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# Noun Phrase Interpretation and Type-shifting Principles

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## 0  Introduction

The goal of this paper is to attempt a resolution of the apparent conflict between two approaches to noun phrase (NP) interpretation, one being Montague's uniform treatment of NP's as generalized quantifiers and the other, argued for by a variety of authors both before and after Montague, distinguishing among referring, predicative, and quantificational NP's (or uses of NP's). I believe that the most important insights of both sides are basically correct and mutually compatible. To try to show this, I will draw on and extend the idea of general type-shifting principles, argued for in Partee and Rooth (1983), together with the idea of type-driven translation developed by Klein and Sag (1985). I will draw heavily throughout on the many recent studies of model-theoretic properties of various generalized quantifiers and determiners, especially the work of Barwise and Cooper and of van Benthem. I believe that these tools can take us a good way toward explaining the diversity of NP interpretations on the basis of general principles relating syntax to semantics plus particular semantic properties of individual determiners, nouns, and NP-taking predicates.

I will retain from Montague's approach the requirement of a systematic category-to-type correspondence, but allow each category to correspond to a family of types rather than just a single type.[1] For an extensional sublanguage I propose basic NP types $e$ ("referential"), $\langle e, t \rangle$ ("predicative"), and $\langle \langle e, t \rangle, t \rangle$ ("quantificational"). While this last, the type of generalized quantifiers, is the most complex, it is also the most general; we can argue that all NP's have meanings of this type, while only some have meanings of types $e$ and/or $\langle e, t \rangle$. Part of our task will be to see to what extent we can find general principles for predicting from the generalized quantifier interpretation of a given NP what possible $e$-type and/or $\langle e, t \rangle$-type interpretations it will have. This enterprise turns out to shed new light on some old puzzles, such as the semantics of singular definite NP's like *the king*, which turn out to be interpretable in all three types but with slightly different presuppositional requirements in each.

Opening up the issue of type-shifting principles and attempting to investigate them systematically also turns out to suggest a new perspective on the copula *be* and on the

determiners *a* and *the*; I will suggest that this perspective may offer some help in explaining why certain semantic "functors" may be encoded either lexically or grammatically or not explicitly marked at all in different natural languages.

In sections 1 and 2 below I review a variety of proposals for interpreting various kinds of NP's and some of the evidence for the claim that there are NP interpretations of all three types mentioned above. The main proposals for type-shifting principles are the subject of section 3. Section 4 deals with the "Williams puzzle" introduced at the end of section 2; the proposed solution exemplifies the possibility of highly language specific type-shifting rules in contrast to the more general principles described in section 3. The paper concludes with a brief sketch of some possible implications of the perspective advanced here for the treatment of English *be* in section 5.

# 1   Alternative Treatments of NP's: Some Examples

I begin by reviewing alternative interpretations for a number of different kinds of NP's, contrasting Montague's treatment with others that can be found in the literature. These are summarized in Table 1; comments follow.

Consider first the first three NP's in the table, *John*, *he_n*, and *every man*. One of Montague's best-known contributions to semantics was to show how these and other NP's could be given a uniform semantic type, by taking the type of all NP's to be $\langle\langle e, t\rangle, t\rangle$.[2] The fruitfulness of this idea is well-attested by now, and there are independent reasons for wanting to analyze at least some occurrences of proper names as generalized quantifiers, for instance when they occur in conjunctions like *John and every woman* and perhaps when they occur as antecedents of "bound variable pronouns".[3] But otherwise it would be more natural to treat proper names and singular pronouns as individual constants and variables respectively; this is indeed the more traditional view. Partee and Rooth (1983), in a discussion which focuses mainly on type assignments to extensional and intensional verbs, argue for a modification of Montague's

**Table 1**   MG Treatment of NP's and alternatives

| NP | Translation | Type |
|---|---|---|
| (1) John | MG: $\lambda P[P(j)]$ | $\langle\langle e, t\rangle, t\rangle$ |
| | j | $e$ |
| (2) he_n | MG: $\lambda P[P(x_a)]$ | $\langle\langle e, t\rangle, t\rangle$ |
| | $x_n$ | $e$ |
| (3) every man | MG: $\lambda P[\forall x[man'(x) \rightarrow P(x)]]$ | $\langle\langle e, t\rangle, t\rangle$ |
| (4) the man | MG: $\lambda P[\exists x[\forall y[man'(y) \leftrightarrow y = x] \& P(x)]]$ | $\langle\langle e, t\rangle, t\rangle$ |
| | (i)  $\iota x[man'(x)]$ | $e$ |
| | (ii) $\lambda x[man'(x) \& \forall y[man'(y) \rightarrow y = x]]$ | $\langle e, t\rangle$ |
| (5) a man | MG: $\lambda P[\exists x[man'(x) \& P(x)]]$ | $\langle\langle e, t\rangle, t\rangle$ |
| | (i)  man' | $\langle e, t\rangle$ |
| | (ii) Kamp-Heim: $x_i$; cond: $man'(x_i)$, $x_i$ "new" | $e$ |
| (6) dogs | (i)  Chierchia: $^\cap dog'$ | $e$ |
| | (ii) Carlson, in effect: $\lambda P[P(^\cap dog')]$ | $\langle\langle e, t\rangle, t\rangle$ |
| | (iii) dog' | $\langle e, t\rangle$ |

strategy of assigning to all members of a given syntactic category the "highest" type needed for any of them. We proposed there that (i) each basic expression is lexically assigned the *simplest* type adequate to capture its meaning; (ii) there are general type-lifting rules that provide additional higher-type meanings for expressions, so that the uniform higher-type meanings Montague posited for a given syntactic category will indeed be *among* the available meanings for all expressions of that category; and (iii) there is a general processing strategy of trying lowest types first, using higher types only when they are required in order to combine meanings by available compositional rules. (For example, *John* would have to be "lifted" from j to $\lambda P[P(j)]$ to interpret the conjunction *John and every woman*.) According to that proposal, *John* and $he_n$ would have basic interpretations of type $e$, and the interpretations Montague assigned to them would be predictably available by way of a general "lifting" rule. *Every man*, however, would have only the generalized quantifier-type interpretation. This dual treatment of proper names and pronouns is one piece of the more general picture we will develop here.

In the case of definite descriptions like *the man*, there are of course many issues of pragmatics to worry about that affect the question of what belongs to the semantic content of such expressions. What I want to do is consider several possible interpretations of different types and see whether they can be related by means of general type-shifting principles; if so, that might relieve us of the burden of trying to decide which is the "right" interpretation – perhaps they all are. One alternative to Montague's generalized quantifier interpretation of *the man* is the iota-operator analysis given in (4i), of type $e$. The iota-operator combines with an open sentence to give an entity-denoting expression, denoting the unique satisfier of that open sentence if there is just one, and failing to denote otherwise. (This interpretation could also be "lifted" to a generalized quantifier interpretation different from Montague's, agreeing with that given by Barwise and Cooper (1981).) Less familiar but at least implicit in some discussions is the possibility of a predicative reading for definites, as given in (4ii), which picks out the singleton set of (or the property of being) the unique man if there is just one and the empty set (or empty property) otherwise.

For indefinites, there again seem to be plausible interpretations of all three types: Montague's generalized quantifier interpretation incorporating an existential quantifier; an $\langle e, t \rangle$ interpretation equivalent to the bare common noun interpretation (the traditional translation of indefinites in predicate positions); and the treatment suggested in recent work of Kamp and Heim, which is not adequately represented by the rough translation into intensional logic given in (5ii) but which can, I think, fairly be said to treat indefinites as $e$-type variables accompanied by conditions on assignments to those variables.[4]

Bare plurals like *dogs*, in (6), were not treated at all by Montague; Carlson (1980) proposed that they be treated as proper names of kinds, and Chierchia (1982a, b, 1984) provides an enrichment of intensional logic including a nominalization operator mapping properties onto property-correlates in the domain of entities, treating the bare plural as one such nominalization.[5] Carlson's $\langle\langle e, t \rangle, t \rangle$ interpretation can then be reanalyzed in retrospect as in (6ii), as bearing the same relation to Chierchia's nominalized property $^\cap dog'$ as Montague's translation of ordinary proper names bears to their translation as individual constants. The simple $\langle e, t \rangle$ translation in (6iii) remains a plausible interpretation for bare plurals in predicate positions.

