Chapter 19
On Partee's "Noun Phrase Interpretation and Type-Shifting Principles"

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Abstract Montague's classic article "The Proper Treatment of Quantification in Ordinary English" (PTQ, 1973) treated all NP occurrences as quantificational. Partee's article "Noun Phrase Interpretation and Type-Shifting Principles" (1987) reconciles PTQ's uniform quantificational strategy with the older distinction between three NP types: entities, predicates and quantifiers. On top of this distinction, Partee introduces operators that allow shifting the denotation of an NP to a different type than the one it is initially assigned. Using these type-shifters, one and the same NP may receive each of the three interpretations. In addition to this synthesis of previous approaches, Partee's article contains a rather elaborate analysis of predicative NPs, as well as insightful hints about the treatment of definite NPs, nominalization phenomena, plural, mass and generic NPs, and the mathematical principles underlying type-shifting. At a more global level, Partee's article marks a methodological transition in formal semantics, highlighting general principles that are relevant to different languages and to different linguistic frameworks, rather than technicalities of artificial language fragments. This general account and the new ways it opened for semantic theory, together with the paper's lucid and friendly style, have made "Noun Phrase Interpretation and Type-Shifting Principles" one of the modern classics in formal semantics. After some necessary background on NPs in PTQ, this review covers the main innovations in Partee's article, and comments on the work and its influence.

Keywords Type shifting · Noun phrase · Quantification · Predication

Different usages of noun phrases appear to involve different semantic objects. In (1a) below the NP seems to refer to a concrete entity, in (1b) the NP looks like a unary predicate applying to an entity, while in (1c) the NP functions like a quantifier.

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(1) a. Look at *the trumpeter* over there!
b. Mary is *a trumpeter*.
c. *Every trumpeter* likes Schoenberg.

In a notable step towards unifying the three usages of NPs, Montague's classic article (Montague, 1973, henceforth *PTQ*) avoided this traditional distinction, treating all NP occurrences as quantificational.[1] Partee's article *Noun Phrase Interpretation and Type-Shifting Principles* (1987/2004) reconciles PTQ's uniform quantificational strategy with the older distinction between three NP types.[2] This three way distinction between NPs is encoded using the following semantic types:[3]

e	entities
et	one-place predicates, or functions from entities to truth-values
$(et)t$	quantifiers, or functions from one-place predicates to truth-values

On top of this distinction, Partee introduces operators that allow shifting the denotation of an NP to a different type than the one it is initially assigned. Using these *type-shifters* (TSs), one and the same NP may receive entity-referring, predicative and quantificational interpretations. In this way, Partee reintroduces the traditional distinction between NPs while retaining Montague's quantificational treatment. In addition to this synthesis of previous approaches, Partee's article contains a rather elaborate analysis of predicative NPs as in (1b), as well as insightful hints about the treatment of definite NPs, nominalization phenomena, plural, mass and generic NPs, and the mathematical principles underlying type-shifting.

At a more general level, Partee's article marks a methodological transition in formal semantics. Following the example of PTQ, many early works in formal semantics focused on language fragments, which demonstrated the application of the theory to selected linguistic facts, usually about English. This focus on small, well-defined fragments of English often obscured the wider linguistic relevance of semantic theory. In contrast, Partee's article concentrates on general principles that are relevant to different languages and to different linguistic frameworks, and it is constructively removed from irrelevant technicalities of specific fragments. This general account and the new ways it opened for semantic theory, together with the paper's lucid and friendly style, have made *Noun Phrase Interpretation and Type-Shifting Principles* one of the modern classics in formal semantics.

This review is structured as follows. Section "Quantificational and Predicative NPs in PTQ" gives necessary background on quantifier denotations and predicative NPs in PTQ. Section "Partee's Type-Shifting Strategy" reviews the main proposals

[1] See Chap. 18. Barwise and Cooper (1981) is another classic article in semantic theory, which follows PTQ in analyzing all NPs as quantifiers (see Chap. 3).

[2] All page references in the present article are to the reprinted version (Partee, 2004).

