Boolean and non-Boolean conjunction

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Abstract
English and-coordinations and analogous constructions in other languages can apparently express a variety of meanings. This chapter explores these meanings and discusses the consequences for the semantic analysis of conjunction morphology. The focus lies on the contrast between ‘Boolean’ and ‘non-Boolean’ conjunction: In some contexts, and appears to denote set-intersection, but in other contexts, it doesn’t. Since several other languages can be observed to be similar to English – a single conjunction form seems to fulfill two different functions – attributing the semantic behavior of English and to lexical ambiguity is not an attractive analytical option. This raises the question which uniform meaning for and could account for the apparent dichotomy. The chapter discusses the motivation and predictions of two kinds of proposals: The ‘Boolean’ analysis, which views the meaning of and to be intersective, and the ‘non-Boolean’ analysis, where and is attributed a weaker meaning.

Keywords conjunction, Boolean conjunction, intersective conjunction, non-Boolean conjunction, collective conjunction, plurality, cumulativity, distributivity

1 Introduction
All natural languages exhibit coordination, a formal strategy that creates new syntactic objects from two or more expressions without any of the latter being in any obvious way syntactically subordinate to the other(s) (cf. Zamparelli (2011) for an overview). This chapter concentrates on and–coordinations in English and analogous constructions in other languages, configurations I refer to as ‘conjunctions’. My aim is to consider the range of meanings they display and to characterize, on the basis of these observations, the semantic operation by means of which the meanings of the conjuncts are connected. I term this semantic operation ‘AND’, distinguishing it from its formal counterparts such as English and, French et etc. The focus will lie on what is known as the opposition of ‘Boolean’ and ‘non-Boolean’ conjunction, which essentially boils down to the question whether AND is an operation analogous to set-intersection (the ‘Boolean’ view), or not. Following a discussion of the syntactic distribution of conjunction and the problems it gives rise to (section 2), sections 3 – 5 will provide the empirical motivation for the afore-mentioned opposition and address three questions: Are there two ANDs, a Boolean one and a non-Boolean one – i.e. is English and ambiguous? Are the Boolean and the non-Boolean construals of conjunction in complementary distribution w.r.t. the semantic category of the conjuncts? And finally, can we derive the Boolean construal of conjunction from an underlying non-Boolean AND or vice versa?

My background will be the framework outlined in Heim and Kratzer (1998), but I will sometimes use set- and function-talk interchangeably, depending on which form of representation seems more adequate for purposes of illustration.

2 The cross-categorial occurrence of conjunction
We start our investigation of AND by looking at sentential conjunction. (1) gives an example from English where the morpheme and coordinates two sentential expressions, S1 and S2. The truth-conditions

1
are straightforward: (1) is true in a situation \(s\) iff both conjuncts – \(S_1\) and \(S_2\) – are true.

\[
\begin{align*}
\text{If both conjuncts } S_1 \text{ and } S_2 \text{ are true.}
\end{align*}
\]

Accordingly, the truth-conditions of a sentential conjunction \(S\) and \(S'\) correlate with the truth-value of the individual conjuncts as in (2):

\[
\begin{array}{c|c|c|c}
S \quad S' \quad \text{AND} \quad 1 & 1 & 1 \\
0 & 1 & 0 \\
0 & 0 & 0 \\
\end{array}
\]

I call the denotation of \(\text{AND}\) when conjoining sentences \(\text{AND}_s\). On the basis of (2), we can determine that \(\text{AND}_s\) is a function which, given the truth-values 1 and 0, maps elements of \(\{0, 1\} \times \{0, 1\}\) to a truth-value: The pair \(\langle 1, 1 \rangle\) to 1 and all other pairs to 0. (I will make use of the curried version of this function below, i.e. a function from \(\{0, 1\}\) to a function from \(\{0, 1\} \times \{0, 1\}\). The insight that \(\text{AND}_s\) is this particular truth-functional connective can already be found in work by the Stoics (cf. (Kneale and Kneale, 1962, 147f)), from which it entered the formal languages: \(\text{AND}\) – \(\wedge\) – in classical propositional logic is the truth-functional connective that maps pairs of truth-values to truth-values as in (2) above. Because of Boole's algebraization of classical propositional logic, \(\wedge\) is also referred to as a ‘Boolean operator’. Therefore, treatments of \(\text{AND}\) in which there is a clear semantic connection to \(\text{AND}_s\) are usually called ‘Boolean’.

### 2.1 Non-sentential conjunction

If we aim to establish the meaning of \(\text{AND}\), however, we have to take into account that it does not only conjoin sentences, but expressions of any syntactic category, (cf. Ross (1967)). The only syntactic constraint on the surface constituents seems to be (3), (cf. Goodall (1987)).

\[
\begin{align*}
\text{Substitutability requirement} \\
[S \ Z \ [X \ and \ Y] \ W] \text{ is well formed iff } [S \ Z \ X \ W] \text{ is well-formed and } [S \ Z \ Y \ W] \text{ is well-formed.}
\end{align*}
\]

(3) does not require the conjuncts to be of the same syntactic category, and accordingly correctly predicts that coordination of AP and PP in (4) is fine, as both coordinates are individually licensed in the position of the coordinate structure; at the same time, it rules out the ungrammatical case in (5), which does not meet this substitutability requirement.

\[
\begin{align*}
\text{(4) } & \text{John is } [\text{AP ugly}] \text{ and } [\text{PP from Boston}]. \\
\text{(5) } & \text{*John } [\text{DP Mary}] \text{ and } [\text{V adores }] \text{ Bob.}
\end{align*}
\]

The cross-categorial occurrence of \(\text{AND}\) in English cannot be explained by incidental homophony of different lexical elements: Apart from the Indo-European languages (cf. Mauri (2008)), many typologically diverse languages use the same form for sentential conjunction and conjunction of (at least) the major syntactic categories V(P), DP, A(P), PP. Haspelmath (2013) gives a coarse survey and Payne (1985), Haspelmath (2004) and Drelishak (2004) provide examples from a number of geographically and genetically unrelated languages.

### 2.2 Conjunction Reduction

From a syntactic perspective, the cross-categorial occurrence of \(\text{AND}\) is disconcerting, as sensitivity towards syntactic categories is one of the hallmarks of natural language syntax. This uneasiness is already evident in (3) above, which can only be formulated as an output constraint on entire sentences but not as
a locally applicable rule. From a semantic perspective, we wonder whether there is a connection between the meaning of and in sentential conjunction – AND – and its other occurrences: It would be surprising if so many languages used the same formal strategy to express a variety of unrelated meanings.

The classical solution to both problems, the so-called ‘Conjunction-Reduction (CR)-analysis’ (cf. Gleitman (1965), Tai (1969)) is based on two observations. First, the non-sentential conjunction in (6a) and the sentential conjunction in (6b) have the same truth-conditions.

(6) a. John [[VP lives in New Jersey] and [VP works in New York]].
    b. [S John lives in NJ] and [S John works in NY]

Second, coordinate structures cross-linguistically exhibit a cluster of phenomena referred to as ‘conjunction reduction’ (CR), (Ross, 1967): All the examples in (7) seem to involve conjunction of category S, but in each case one of the coordinates is missing vital parts, indicated by “—.” (⇒ chapter ‘Ellipsis’)

(7) a. What a coincidence! [S Last night, Mary bought — and [S Peter broke an expensive Chinese vase]. adapted from Abels (2004, 45:(1))
    b. [S All girls admired — but [S most boys detested one of the saxophonists].
        Geach (1970, 8) [my brackets]

Combining these two observations, the CR-analysis views all instances of non-sentential conjunction as derived from sentential conjunction. Arguably, there is more than one CR-operation: (7a) suggests that the missing material is elided under semantic (and syntactic) identity with the antecedent in bold-face (cf. Hartmann (2000) a.o.), because we find an ‘independent construal’: The antecedent an expensive Chinese vase is independently construed in both conjuncts, as the vase that Mary bought can be different from the one Peter broke. The prominent reading of (7b) on the other hand, does not involve an independent construal. Rather, it conveys that there is a single musician who is the object of the children’s attitudes. This suggests that (7b) is derived by (overt or covert) across-the-board (ATB) –movement (Ross (1967), Williams (1978)), rather than ellipsis. I treat movement here as in Heim and Kratzer (1998), yielding the structure in (8a), where I is the syntactic correlate of abstraction over the variable I (of type e) in its sister constituent. Accordingly, (8a) is interpreted as in (8b).

(8) a. [I [S All girls admired t₁] but [S most boys detested t₁] [one of the saxophonists]]
    b. [one of the saxophonists] ([∀x, all the girls admired x ∧ most boys detested x ])

In sum, the CR-analysis boils down to the claim schematized in (9). Thus, (6a) has the underlying structure in (6b) and both our our problems are solved: and always selects the category S and always denotes AND.

(9) [S Z X W] and [S Z Y W] underring form

ellipse or ATB–movement

⇒ [S Z [X and Y] W] surface form

In order to not complicate matters too much, I omit the discussion of examples such as (10), brought up by Perlmutter and Ross (1970) and Jackendoff (1977), which seem to be clear cases of CR but cannot be derived by (9).

(10) John lives next to — and works opposite of the very same building!

