syntax, and the proposals to be discussed will prove to be directly relevant. Beyond specific details two larger semantic questions emerge. One pertains to where quantifier domain restriction is anchored in syntax and whether its locus is cross-linguistically invariant. Another is how the composition of quantifier words meaning ‘every’ and ‘some’ reflects their relationship to other fundamental operators, such as those meaning ‘and’ and ‘or’. The discussion will be based on work directed at Lillooet, Mandarin, Modern Greek, Hungarian, German, Swedish, Japanese, Korean, and Malayalam, with occasional glimpses at English.

12.1 Is there interesting syntax in and around universal quantifiers?

Chapters 7 and 8 argued that sentences involving quantifier phrases such as every dragon are built in the following semi-formal steps:

(2)  
\[
\begin{align*}
&\text{ dragon'} & f(\text{Pow}(\text{dragon'})) \\
&\text{ every } & \text{ sends } every \text{ dragon to Spec, DistP} \\
&\text{ Dist'} & \lambda x P \forall x [x \in P][Q(x)] \\
&\text{ Every dragon coughed'} & \forall x [x \in f(\text{Pow}(\text{dragon'}))][\text{cough'}(x)]
\end{align*}
\]

The NP dragon denotes one element of the powerset of dragons that a contextually given choice function \( f \) selects. The fact that the set of dragons quantified over is selected by a choice function (which could be Skolemized in other examples) captures the domain restriction. What the particular choice function is must be clearly contextually given: it is not enough for the existence of some choice function to be asserted or presupposed. According to §7.2.3 this is what distinguishes Every dragon coughed from Some dragons coughed, although both sentences can be true when every element of a proper subset of all the world’s dragons coughed. The word every is not a universal quantifier, it merely signals that the set of dragons picked by \( f \) is going to be quantified over by a phrase-external universal quantifier; in the jargon of one kind of syntax, every sends the phrase every dragon to the Specifier of Distributive Phrase (DistP) to check a \[\text{dist}\] feature. On this proposal, the universal quantifier is the head of DistP.

Providing that this is by and large correct, can we say more about the compositional derivation of the phrase every dragon and its relatives, in English and cross-linguistically? Unlike modified numeral phrases such as more than five dragons, whose syntactic complexity is visible to the naked eye, the internal syntax of phrases such as every dragon initially seems
The view from Lillooet: quantifier words operate on DP

Matthewson (1999: 109) puts forth the following proposal, by now familiar from Chapter 7:

(3) a. All non-polarity determiners are obligatorily interpreted as variables which range over choice functions.
   b. The polarity determiner is not interpreted as a variable that ranges over choice functions.
   c. The choice-function variables are always existentially closed at the highest level.

She specifically argues that St’át’imcets (Lillooet Salish) encodes the distinction between the two kinds of determiner, discontinuous \((t)i\ldots a\) being a marker of the choice-functional interpretation, while \(ku\) is a polarity determiner. Matthewson (2001) uses \(i\ldots a\) to make a novel proposal regarding the composition of quantifier phrases. She observes that all argumental phrases in Lillooet require the presence of \(i\ldots a\), and conversely, this element only occurs with arguments. Matthewson dubs \(i\ldots a\) a determiner, D, but emphasizes that the label has no particular significance.

(4) \(i\) smúlhats-a smúlhats
det woman-det woman

‘the/a woman, argument’ vs. ‘the/a woman, predicate’

The claim directly relevant to present concerns is that quantifier words must combine with an argumental DP: a nominal flanked by \(i\ldots a\):

(5)

Matthewson translates \(tákem\) and \(zi7zeg\) variably as ‘all’, ‘every’, and ‘each’; \(cw7it\) is ‘many’. In the data of Matthewson (1999) \(i\ldots a\) may actually flank \(zi7zeg\) itself, e.g. \(i\) \(zi7zeg\) `-a pukw ‘each book’ in her (48), or the noun, \(zi7zeg\) \(i\) smelhmúlhats-a ‘each woman’ in her (47), or \(i\ldots a\) can be entirely absent: \(zi7zeg\) smelhmúlhats ‘each woman’ in her (46), in
addition to other constructions in which *zi7eg* participates. In unmodified
numeral indefinites where i . . . a is present it appears to consistently flank
the numeral, not the noun, e.g. i ánt was-a sqaqw ’two men’ in her (39).
This variation in the attachment site of i . . . a may be relevant to the
compositional semantics, see §12.3; I restrict attention to tákem ’every,
all’. All the 1999 tákem-data conform to the 2001 claim.