[3] Here and henceforth I use short notation for extensional types, where e and t are the types for *entities* and *truth-values* respectively, and $(\tau\sigma)$ is the type of functions from objects of type τ to objects of type σ. Suppressing outermost parentheses, we abbreviate this type as $\tau\sigma$. Partee uses the $\langle\tau, \sigma\rangle$ notation for types of this form, hence, for instance, her notation $\langle\langle e, t\rangle, t\rangle$ for the quantifier type that I here denote $(et)t$.

in Partee's article, and sections "Critical Comments" and "Influence on Further Work" comment on the work and its influence.

Quantificational and Predicative NPs in PTQ

PTQ treats all NPs as quantifiers, i.e. functions from predicates to truth-values. This immediately accounts for the interpretation of NPs in subject positions. For example, in an extensional framework, the noun phrase *a trumpeter* denotes the following function:[4]

(2) $\lambda P_{et}.\exists x_e.\mathbf{trumpeter}(x) \wedge P(x)$

In words, this is the function mapping a predicate P to *true* if and only if P holds of some trumpeter. For example, in the analysis (3b) of sentence (3a) below, the function (2) applies to the predicate **smile**. By simplifying the analysis, we get the intuitive result in (3c):[5]

(3) a. A trumpeter smiled.
b. $(\lambda P_{et}.\exists x_e.\mathbf{trumpeter}(x) \wedge P(x))(\mathbf{smile}_{et})$
c. $\exists x_e.\mathbf{trumpeter}(x) \wedge \mathbf{smile}(x)$

The quantificational analysis is applicable to all NPs in argument position. Notably, even proper names, which intuitively denote simple entities, can be analyzed using quantificational operators of type $(et)t$. For example, the extensional version of PTQ uses the following quantifier as the denotation for the proper name *Berg*, relying on the entity **berg**:

(4) $\lambda P_{et}.P(\mathbf{berg})$

In words, this is the $(et)t$ function that sends a predicate P to *true* if and only if P holds of the entity **berg**. In the sentence *Berg smiled*, this quantifier applies to the predicate **smile**. In formula:

(5) $(\lambda P_{et}.P(\mathbf{berg}))(\mathbf{smile})$

After simplification, we get the intuitive analysis **smile**(**berg**).

Let us now consider NPs with a predicative use, as in *Mary is a trumpeter* (=(1b)). To analyze such sentences, PTQ treats the copula *is* as a function that

[4] Like Partee, I ignore the intensional aspects of the PTQ analysis.

[5] Here and henceforth I refer by "simplification" to the *β-conversion* rule of the Lambda Calculus, which is used to simplify terms with function application. A λ-term $(\lambda x.\varphi)(exp)$ describes a function $\lambda x.\varphi$ applying to an expression *exp*. The β-reduced term $\varphi[x := exp]$, which is obtained by substituting *exp* for all free occurrences of x within φ, denotes the same semantic object as the original λ-term. For instance, the expression (3b) has the same denotation as (3c) since the latter is obtained by substituting the predicate **smile** for P in the term $\exists x_e.\mathbf{trumpeter}(x) \wedge P(x)$ within (3b).

takes quantifiers and turns them into predicates. Specifically, in sentence (1b) the quantifier denotation (2) of *a trumpeter* is mapped to a predicate. To see how this mapping works, let us consider that the function in (2) can isomorphically be described as *the set of all sets that contain a trumpeter*.[6] To illustrate this fact, let us look at the following situation:

(6) Let S be a situation with three entities: two trumpeters $\mathbf{t}_1$ and $\mathbf{t}_2$ and a non-trumpeter $\mathbf{u}$.

In this situation, the sets of entities that contain a trumpeter are the following:

(7) $\{\mathbf{t}_1\}$ $\{\mathbf{t}_1, \mathbf{u}\}$ $\{\mathbf{t}_2\}$ $\{\mathbf{t}_2, \mathbf{u}\}$ $\{\mathbf{t}_1, \mathbf{t}_2\}$ $\{\mathbf{t}_1, \mathbf{t}_2, \mathbf{u}\}$

With the description (7) of the quantifier for *a trumpeter*, let us now look at PTQ's analysis of the predicate *be a trumpeter*. This analysis is derived in two steps:

Step 1 Of the sets that the quantifier function describes, consider the singleton sets. In example (7), these are the singletons $\{\mathbf{t}_1\}$ and $\{\mathbf{t}_2\}$.