2.3 Two problems

The CR analysis faces two problems of different quality. While what I term the ‘syntactic problem’ does not question the semantic connection of non-sentential conjunction and AND, but concerns the syntactic connection between surface structure and logical form (LF), the problem I refer to as the ‘semantic problem’ casts doubt on the assumption that all occurrences of and denote a semantic operation identical to or derived from AND (cf. Lasersohn (1995) for an overview of both problems).
Let us first consider the syntactic problem. Take (11a). If it were derived from sentential conjunction via ellipsis, then (11a) should have the same truth-conditions as (11c) – but it doesn’t: Whereas (11c) involves an independent construal of the subject quantifier in each conjunct, the truth-conditions of (11a) are those in (11b). Nevertheless, not all is lost for the CR-analysis in this case: The subject quantifier could move ATB from both sentential conjuncts, deriving the LF in (11d) which would be assigned the correct truth-conditions in (11b).

(11) a. Some student lives in New Jersey and works in New York.  
               Keenan and Faltz (1984, 5:(9a))

b. 1 iff ∃x [ x is a student ∧ x lives in NJ ∧ x works in NY]

c. Some student lives in NJ and some student works in NY.

d. Some student [1 [ t1 lives in NJ ] and [ t1 works in NY ]]

Neither ellipsis nor ATB-movement, however, will save the CR-account in light of (12a). The only LF which would allow and to denote ANDt and derive the correct truth-conditions in (12b) is the one in (12d). But none of the syntactic operations at our disposal will derive this structure from the sentential source in (12c).

(12) a. Some poet and actor is contemplating suicide.

b. 1 iff ∃x [ x is a poet ∧ x is an actor ∧ x is contemplating suicide ]

c. [ S Some poet is contemplating suicide ] and [ S some actor is contemplating suicide ].

d. [ S Some [ 1 [NP t1 poet ] and [NP t1 actor ]] [VP is contemplating suicide ]]

While the examples discussed so far do not question the connection between and and ANDt, data like (13a) suggest that there are occurrences of and where its meaning is not connected to ANDt: There is no obvious way in which (13a) can be paraphrased by means of sentential conjunction – its presumed sentential source in (13b) is not well-formed. This is the semantic problem for the CR-approach.

(13) a. Mary and Sue met.

b. # Mary met and Sue met.

In sum, these two problems suggest that the CR-analysis of non-sentential conjunction cannot be correct. However, they have different implications for the alternative treatment pursued. The syntactic problem suggests that there is a semantic connection between the denotation of and in sentential conjunction and its other occurrences. This is the fundamental property of ‘generalised Boolean conjunction’, which I turn to in section 5. The semantic problem, on the other hand, indicates that there is no such connection. This stands behind the notion of ‘non-Boolean conjunction’, which will be the subject of section 4.

It should be noted that some proposals, in particular Schein (1997), maintain the CR-account in spite of the problems. His motivation are cases like (14), brought up by Collins (1988): (14) is similar to (13a) but the occurrence of the sentential adverb possibly inside the conjunction indicates that even this configuration might require sentential conjunction at some level.

(14) Mary, Sue and possibly John met.

Schein argues that if we add events to our ontology and allow for richer logical forms (LFS), and can always denote ANDt. (15) is the simplified paraphrase of the meaning of (13a) in his account – it only involves instances of ANDt.

(15) There is a meeting-event e s.th. Mary is an agent of e ∧ Sue is an agent of e.

As pointed out by Lasersohn (1995), this leaves open why (13b) is bad, i.e. why Mary and Sue cannot each be agents of different meeting-events – unless, of course, further assumptions are made about the nature of meeting-events (cf. Schein (1997)). Furthermore, in order to make sure that Mary and Sue are the only agents of the meeting event in (13a).
Schein has to conjoin (15) with the exhaustivity requirement in (16). This, however, raises the question what the object-language representation of sentences like (13a) looks like and furthermore how exactly these object-language expressions are interpreted by a compositional system (cf. Winter (2001a) for this point).

Finally, Schein does not address instances of the syntactic problem such as (12a) and it is not obvious how his account would derive the correct truth-conditions. I thus won’t pursue this alternative any further; nevertheless Schein is correct in pointing out that examples like (14) represent an obstacle for other accounts of conjunction (but cf. Landman (2004) for a potential solution).

3 Boolean conjunction

In this section, we will focus exclusively on the syntactic problem, considering a solution which meets all of the desiderata following from the discussion above: It provides a cross-categorial meaning for and that will allow for it to be interpreted in situ without assuming CR, it avoids multiple ambiguity of and it maintains the semantic connection between AND and the denotation of and in non-sentential conjunction which was witnessed on the basis of examples like (11) and (12).

3.1 A syntactic solution

I have so far employed what could be called a ‘Government-and-Binding (GB)-approach’ to the syntax-semantics interface (cf. von Stechow (1991), Heim and Kratzer (1998), Fox (2003) for discussion): All levels of syntactic representation, including LF, are formed by the syntactic operations ‘merge’ and ‘move’, and type-conflicts are usually resolved by syntactic movement.

Geach’s [1970] cross-categorial syntactic analysis of and on the other hand, was developed within categorial grammar, a syntactic framework initially developed by Ajdukiewicz (1935) (cf. van Benthem (1991) for an overview of different categorial systems and their properties). Syntactic structures are derived (exclusively) by rules on the logical types of expressions, given in (17), which in turn reflect the denotation of the expression. The domains these denotations live in are given in (18).

(17) The set of extensional types $T$ is the smallest set $S$ s.th. $e \in S$, $t \in S$ and if $a \in S$ and $b \in S$, then $(a, b) \in S$.

(18) a. $D_e =$ the (non-empty) set of all individuals
b. $D_t = \{0, 1\}$
c. $D_{(a, b)} =$ the set of all functions $f : D_a \rightarrow D_b$

Syntactic rules on types adhere to what van Benthem [1991] calls ‘semantic recipes’, which I will supplement Geach’s syntactic proposal with. Take for instance function(al) application: The semantic recipe for the syntactic rule FA in (19a) is FA in (19b).

(19) a. $FA((a, b))(a) = b$
b. For any $f \in D_{(a, b)}$, $u \in D_a$, $FA(f)(u) = f(u)$.

Now consider the syntactic problem from this perspective: Sentential and is an expression of type $(t, (t, t))$ – denoting AND, i.e. the function $[\lambda p, \lambda q, p \land q]$ – but and can occur with conjuncts of types other than $t$, as in (20). So if (19a) is the only rule at our disposal, we cannot derive (20) as grammatical.

(20) $[[\text{lives in NJ}]_{(e, t)} [[\text{and}]_{(t, (t, t))} [\text{works in NY}]_{(e, t)}]]$

The first step of Geach’s proposal is to capture the distribution of and in terms of the type of the conjuncts. We replace the substitutability requirement by (21): (21) rules out [5] because Mary and smoke
don’t have the same logical type.

(21) **type identity requirement**

For any (well-formed) expressions $X$ of type $a$, $Y$ of type $b$, $[X$ and $Y]$ is well-formed iff $a = b$.

(21) does not rule out (20) of course – we still must explain how *and* in (20) can combine with the two conjuncts. Crucially, Geach makes use of another type-combinatorial rule, function(al) composition (cf. also [Lambek (1958)]): FC in (22a), with the semantic recipe FC in (22b). FC will combine two functions $f$ and $g$ if the range of $g$ is the domain of $f$, yielding that function $h$ which maps any $X$ from the domain of $g$ to what we obtain by applying $f$ to the value which $g$ yields for that $X$. More informally, we push $g$’s argument out of the way, promising to take care of it later.

(22) a. $\text{FC} \left( \langle a, b \rangle \right) \left( \langle c, a \rangle \right) = \langle c, b \rangle$

b. For any $f \in D_{\langle a, b \rangle}$, $g \in D_{\langle c, a \rangle}$, $\text{FC}(f)(g) = [\lambda x. f(g(x))]$

As an example, consider negation: *not* has the type $(t, t)$, denoting the function $[\lambda p. \neg(p)]$. In a system that only includes FA, it may combine exclusively with expressions of type $t$ – whereas in a system containing both FA and FC, it can, for instance, combine with expressions of type $(e, t)$, such as *smoke*: By FC, *not smoke* is of type $(e, t)$, denoting, qua FC the function $[\lambda x. \neg(x \text{smokes})]$. For *and*, Geach requires the transitive version of FC, here called FC’’, (23a). Its semantic correlate is given in (23b).

(23) a. $\text{FC}'' \left( \langle a, (a, b) \rangle \right) \left( \langle c, a \rangle \right) \left( \langle c, a \rangle \right) = \langle c, b \rangle$

b. For any $f \in D_{\langle a, b \rangle}$, $g \in D_{\langle c, a \rangle}$, $h \in D_{\langle c, a \rangle}$, $\text{FC}''(f)(g)(h) = [\lambda x. f(g(x))(h(x))]$

According to (23a) *and* of type $(t, (t, t))$ can combine directly with two conjuncts of, for instance, type $(e, t)$, such as *works in NY* and *lives in NJ*, resulting in an expression of type $(e, t)$: The entire conjunction ends up with the same type as the individual conjuncts. Given FC’, combining the denotation of *and*, $[\lambda p, q. p \land q]$ with the conjuncts’ denotations gives us $[\lambda x. \text{works in NY} \land x \text{lives in NJ}]$ – i.e. that function which maps any individual $x$ to 1 iff AND, when applied to the values the two predicates return us for $x$, yields 1.