Regarding the compositional semantics, Matthewson (2001) proposes
that the noun is first pluralized by Link’s (1983) * operator. Because
plural morphology is not obligatory on the surface, * is the denotation of
an abstract plural feature. D combines with *N and returns one plural
individual from the join semi-lattice. Tákem universally quantifies over
the atoms of this plural individual. The head of DP, i . . . a, which delivers
the plural individual argument of tákem ensures that the complement of
Q is an argument, not a predicate, makes the denotation of this argument
specific or contextually unique, and restricts the domain of quantification.
(We return to the argument-maker property of i . . . a below. Specificity
or contextual givenness follows from the widest scoping choice-functional
interpretation. The assimilation of quantifier-domain restriction to choice-
functional interpretation was discussed in Chapter §7.2.3.)

Matthewson (2001: 153-154) points out that her analysis would be
fully compatible with the choice function being contextually given as op-
posed to existentially closed, or with using an iota-operator instead of
a choice function (i.e. an epsilon-operator). What matters to her is that
specificity and domain restriction are achieved in a way that makes the
complement of the quantifier word denote an entity (type e), not a set
(type ⟨e, t⟩). On her analysis quantifier words are of type ⟨e, ⟨⟨e, t⟩, t⟩⟩,
not ⟨⟨e, t⟩, ⟨⟨e, t⟩, t⟩⟩, as in generalized quantifier theory.

On this basis Matthewson puts forth the interesting proposal that
by taking the cue from Lillooet in analyzing quantifier words in English
(French, Italian, etc.) one can make better sense of their distribution and
interpretation. She first considers the fact that the majority of quantifier
words enter into overt partitive constructions. The contrasts below reflect
what is known as the Partitive Constraint:

(6) most/many/some/three/few/all/both of the (ten) chiefs
(7) *most/many/some/three/few/all/both of chiefs/ten chiefs/every
    chief

The complement of partitive of must be a definite plural; see Ladusaw
Ladusaw proposes that the complement denotes a group of individuals,
and the role of of is to convert this group into a set that the quantifier
word (semantic determiner) can operate on. On Matthewson’s analysis of
can be meaningless; as seen from Lillooet, the complements of quantifier
words are always definite/specific plural individuals. This of course entails that the same holds even when no overt partitive construction is present. In what is probably the first illuminating discussion of these data she proposes that all and most modify bare plurals. Pulling together well-known and novel observations she points out that the distribution and interpretation of all NP and most NP matches that of bare plurals on the generic reading (Partee 1995; Brisson 1998; Gil 1995) or on Condoravdi’s (1994) so-called functional reading, known for her haunted campus example. They contrast with all (of) the NP and most of the NP. Below are some examples with all; Matthewson suggests that the most-data are more complicated but the basic pattern is the same.

(8) a. Desks are brown.
   b. All desks are brown.
   c. #All pages in this book were torn.
   d. All the pages in this book were torn.

(9) a. I admire linguists.
   b. I admire all linguists.
   c. #I talked to all linguists.
   d. I talked to all the linguists.

(10) In 1985 there was a ghost haunting the campus...
    a. Students were aware of the danger.
       ‘the students on campus’, not ‘there were students who . . .’
    b. All students were aware of the danger.

Matthewson adopts Chierchia’s (1998) version of Carlson’s (1977) theory that bare plurals in English denote kinds and, therefore, individuals.

The quantifier word every is problematic for this analysis, because it always takes a singular complement and never a definite DP. If every is a determiner and selects the individual corresponding to the maximal contextually salient subset of the set denoted by NP, it is similar to the. But then what accounts for the distributive interpretation of every linguist? Here Matthewson proposes to follow Beghelli and Stowell (1997) and Szabolcsi (1997a) in assuming that every merely associates its DP with a distributive operator, it is not a distributive operator itself. In sum, the contrasting structures she proposes are as follows. The indices on syntactic categories indicate semantic types.
Towards a compositional semantics of quantifier words

A closer look at determiners: Mandarin, Modern Greek, and Hungarian

Matthewson (2001) attributes a rather complex role to the determiner *... a*: its output is (i) argumental, (ii) of type e, (iii) maximal, and (iv) context-dependent. She moreover glosses over some variation in the attachment of *... a* in her earlier data. Giannakidou (2004) and Cheng (2008) single out particular aspects of the analysis of Lillooet for adoption in generalizing the proposal to other languages, Modern Greek and Mandarin among them.