## 2    Evidence for Multiple Types for NP's

So far I have just enumerated a number of cases where interpretations of differing types have been proposed for various NP's, without giving many arguments that a single NP may in fact have multiple interpretations. And indeed I do not intend to try to settle the question of how many distinct interpretations any given NP has and just what they are, although I will make some suggestions. In this section I will review some evidence for the plausibility of the claim that there are NP interpretations of at least types $e$ and $\langle e, t \rangle$ as well as $\langle \langle e, t \rangle, t \rangle$, and in what follows I will try to show how interpretations of these types can be systematically related to one another.

### 2.1    Evidence for type e

The claim that proper names are basically of type $e$ and only derivatively of type $\langle \langle e, t \rangle, t \rangle$ hardly needs defense, and there is almost as much tradition (though more controversy) behind the treatment of singular definite descriptions as entity-denoting expressions. However, there seemed to be no harm and considerable gain in uniformity in following Montague's practice of treating these NP's always as $\langle \langle e, t \rangle, t \rangle$, until attention was turned to the relation between formal semantics and discourse anaphora by the work of Kamp (1981) and Heim (1982). As illustrated in examples (7) and (8), not only proper names and definites license discourse anaphora, but indefinites as well; other more clearly "quantificational" NP's do not.

(7)    John/the man/a man walked in. He looked tired.
(8)    Every man/no man/more than one man walked in. *He looked tired.

The generalization seems to be that while any singular NP can bind a singular pronoun in its (c-command or f-command)[6] domain, only an $e$-type NP can license a singular discourse pronoun. The analysis of indefinites is particularly crucial to the need for invoking type $e$ in the generalization, since if it were only proper names and definite descriptions which licensed discourse anaphora, one could couch the generalization in terms of the retrievability of a unique individual from the standard Montagovian generalized quantifier interpretation (an ultrafilter in those cases).

### 2.2    Evidence for type ⟨e, t⟩

Certain verbs appear to take $\langle e, t \rangle$ arguments; some allow only adjective phrase complements (*turn introverted*, **turn an introvert*), while others, like *become* and *consider*, allow both AP and NP complements. Particularly strong evidence for these NP's being of type $\langle e, t \rangle$ comes from their conjoinability with AP's in such positions, since I assume that true constituent conjunction requires identical types and I have seen no evidence for treating adjective phrases as either type $e$ or $\langle \langle e, t \rangle, t \rangle$.

(9)    Mary considers John competent in semantics and an authority on unicorns.

Although not all verbs that seem to take $\langle e, t \rangle$ complements allow exactly the same range of NP's in such complement positions (see Reed (1982)), I will for simplicity take occurrence with *consider* as diagnostic for "predicative NP's", i.e. NP's that can have an $\langle e, t \rangle$ interpretation.

(10)   Mary considers that an island / two islands / many islands / the prettiest island / the harbor / *every island / *most islands / *this island / *?Schiermonnikoog / Utopia.

In general, the possibility of an NP having a predicative interpretation appears to be predictable from the model-theoretic properties of its interpretation as a generalized quantifier; in fact we will argue below that *all* NP's in principle have an $\langle e, t \rangle$ interpretation, but some of them (like *every island, most islands*) yield unsatisfiable or otherwise degenerate predicates.

Williams (1983) notes that sentences like (11) provide counterexamples to the above claim.

(11)   This house has been *every color*.

We will take up such examples in section 4, arguing that in these cases the possibility of an $\langle e, t \rangle$ reading results from a language-specific and quite idiosyncratic property of the head noun of the construction, which affects the syntactic as well as the semantic properties of the resulting phrase.

## 3   Type-Shifting: General Principles and Particular Rules

### 3.1   A general picture

While I aim to uncover considerable systematicity in the phenomenon of type-shifting, I do not want to suggest that there is a single uniform and universal set of type-shifting principles. There are some very general principles which are derivable directly from the type theory, others which are quite general but which depend on the algebraic structure of particular domains (such as the $\langle \langle e, t \rangle, t \rangle$ domain), others which require the imposition of additional structure on the domain of entities or other domains, and still others which seem to be language-particular rules. (Note that lexical rules of the sort discussed by Dowty (1978, 1979) usually involve a change of type; those which employ zero morphology may be thought of as a species of language-particular type-shifting rules.) Even the most general type-shifting principles, such as the "lifting" operation that maps j (type $e$) onto $\lambda P[P(j)]$ (type $\langle \langle e, t \rangle, t \rangle$), need not be universal, but I would expect such a principle to be universally available at "low cost" or "no cost" for any language that has NP's of type $\langle \langle e, t \rangle, t \rangle$ at all.[7] Conversely, there might be type-shifting rules which are not of any formal generality but which are universal or at least very commonly employed because their substantive content has some high cognitive naturalness (such as perhaps the rule which turns proper names into common nouns denoting a salient characteristic, as in "He's a real Einstein"). The general picture I will sketch below will focus on formally definable

type-shifting principles which I believe are linguistically exploited in English and at least potentially universal; I believe this perspective might be helpful for studying semantic universals and typology, but I have not carried out any serious cross-linguistic study.

In Figure 1, the circles represent the three model-theoretic domains $D_e$, $D_{\langle e,t\rangle}$, and $D_{\langle\langle e,t\rangle,t\rangle}$, labelled by their types, and the arrows represent mappings between them, operations which map objects in one domain onto corresponding objects in another domain. I will say more about some of them below; others will be discussed in subsequent sections.

I should note here that while my focus in this paper is on type-shifting operations that can map NP-meanings onto other meanings for those same NP's, the same operations can of course be involved in rules which relate expressions in distinct syntactic categories as well. In particular, I consider $\langle e,t\rangle$ a "marked" type for full NP's in English (as opposed to the "unmarked types" $e$ and $\langle\langle e,t\rangle,t\rangle$); it is the "unmarked" type for common noun phrases and verb phrases, and one of the possible types for adjective phrases and prepositional phrases, so we should not be surprised if the type-shifting operations mapping to or from type $\langle e,t\rangle$ show up even more in rules relating NP's to expressions of other categories than in rules providing multiple meanings for single NP's. On the other hand, not all languages make as clear a syntactic distinction between NP's and CN's as English does, and the naturalness of some of these type-shifting operations may help to account for that fact.
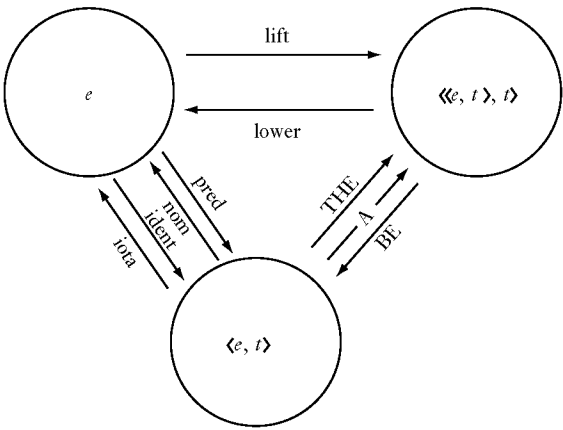


**Figure 1**

| lift | : | $j \rightarrow \lambda P[P(j)]$ | total; injective |
|---|---|---|---|
| lower | : | maps a principal ultrafilter onto its generator; lower(lift(j)) = j | partial; surjective |
| ident | : | $j \rightarrow \lambda x[x = j]$ | total; injective |
| iota | : | $P \rightarrow \iota x[P(x)]$<br>iota(ident(j)) = j | partial; surjective |
| nom | : | $P \rightarrow {}^\cap P$ (Chierchia) | almost total; injective |
| pred | : | $x \rightarrow {}^\cup x$ (Chierchia)<br>pred(nom(P)) = P | partial; surjective |