3.2 Generalized Boolean conjunction

We just tackled type-polymorphism – the fact that expressions like *not* or *and* can syntactically combine with expressions of various types – by syntactic rules FC and FC’’. There is another way to conceive of this basic strategy (cf. [Cresswell (1973)]): Rather than positing syntactic rules that combine certain types $\alpha$ with certain types $\beta$ to form types $\gamma$, we can introduce a regular type-change for type-polymorphic expressions that essentially encodes the effect of FC/FC’’ . This is what G in (24a), known as the ‘Geach-rule’, and its transitive version $G''$ in (25a) do: They map functional types to their parametrised forms which encode their combinatorial potential w.r.t. FC and FC’’, respectively.

(24) a. $G((a, b)) = \langle (c, a), (c, b) \rangle$

b. For any $f \in D_{\langle a, b \rangle}$, $G(f) = \lambda g_{\langle c, a \rangle}. \lambda x. f(g(x))$

(25) a. $G''((a, (a, b))) = \langle (c, a), (c, a), (c, b) \rangle$

b. For any $f \in D_{\langle a, (a, b) \rangle}$, $G''(f) = \lambda g_{\langle c, a \rangle}. \lambda h_{\langle c, a \rangle}. \lambda x. f(g(x))(h(x))$

For *and* we obtain the parametrised form $G''((t, (t, t))) = \langle (c, t), (c, t), (c, t) \rangle$ – or, more generally, the parametrised form $(\langle a, (a, a) \rangle$, where $a$ is a $t$-conjoinable type, as defined in (26) (cf. [von Stechow (1974)], [Gazdar (1980), a.o.). In other words, *and* can combine – now simply by FA – with any two conjuncts as long as they have the same $t$-conjoinable type.

(26) The set of $t$-conjoinable types $TC$ is the smallest set $S$ s.th. $t \in S$ and for any type $a \in T$, $\langle a, t \rangle \in S$. 

6
Mapping an expression of type \( \alpha \) to its parametrised form requires a semantic recipe that captures the underlying intuition that the type change encodes a systematic transfer of meaning (cf. in particular van Benthem (1991)). The semantic blueprints \( G \) and \( G' \) in (24b) and (25b) – which reflect FC and FC’ above – essentially let us define operations on some domain in terms of operations on another domain. For and, this has the following effect: Taking it from type \( \langle t, \langle t, t \rangle \rangle \) to type \( \langle a, \langle a, a \rangle \rangle, a \in TC \), means that take we take its denotation AND\(_D\) from \( D_{\langle a, \langle a, a \rangle \rangle} \) and map it to a function in \( D_{\langle a, a \rangle} \) via \( G' \), defining what that function does to its arguments in \( D_a \) by appealing to what AND\(_D\) does to its arguments in \( D_t \), (27).

\[
G'(\text{AND}_D) = [\lambda h_{(a,a)} \cdot \lambda g_{(a,a)} \cdot \lambda x_a \cdot h(x) \land g(x)]
\]

Given this background, we can now introduce the cross-categorial Boolean meaning for and – \( \text{AND}_B \) – proposed (in slightly different variants) by von Stechow (1974), Keenan and Faltz (1978), Gazdar (1980) and Partee and Rooth (1983). \( \text{AND}_B \) – \( \cap \) – in (28) recursively extends \( \text{AND}_D \) – \( \land \) – to objects of any semantic domain \( D_a \), as long as \( a \) is a t-conjoing type.

\[
\text{AND}_B \quad (X)(Y) = X \cap Y = \begin{cases} X \land Y & \text{if } X, Y \in D_t \\ \lambda Z_a. (X \cap Y)(Z) & \text{if } X, Y \in D_{\langle a, a \rangle} \text{ and } \langle a, b \rangle \in TC \end{cases}
\]

The (recursive) definition of the operation \( \text{AND}_B \) based on \( \text{AND}_D \) retrieves part of the Boolean structure of any domain \( D_a \), where \( a \) is a t-conjoing type: All such domains \( D_a \) have the structure of a power-set (Boolean) algebra and accordingly are closed under the \text{meet}-operation, \( \cap \). (28) gives us a point-wise definition of this \text{meet}-operation on any \( D_a, a \in TC \), in terms of the \text{meet} on \( D_t \) (\( \land \)). Effectively, we could say that \( \text{AND}_B \) is simply the \text{meet} operation on any domain \( D_a \) (and accordingly, the Boolean meaning for and is also called the ‘intersective’ meaning). Note, however, that this only works if we don’t impose any restrictions on our domains – if, for instance, we limit them in such a way that they only contain the denotations of actual natural language expressions, then this point-wise definition will no longer work (cf. Keenan and Faltz (1984), van Benthem (1991)).

3.3 Expanding the scope of the analysis

and in (6) and (11a) above is now analysed as a VP-coordinator, as shown in (29a) and (29b). We obtain (29c) as the denotation of the conjunction. In (29a), this function will apply to [John]: The sentence is true iff John both lives in NJ and works in NY. In (29b) it will serve as the argument of the subject quantifier: The sentence is predicted true iff there is a student that both lives in NJ and works in NY.

\[
\text{John} \quad [\text{VP} \ [\text{VP lives in NJ}] \text{ and } [\text{VP works in NY}]]
\]

\[
\text{Some student} \quad [\text{VP} \ [\text{lives in NJ}] \text{ and } [\text{works in NY}]]
\]

\[
[\text{lives in NJ}] \cap [\text{works in NY}] = [\lambda x_a. \text{x lives in NJ} \land \text{x works in NY}]
\]

and in (12a) can now be analysed as coordinating NPs, (30a). This yields (30b) as the denotation for the conjunction, which serves as the restrictor of [some]: The sentence comes out as true iff there is an individual that is both a poet and and actor and is contemplating suicide.

\[
[\text{poet}] \cap [\text{actor}] = [\lambda x_a. \text{x is a poet} \land \text{x is an actor}]
\]

We thus derive the desired truth-conditions for all three sentences and no longer obtain the undesired independent construals for (29b) and (30a) predicted by the CR-account. Interestingly, however, there are some instances of conjunction where an independent construal still seems observable: (31a) for instance, where a referentially opaque verb is conjoined with an transparent one, can be paraphrased by (31b) \( \Rightarrow \) chapter ‘Referentially opaque transitive: I owe you a horse’

\[
\text{John needed and bought a new coat.}
\]

Rooth and Partee (1982 354:(8))
b. John needed an unspecific new coat and bought a specific new coat.

According to [Rooth and Partee (1982) and Partee and Rooth (1983), (31a) forms a minimal pair with (32a) which involves coordination of two transparent verbs and lacks an independent construal, i.e. cannot be paraphrased by means of (32b). This suggests that (31) cannot be taken as straightforward evidence that we (sometimes) need a CR-analysis after all – because why would ellipsis be licensed in (31a) and not in (32a)?

(32) a. John caught and ate a fish.  
    b. John caught a fish and ate a fish.

Partee and Rooth (1983) explain this contrast by appealing to type-shifting principles and constraints on when they apply. The basic assumption is that a syntactic category \( \mathbf{X} \) is not mapped to exactly one kind of denotation, but rather associated with a whole collection of kinds of denotations, the members of which are determined by type-combinatorial properties, set-theoretic properties of the semantic domains or possibly also more general cognitive factors (cf. Partee (1987), van Benthem (1991), Winter (2001a)).

For instance, while some empirical facts suggest that proper names denote objects in \( \mathbf{D} \) (cf. Partee (1987) for discussion), the fact that we can conjoin Pedro and every other farmer in (33), in combination with the identical type requirement, indicates that Pedro can denote an object in \( \mathbf{D}_{\langle \langle \mathbf{e}, \mathbf{t} \rangle, \mathbf{t} \rangle} \).

(33) Pedro and every other farmer beat donkeys.  

The observation that proper names can have their extensions not only in \( \mathbf{D} \) but also in \( \mathbf{D}_{\langle \langle \mathbf{e}, \mathbf{t} \rangle, \mathbf{t} \rangle} \) is captured by adding the type-shift \( \mathbf{M} \) in (34a) to the grammar, the semantic effect of which in (34b) is to map any individual to its principal ultrafilter, i.e. to the set of all its properties (cf. Montague (1973), Partee (1987)).

(34) a. \( \mathbf{M}(\mathbf{e}) = (\langle \langle \mathbf{e}, \mathbf{t} \rangle, \mathbf{t} \rangle) \)  
    b. \( [\mathbf{M}] = [\lambda x. \lambda y. \mathbf{V}(x)(y)] \)

If AND\( _B \) is our uniform denotation for \textit{and}, we will require \( \mathbf{M} \) not only in (33) but also in conjunctions of proper names as in (35a) since \textit{and} can only combine with conjuncts of \( \mathbf{t} \)-conjoinable types. Affixing the individual conjuncts with \( \mathbf{M} \) gives us the right result, as laid out in (35b).

(35) a. Mary and Sue are blond.  
    b. \( [\mathbf{M}] (\mathbf{Mary}) \cap [\mathbf{M}] (\mathbf{Sue}) ([\mathbf{blond}]) = [\lambda x. \lambda y. \mathbf{V}(x)(y) \wedge \mathbf{P}(\mathbf{Mary}) \wedge \mathbf{P}(\mathbf{Sue})]\langle \mathbf{blond} \rangle = 1 \text{ iff Mary is blond and Sue is blond} \)

Returning examples (32) and (31) Partee and Rooth (1983) argue that those grant us insight in how such type-shifts are constrained. Given type-shift \( \mathbf{M} \), extensional verbs such as catch and eat could have two denotations, (36).