Cheng’s (2008) starting point is Lin, Jo-Wang’s (1998) analysis of Mandarin *dòu*, as in (12):

(12) Mèi-ge xuéshèng *(dòu) mǎi-le* shū. 'Every student bought a book'

*Mèi* is typically glossed as ‘every’. It requires the presence of *dòu*, normally glossed as ‘all’. Following Beghelli and Stowell (1997) Lin, Jo-Wang proposed that *mèi* is like English *every* in that it is not a distributive operator, it merely carries a [dist] feature. The real distributive operator is *dòu*.

Cheng notes, drawing from Lin, Tzong-Hong (1998) and Huang, Shizhe (1996) that *dòu* is possible in non-distributive contexts, and that *mèi* can sometimes do without *dòu*, but in its absence requires an element like zhèr ‘here’:

(13) Tāmén dòu yìqí lái. ‘All of them came together’
A closer look at determiners: Mandarin, Modern Greek, and Hungarian

(14) ⟨Zhèr⟩ Méi yī-ge chūshǐ ⟨dōu⟩ zuò-le yī-dào here every one-classifier chef dōu make-perf one-classifier cài.
dish
‘Every chef here made a dish’

Cheng concludes that dōu is not a distributive operator, instead, it is a definite determiner, contributing familiarity, maximality, and domain restriction. In line with this, the optional presence of dōu with weak determiners makes the interpretation specific or definite. Méi on the other hand is indeed a universal, and it demands domain restriction, which may be accomplished by dōu or zhèr ‘here’. In this respect méi is like other strong determiners, such as dābūfēn ‘most’ and suǒyǒu ‘all’.

Dōu is in VP-adjoined position. As long as it was considered a distributive operator, this did not raise a problem. But, Cheng observes, the definite determiner analysis makes this fact surprising – unless Sportiche’s Split-DP hypothesis is adopted. According to this hypothesis verbs take NPs as arguments, and determiners are always generated in a separate layer, somewhere outside VP; see §9.4. In languages like French and English NP typically raises in overt syntax to join its D; in Mandarin it apparently does not. In Cheng’s view the Split-DP hypothesis may offer a new way to look at languages that are traditionally thought not to have determiners, like Mandarin.

Giannakidou (2004) argues that familiarity and the restriction of the domain of quantification are not necessarily expressed on the complement of the quantifier, as Stanley and Szabó (2000) and, following them, Matthews would have it; it may be expressed on the determiner, as is proposed in Westerståhl (1985). According to Giannakidou, the sole function of i . . . a is to embody familiarity by contributing a context-variable. When it attaches to NP i . . . a effectively produces a definite generalized quantifier, which is then shifted to a predicate by a “silent of”. In other words, i . . . a is not a predicate-to-individual shifter. Giannakidou observes that i . . . a can alternatively attach to the universal quantifier word zī’èzeg (see above), and in many languages the attachment of the definite article to the quantifier word is the norm. Such a language is Modern Greek, where for example ‘each’ is composed of the definite article (with gender agreement) plus kathe ‘every’:

(15) o kathé fititis
the.masc.sg every student
‘each student’

Thus, Giannakidou argues, Modern Greek expresses domain restriction on the quantifier word (semantic determiner), and Lillooet has both ty-
Towards a compositional semantics of quantifier words

There may be alternative ways to look at the fact that the definite determiner is sometimes higher and sometimes lower than quantifier words. Definite articles in Hungarian initially seem to be in complementary distribution with quantifier words. But both obligatorily surface when something linearly intervenes between them, and so it becomes clear that QPs are dominated by a DP layer, headed by a(z) ‘the’ (Szabolcsi 1994). One eligible intervener that reveals the co-occurrence is a nominative pronominal possessor. Because personal pronouns never take articles, the definite article unambiguously belongs to the larger construction:

(16) az én minden / legtöbb / ezen szavam
    the I-nom every / most / this word.poss.1sg
    ‘every/most/this word(s) of mine’