Many of the mappings come in pairs which are inverses. For example, the operation *lift*, which has been mentioned before, has an inverse *lower*. *Lift* maps any entity *a* onto the principal ultrafilter generated by *a*; in IL terms, it maps (the denotation of) j onto (the denotation of) $\lambda$ P[P(j)]; in set-theoretic terms, it maps *a* onto $\lambda$X [a $\in$ X]. *Lift* is total and injective ("into"). Its inverse, *lower*, is partial and surjective ("onto"), mapping any principal ultrafilter onto its generator. So *lower*(*lift*(*a*)) = *a*, and if *lower* ($\mathcal{P}$) is defined, *lift*(*lower*($\mathcal{P}$)) = $\mathcal{P}$.[8]

The pair *ident* and *iota* are similarly inverses. *Ident* is the total, injective operation mapping any element onto its singleton set; in IL terms, it maps j onto $\lambda$x[x = j]. *Iota* is its partial surjective inverse, mapping any singleton set onto its member; in IL, augmented by the iota operator, it maps P onto $\iota$x[P(x)]. (In an intensional system, we would want in addition or instead a version of *ident* mapping an entity onto the *property* of being that entity, and a version of *iota* mapping a property onto the unique individual having that property, if there is indeed just one, and undefined otherwise. In either case we would have *iota*(*ident*(*a*)) = *a* and, when defined, *ident*(*iota*(P)) = P.)

The other pair of mappings between e and $\langle e, t \rangle$, *nom* and *pred*, are extensional misrepresentations of the operators "$\cap$" and "$\cup$" from Chierchia (1984).[9] *Nom* maps properties onto their entity-correlates if these exist (the Russell property, for instance, will be acceptable as a predicate but will not have any entity-correlate); this is the operation which on Chierchia's analysis is involved in nominalizing the common noun *dog* to form the bare plural *dogs* and the adjective *blue* to the proper noun *blue*, and in the formation of infinitives and gerunds from verb phrases. It is "almost" total, applying to all "ordinary" properties at least, and injective. Its inverse, *pred*, applies to those entities which are entity-correlates of properties, and returns the corresponding property. *Pred* is partial and "almost" surjective. Where defined, *nom* and *pred* are inverses. We will make use of these operators in our analysis of the Williams counterexample.

These three pairs of operators illustrate the heterogeneity of type-shifting principles I alluded to at the beginning of this section: *lift* is a matter of simple combinatorics that falls directly out of the type theory, and would have an analogue between types *a* and $\langle \langle a, b \rangle, b \rangle$ for any *a* and *b*. *Lower* is not independently definable in combinatoric terms since it does not apply to the whole of the higher domain, but is definable as the inverse of *lift* or independently in terms of generators of ultrafilters. *Ident* and *iota* are not merely combinatorial but are still "formal" insofar as they do not depend on any particular assumptions about the domain $D_e$. *Nom* and *pred* are more "substantive" in that they depend on the inclusion of properties or property-correlates among the entities.

There is also room for considerable diversity in how natural languages make use of such type-shifting principles, encoding them with lexical items (*iota* might be a candidate meaning for the definite article), via lexical rules (*nom* or *pred* for the rule relating *blue* as adjective to *blue* as proper noun, depending on which one takes as basic), syntactic rules (*nom* for the formation of bare plurals), or not encoding them at all (e.g. if *lift* is universal for proper nouns.) I will return to these linguistic issues at various points below. I should note here that *lower* is not necessarily part of the grammar of English at all, but is useful in the metatheory for predicting which NP's have *e*-type readings from their generalized quantifier interpretations.

## 3.2   Sample application: *the king* in all three types

By the criteria presented in section 2, singular definite descriptions like *the king* can occur in all three types.[10] Figure 2 below shows mappings that could provide a possible account of this distribution and of the slight differences in meaning and presupposition that accompany the three uses. (The reader can fill in the caveats needed here about the wealth of research these suggestions need to be tested against and integrated with, etc.) Solid lines indicate total functions, dotted lines partial ones.
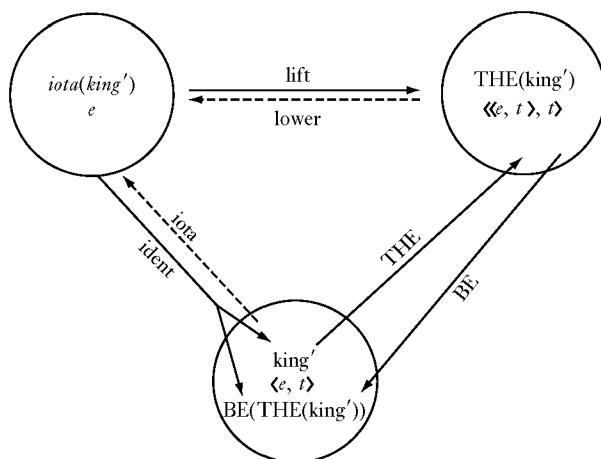


**Figure 2**

Four of these mappings were described in the previous section: *lift*, *lower*, *ident*, and *iota*. *THE* is the total function which maps any set Q onto the generalized quantifier given by Montague's syncategorematic interpretation rule for the introduction of *the* (see entry (4) in Table 1). In subsequent work in Montague grammar, this operation is usually assigned as the meaning of the determiner *the* itself; it is expressed in IL as $\lambda Q \lambda P[\exists x [\forall y[Q(y) \leftrightarrow y = x] \& P(x)]$; in languages lacking an overt definite article, one would have to look for grounds for choosing between a syncategorematic treatment and the positing of a zero definite article. Since *THE* is a total function, there are no presuppositions required for the use of definite descriptions as generalized quantifiers.[11] If there is a unique king, *THE(king′)* denotes the set of all his properties; otherwise it denotes the empty set of properties, so that any sentence in which *THE(king′)* has maximal scope comes out simply false. *Iota(king′)*, on the other hand, is defined iff there is one and only one king; if we assume that *e* is the unmarked type for subject position,[12] and the preferred type for arguments of extensional verbs generally, this would help to explain the strong but not absolute preference for taking existence and uniqueness as presuppositions rather than as part of the content in subject and other argument positions.

So far, we have a contrast between an *e*-type meaning *iota(king′)* and an $\langle \langle e, t \rangle, t \rangle$ meaning, *THE(king′)*, traceable to two alternative meanings for *the*, namely *iota* and

*THE*. These are related to each other by the fact that whenever *iota* is defined, i.e. whenever there is one and only one king, $lift(iota(king'))$ = $THE(king')$ and *lower* $(THE(king'))$ = $iota(king')$, and furthermore whenever *iota* is not defined, $THE(king')$ is vacuous in that it denotes the empty set of properties. ($THE(king')$ will generally have a non-vacuous intension, of course, which is presumably why it is useful to have a presuppositionless version of definite descriptions.)

Now what about a possible predicative ($\langle e, t \rangle$) reading for *the king?* Suppose we start with the $\langle \langle e, t \rangle, t \rangle$ reading $THE(king')$. We know that one way of getting from a denotation of type $\langle \langle e, t \rangle, t \rangle$ to one of type $\langle e, t \rangle$ is to apply the function denoted by Montague's PTQ translation of English *be*, $\lambda \mathcal{P} \lambda x [\mathcal{P}(\lambda y [y = x])]$. This is the function called BE in the diagram; I will say more to argue for its "naturalness" in the next section. For now let me just present the suggestion that we treat this operator not as the meaning of the word *be* but as a type-shifting functor that we apply to the generalized quantifier meaning of an NP whenever we find the NP in an $\langle e, t \rangle$ position.[13] The English *be* itself, I will suggest (following Williams (1983)), subcategorizes semantically for an *e* argument and an $\langle e, t \rangle$ argument, and has as its meaning "apply predicate", i.e. $\lambda P \lambda x [P(x)]$. This pair of proposals gives the same result as Montague's for phrases like *be the king, be a man, be John*, but distributes the meaning among the parts differently, in such a way that we now have a predicative reading for NP's in positions other than after *be* (which Montague's treatment did not provide), and we can now have the same *be* occurring with NP's and with predicates of other syntactic categories. I think this is an important advantage and will say more about it in later sections; let's return now to the implications of this proposal for the predicative reading of *the king*, which can be defined as $BE(THE(king'))$.