(36) a. \( \lambda x. \lambda y. \mathbf{V}(x)(y) \)  
    b. \( \lambda Q_{\langle \langle \mathbf{e}, \mathbf{t} \rangle, \mathbf{t} \rangle}. \lambda y. Q(\lambda x. \mathbf{V}(x)(y)) \)

If both were always available, (32a) should have two readings: Conjoining the verbs in their lower type gives us the function in (37a) which takes an individual argument, and can thus only combine with a variable bound by the object quantifier, (37b) resulting in the ‘single fish’-reading. Conjoining them in their higher type as in (38a) means they can combine directly with the object quantifier, (38b). Here we obtain the ‘two fish’ (independent) - reading.

(37) a. \([\lambda x. [\lambda y. x \text{ caught } y \wedge \lambda y. \text{ ate } y]] \)  
    b. \([a \text{ fish }] \) ([\lambda z. \text{ John caught } z \wedge \text{ John ate } z])
Partee and Rooth (1983) argue that the two-fish-reading is absent in (32a) because (38a) is blocked by the general principle that expressions are assigned their lowest type by default and that type-shifting occurs only to prevent type-mismatch, as in (33) or in (35). As no type-shift is required in (32a), the verbs are conjoined in their lowest type, (37a) and the independent construal does not arise. The default-denotation of need in (31a) on the other hand is \( \lambda P_{\langle (e,t) \rangle} \). The type-shift \( D \) in (41a), variants of which were proposed by Cooper (1979), Partee and Rooth (1983) and Dowty (1988), recovers this observation: \( D \) maps the NP-denotation to a function that takes a determiner-denotation as its argument and applies the latter to the former, (41b).

In order to derive the correct meaning for (40) we affix the conjuncts with \( D \) and then conjoin them by \( \text{AND}_B \) – the resulting function applies to the determiner, which means that the determiner will end up applying to each conjunct-denotation individually, (42).

This strategy gives us the correct truth-conditions for (40) but we are lacking a principled account when type-shift \( D \) occurs. It is not triggered by type-mismatch, nor does it generally apply to NPs in this particular syntactic context: (29b) above shows that it does not occur in the context of (singular) some. We will see more data from NP-conjunction below.

4 Non-Boolean conjunction

The generalised Boolean analysis for and essentially transfers AND, to other domains for \( t \)-conjoinable types and thus rides us of the syntactic problem. The semantic problem sketched in section 2.3 above, on the other hand, suggests that there is no semantic connection between AND, and other instances of AND. We will now take a closer look at this problem, addressing three questions: Is and ambiguous, i.e. does it have a Boolean meaning and another, ‘non-Boolean’ one? How do we characterize this
non-Boolean meaning? And finally, is there a way to maintain that and uniformly denotes AND_B even in light of this problem?

4.1 Non-Boolean construals and ambiguity of and

The sentences in (43a) and (43b) involve conjunction of proper names.

(43) a. Mary and Sue met.
   b. Mary and Sue fed these three cats.

Our strategy from (35) above – using type-shift M and AND_B – fails in both cases. It yields (44), where the VP-denotation will apply to Mary and Sue separately.

(44) \[ \lambda P_{(e)}. P(Mary) \land P(Sue) \] \( [\text{VP}] \)

For (43a) to be true Mary and Sue thus each have to be in the extension of meet, but the unacceptability of (45) suggests that this predicate cannot have such ‘atomic’ individuals in its extension. Hence (43a) is falsely predicted to be as unacceptable as (45).

(45) # Mary met.

For (43b) we predict that \[ \text{fed the three cats} \] must hold of each of Mary and Sue for the sentence to be true, but the actual truth-conditions are much weaker: The sentence is also true in scenarios where Mary and Sue fed the three cats between them (e.g. Mary feeding cats 1 and 2, Sue feeding cat 3).

The examples we considered in section 3.3 above exhibit what I will call ‘Boolean construals’ (BC) – construals of conjunctions that can be derived by use of AND_B. The sentences in (43) on the other hand, display ‘Non-Boolean-Construals’ (NBC) – construals of conjunctions for which no straightforward derivation by means of AND_B is available. Does the availability of two types of construals indicate that there are two meanings for English and, i.e. that and is ambiguous between AND_B and another meaning?

If we were dealing with ambiguity, encoding BC and NBC by identical forms should be more or less idiosyncratic to English. If, on the other hand, other languages behave like English and use the same formal strategy to encode BC and NBC, it is unlikely that and is ambiguous.

Unfortunately, most typological research is not informative on this matter. The most extensive cross-linguistic survey of coordination, Dryer and Haspelmath (2013), does not consider the semantic distinction between BC and NBC but rather investigates whether a language may use different formal strategies for VP- and DP-conjunction. Not only does this study focus on syntactic categories, but its query – whether a language can employ different strategies – is different from what we are interested in, namely, whether it must employ different strategies. Therefore, the results have to be interpreted with care: Out of 301 investigated languages, the survey finds that 176 (typologically diverse ones) do not exhibit different strategies. If VP-conjunction allows for BC and if DP-conjunction, as in English, sometimes exhibits NBC, then this results tell us that at least 176 languages in the sample are like English and that therefore English and is not ambiguous (cf. Winter (2001a) and Champollion (2015b) for the same assumption).

This conclusion obviously rests on assumptions about form-meaning mappings that could prove to be flawed, nevertheless, it is supported by language-specific discussions of some non-Indo-European languages, such as Lezgian (Haspelmath, 1993) and Hungarian, (Szabolcsi and Haddican, 2004), where the relevant semantic contrast is found to have no effect on the formal strategy employed (but cf. section 5.2).

So, if and is not ambiguous, how do we explain that it gives rise to both BC and NBC?

4.2 Conjunctions and plurals

The examples of NBC in (43) involve conjunction of DPs that have \( e \) as their basic type – henceforth ‘e-conjunctions’. e-conjunctions in English and other languages exhibit clear parallels to morphologi-
cal plurals (here simply ‘plurals’) concerning morpho-syntactic properties such as agreement but also combinatorial and interpretative properties (cf. Payne (1985), Corbett (2000) a.o.). In particular, all predicates that can occur with plurals can also occur with *-conjunctions and the resulting sentences have analogous truth-conditions (cf. Link (1983), Schwarzschild (1996)).]

Example (35) above showed that in the context of distributive predicates like blond, *-conjunctions display BC: The predicate has to hold of the denotation of each conjunct. Combining such predicates with plurals yields a similar picture: the girls intuitively denotes the collection of all salient girl-individuals, and (46) is true iff each of these individuals is blond.

(46) The girls are blond.

The behavior of plurals and *-conjunctions is also parallel when they occur as co-arguments with another plural or *-conjunction, as in (43b) above and (47) below (cf. Schwarzschild (1994) a.o.). Such structures exhibit cumulative truth-conditions (cf. Langendoen (1978), Krifka (1986) a.o.): For every member x of collection 1 (girl-collection / collection of Mary and Sue) there is a member y of collection 2 (cat-collection) such that R(y)(x) (where R is the feeding-relation), and for every member y of collection 2, there is a member x of collection 1 such that R(y)(x). I.e. (43b) is true as long as Mary and Sue each fed some of the three cats and all three cats were fed by either Mary or Sue. (47) is analogous: It is true if each girl fed some of the three cats and all three cats were fed by one of the girls.[⇒ chapter ‘Distributivity, collectivity and cumulativity’]

(47) The girls fed these three cats.

Finally, (43a) above and (48) show that plurals and *-conjunctions can both combine with collective predicates like meet, which are not defined for ‘atomic’ individuals.

(48) The girls met.

This parallel behavior suggests that plurals and *-conjunctions have the same kind of denotation.

But what is denotation of a plural? [⇒ chapter ‘Distributivity, collectivity and cumulativity’] Link (1983) argues that the domain of individuals D_e does not only contain individuals that have no parts other than themselves – ‘atoms’ – but also individuals that do have such parts – ‘pluralities’. Using Schwarzschild’s (1996) version of Link’s proposal (which is more suitable for our purposes below), plurals denote sets of individuals, which live in the domain of individuals. I.e. D_e can be partitioned into a set AT of atoms and a set A = \varphi(AT) \setminus \{\emptyset\} – the set of all non-empty subsets of A, which is partially ordered by the ‘part-of’ or ‘non-empty-subset’-relation. I.e. if AT = \{a, b\}, then A = \{\{a\}, \{b\}, \{a, b\}\}. Assuming that singletons can be identified with their only element – which for our limited purposes simply means that we will not distinguish between elements of AT and their corresponding singleton (cf. Schwarzschild (1996) and Van der Does (1992) for motivation and explicit discussion) – we can now get a grasp on plural denotations and plural formation: The denotation of a singular proper name (such as Mary) will be an atom, the denotation of a plural (such as the girls) a set of atoms and the operation that forms plurals (from singletons and non-singletons) is ‘∪’, set-union.