Szabolcsi (1994) draws a syntactic parallelism between DP and CP, assimilating D to C in its subordinator (argument-maker) function. She contrasts argumental DPs not with predicates but with vocatives, the analogues of main clauses. She observes that definite articles are cross-linguistically absent from vocatives, just as subordinating complementizers are absent from main clauses. A simple illustration comes from languages or dialects in which proper names have definite articles (German, Modern Greek, Portuguese, Hungarian, etc.):

(17) a. Der Hans kommt.
    ‘Hans is coming’
    b. (*Der) Hans, komm her!
    ‘Hans, come here’

She likens quantifier words to clause-type indicators (interrogative, declarative, etc.). Many languages, Korean, Japanese, Kashmiri, and Hungarian among them, systematically lexicalize subordinators and clause-type indicators separately. A Korean example:

    Bill-top John-nom come-past-interrog-subord ask-past-decl
    ‘Bill asked if John came’

In the same spirit, Hungarian lexicalizes D and Q separately. A(z), the item glossed as ‘the’ is not a definite article in the traditional semantic sense, just a subordinator. Definiteness is encoded by a phonetically null feature [def]; Szabolcsi (1994) places [def] in the same position as Q-words. The relation between a(z) and ‘every’, ‘most’, ‘this’ and [def] is analogous to the matching relation between that and finiteness vs. for
and non-finiteness in English. The subordinator D that co-occurs with indefinites in Hungarian is phonetically null.

Focusing on the determiner–quantifier issue and setting aside the rest of the DP–CP analogy, putting Hungarian together with Lillooet one might obtain (19). The high D2 is what Szabolcsi (1994) and the related syntax literature call D. The low D1 is what Matthewson (2001) calls D, but it is now stripped of its argument-maker function:

(19)

When a language does not have three separate overt elements corresponding to D1, Q, and D2, one may think of what overt elements it does have either as mono-functional heads that are accompanied by null heads in the other positions, or as portmanteau words that spell out multiple heads, possibly glummed together by head movement. The predictions of the two analyses could be distinguished if parts of the structure undergo movement, but this does not concern us here. Relevant to us is the fact that the argument-maker and the maximalizer/domain-restrictor functions are performed by different heads. It is then possible for one language (Hungarian) to possess an overt argument-maker D2, and another (Lillooet, as in the examples Matthewson 2001 discusses) an overt maximalizer/domain-restrictor D1. This would reconcile the high D vs. low D data. But even with argument-making factored out, Matthewson, Giannakidou, and Cheng attribute rather complex activities to D. Definiteness (maximization) and context-dependency (domain-restriction) are not logically inseparable and thus need not be ensured by the same operator. It may be necessary to add a new player.

Which D does the Modern Greek definite article represent? Its surface position recalls the Hungarian argument-maker. But Greek also differs from Hungarian in that the article bears agreement morphemes. In §12.4 a proposal will be reviewed that pays special attention to languages whose definite articles carry agreement morphology, such as German and Modern Greek.
12.4 And finally, the deep end: diving into quantifier words in German

The line of research reviewed above makes it natural to look for syntactic structure, and thus compositionality, inside quantifier words as well. Sometimes etymology makes it clear that the word is composed of several relevant morphemes. Take German jeder, jede, jedes ‘every’. It consists of the independently known distributive particle je, the d- of the definite article plus, somewhat surprisingly, adjectival inflection. Notice that its agreement morphemes are not identical to the ones that articles followed by nouns take:

\[
\begin{align*}
\text{je - d - er Mann} & \quad \text{cf. gut-er Mann vs. der Mann} \\
\text{je - d - e Frau} & \quad \text{cf. gut-e Frau vs. die Frau} \\
\text{je - d - es Kind} & \quad \text{cf. gut-es Kind vs. das Kind}
\end{align*}
\]

The question is whether such facts have synchronic syntactic significance. Leu (2008, 2009) argues that they provide the key to the internal syntax of determiners, broadly speaking. His starting point is the syntax of the determiner/adjective interaction.\(^99\)

German has two different adjectival declensions: the so-called strong one in indefinites (with agreement, to be glossed as AgrA) and the so-called weak one in definites. In definite DPs the strong adjectival declension appears on the article instead. Updating an analysis by Milner and Milner (1972), Leu proposes to relate these in the following way. Definites reflect the original “article > agreement > adjective” hierarchy. Agreement attaches to the article. The notation xAP, as earlier, stands for an unspecified adjectival projection.\(^100\)

\[
\begin{align*}
\text{(21) } & \quad d-\text{er gute Wein} \\
& \text{the-AgrA good wine} \\
& \quad [\text{xAP } d\ldots \text{AgrA } \ldots \text{Adj } \ldots]
\end{align*}
\]