In IL terms, $BE(THE(king'))$ works out to be $\lambda x [king'(x) \ \& \ \forall y [king'(y) \rightarrow y = x]]$, or equivalently, $\lambda x [\exists y [king'(x) \leftrightarrow x = y]]$. This gives the singleton set of the unique king if there is one, the empty set otherwise. Since both *BE* and *THE* are total functions, this is always available as a possible $\langle e, t \rangle$ reading of *the king*; no presuppositions are required. Note that if there is *at most* one king, $king'$ = $BE(THE(king'))$, i.e. this predicative reading of *the king* is the same as the common noun *king* in that case, since both pick out the empty set if there is no king and a singleton set if there is exactly one king. The fact that the common noun and the predicative definite description agree modulo this "at most one" presupposition may help explain why in English the definite article is sometimes but not always optional in predicative constructions, as illustrated in (12).

(12)   (a)   John is {the president / president}
       (b)   John is {the teacher / *teacher}

It appears that the definite article is optional in such constructions just in case the presupposition that there is at most one such-and-such in any context is virtually built into the language, so that the conditions for the equivalence of predicative *the president* and *president* can generally be taken for granted. While this somewhat functional account may help to explain the contrast between (12a) and (12b), it cannot be taken as a predictive explanation, since as we will see in the next section, predicative *in*definites like *a man* are always fully equivalent to the common noun, so it would seem even more natural for a language to omit redundant indefinite articles, as in French, than redundant definite articles.

The double-headed arrow on the *ident* mapping reflects the fact that for *iota* to be defined there must be one and only one king, hence $king' = BE(THE(king')) = ident(iota(king'))$. In fact, when *iota* is defined, the diagram is fully commutative: $king' = BE(THE(king')) = ident(iota(king')) = ident(lower(THE(king'))) = BE(lift(iota(king')))$, etc. This property of the mappings lends some formal support to the idea that there is a unity among the three meanings of *the king* in spite of the difference in type. There are of course alternatives that should be considered; the diagram would also be commutative if we replace the total function *THE* by a partial function identical to the composition *lift · iota*, so that there would be the same presuppositions for the meanings in every type, and no reading of *the king* lacking those presuppositions. I tend to believe there *is* a presuppositionless reading, but I doubt that clear arguments can be found within a purely extensional sublanguage.

### 3.3   A and BE as "natural" type-shifting functors

When we consider possible functions mapping from $\langle e, t \rangle$ to $\langle \langle e, t \rangle, t \rangle$, the obvious candidates are all the determiners, since that is exactly their type. Natural language data suggest that *a* (and plural *some*) and *the* are particularly natural, since they are often not expressed by a separate word or morpheme but by constructional features, or not expressed at all. Sometimes definites are marked but indefinites unmarked. Determiners like *every, many, most*, and numerals are always expressed by a word or morpheme, as far as I know. Sometimes an indefinite article is overt in referential positions, unexpressed in predicative positions. Can we find formal backing for the intuition that what *a* and *the* denote in English are particularly "natural" type-shifting functors? We have already done this to some extent for *the*; here we will consider *a*, and also strengthen the case for the naturalness of the functor *BE* introduced in the previous section.

Let $A$ be the categorematic version of Montague's treatment of *a/an*: in IL terms, $\lambda Q[\lambda P[\exists x[Q(x) \& P(x)]]]$. We will focus first on the naturalness of $BE$,[14] then argue that $A$ is natural in part by virtue of being an inverse of $BE$.

*Fact 1:*   $BE$ is a homomorphism from $\langle \langle e, t \rangle, t \rangle$ to $\langle e, t \rangle$
viewed as Boolean structures, i.e.:
$BE(\mathcal{P}_1 \sqcap \mathcal{P}_2) = BE(\mathcal{P}_1) \sqcap BE(\mathcal{P}_2)$
$BE(\mathcal{P}_1 \sqcup \mathcal{P}_2) = BE(\mathcal{P}_1) \sqcup BE(\mathcal{P}_2)$
$BE(\neg \mathcal{P}_1) = \neg BE(\mathcal{P}_1)$

*Fact 2:*   $BE$ is the unique homomorphism that makes Figure 3 commute.
(There are other homomorphisms, and other functors that make the diagram commute, but no others that do both.)[15]

What exactly does $BE$ do? Perhaps more perspicuous than Montague's IL formulation is its expression in set-theoretical terms: $\lambda \mathcal{P}[\lambda x[\{x\} \in \mathcal{P}]]$. That is, it applies to a generalized quantifier, finds all the singletons therein, and collects their elements into a set. The commutativity of Figure 3 is then straightforward, since a generalized quantifier obtained by applying *lift* to an entity *a* will contain just one singleton, $\{a\}$. And as Keenan and Faltz (1978, 1985) showed, the full $\langle \langle e, t \rangle, t \rangle$ domain can be generated by applying Boolean operations to generalized quantifiers of that special sort (the
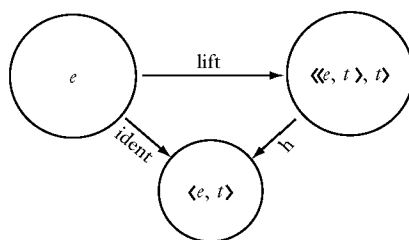
**Figure 3**

"individual sublimations", in the terms of Dowty, Wall and Peters (1981)). So *BE* does indeed seem to be a particularly nice, structure-preserving mapping from $\langle\langle e,t\rangle, t\rangle$ to $\langle e, t\rangle$.

The semantic naturalness of the *BE* operator is of course independent of whether we take it to be the meaning of English *be*, analyzed as a transitive verb taking $\langle\langle e, t\rangle, t\rangle$ objects as in PTQ, or, as I proposed above, treat it as a (potentially universal) operator that is always available to turn an $\langle\langle e,t\rangle, t\rangle$ meaning into an $\langle e,t\rangle$ meaning. The choice between the analyses will depend heavily on syntactic considerations. In either case, *BE* is a total function, so we still have to explain why some NP's don't occur naturally after *be* or in other predicative positions. The explanation is that although *BE* is total, and preserves important structure of the $\langle\langle e,t\rangle, t\rangle$ domain, it also ignores a lot of structure by looking only at the singletons in any generalized quantifier. *Most men*, for instance, will never contain any singletons, so *be most men* will always be empty; similarly for distributive readings of plurals like *two men, several men*, etc. (Group readings of such plurals yield good predicative readings, which is predicted if groups or plural individuals are treated as entities, as in Link (1983).) *Every man* contains a singleton only if there is just one man; although it is probably too strong (certainly among logicians!) to claim that *every* presupposes "more than one", one and zero are degenerate cases, usually included only for the sake of generality, and to use *every man* predicatively you would have to *know* you were dealing with a degenerate case, in which case *the* or *the only* would be appropriate and more straightforward. Note that *BE*(no man′) = not(*BE*(a man′)); English seems to prefer the latter construction, Dutch the former, although I don't think either would be declared ungrammatical in either language.

In general it seems that the NP's that yield sensible predicative readings fall into two categories: those formed with "weak" determiners (Milsark 1977; Barwise and Cooper 1981), which are intuitively the indefinites, and definite singular NP's. In the former case the predicative reading is tantamount to stripping *A* off the generalized quantifier reading and leaving the common noun meaning (since *BE* and *A* are inverses); in the case of definite singulars, the extensionality of the system discussed here would make the predicative reading tantamount to applying *ident* to the corresponding entity, probably an unsatisfactory analysis.[16]

Having established the naturalness of *BE* as a type-shifting functor from $\langle\langle e,t\rangle, t\rangle$ to $\langle e,t\rangle$, one question that springs to mind is: For what possible *DET* meanings is it true that $BE(DET(\mathrm{P})) = \mathrm{P}$?[17] One answer is *A*, as is familiar from the fact that in PTQ, (*be a man*)′ comes out equivalent to *man*′; hence *A* meets one reasonable condition for

naturalness by virtue of being an inverse of *BE*. (But *exactly one* is also an inverse for BE; the general requirement is that the singleton sets contained in *DET*(P) must be all and only the singletons of elements of P.)