Predicate extensions may thus contain pluralities. Extensions of collective predicates like meet do so primitively. Those of distributive predicates, such as blond, which intuitively hold of atomic individuals, do so via closure under ∪, so-called cumulation, represented here by ‘∗’ and spelled out in (49). (I omit Link’s more explicit treatment of distributive predicates here.) If [blond] primitively holds of Mary and of Sue, its cumulated counterpart *[blond] contains the plurality \{ Mary, Sue \}.[⇒ chapter ‘Distributivity, collectivity and cumulativity’]

(49) For any \(P \in D_{(e,t)}\), \(\ast P\) is the smallest set \(S \in D_{(e,t)}\), s.th. \(P \subseteq S\) and for all \(x, y \in S\), \(x \cup y \in S\). Krifka (1986) and Sternefeld (1998) extend cumulation to transitive predicates as in (50), via the operator
** (cf. Sternefeld [1998] for further expansion). Take a situation where Mary fed cat 1 and cat 2, Sue fed cat 3 and noone else fed anyone. The basic extension of feed is thus \( \langle \text{cat 1, Mary } \rangle, \langle \text{cat 2, Mary } \rangle, \langle \text{cat 3, Sue } \rangle \). We expand it by means of **, adding all pairs of feedee-pluralities and feeder-pluralities which we obtain by summing up the feeders while simultaneously summing up their respective feedees (and vice versa). Hence, **[feed] is the set \( \{ \langle \text{cat 1, Mary } \rangle, \langle \text{cat 2, Mary } \rangle, \langle \{ \text{cat 1, cat 2 } \}, \langle \{ \text{cat 1, cat 2, cat 3 } \}, \langle \{ \text{Mary, Sue } \} \rangle \} \). [⇒ chapters ‘Distributivity, collectivity and cumulativity’, ‘Plurality and Cumulation: Dutch computers’]

\[(50)\] For any \( P \in D(e, (e, t)) \), **\( P \) is the smallest set \( S \in D(e, (e, t)) \), s.th. \( P \subseteq S \) and for all \( x_1, x_2, y_1, y_2 \), if \( \langle x_1, x_2 \rangle \in S \) and \( \langle y_1, y_2 \rangle \in S \), then \( \langle x_1 \cup y_1, x_2 \cup y_2 \rangle \in S \).

A plural the NP denotes the maximal element of * [NP]: If \( \text{[girl]} = \{ \text{Sue, Mary} \} \), then \( \text{the girls} \) denotes the maximal element of \( \{ \text{Mary, Sue}, \{ \text{Mary, Sue } \} \} \), i.e. the plurality \( \{ \text{Mary, Sue} \} \). Given the parallel between plurals and \( e \)-conjunctions, the denotation of \( \text{Mary and Sue} \) should thus also be \( \{ \text{Mary, Sue } \} \). For Link (1983) and Schwarzschild (1996), this is the result of the denotation of \( \text{and} \) in \( e \)-conjunctions – \( \text{AND}_e \) – which simply gives us the union of the conjuncts’ denotations (51). (Cf. Hoeksema (1983, 1988) and Landman (1989) for partially related proposals).

\[(51)\] \( \text{AND}_e = [\lambda x_1, \lambda y_1, x \cup y] \)

\( \text{AND}_e \) in \( e \)-conjunction derives the semantic parallel to plurals and provides us with the correct truth-conditions for the sentences considered so far. For (35a) above we no longer require \( \text{AND}_B \), as we now obtain the desired truth-conditions \( \text{qua} \) the lexical properties of the predicate: The plurality in (52a) is in the cumulated extension of \( \text{blond} \) iff its atomic parts are. (43a) involves attributing a primitive property of pluralities to a plurality, as shown in (52b) and the cumulative truth-conditions of (43b) are derived by application of ** to the extension of feed, (52c).

\[(52)\] a. \( \text{[Mary and Sue are blond]} = 1 \) iff \( \{ \text{Mary, Sue } \} \in * \text{[blond]} \)

b. \( \text{[Mary and Sue met]} = 1 \) iff \( \{ \text{Mary, Sue } \} \in \text{[meet]} \)

c. \( \text{[Mary and Sue fed the three cats]} = 1 \) iff \( \{ \{ \text{cat1, cat2, cat3 } \}, \{ \text{Mary, Sue } \} \} \in ** \text{[feed]} \)

Crucially, \( \text{AND}_e \) – the meaning for \( \text{and} \) in \( e \)-conjunctions according to the proposal just considered – is a very different operation from \( \text{AND}_B \): The former is the \( \text{conj} \) operation on \( D_e \), whereas the latter is the \( \text{meet} \) operation of \( D_a \) (with \( a \) a t-conjoinable type). This is unattractive in light of the typological situation addressed above, but at least the two meanings have so far been in complementary distribution w.r.t. the type of the conjuncts, which might suggest that we are dealing with some form of aloosemy.

4.3 The cross-categorial occurrence of the non-Boolean construal

Data as in (53), first brought up by Link (1983, 1984), complicate the picture, as they show that NBC are also found for predicate conjunctions, where the conjuncts are of t-conjoinable type \( (e, t) \).

\[(53)\] a. \( \text{What’s going on? The animals are [(P crowing) and (Q barking)] and the barn is on fire!} \)

b. \( \text{Good Lord! The six children are [(P smoking) and (Q dancing)] in the street and the parents are completely wasted!} \)

\( \text{AND}_B \) gives us the VP-denotation \( [\lambda x, \text{P}(x) \land \text{Q}(x)] \) and consequently, \( \text{qua} \) our discussion of plural predication in the previous paragraph, predicts the sentence-meaning schematically paraphrased in (54a).

The actual meanings of the two sentences, paraphrased in (54b), are much weaker, however: (53a) is true, for instance, in a situation with two barking dogs and a crowing rooster and (53b) in a situation where half the children are dancing and the other half is smoking.
(54)  a. Each NP is both P and Q.  
    b. Some of the NP are P, some of the NP are Q and all NP are P or Q.

NBC of predicate-conjunctions might appear to be quite rare (cf. [Winter (2001a,b)]. There is a clear contrast, for example, between the sentences in (53) and those in (55), which seem to only have the BC-paraphrase in (54a). In fact (55b) sounds contradictory – which use of AND would derive, requiring each child to be both blond and brunette.

(55)  a. The three animals are \([P \text{ old}] \text{ and } [Q \text{ fat}]\).
    b. The children are \([P \text{ blond}] \text{ and } [Q \text{ brunette}]\).

Closer scrutiny nevertheless reveals that both conjunctions in (55) permit the NBC-paraphrase in (54b) after all: A vet examining two elderly, thin dogs and a young, obese rooster may utter (56a) truthfully as long as all of them are healthy. Furthermore, (56b) as opposed to (55b), does not sound contradictory. Hence, albeit there seem to be factors that make NBC more accessible, including the semantic relation between the conjuncts’ denotations (cf. [Winter (2001b), Poortman (2014)]) and the context in which the conjunction occurs (cf. Schmitt (2013)), (56) suggests that NBC in predicate conjunction are more pervasive than it might seem at first sight.

(56)  a. The three animals are \([P \text{ old}] \text{ and } [Q \text{ fat}]\), but none of them is ill.
    b. How strange! The children in John’s class are \([P \text{ blond}] \text{ and } [Q \text{ brunette}]\), but the ones in my class all have red hair!

Accordingly, we now have two construals for predicate-conjunction: BC and NBC. Again, this cannot be due to ambiguity of and: Although no cross-linguistic study on this matter exists, anecdotal evidence shows that several languages are like English and use the same form for BC and NBC with t-conjoinable types. The predicate-conjunction in the Hungarian example in (57) is an instance of NBC – its truth-conditions being identical to those of (53a) above – but exhibits the same conjunctive morpheme `és that is also found in sentential conjunction and other instances of BC.

(57)  Az állatok krákoztak és ugattak.
The animals crowed and barked

Edgar Onea (pc)

4.4 Generalized non-Boolean conjunction

A number of proposals argue that NBC show that the cross-categorial meaning of and isn’t AND\(_B\), but ‘non-Boolean’ – i.e. non-intersective (henceforth ‘AND\(_{NB}\’)).

The basic rationale of [Krifka’s (1990) generalized non-Boolean account of AND\(^7\) – here AND\(_{NB1}\) – draws on the parallels between the truth-conditions of (47) and (53b) above, repeated in (58a) and (58b) respectively. (58a) is true iff each of the girls fed at least one of the cats and each of the cats was fed by at least one of the girls. And (58b) is true iff each child has at least one of the two properties and for each property we find at least one child that has it.

(58)  a. The girls fed the three cats.
    b. The six children are smoking and dancing.

We derived the truth-conditions of (58a) via cumulation of the predicate-extension, which meant forming pairs of pluralities, such that if an individual \(u\) is added via \(\cup\) to one component, the individual \(v\) that is in the relevant relation to \(u\) is added via \(\cup\) to the other component. Krifka’s proposal for AND\(_{NB}\) is similar to this synchronized expansion of two components and accordingly to cumulation: Informally speaking, summing up two individuals by \(\cup\) allows us to sum up their properties in parallel. This means that \(P\) and \(Q\) will hold of all those individuals that are made up of P-parts and of Q-parts.
As we sum up properties \textit{qua} summing up the individuals that have them, the basic operation is the \textit{union}-operation \( \cup \) on \( D_e \); this operation is now extended to semantic domains that are non-trivially generated on the basis of \( D_e \). Hence, while \( \text{AND}_B \) essentially expands \( \text{AND}_e \) to all domains for \( t \)-conjoinable types, the present proposal expands \( \text{AND}_e \) to all domains for \( e \)-conjoinable types. The set of the latter is defined in (59).