Indefinites have no article in xAP. The adjective moves into initial position. Agreement attaches to the moved adjective.

\[
\begin{align*}
\text{(22) } & \quad gut-\text{er Wein} \\
& \text{good-AgrA wine} \\
& \quad [\text{xAP Adj}_i \ldots \text{AgrA } \ldots]
\end{align*}
\]

Leu observes that not only run-of-the-mill adjectives may occupy these two different positions: certain quantifier words do too. Swiss German b"a"id- ‘both’ (German beid-) is an example. Observe that (23) replicates the (21) pattern in the plural: strong declension appears on the initial article di, followed by the quantifier in its weak form b"a"id"a; (24) replicates the (22) pattern: the quantifier is in initial position and carries strong
And finally, the deep end: diving into quantifier words in German

(23) **D-i bāidā māitli hend es piēr trunkā.**
    the-AgrA both girls have a beer drunk
    \[xAP d\ldots AgrA \ldots both \ldots]\n
(24) **Bāid-i māitli hend es piēr trunkā.**
    both-AgrA girls have a beer drunk
    \[xAP both\ldots AgrA both\ldots]\n
Leu argues that constituent order and morphology indicate that such quantifier words are, syntactically speaking, adjectives.

Before moving on to the analysis of quantifier words it will be useful to spell out the derivation of (21) in some detail. The derivation involves remnant movement, whereby a smaller constituent A is moved out of a larger B, followed by the movement of the remnant of B. The semanticist reader will immediately want to know how remnant movement affects interpretation. It doesn’t. One may think of the movement of remnants as one that will undergo “semantic reconstruction”, i.e. one that leaves a higher-order variable as its trace. One reason why it must reconstruct is that the remnant contains the trace of a moved element that needs to be bound. This means that the initial structures obtained by Merge must get the interpretation right; remnant movement will not change the interpretation, it just delivers the order and constituency observed on the surface.

Leu’s analysis is designed to unify the structures for der gute Wein, Scandinavian double definiteness (exemplified below with Swedish), and Greek determiner spreading. The latter constructions contain a definite article that is directly dependent on the presence of the modifier, in addition to the regular definiteness marking.

(25) **den stora bil-en**
    the.agr big car-definite
    ‘the big car’

(26) **to megalο (to) vivlio**
    the.agr big (the) book
    ‘the big book’

The unification explains the presence of the second D, which I notate as \(D^\perp\), and the resulting unorthodox constituent structure highlighted in (27).
The derivation goes as follows. NP first moves to the Specifier of AgrA to trigger gender/number agreement, and then out of xAP. The structure of xAP is analogous to a relative clause (Kayne 1994; Koopman 2001, 2005); its initial D is the relative complementizer. After NP leaves xAP, AgrA cliticizes to D. D* is merged and the remnant xAP that dominates *der gute* and traces of *Wein* moves to its Specifier.

Elaborating on these ideas Leu (2008) works out analyses for the *ein–kein–mein* ‘one–not even one–my’ series and the *welch–solch* ‘which–such’ series, which we do not detail here. Instead, we consider Leu’s (2009) extension to *jed- ‘every’. As was mentioned at the outset, *jed-* incorporates a quantificational morpheme and a definite article, and takes adjectival agreement. The derivation differs from (28) in one step. In contrast to the derivation with AP, the one with (what I label as) je-P involves preposing the remnant je-P to the Specifier of xAP, forming *jeder*.
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12.4 And finally, the deep end: diving into quantifier words in German

This proposal revises the analysis of *jeder* in Kallulli and Rothmayr (2008). The latter is more like Matthewson’s (2001) for Lilooet *tâkem i snelmûlhats-a* ‘every woman, all the women’:

Leu (2009) points out that (30) predicts the wrong kind of morphology on *jed-* (article agreement, not the strong adjectival declension that actually occurs). He also believes that the complement of *je-* is NP, not DP. Recall that Matthewson (2001) proposes that the complement of English *every*, in contrast to *all*, is NP, not DP. In Leu’s view D* is the definite article
that also appears in the absence of adjectival modification (argument-maker and/or definiteness marker).