Two other potentially significant properties of $A$ are that it is symmetric and is monotonically increasing in both arguments; I conjecture that these are both "nice" properties. That's a vague claim, but I would expect to see it borne out in order of acquisition and in cross-linguistic distribution of determiners and of any other functor categories for which those properties are definable. The properties certainly distinguish $A$ from *exactly one*, which has neither of them.

I would conjecture, in fact, that among all possible DET-type functors. $A$ (which combines English *a* and *some*) and *THE* are the most "natural" and hence the most likely to operate syncategorematically in natural languages, or not to be expressed overtly at all, and that *BE* is the most "natural" functor from $\langle\langle e,t\rangle, t\rangle$ meanings to $\langle e,t\rangle$ meanings. On the formal side, this requires finding and arguing for further formal criteria for what makes a functor "natural", and showing that $A$, *THE*, and *BE* score high under such criteria. On the linguistic side, I would expect to see further evidence that the semantic force of $A$, *THE* and *BE* is often carried by constructional rather than lexical meaning.[18]

## 3.4   Mappings to and from type e

In Montague's *PTQ*, no English expressions were analyzed as type *e*; on our approach, there is still no syntactic category uniformly interpreted as type *e*, but many NP's have type *e* interpretations as one of their possible interpretations. Lexical NP's, proper nouns and singular pronouns may be basically of type *e* and acquire $\langle e,t\rangle$ and $\langle\langle e,t\rangle, t\rangle$ meanings by *ident* and *lift* respectively. Non-lexical NP's with *e*-type interpretations are probably most easily accounted for as resulting from type-shifting operations applied to initially higher type interpretations, although it is possible that type-lowering has become grammaticized so that, for instance, *the* may have an interpretation as *iota* as well as (or instead of) an interpretation as *THE*. (It may not be easy to find arguments to decide whether the *e*-type interpretation of *the king* is best analyzed as *iota(king′)* or as *lower(THE(king′))*.) We have already mentioned several mappings to and from type *e:* *lift* and *lower*, *ident* and *iota*, *nom* and *pred*. In this section we will say a bit more about *lower*, and particularly about the Kamp–Heim treatment of indefinites as type *e*. Then we will suggest that the type-shifting perspective fits well with recent proposals by Link and others for the treatment of mass and plural noun phrases using model structures which impose additional structure on various subdomains of the domain of entities.

### *3.4.1   Lower and indefinites*

As described in section 3.1, *lower* applies to any generalized quantifier which is a principal ultrafilter and maps it onto its generating element in the *e* domain. This accounts for *e*-type readings of definite singular NP's like *the king*, *this dog*, *Bill's car* (and *John* and *he*, if these are not directly generated as type *e*.) It does not directly give *e*-type readings for definite plurals like *those three men*, a principal filter whose generator is a set, nor to indefinite singulars like *a man*, which on their standard

treatment are not principal filters at all. The former case will be taken up when we discuss Link's treatment of plurals, the latter right now.

While Kamp's and Heim's proposals for the treatment of various kinds of noun phrases and anaphora suggest rather far-reaching changes in the semantic framework, Zeevat (1984) has recast central parts of their proposals in terms that help to localize the major innovations around the treatment of free variables and the mechanisms of variable-binding. Using Zeevat's notation, an "indexed indefinite" like $[a \ man]_n$ can be translated as in (13),

(13)   $\lambda P[P(x_n^*) \wedge man'(x_n)]$

where the asterisk is a diacritic that plays a role in the non-standard rules for variable-binding. Alternatively, it could be translated as $\lambda P[P(x_n^*)]$ plus the condition $man'(x_n)$, if the condition is treated as a separate clause as in Heim (1982). In either case, as Heim has emphasized, the removal of the existential quantifier from the interpretation of indefinites makes their meanings much more like pronoun meanings, and apart from the complication that we are here dealing with variables, the meanings are similar to proper noun meanings like $\lambda \ P \ [P \ (j)]$, and *lower* can apply to give *a man* an *e*-type reading $x_n^*$ (together with the condition $man'(x_n)$).[19]

### 3.4.2   *Plurals and mass noun phrases*

Link (1983) proposed additional structure within the domain of entities, including the recognition of a subdomain of "plural individuals" and a subdomain of quantities of matter, each with a certain amount of Boolean structure and with a mapping from the former to the latter; in terms of this structure Link is able to solve a number of puzzles in the semantics of plurals and mass nouns. To integrate his structure with the perspective suggested here, we can see that there is a natural pair of mappings relating Link's plural individuals in the *e* domain to sets of ordinary individuals, in the $\langle e, t \rangle$ domain; let us call these mappings *link* and *delink*, as in Figure 4 below.

Then $link(\{a, b\}) = a \oplus b$; $delink \ (a \oplus b) = \{a, b\}$. *Link* is total (singleton sets map onto the single individuals which are the atoms of the plural-individual structure) and injective; *delink* is partial and surjective.

With this possibility of easy shifting between the group (individual) perspective and the set perspective, we can readily generate *e*-type readings of definite plurals like *the three men*, in fact via several equivalent routes. If we start with a distributive reading
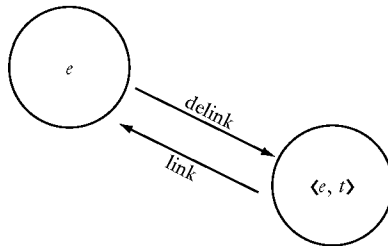


**Figure 4**

like Barwise and Cooper's, taking the generator set of the principal filter (a new operation we call *genset*) would get us a set of (the) three men, whence *link* would get us a plural individual. Starting with the kind of group reading provided by Link, we could apply *lower* directly to get the same plural individual.

The behavior of the cardinals *two, three, ...* can probably also be illuminated on this perspective; briefly, I would suggest that the primary interpretation of *three* is as an $\langle e, t \rangle$ adjective applying to plural individuals (here it means "exactly three"), which can be promoted to an $\langle \langle e, t \rangle, \langle e, t \rangle \rangle$ prenominal (intersective) adjective by standard techniques. Then either by composition with $A$ or by the Kamp-Heim treatment of indefinites it can become a determiner (group reading), picking up the explicit or implicit existential quantifier which would account for the "at least" reading normally associated with cardinal determiners. Lastly, the *delink* operation could naturally be extended to a corresponding operation on all "group" determiners to yield corresponding distributive determiners; an analogous operation was proposed in Michael Bennett's dissertation (Bennett 1974).

Pelletier and Schubert (1989) discuss a wide range of problems in the syntax and semantics of mass expressions and provide an excellent critical survey of suggested solutions, offering some new proposals of their own. Drawing in part on the work of Link and of Chierchia discussed here, as well as earlier work by Parsons, Pelletier, ter Meulen and others, they sketch several alternative approaches which make use of implicit semantic operations. Some of these operators perform type-shifting operations, others have what we might call "sort-shifting" effects within a single type; as noted earlier, the distinction is a very theory-dependent one that we don't wish to lay any emphasis on here. Much of the heaviest debate in the mass noun literature concerns the semantics of predicative mass expressions and the question of what they are true of: ordinary objects, quantities of matter, and/or substances or kinds. Pelletier and Schubert show how one can take various positions both on the number and nature of the ontological distinctions made in the model and on the number and nature of discrete senses of mass predicates relative to a given ontological background. A number of the proposals they describe involve sort-shifting operators which convert, for example, a mass predicate true of kinds (as in "Red wine is *wine*") into one true of objects or quantities of matter (as in "The puddle on the floor is *wine*") or vice versa. Their own proposals suggest the desirability of letting the "unmarked" or default case for mass predicates be that a given mass predicate such as *beer* can apply indifferently to entities of a number of different sorts: quantities of beer, kinds of beer, conventional servings or kinds of servings of beer; objects coincident with or constituted by quantities of beer, and involving what we might call "sort-restricting operators" as part of the semantics of constructions which limit the applicability of the predicate to some proper subset of these cases; these can be viewed as a special kind of sort-shifters which take a more general sort onto a subsort. Such a possibility does not exist for type-shifting operators in a type theory like Montague's but would in some more general theories of types and is therefore an interesting potential addition to the inventory of natural type-shifting operations.