(59) The set \( EC \) of \( e \)-conjoinable types is the smallest set \( S \) s.t. \( e \in S \) and if \( a \in S \) and \( b \in TC \), then \( \langle a, b \rangle \in S \) and if \( a_1, \ldots, a_n \in S \) and \( b \in TC \), then \( \langle a_1, \ldots, (a_n, b) \ldots \rangle \in S \).

The recursive expansion of \( \cup \) is given in (60). Since \( t \) is not an \( e \)-conjoinable type, \textit{and} in \( t \)-conjunctions is not concerned by this expansion and defined primitively as our (known) \( \text{AND}_t \), the \textit{meet} on \( D_t \). Accordingly, we still have two different operations, \( \cup \) and \( \land \). In analogy to the discussion at the end of section 4.2, this is again a case of contextual allosemy, as the type of the conjuncts determines which operation is used. But whereas above \( e \) represented the special case, it is \( t \) that is exceptional now.

(60) \( \text{AND}_{NB1} \)
\begin{align*}
\text{a. } \quad \left[ \text{U and V} \right] &= \left[ \text{U} \right] \land \left[ \text{V} \right] \quad \text{if } U, V \text{ are of type } t \\
\text{b. } \quad \left[ \text{U and V} \right] &= \text{AND}_{NB1}(\left[ \text{U} \right])\left(\left[ \text{V} \right]\right) = \left[ \text{U} \right] \cup \left[ \text{V} \right] \quad \text{if } U, V \text{ are of type } a \in EC
\end{align*}
where
\begin{align*}
X \cup Y = \begin{cases}
\lambda Z_1 : Z_1, Z_2 : [Z = Z_1 \cup Z_2 \land X(Z_1) \land Y(Z_2)] & \text{if } X, Y \in D_e \text{ and } \langle a, t \rangle \in EC \\
\lambda Z_1^1, \ldots, Z_m^1, Z_1^2, \ldots, Z_n^2 : Z_1^1 \cup \ldots \cup Z_m^1 \land Z_1^2 \cup \ldots \cup Z_n^2 = Z^1 \land X(Z_1^1) \land Y(Z_1^2) \land \ldots \land Y(Z_n^2) & \text{if } X, Y \in D_{(a, t)} \text{ and } \langle a_1, \ldots, (a_n, t) \ldots \rangle \in EC
\end{cases}
\end{align*}

This yields us the denotation in (61) for the conjunction in (58b). The function characterising the set of all individuals consisting exclusively of smokers and dancers, (61). This function returns 1 for \( \text{[the six children]} \) iff the children-plurality consists only of smoking children and dancing children. In a scenario where half of the children are smoking and the other half dancing, the sentence is thus correctly predicted to be true.

(61) \( \text{smoking and dancing} = \text{AND}_{NB1}(\ast \text{[smoking]})(\ast \text{[dancing]})) = \lambda x, y, z [y \cup z = x \land \ast \text{[smoking]} (y) \land \ast \text{[dancing]} (z)]. \)

\( \text{AND}_{NB1} \) does not exclude that each part of the plurality has both properties in question: (58b) also comes out as true in a scenario where each child is both smoking and dancing, since the child-plurality will still consist exclusively of smoking parts and dancing parts. This means that the only scenario where \( \text{AND}_B \) would render (53b) true is included in the scenarios in which \( \text{AND}_{NB1} \) renders (53b) true. Furthermore, the present analysis correctly predicts that for (62), one of our initial examples of BC – to be true, both conjunct-denotations must hold of John: The argument of the conjunction is required to consist of \( \text{[lives in NJ]} \) -parts and \( \text{[works in NY]} \) and since John is atomic, he must have both properties.\(^8\)

(62) \( \text{John lives in NJ and works in NY}. \)

Let us now look at how \( \text{AND}_{NB} \) can be applied to instances of NBC that we have not addressed so far – in particular NBC of DP-conjunction and conjunction of DP-internal material (cf. \text{King and Dalrymple (2004), Heycock and Zamparelli (2005)}). I focus on cases such as (63a) and (63b), a discussion of the analysis of NBC of modifier conjunction as in (64) and its problems) can be found in \text{Krifka (1990)}.

(63) \( \text{a. } \quad \text{[[Five men] and [five women]] met}. \)
\( \text{b. } \quad \text{Five [[men] and [women]] arrived}. \)
(64) \( \text{The [[young] and [middle-aged]] scholars love Ferdydurke, but the old ones adore Broch}. \)
Consider first (63b) which has the two readings paraphrased in (65b) and (65a).

(65) a. Five individuals arrived, among them exclusively men and women.
   b. Five men arrived and five women arrived.

The reading in (65a) falls into our class of NBC, as it cannot be derived by \( \text{AND}_{B} \). If \( \text{AND} \) denotes \( \text{AND}_{NB} \), on the other hand, the NP-conjunction will denote the function characterizing set of all pluralities consisting exclusively of men and women and we derive the correct truth-conditions, (66) (cf. Szabolcsi (2010) for more discussion of the determiner-denotation assumed here).

(66) \[ \text{five} (\text{men and women}) (\text{arrived}) = 1 \text{ iff } \exists x \exists y \exists z \ y \cup z = x \wedge \text{*} \text{man} (y) \wedge \text{*} \text{woman} (z) \wedge \text{*} \text{arrived} (x) \]

Some languages, including English, also allow NBC of conjunctions of singular NPs as in (67) – where the NP-conjunction denotes apparently denotes the set of man-woman pairs (cf. Heycock and Zamparelli (2005)).

(67) This man and woman are in love.  \( \text{Heycock and Zamparelli (2005) 204:(6b)} \)

This observation is in principle not incompatible with \( \text{AND}_{NB1} \) (although we would have to add assumptions about when * targets NP-extensions), but Heycock and Zamparelli (2005) take it to show that such pair-formation must be part of \( \text{AND}_{NB} \) itself and thus propose a revision of Krifka's proposal. Their account involves a slight technical modification: Instead of assuming that atoms and pluralities – sets of such atoms – live in the same domain \( (D_{e}) \), atoms live in \( D_{e} \), while pluralities live in \( D_{(e,t)} \), \( (D_{(e,t)}) \) will also contain all singletons of atoms, therefore, each element of \( D_{e} \) has a correlate in \( D_{(e,t)} \). Accordingly, predicates are now of type \( \langle \langle e, t, t \rangle, t \rangle \). Given this background, Heycock & Zamparelli’s version of \( \text{AND}_{NB} \) – ‘here \( \text{AND}_{NB2} \),’ (68) – is defined for all \( t \)-conjoinable types except for \( t \) itself, which remains the special case, \( \text{AND}_{t} \). If the conjuncts denote individuals or pluralities, \( \text{AND}_{NB2} \) forms their union (in the case of individuals, targeting the corresponding singletons). If the conjuncts denote higher-order objects \( P, Q \), \( \text{AND}_{NB2} \) will return the set of all sets we obtain by forming the union of each element in \( P \) with each element in \( Q \). I.e. if \[ \text{man} = \{\{m1\}, \{m2\}\} \] and \[ \text{woman} = \{\{w1\}, \{w2\}\} \], \[ \text{man and woman} = \{\{m1,w1\}, \{m1,w2\}, \{m2,w1\}, \{m1,w2\}\} \]. This set may subsequently targeted by *.

(68) \( \text{AND}_{NB2} \)

\begin{align*}
\text{a. } & \text{[U and V] = } [\text{U}] \wedge [\text{V}] & \text{if U, V are of type } t \\
\text{b. } & \text{[U and V] = } \text{AND}_{NB2}(\text{[U]}) ([\text{V}]) = [\text{U}] \sqcup [\text{V}] & \text{if U, V are of type } a \in TC, a \neq t \\
\text{where } & \text{[U] \sqcup [V]} = \{ \begin{array}{ll} 
X \cup Y & \text{if } X, Y \in D_{(e,t)} \\
\{Z_{1}, Z_{2} \mid Z_{1} \in X \wedge Z_{2} \in Y \wedge Z = Z_{1} \cup Z_{2} \} & \text{if } X, Y \in D_{(b,t)} \text{ and } b \in TC, b \neq t 
\end{array} \}
\end{align*}

In terms of the predictions and problems discussed in the following, the two accounts do not differ. For the remainder of this chapter, I employ \( \text{AND}_{NB2} \) because it is more suitable for informal discussion. Returning to (63b) we still have to account for its second reading in (65b). We can do so straightforwardly by assuming ellipsis of the determiner – hence the derivation of this reading is identical to that of the full DP-conjunction in (69) (but cf. section 3.3 for more discussion of determiner ellipsis).

(69) Five men and five women arrived.

Put informally, five men denotes the set of sets containing five (or more) men and five women the set of sets containing five (or more) women. Therefore, five men and five women, in our present analysis, gives us the set of sets that each contain (at least) five men and (at least) five women – which is exactly what we want in order to capture the reading in (65b). The derivation of (63a) above is analogous. Note that the basic of idea of \( \text{AND}_{NB} \) given here can in principle be extended to a larger inventory of primitives. In particular, Lasersohn (1995) argues that we require a version of \( \text{AND}_{NB} \) that makes
reference to events – according to Lasersohn, the possibility of using alternately in (70) shows that hot and cold must denote a set of plural events, each consisting of hot and cold sub-events.