12.5 Word-internal compositionality? Cross-linguistic isomorphy?

The very new line of research reviewed in this chapter is significant from multiple perspectives. Although the analysis of the “logical words” of natural languages is one of the classical tasks of a formal semanticist, we often play fast and loose with the precise differences between similar quantifiers within one language (say, every, each, all, all the, etc.) and across languages (assuming that whatever holds true of a quantifier in one language works for its dictionary equivalents in other languages). Such practices do not only result in inaccurate descriptions – they may well affect general theoretical conclusions regarding quantification.

In addition to such specific issues, two fundamental questions in this domain are as follows:

(31) To what extent does compositionality systematically extend below the word level, at least in “logical words”? 
(32) If word-internal compositionality turns out to be the norm, how uniform is the composition of “logical words” across languages (give or take some well-motivated null elements)?

There is a set of data that raises such questions particularly sharply. It is well-known that in many languages morphemes that may be said to signify disjunction and conjunction build connectives, discourse particles, quantifier words, and clause-type indicators. Japanese is one example (Nishigauchi 1990, Shimoyama 2006, among many others).

(33) a. Taro-ka Yamada-ka ‘Taro or Yamada’
   b. dare-ka ‘someone’
   c. dono NP-ka ‘some NP’
   d. Dare-ga odorimasu ka ‘Who dances?’
   e. Taro-ga odorimasu ka ‘Does Taro dance?’

(34) a. Taro-mo Yamada-mo ‘Taro and Yamada’
   b. dare-mo ‘everyone/anyone (depending on stress)’
   c. dono NP-mo ‘every/any NP (depending on stress)’
   d. Taro-mo ‘also/even Taro (depending on stress)’

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and Gil (2008) from a wider typological perspective. Much of the literature focuses on the fact that some of the relevant morphemes can also attach to a larger phrase containing an indeterminate (“wh”) pronoun. An example is (35) from Shimoyama (2006). The analysis has been either in terms of movement or in terms of the expansion of alternatives introduced by the indeterminate pronouns in a Hamblin/Rooth-style semantics:

(35) [[Dono gakusei-ga syootaisita sensei]-mo odotta.
    which student.nom invited teacher-mo danced
   ‘For every student x, the teacher(s) that x invited danced’

In contrast, my interest here is in the “multi-functionality” of the conjunction and disjunction morphemes, which typically remains undressed in the literature. I propose that ka and mo signify the general lattice-theoretic operations:

(36) a. ka least upper bound (join, union, disjunction)
    b. mo greatest lower bound (meet, intersection, conjunction)

This assumption makes the range of uses associated with each morpheme coherent. First, recall (4) of §4.1.1, repeated here:

(37) a. The generalized quantifier everyone’ is the intersection (greatest lower bound) of the Montagovian individuals.
    b. The generalized quantifier someone’ is the union (least upper bound) of the Montagovian individuals.

(36) explains why mo builds a universal and ka an existential quantifier. Second, ‘also, too’ and ‘even’ have conjunctive semantics in that part of the interpretation of I saw X too/even X is that I saw X and another entity Y; it is not surprising that the morphemes carrying these meanings come from the greatest lower bound family. Third, Who dances? is understood as denoting the set of propositions such that, for some individual or other, the proposition is that this individual dances (mutatis mutandis, similarly for yes/no questions); it is not surprising that question-markers are morphemes that belong to the least upper bound family. Or, the range of uses of ka and its cross-linguistic counterparts may follow from the Hamblin-style alternative semantics for disjunction. What this latter view would imply for mo and its counterparts is an open question.104

Recognizing the operations least upper bound and greatest lower bound as dramatis personae in quantification does not throw us back to the traditional position according to which natural language quantifiers are one-step primitives. Jayaseelan (2005) observes that the distributive universal quantification exemplified in Malayalam (38) involves the numeral ‘one’ and the disjunction morpheme in addition to the conjunction morpheme:
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(38) oor-oo kuTTi-(y)uDe-(y)um paraati
    one-disjunction child-gen-conjunction complaint
    ‘each child’s complaint’

His analysis is that the numeral ‘one’ plus the disjunction morpheme form a partition of the class of ‘child’, such that each cell of the partition has just one element. The conjunction morpheme ensures that the elements of the cells, taken together, exhaust the class of ‘child’. The added complexity in oor-oo kuTTi- . . . um is due to the fact that it has a nominal restriction, unlike dare-mo.