Pelletier and Schubert, following Chierchia, also propose type-shifting operators converting mass predicates (typically expressed as common noun phrases) of these various sorts to mass terms denoting substances (typically expressed as determinerless full NP's)

and vice versa. As in Chierchia, these are basically the same *nom* and *pred* operators that apply in the semantics of bare plurals and other nominalization phenomena.

And of course the ease of shifting between mass and count senses of the same common noun phrase has long been noted and illustrates the existence of other apparently very natural short-shifting operations that may or may not be grammaticized in different languages: count to mass via the Pelletier/Lewis "universal grinder" (put in a chair and you end up with chair all over the floor); mass to count with either a "conventional portion of" or "kind of" interpretation.

### 3.4.3   Structure in the e domain

All of the operations *nom* and *pred, link* and *delink*, and analogs for mass terms depend on the existence of richly structured subdomains in the domain of entities; these structures can be seen to be taking over some of the work previously done by the type theory. More of the same sort of shift can be seen in proposals for the semantics of comparatives which treat "degrees" as entities, and in proposals for an event-based ontology in which events are also entities. First-order theories put virtually *all* of the burden on structure internal to the entity domain; Chierchia (1984) argues that linguistic evidence favors a semantics which is at least second-order but not a fully recursive type system like Montague's. This kind of investigation of trade-offs between strongly typed systems and less strongly typed systems with multiple subsorts of entities is also being carried out in the domain of programming languages; see Goguen and Meseguer (1984), Meseguer and Goguen (1984) and Futasugi et al. (1985).[20] It is partly because this kind of study opens up so many possibilities that have not been explored that I feel in no position to argue for a "best" way of analyzing particular constructions.

In closing this section, let me note that there remain NP's for which none of our operations provide *e*-type readings; these, not surprisingly, are the ones traditionally thought of as most clearly "quantificational": *no man, no men, at most one man, few men, not every man, most men.*[21] *Every man* could get an *e*-type reading via *lower* in case there is only one man; but linguistically it never seems to act as a singular "referential" term, suggesting again (cf. section 3.3) that it is at least pragmatically anomalous to use *every* in a way that constrains it to just one. Such NP's can occur in *e*-type positions only by "quantifying in", which would account for the traditional distinction between them and "referring expressions". On the perspective advanced here, we can capture such traditional distinctions without giving up the unification achieved by Montague's work, which we still need in order to account for the possibility of conjunctions like "King John and every peasant", which would be inexplicable on an analysis which captured only the differences and not the common $\langle \langle e, t \rangle, t \rangle$ structure.

## 4    The Williams Puzzle

Anticipating the kind of proposal put forward in section 3.3, Williams (1983) argued that the possibility of $\langle e, t \rangle$ readings for NP's can*not* be predicted from the determiner, citing examples like (14), where virtually any determiner can occur.

(14)    This house has been every color.

I believe this apparent counterexample and others like it can be explained in terms of the idiosyncratic and language-particular behavior of the head noun. In English (but not e.g. in Dutch) many "attribute" nouns allow this kind of construction: *color, size, length, weight, age, price*. A relatively "tolerant" context which accepts such nouns rather easily is "This dress is the wrong – ", a more restrictive one is in the use of these "attribute NP's" as postnominal modifiers, as in (15), where grammaticality judgments are my own – there appears to be considerable individual variation on judgments about particular words, reinforcing the idea that this is a quite idiosyncratic lexical property.

(15)    a dress that size / that color / that length / that price / *that material / *that design / ?that pattern / *that origin.

In this construction we have a predicative ($\langle e, t \rangle$) use of an NP that does not correspond to the result of any of the type-shifting operations we have seen so far. To see what's going on semantically, consider the following pattern:

(16)    (a)    This shirt is blue.
        (b)    Blue is a nice color.
        (c)    This shirt is a nice color.

In (16a), *blue* is an adjectival predicate ($\langle e, t \rangle$), predicated of the shirt. In (16b), we have the nominalized property *blue*, type $e$, and the expected $\langle e, t \rangle$ predicative use of *a nice color*; the entities in the extension of *color* are colors: blue, red, green, etc. – not shirts. Semantically, (16c) is quite different from (16b), and amounts to something like a combination of (16a) and (16b) with the color unspecified. Many languages do not allow this kind of predication to be expressed with a simple noun phase but require the equivalent of (17a) or (17b) below, construction types which also occur with some attribute nouns in English.

(17)    (a)    This shirt is of a nice color.
        (b)    This shirt has a nice color.

The possibility of using bare NP's as predicates in this way in English is reminiscent of the adverbial use of NP's studied by Larson (1985), which is also quite idiosyncratic: *that day, that way, *that manner*.

The crucial formal tool that allows a straightforward account of this special predicative use of attribute NP's is Chierchia's nominalization theory, which relates predicative properties like *blue* as in (16a) to their type $e$ nominalizations as in (16b). Although Chierchia's theory takes properties as (intensional) primitives, I don't think it does any harm here to misrepresent the predicative property as type $\langle e, t \rangle$ for ease of exposition.

If we take adjectival *blue*, $\langle e, t \rangle$, as basic, the $e$-type proper noun *blue* can be translated in Chierchia's system as $^\cap blue'$; if we take the $e$-type noun as basic, the adjective is $^\cup blue'$; in either case the two are related by those inverse operators, the ones

we called *nom* and *pred* in section 3.1. Recall that *pred*, or "$\cup$", is defined only for entities which are the "entified" counterparts of properties.

*Color* is a common noun, its type $\langle e, t \rangle$; entities in its extension are, as noted above, properties (*blue*, *red*, etc.). This is the semantic content of what I mean by "attribute noun": these nouns express properties of properties. In addition to knowing this semantic fact about the noun *color*, we must encode with a diacritic syntactic feature – say, +A – the syntactic difference between "adjectival" attribute nouns like *color, size, weight* and *age* which do fit into constructions like those in (14), (15), and (16c) and other attribute nouns like *property, virtue,* and *origin* which do not. The combining stem -*thing* can function as a + A attribute noun, as in the frequently puzzled-over construction in (18).

(18)   He is everything I hoped he would be (intelligent, non-sexist, vegetarian, etc.)

I am not sure what to call the syntactic category of this special predicative use of attribute NP's; here I will assume that they belong to a syntactic category *Pred* (semantic type $\langle e, t \rangle$) which includes predicative adjective uses of NP's, since these special attribute NP's can occur in constructions where other predicative NP's cannot, such as postnominal position as in (15) and in *there*-constructions as in (19) below (on some analyses these are the same fact):

(19)   (a)   There's nothing here a good color.
       (b)   There's no one here the right age.
       (c)   *There's no one here a good teacher.
       (d)   *There's nothing here the right answer.

To complete the analysis, I need just one syntactic and semantic rule and a couple of uncontroversial assumptions. The first assumption is that any NP whose head noun has the feature +A also has the feature +A; this follows from most theories of feature inheritance.[22] The second is that the rule of quantifying-in[23] quantifies generalized quantifiers into *e*-type positions only, not into $\langle e, t \rangle$ positions. I will also assume a pro-form *that$_i$* as an *e*-type +A variable over (entified) properties; this corresponds to the use of *that* discussed by Ross (1969), illustrated in (20).