(70)  John was alternately hot and cold.  
adapted from (Lasersohn, 1992, 385)

4.5 Capturing non-Boolean construals with Boolean AND

So far, we assumed NBC to result from the meaning of and itself. Nevertheless, it could be argued – as in Winter (2001a) and Champollion (2015b) – that the denotation of and itself is uniformly AND\(_B\) and that NBC arise due to additional operations.

Take example (43a) from above, repeated in (71a) below. Analysing the conjunction by means of AND\(_B\) gives us (71b) – the intersection of Mary’s properties and Sue’s properties, as spelled out in (71c). We saw above that applying (71b) directly to the VP-denotation yields a non-sensical result.

\[
(71) \quad \text{a. } \text{Mary and Sue met.} \\
\text{b. } \lambda P_{(et)}: P(\text{Mary}) \cap P(\text{Sue}) \\
\text{c. } \{P : P(\text{Mary})\} \cap \{P : P(\text{Sue})\} \\
\]

Winter (2001a), however, argues that the structure of Mary and Sue is more complex than assumed before, including the additional morphemes min and er as in (72), which will allow for us to retrieve the plurality of Mary and Sue from (71b).

\[
(72) \quad [\text{er} \ [\text{min} \ [\text{Mary and Sue}]]] \\
\]

First, the minimization-operator min, (73), applies to the conjunction-denotation, returning the set containing the smallest set in (71c). As each element of \{P : P(\text{Mary})\} contains Mary and each element of \{P : P(\text{Sue})\} Sue, the result will be the singleton in (74), containing only the plurality of Mary and Sue.

\[
(73) \quad \text{[min]} = \lambda Q_{(a,t),t}: \lambda P_{(et)}: P \in Q \land \forall P' : P' \in Q \land P' \subseteq P \rightarrow P' = P \\
(74) \quad (\text{[min]}(\lambda P_{(et)}: P(\text{Mary}) \cap P(\text{Sue})) = (\{\text{Mary, Sue}\}) \\
\]

(74) then forms the input to existential raising, er in (75), which requires (74) and the VP-denotation (from D\(_{(et,t),t}\)) to have an element in common. 

\[
(75) \quad \text{[er]} = \lambda P_{(et)}: \lambda Q_{(a,t),t}: \exists x[Q(x) \land P(x)] \\
\]

Thus we derive us the correct truth-conditions for (71a) in (76).

\[
(76) \quad \text{[[[er] \ [min] \ [Mary and Sue]]] (\text{[met in the bar]}) = 1 \text{ iff } \exists x : x \in \{\text{Mary, Sue}\} \land x \text{ met.} } \\
\]

Champollion (2015b) employs an analogous technique to account for NBC in NP-conjunction as in (77), repeated from (67) above.

\[
(77) \quad \text{This man and woman are in love.} \\
\]

Recall that (77) requires us to form man-woman pairs. Simplifying slightly, Champollion derives this by using the same operations employed above – min and er, except that their syntactic position differs from before, (78a) er combines with each conjunct separately, so the resulting conjunction-denotation, employing AND\(_B\) is the one in (78b). The set of all sets of individuals that contain at least one man and one woman. We then gather all the minimal sets in this set by application of min – namely, the set of all sets that contain only one man and one woman. Accordingly, Champollion derives exactly the same result as Heycock and Zamparelli (2005), but without appealing to AND\(_{NB}\).

\[
(78) \quad \text{a. } \text{[[min] \ [er man] and [er woman]]] } \\
\text{b. } \text{[[[er man] and [er woman]]] = \lambda P_{(et,t)}: \exists x \exists y [\text{man}(x) \land \text{woman}(y) \land P(x) \land P(y)] } \\
\]
c. \[ \min ( \lambda P_{(e,t)} \exists x \exists y [ \text{man}(x) \land \text{woman}(y) \land P(x) \land P(y)] ) = \lambda P \exists x \exists y [ \text{man}(x) \land \text{woman}(y) \land P = \{ x, y \}] \]

This short discussion shows that at least in some cases, NBC do not force us to assume that \textit{and} itself is non-Boolean: In principle, we could maintain our Boolean meaning \( \text{AND}_B \) and assume that the NBC is the result of additional material present in the structure.

5 Summing up: What is the meaning of \textit{and}?

We saw that English conjunctions exhibit what seem to be two different meanings, giving rise to Boolean and non-Boolean construals, respectively. This is no idiosyncratic property of English but – as far as we can tell – a typologically common phenomenon, hence we cannot appeal to lexical ambiguity of \textit{and} but rather have to posit a single meaning for the latter. We considered two types of analysis: The Boolean analysis assumes that \textit{and} is uniformly intersective (\( \text{AND}_B \)) and that non-Boolean construals are the result of additional morphemes present in the structure, while the non-Boolean analysis takes \textit{and} to be uniformly non-intersective (\( \text{AND}_{NB} \)) and views Boolean construals as a particular class of scenarios where the sentence happens to be true.

Are there any reasons that compel us to chose one type of analysis over the other? Or might it even be the case that neither analysis, in its present form, is sufficient? Below, I outline three points that might shed some light on these issues. None of them has been fully investigated so far, thus the discussion raises several issues for future research.

5.1 The empirical scope of the analyses

The first question is how much data each analysis, in its present formulation, covers. The Boolean analysis has been expanded to NBC of \( e \)-conjunction and conjunction within or of DP, but not to instances of VP-conjunction as in (55b) above – hence its predictions concerning these cases remain unclear, whereas the non-Boolean analysis derives them straightforwardly. However, the non-Boolean analysis itself fails to capture some instances of DP-conjunction, as noted by Krifka (1990), Heycock and Zamparelli (2005) and Champollion (2015b): While \( \text{AND}_{NB} \) gives us the correct results for conjunctions of (right)-upward monotonous quantifiers as in (63a) and (69), it gives us the wrong meanings for conjunctions of non-monotonous or (right)-downward monotonous quantifiers. This includes instances of NBC as in (79) (cf. Hoeksema (1983), Krifka (1990) and Sher (1990) for discussion, partially based on Barwise (1979)) as well as instances of BC as in (80).

(79) a. Exactly 10 men and exactly 10 women met.
   b. Less than 10 men and less than 10 women like each other.

(80) No man and no woman smiled.

Champollion (2015b) illustrates the problem on behalf of (80). In a situation with a smiling man, John, and a smiling woman, Mary, \[ \text{no man} \] will hold of \{Mary\} (as \{Mary\} \( \notin \) \[ \text{man} \]) and \[ \text{no woman} \] of \{John\} (because \{John\} \( \notin \) \[ \text{woman} \]). If \textit{and} denotes \( \text{AND}_{NB} \), we predict that \[ \text{no man and no woman} \] holds of every set that is the union of an element of \[ \text{no man} \] – e.g. \{Mary\} – and an element of \[ \text{no woman} \] – e.g \{John\}, which means it should hold of \{John, Mary\} and that therefore the (80) should be true in the scenario just given (cf. Heycock and Zamparelli (2005), Champollion (2015b) for more discussion). \( \text{AND}_{B} \) on the other hand, yields the conjunction-denotation in (81) which does not hold of \[ \text{smile} \] in the scenario above and hence derives the correct result.

(81) \[ \lambda P_{(e,t)} \exists x \exists y (\text{man} \land P = \emptyset \land \text{woman} \land P = \emptyset) \]

In addition, there are some cases that neither analysis can capture. Consider (82), modelled after examples in Schmitt (2013). The sentence is true, for instance, in a scenario where the Moscow agency insists...
on Obama doing P and the North Korean agency on him doing Q.

Our agencies from Moscow and Pyongyang insist that Obama must [P consult with Putin] and [Q play golf with Kim Jong-un], but the president just wants to have a good time.

AND\textsubscript{B} does not derive the correct truth-conditions: It predicts (82) to be true only if both agencies insist that Obama must do both P and Q. Yet AND\textsubscript{NB} does not fare any better: It derives a complex predicate \([P \text{ and } Q]\) that requires of its argument to consist of P-parts and of Q-part – yet, the individual that needs to be ‘split up’ in (82) (into parts insisting that Obama do P and parts insisting that Obama do Q) is not the argument of the conjunction, but the subject of the matrix clause. Schmitt (2013) takes this to indicate that the meaning of \textit{and} is neither AND\textsubscript{B} nor any of the versions of AND\textsubscript{NB} discussed above, arguing that AND does not form complex predicates but rather pluralities of the conjuncts’ denotations, expanding the notion of plurality to objects other than individuals. Schmitt and Gawron and Kehler (2004), who propose a related analysis, take this to be corroborated by the fact that some expressions like respectively or both make a similar semantic contribution when combining plurals and with predicate-conjunction: both, for instance, yields a ‘distributive’ effect in both cases in (83).

(83)  a. Both the boys ate a pizza.
    b. John was both drinking and smoking.

Schmitt (2013) furthermore argues that plurals and conjunction exhibit parallels w.r.t. an ‘all-or-nothing’-behavior visible in the context of negation – i.e. the phenomenon known as ‘homogeneity’ in the case of plurals and \(e\)-conjunctions (cf. Fodor (1970), Löbner (1987, 2000), Schwarzschild (1994) a.o.). While (84a) conveys that Mary fed all the cats, (84b) conveys that she fed none of them.

(84)  a. Mary fed the cats.
    b. Mary didn’t feed the cats.