How far can such analyses be pushed cross-linguistically? Jayaseelan (2005) draws attention to the fact that according to the Oxford English Dictionary every is composed of ever and each; the each part is preserved in the -y of every:105

(39) [OE. ãfre ãlec, *ãfre ylc: see EVER adv. and EACH.
    The OE. ãlec, ylc, was a compound of ã, synonymous with ãfre; but, owing to umlaut and contraction, the etymological force of the word had become obscured, and ãfre was prefixed in order to express more distinctly the original sense. Although the phrase was always written in OE. (as sometimes in ME.) as two words, it had in 10th c. already come to be felt as a compound, and when it is governed by a prep. this is placed before the first of the two words. […]

1558 Q. KENNEDY Compend. Tract. in Wodr. Soc. Misc. (1844)
    117 Bot everilk faithfull minister to bestowe the grace quhilk God hes gevin hym. OED: every

Jayaseelan goes on to note that each was often followed by the number word one or its weakened form a(n) before the noun, and that each was at least sometimes used to carry the meaning of ‘any’.

(40) a1300 Cursor M. 510 (Gött.) Iornays . . . fourti mile euerilk a day.
    c1325 Pol. Songs (1839) 157 Everunch a parooshhe heo polketh in pyne. 1352 MINOT Poems x. 51 God save sir Edward his right In everilka nede. c1440 HYLTON Scala Perf. (W. de W. 1494) II. xlii, Euericye a soule resonable owyth for to coueyte . . . nyghynge to Jhesu. OED: every

(41) † 2. After without: = ANY. Cf. ALL A. 4.
    c1300 Beket 480 Withoute ech delay. OED: each

Thus Jayaseelan suggests that every child is underlyingly ever each one child. Because ever occurs in whoever, whatever, etc. and contributes universal quantification, Jayaseelan takes ever to be the conjunction operator and conjectures that each is the disjunction operator. If this is correct,
then Old and Middle English, perhaps even Modern English, compose the meaning of the operator the same way as Malayalam does.

Are these semantically reasonable and cross-linguistically prevalent patterns the stuff of compositional semantics? Some of the questions that we have to answer are the following.

One, it is sometimes proposed that not all uses of the same superficial morpheme represent the same lexical item; e.g. Shimoyama (2006) argues, based on the absence of intervention effects, that *mo ‘every’ and mo ‘also’ are distinct. Do these mo’s then share a semantic core and differ in what some phonetically null material contributes, or are they truly independent and their identical shapes a historical accident?

Two, not all languages possess as elaborate an inventory as Japanese. Is there a principled explanation for the gaps (or, can they at least be thought of as normal products of language change)?

Three, there is significant cross-linguistic variation in what stretches of the sentence such morphemes operate on, cf. (35), addressed in Ramchand (1997), Kratzer and Shimoyama (2002), and Zimmermann (2009). Is this variation compatible with a unified semantics?

Four, if Jayaseelan’s conjecture about English is correct, then the morphological matches sometimes break down: *ever may be a conjunction (greatest lower bound) operator, but its shape does not bring *and to mind. How fine-grained should the compositional analyses be, then?

Five, recognizing *ever as a component of *every is not too controversial, but is it legitimate to treat -y as a representative of *each? Where should the line be drawn between diachronic and synchronic analysis in this domain? How suggestive is the Malayalam data of the analysis of English? How strong is the English-internal motivation?

Six, the Malayalam construction in (38) works only with the numeral ‘one’; with higher cardinalities Malayalam uses reduplication, and neither disjunction nor conjunction is present. It is an interesting question whether sorting-key reduplication in Malayalam creates a blocking effect, or the divergence is semantically significant. If the former is correct, how should compositional semantics deal with blocking effects?

These questions go beyond the ones we are familiar with from sentence-level compositional analysis. Answering them calls for novel theorizing, in addition to commonsensical case-by-case argumentation. Since the questions arise at the intersection of productive lines of research in morphology, syntax, and semantics, the theories and the best practices of all these fields can and should inform the development of the requisite methodology and analytical standards.

Despite the fact that so many important questions are currently open, the issues arising from the work reviewed in this chapter seem to be among the most intriguing ones that research on quantification has recently begun to tackle, and they promise genuinely new insights.