(20)   They said she was beautiful and {that she was / she was that }

The syntactic and semantic rule for attribute predicates can be formulated as follows:
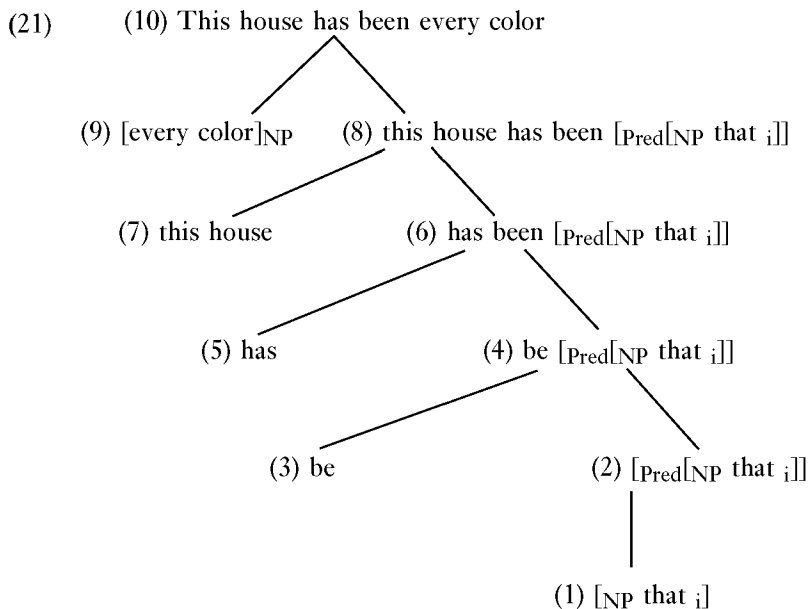
*Attribute Predicate Rule*
*Syntactic Rule*: If [$_{NP}$ α] is +A, then [$_{Pred}$[$_{NP}$ α]] is a Pred.
*Semantic Rule*: If [$_{NP}$ α] translates as α′, then [$_{Pred}$[$_{NP}$ α]] translates as $\cup$α′.

Note that the semantic rule is defined only for NP's of type *e* and turns them into $\langle e, t \rangle$ predicates; so this rule applies to attribute NP's like *that color, the color Mary liked best, a color I once saw in a sunset, two colors* (group reading), and the pro-form *that$_i$*, which all have *e*-type readings via the general principles discussed earlier, but not *every color*.

The generalized quantifier reading of +A NP's is just like that of any other NP, and no special rules apply to them; we only need assume that only a +A NP can be quantified into a +A position. We can now illustrate the syntactic derivation and semantic interpretation of Williams' example (14).

(21)   (10) This house has been every color

(9) [every color]$_{NP}$   (8) this house has been [$_{Pred}$[$_{NP}$ that $_i$]]

(7) this house   (6) has been [$_{Pred}$[$_{NP}$ that $_i$]]

(5) has   (4) be [$_{Pred}$[$_{NP}$ that $_i$]]

(3) be   (2) [$_{Pred}$[$_{NP}$ that $_i$]]

(1) [$_{NP}$ that $_i$]

(1)   $x_i$   (type $e$)
(2)   $^{\cup}x_i$   (type$\langle e, t\rangle$)
(3)   $\lambda P \lambda x[P(x)]$
(4)   $\lambda P \lambda x[P(x)](^{\cup}x_i) \dashrightarrow \lambda x[^{\cup}x_i(x)]$ (type$\langle e, t\rangle$)
(5)   $\lambda Q \lambda y[H(Q(y))]$   (here H is a past operator)
(6)   $\lambda Q \lambda y[H(Q(y))](\lambda x[^{\cup}x_i(x)]) \dashrightarrow \lambda y[H(^{\cup}x_i(y))]$ (type$\langle e, t\rangle$)
(7)   $h_1$ (type $e$; I ignore the internal structure of this NP here)
(8)   $\lambda y[H(^{\cup}x_i(y))](h_1) \dashrightarrow H(^{\cup}x_i(h_1))$
(9)   $\lambda P[\forall x[color'(x) \longrightarrow P(x)]]$
(10)   $\lambda P[\forall x[color'(x) \longrightarrow P(x)]](\lambda x_i[H(^{\cup}x_i(h_1))]) \dashrightarrow \forall x[color'(x) \longrightarrow H(^{\cup}x(h_1))]$

The last line gives the desired interpretation: for all x, if x is a color, at some time in the past this house has had the property $^{\cup}x$, the predicative version of the property x.

Semantically, this analysis depends heavily on Chierchia's treatment of nominalization; syntactically, it depends on having a syntactic derivation in which the $e$-type NP position contained within the derived Pred remains accessible to quantifying in, since I assume one cannot generally quantify into $\langle e, t\rangle$ positions. I believe that the same principles account for the exceptional relativization out of predicate position exemplified in (18).

A similar approach might account for another kind of case of quantified NP's appearing in predicate position, as in (22).

(22)   Olivier has been every Shakespearean king.

Here we have an ordinary noun as head, and various treatments are possible, depending on what one considers the best analysis of sentences like (23).

(23)   Oliver is Richard III.

If one analyzes both NP's as $e$-type, either treating this *is* as "is playing" or by admitting a *be* of identity, then this isn't really a predicative position and quantifying in is to be expected. I would suggest that we have the same *be* here as elsewhere, and that Richard III as a role is a non-rigid individual concept of (type $\langle e, t \rangle$) (see Janssen (1984) for related discussion), which can be turned into a predicate nominal, in this case [$_\text{PNOM}$ [$_\text{NP}$ Richard III]], interpreted as $\lambda x[x = {}^\vee r]$. However, unless we map "roles" as individual concepts back into the entity domain in a move analogous to Chierchia's, we would still need to give a non-standard type analysis to *every Shakespearean king*.

# 5   English *be*

In section 3.2 above we suggested that the semantic operation we called *BE* should be treated not as the meaning of English *be* but as a type-shifting functor freely applicable to generalized quantifier meanings of NP's to yield predicative readings for those NP's. We suggested further, following Williams (1983), that English *be* subcategorizes semantically for an $e$ argument and an $\langle e, t \rangle$ argument, with a meaning paraphrasable as "apply predicate". (This treatment of *be* was adopted in the derivation (21) of example sentence (14).) We may want to say further that *be* imposes no sortal restrictions of its own, requiring that its $\langle e, t \rangle$ argument be predicable of its $e$ argument. Depending on how inclusive the $e$ domain is, one may want to go further and call *be* genuinely polymorphic, taking one $X$-type and one $\langle X, t \rangle$-type argument, for any type $X$.

If we accept Williams's argument that the arguments of *be* may occur in either order, we get the added benefit of automatically generating both readings of ambiguous pseudoclefts; this is discussed further in Partee (1986). An appropriate treatment of this "semantic transparency" of *be* should also be able to account for cases of control phenomena and other instances of "syntactic connectedness" (Higgins 1973) across *be*, provided the control phenomena are treated semantically; but this is a suggestion in need of considerable work before it becomes a serious proposal.

It may be going too far to think of *be* as making no semantic contribution of its own, although this is a fairly traditional view. On the proposals just sketched, there would be no difference in meaning at all between *cat* and *be a cat*, *asleep* and *be asleep*, etc. While this is also true of Montague's treatment and of most proposals that are expressible in first-order logic, it seems questionable. One should consider in this regard the insightful work of Stump (1985), who assigns to *be* a kind of sort-shifting meaning, turning predicates of stages (G. Carlson ontology) into predicates of individuals but otherwise still semantically transparent.

The syntax and semantics of the copula in English and other languages is of course a vast subject which I can't hope to do justice to in a few paragraphs. But it does seem promising that the present approach allows a treatment of *be* that accords well with traditional views suggested by the word *copula*, preserving the positive aspects of Montague's treatment of the *be* + *NP* construction while unifying that construction with other kinds of *be* + *Pred* construction.

# 6   Conclusions

Much work remains to be done to determine the appropriate way to incorporate the kinds of operators studied here into a theory of grammar. I have said very little about syntax or about constraints on the mapping of syntax to semantics in this paper. Most of the emphasis has been on the exploration of certain kinds of operations which I believe are at work somewhere in the semantics of English and many of them probably universally. Some of them may be built into the operation of specific rules, e.g. the *nom* operator in the semantics of rules of nominalization: some may apply freely whenever there is a mismatch between the simplest type of a given expression and the type needed for a particular occurrence of it to be well-formed, e.g. *lift* provides a simple *e*-type NP like *John* with a generalized quantifier meaning so that it can occur in conjunctions like *John and every other student*. Some may be language-specific, like the +A-rule discussed in connection with the Williams puzzle in section 4; others, like the free applicability of *lift* to provide generalized quantifier meaning to *e*-type NP's, may well be universal, at least among languages which have NP's with generalized quantifier meanings at all. Finding which are which, and undoubtedly uncovering new type-shifting and sort-shifting principles in the process, would appear to be an important and promising venture which will require close study of a wide range of languages.