Predicate conjunction displays a similar behavior, according to Schmitt (2013) and also Geurts (2005): Whereas (85a) conveys that Brown has both properties, (85b) can express that he doesn’t have either. (The status of adult judgements might be debatable, but the effect is consistently observable in English-speaking children, Crain (2012).) Both the Boolean and the non-Boolean analysis however, predict that (85b) is true in all those cases where Brown lacks one or both of the properties, unless, of course, \textit{and} is assumed to take wide scope above negation.

(85)  a. Brown is tall and handsome.

In sum, neither the Boolean, nor the non-Boolean analysis achieve full generality. It should be noted that further questions might arise once we widen the scope of our investigation: Above, we only considered BC and NBC, but the range of meanings expressible by conjunction in English is larger than this. The conjunction in (86a) for instance, has a conditional reading, paraphrased in (86b) (cf. Culicover and Jackendoff (1997)). Again, this is not an idiosyncratic property of English, since a number of other languages (including non-Indo-European ones) exhibit the same phenomenon (cf. Kaufmann (2012) for an overview and a more detailed semantic discussion). Accordingly, an adequate hypothesis about AND should also be able to deal with these observations.

(86)  a. You drink another beer and I’m leaving.  Culicover and Jackendoff (1997, 197:(3a))
    b. If you drink another beer, I am leaving.

## 5.2 Semantic and morphological markedness

Given our discussion above, the non-Boolean analysis does not treat BC and NBC as different readings – both BC-scenarios and NBC-scenarios happen to make a sentence such as (53b) true – while the Boolean analysis does: Without additional morphology, we only obtain BC. Accordingly, it seems that if we find...
configurations that only exhibit BC, we could take this as evidence for the Boolean analysis. Szabolcsi and Haddican (2004) argue that conjunctions where \textit{and} is stressed represent such a case, as stress on \textit{and} in (87) blocks NBC – the \textit{e}-conjunction cannot combine with a collective predicate. (87) thus seems to reveal \textit{AND}_2 as the basic meaning for \textit{and}.

(87) \textit{Mary and /# AND} Susan solved the puzzle together.

adapted from Szabolcsi and Haddican (2004 227:(21a))

However, this conclusion is not as straightforward as it might seem. On the one hand, Haslinger and Schmitt (2015) show that at least in German, stressed \textit{und} (\textit{and}) is compatible with NBC of \textit{e}-conjunctions whenever we conjoin more than two singulars and the conjunct-denotations are salient, as in (88).

(88) \textit{Susi hatte befürchtet, dass sich Kai und Ron in ihrer Stammkneipe treffen würden und außerdem versucht, den schrecklichen Max zu vermeiden. Und was ist passiert? Kai, Ron UND Max haben sich dieser Kneipe getroffen!}

‘Susi had been worried that Kai and Ron would meet in her local bar and she also tried to avoid terrible Max. Guess what happened: Kai, Ron AND Max met in the bar.’

adapted from Haslinger and Schmitt (2015 1:(2))

On the other hand, we could amend the non-Boolean analysis by additional morphemes that would turn BC into a second reading – one that is stronger than the one yielded by \textit{AND}_{NB}. This morphology would essentially have the same distributive effect as \textit{both} in (84b) above. As a result, both analyses could be treated as mirror images of one another: The Boolean analysis gives us BC as the primitive reading, requiring additional morphology for the weaker reading, while the non-Boolean analysis derives the weaker reading (including NBC and BC) primitively and can single out the stronger one (BC) via extra morphology.

Given this assumption, the Boolean analysis predicts that we should find additional morphology that makes the NBC available, while the non-Boolean predicts that we should find additional morphology that makes only the BC available. Hungarian, discussed by Szabolcsi (2015), follows the latter pattern: The morphologically less marked conjunction in (89a) allows for both BC (each girl weighs 100 kilograms) and NBC (the girls weigh 100 kilograms together), while (89b) with the additional morpheme \textit{is}, only allows for BC. As of yet, there is no cross-linguistic study investigating whether languages generally follow the Hungarian pattern, which would adhere to the predictions of the non-Boolean analysis.

(89) a. \textit{Kati és Mari 100 kilót nyomott}\n\text{Kate and Mary 100 kg weighed}

b. \textit{Kati is (és) Mari is 100 kilót nyomott}\n\text{Kati is and Mary is 100 kg weighed}

Szabolcsi (2015 180f: (44),(45))

The acquisition of the meaning of conjunctions could also provide vital clues in this respect. As the two analyses make different assumptions concerning the morpho-syntactic complexity of the BC and the NBC, they (arguably) make different predictions concerning which one should be attested earlier: If the Boolean analysis is correct, then the stronger reading (BC) should be acquired first, whereas the non-Boolean analysis would lead to to expect that the weaker reading (subsuming both NBC and BC) is available right from the start. To my knowledge, no studies on this matter exist.

Finally, taking a broad typologically stance might lead us to more fine-grained queries. Several languages exhibit morpho-syntactically complex conjunctions, which might indicate that \textit{AND} is in fact a combination of several discrete meaning parts. Moreover, in some languages we find that the morphemes that surface in conjunction also appear in other contexts with seemingly different functions, such as the Japanese particle \textit{mo}, which is found in \textit{e}-conjunction as in (90) but can also function as a universal quantifier over individuals. The obvious question, raised by Mitrović and Sauerland (2014) and...
Szabolcsi (2015) is whether the meaning contribution of elements such as *mo* is stable across contexts and, if so, what this can tell us about AND itself.

(90)  

*John-mo Mary-mo hanashumasu*  
John-mo Mary-mo talked  
‘John and Mary are talking’ adapted from [Mitrović and Sauerland (2014)](10:41)

5.3 Related expressions

The final issue concerns the relations to other expressions that the two analyses predict. In the Boolean analysis, AND is the correlate of universal quantification. The denotation of its syntactic counterpart *or*, on the other hand, can be viewed as the correlate of existential quantification: In sentential coordination as in (91) it denotes the function that maps any two truth-values to 1 iff at least one of the two is 1 and its cross-categorial contribution can be generalised in analogy to generalised Boolean conjunction – which essentially boils down to *or* expressing set-union for all domains for *t*-conjoinable types (cf. von Stechow (1974), [Partee and Rooth (1983)](92)). Accordingly, in the Boolean analysis, the semantic relation between *and* and *or* is parallel to that between *every* and *some*.

(91)  

*Sue went to the gym or Mary went to the office.*

This has two consequences: On the one hand, it means that scalar implicatures triggered by *some* (*≈ not all*) and by *or* (*≈ not and*) can be derived in a similar vein. [ ⇒ chapter ‘Semantics and Pragmatics’]. As pointed out by Haslinger and Schmitt (2015), it is unclear how scalar implicatures triggered by *or* can be derived on the basis of a non-Boolean analysis. On the other hand, the fact that many languages lexicalize AND and OR differently (cf. Payne (1985), Haspelmath (2007)) – albeit ASL, [Davidson (2013)](93), Warlpiri, [Bowler (2014)](94) and Japanese, [Sauerland et al. (2015)](95) exhibit elements that have properties of both) could then be correlated with the observation that many languages show a formal distinction between universal and existential quantification over individuals (but cf. [Gil (2001)](96) for more discussion). The analogy to quantification raises another issue, however. In particular, many DPs in English are known to exhibit two readings – a quantificational one and a ‘plural-like’ one (cf. Kroch (1974), [Schei (1986)](97), Sher (1990), a.o.): Given the sentence in (92a), (92b) and (92c) paraphrase the result of the former and the latter, respectively. [ ⇒ chapters ‘Quantifiers, Scope and Pseudo-Scope’, ‘Plurality and Cumulation: Dutch computers’]. This observation bears a striking parallel to the construals of conjunction witnessed above, with the quantificational reading corresponding to BC and the ‘plural-like’-reading corresponding to NBC.

(92)  

a.  
*Three hunters shot at every bird in this forest.*

b.  
*Three hunters each shot at every bird in this forest.*

c.  
*Three hunters, between them, shot at every bird in this forest.*

This, in turn, gives rise to a number of questions: Do we find, for instance, that cross-linguistically, one of the readings of the DPs is morphologically less marked than the other (cf. [Gil (2001)](98) for discussion)? And does this correlate with our findings for conjunction concerning our questions in section 5.2? Further, do we find parallels in how the meanings of such DPs are acquired (cf. Rouwele and Hollebrandse (2015)) a.o.) and how the meanings of conjunction are acquired? If so, it could suggest that the semantic behavior of *and* discussed in this chapter is not an isolated factor in natural language grammars.

Notes

1 I want to thank Nina Haslinger, Jan Köpping, Clemens Mayr, Edgar Onea, Martin Prinzhorn and two anonymous reviewers for providing data, helpful discussion and valuable comments. All mistakes are my own.

2 It will become clear below that the term ‘non-Boolean’ is misleading. I use it here because it is employed in a great part of the literature.

3 In the following sections, I suppress reference to situations unless it could lead to confusion.
If we think of sentence meanings as propositions, the proposition expressed by (1) is the function that characterizes the intersection of the sets characterized by the propositions \( S_1 \) and \( S_2 \).

Schein’s forthcoming ‘And’. Conjunction reduction redux, MIT Press, has not been available at the time of writing.

As discussed by van Benthem (1991) ch.5, FC requires an extension of Lambek’s original grammar.

I here use the version he discards, which is more explicit in its predictions than the version he eventually opts for.

Cf. Krifka (1990) for an expansion of AND\(_{NB}\) that can also target material parts of individuals.


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Cross-references

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