Another general direction of research suggested by these beginnings that may be of interest beyond the study of semantics is the search for "cognitively natural" operations. As I suggested at various points above, I believe an interesting case can be made for regarding certain semantic operations or functions of a given type as more "natural" than others on various plausible criteria, vague as such a notion must be. I will close by reiterating the need for interdisciplinary collaborative efforts on this issue, empirical studies to help determine what kinds of operations and functions are particularly widespread in the world's languages, frequently occur syncategorematically, are acquired early, etc.; and formal studies to help us gain a better understanding of the possible structures of semantic domains and possible formal criteria of naturalness to apply to mappings between them. One can imagine such studies of "natural mappings" extending well beyond the sorts of cases studied here, and relating to such disparate issues as the role of symmetry in perception, the problem of projectible predicates ("grue" vs. "green"), the interpretation of metaphors, and the development of mathematical intuition. Wherever one can uncover richly structured domains and evidence of an important role being played by mappings between them, it should be possible to investigate the relative cognitive "naturalness" of various such mappings, and such studies should in principle help to advance our understanding of the contribution our

"hardwired" predilections make to the way we make sense of the world we find ourselves in.

# Notes

1   Since the requirement of a homomorphism from syntactic categories to semantic types is fundamental to Montague's approach, one cannot literally allow a single syntactic category to map onto more than one semantic type within that approach. There are various ways of reformulating my proposal to conform to the homomorphism requirement, e.g. by exploiting the common view of syntactic categories as feature bundles. Flynn (1981) argues for the inclusion of both X-bar and categorial identification in syntactic categories, and there is considerable independent motivation for such a move, e.g. in the cross-classification of X-bar categories such as "PP", and "AdjP" and categorial grammar categories such as "predicate", "predicate modifier", etc.

  Incidentally, nothing I say in this paper is meant to decide between the use of type theory and the use of sorted domains in a type-free or less strongly typed theory. I use type theory because it

is more familiar to me; I don't really know how much difference it makes. Chierchia and Turner (1988) discuss this question.

2  Here and throughout I am simplifying to a purely extensional sublanguage unless explicitly stated otherwise. That is one of the big gaps in this work that needs to be filled.

3  See, for instance, Partee and Rooth (1983) on conjunction, Reinhart (1983) on bound-variable anaphora.

4  See Chierchia and Rooth (1984), Zeevat (1984).

5  This of course goes beyond the bounds of a purely extensional fragment; what I do in this paper is systematically misrepresent properties as sets, hoping that the differences between them will not affect the main ideas.

6  See Bach and Partee (1980), Reinhart (1983).

7  So I would predict that any language which has expressions like "every man" as a syntactic NP of semantic type $\langle\langle e, t\rangle, t\rangle$ will also allow proper names like "John" to be $\langle\langle e, t\rangle, t\rangle$, hence will allow conjunctions like "John and every man". Similarly, while children acquiring English may start out with only e-type NP's, once they acquire quantificational NP's they should soon show signs of promoting simpler NP's to the higher type as well.

8  I am using expressions of Montague's intensional logic, with his conventions as to the types of variables, to denote corresponding model-theoretic objects, occasionally recasting things in set-theoretical vocabulary where it may add perspicuity. The type-shifting operations are defined on model-theoretic objects; we might find it useful to add their names as logical constants to the intensional logic or other intermediate representation language.

9  See note 5.

10  In a fuller treatment, the same should apply to definite plural and mass terms as well, like *the men* and *the water*.

11  There could be (and would be unless something rules it out) a second generalized quantifier reading of *the king, lift(iota(king'))*. I'm not sure how one would get evidence for or against such an ambiguity.

12  I believe one can interpret Frege (1892) as making such a claim about subject NP's.

13  I assume that the grammar specifies various positions as $e$, $\langle e, t\rangle$, etc., via subcategorization and other rules. I believe that positions are not subcategorized as $\langle\langle e, t\rangle, t\rangle$ unless they are also intensional, like the object of *seek*, hence outside the scope of this discussion. In cases of ambiguity, I would predict that if any NP can be either $e$ or $\langle e, t\rangle$ in a certain position, $e$ would be the preferred choice not only because it is a simpler type, but also because $e$ and $\langle\langle e, t\rangle, t\rangle$ are (I believe) unmarked types for NP's, while $\langle e, t\rangle$, the unmarked type for VP's, AdjP's, and many PP's, is a marked type for NP's. I don't know what to expect in cases of ambiguity between $\langle e, t\rangle$ type and $\langle\langle e, t\rangle, t\rangle$ type for a given NP in a given position, since there is then a conflict between simplicity of type and markedness as an NP-type.

14  My thanks to Johan van Benthem for showing me that Montague's BE functor is indeed "natural", both intuitively and by various formal criteria, something I had never appreciated in spite of years of familiarity. This section was much weaker before he helped with it.

15  Thanks to Johan van Benthem for the fact, which he knows how to prove but I don't, and to Hans Kamp who gave me further help in understanding it.

16  This is yet another place where it seems evident that we want properties and not sets to play a basic role in what we are calling the $\langle e, t\rangle$ domain. The *predicate* reading of "the owner of this land" should neither presuppose that the land has an owner nor depend on who the owner is if there is one. Although intensionality will probably complicate the type-shifting picture, I believe it is indispensable for a satisfactory analysis.

17  That is, we are asking what determiner-type meanings are inverses of *BE* in one direction. We cannot expect any determiner meaning to be an inverse in the other direction, i.e. to satisfy $DET(BE(\alpha)) = \alpha$ for all $\alpha$, since *BE* loses information: $BE(\alpha) = BE(\beta)$ for any $\alpha$ and $\beta$ that contain the same singletons.

18   Moortgat (1985) gives evidence of *the*, *a*, and Carlson-type bare-plural readings in first elements of noun-noun compounds in English, Dutch, and German, where semantic NP-type readings are carried by syntactic CN's. The formation of bare plurals should also count as "natural", I would hope, but I am following Chierchia in viewing it as basically a nominalization operation ($\langle e, t\rangle$ to $e$) rather than a DET-type functor; its composition with *lift* would then be a DET-type functor.

19   Johan van Benthem has warned me that the kinds of type-shifting functors I have been employing cannot be assumed to apply straightforwardly to variables, since we are not then dealing directly with model-theoretic objects in the same way. But I believe that the same principles *ought* to apply, and it would at least be straightforward if we included logical constants like *lower* and *lift* in an intermediate representation language such as Zeevat's reconstruction of Kamp's DRS language.

20   My thanks to Jose Meseguer, Joseph Goguen, and Ray Turner for making me aware of related work in the semantics of programming languages. I'm not able to understand and appreciate much of the technical work in that field, but it seems clear to me that this is another problem area where interdisciplinary collaboration could have considerable payoff.

21   Sometimes "most men" seems to have an *e*-type reading paraphrasable as "a group containing most men"; this seems even easier to get with "most of the men". See Doron (1983) for discussion of some of these issues and of differential availability of predicative $\langle e, t\rangle$ readings for partitive and non-partitive plural NP's. Plurals and mass terms raise many more semantic issues than can be touched on here; it would take at least another paper to examine a significant fraction of current work on mass terms and plurals in the light of the type shifting perspective suggested here. See, for instance, Scha (1981), Hoeksema (1983); van Eijck (1983). Westerståhl (1989), Pelletier and Schubert (1989). Lønning (1984).

22   NP's formed with the bound CN-stem *-thing* must also be able to be marked $+$ A, perhaps optionally as illustrated in (18); there should probably be some general way of indicating that *-thing* has maximally permissive selectional features and corresponds to a maximally inclusive "sortal range" of entities.

23   The same restriction could be applied to other proposed mechanisms for dealing with quantifier scope, such as Cooper-storage, quantifier-lowering, or QR (quantifier-raising)

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