Step 2 Construct the predicate that holds of the entities in these singletons. In our example this is the predicate holding of $\mathbf{t}_1$ and $\mathbf{t}_2$ and nothing else.

Consequently, in the situation S, sentence (1b) is analyzed as claiming that Mary is either $\mathbf{t}_1$ or $\mathbf{t}_2$, i.e. she is one of the trumpeters in the situation. This is the desired reading.

In more general terms, the extensional version of PTQ's treatment of *be* is defined as the following function:

(8) $BE = \lambda \wp_{(et)t}.\lambda y_e.\wp(\lambda z_e.z = y)$

In words, BE maps any quantifier $\wp$ to the predicate holding of an entity y if and only if $\wp$ holds of the function $\lambda z_e.z = y$. The latter function is the predicate holding of y and nothing else, which in set notation is described as the singleton $\{y\}$. Accordingly, BE can be described as the function mapping every quantifier $\wp$ to the predicate holding of y iff $\wp$ holds of $\{y\}$. Thus, for every entity y, if the singleton $\{y\}$ is one of the sets described by the quantifier $\wp$, we have y as one of the entities in the predicate assigned to $\wp$ (cf. Step 2).

There is an intuitive reason for Montague's choice to use the BE function in his analysis of the English copula. Since PTQ only treats singular NPs, the BE operator

[6] The operator (2) sends a function P of type et to *true* if and only if the proposition $\exists x_e.\mathbf{trumpeter}(x) \wedge P(x)$ holds of P. Of the entities in a given set E, let $S_P \subseteq E$ denote the set of entities $\{x \in E \mid P(x)\}$ of which such a predicate P holds. Since S_P includes at least one trumpeter, we conclude that the set $S_P \cap \{x \in E \mid \mathbf{trumpeter}(x)\}$ is not empty. Formally: the function (2) is isomorphic to the following set of sets:

$$\{S_P \subseteq E \mid S_P \cap \{x \in E \mid \mathbf{trumpeter}(x)\} \neq \emptyset\}$$

This presentation of a quantifier function as a set of sets follows from a general isomorphism between type-theoretical and set-theoretical perspectives on meaning. For more on this isomorphism and its use in formal semantics, see Chap. 3 and 4 in (Winter, 2016).

only applies to denotations of NPs like *Berg*, *a trumpeter*, *every trumpeter*, etc. By only considering the singletons in such quantifiers, the *BE* function does something rather basic: it recovers the predicate denotation of the noun, at least in those cases where the copular sentence is clearly acceptable.[7]

To see how this analysis works in lambda notation, let us consider what happens when we apply the *BE* operator to the quantifier in (2):

(9) $BE\ (\lambda P_{et}.\exists x_e.\mathbf{trumpeter}(x) \wedge P(x))$

This expression can be simplified as follows:

$$\begin{array}{ll} = (\lambda\wp.\lambda y.\wp(\lambda z.z = y))(\lambda P.\exists x.\mathbf{trumpeter}(x) \wedge P(x)) & \triangleright \text{ by definition of } BE \\ = \lambda y.(\lambda P.\exists x.\mathbf{trumpeter}(x) \wedge P(x))(\lambda z.z = y) & \triangleright \text{ simplification} \\ = \lambda y.\exists x.\mathbf{trumpeter}(x) \wedge (\lambda z.z = y)(x) & \triangleright \text{ simplification} \\ = \lambda y.\exists x.\mathbf{trumpeter}(x) \wedge x = y & \triangleright \text{ simplification} \\ = \lambda y.\mathbf{trumpeter}(y) & \triangleright \text{ because for every predicate } P' \text{ and entity } y\text{:} \\ & \quad \exists x.P'(x) \wedge x = y \text{ is equivalent to } P'(y) \end{array}$$

This sequence of simplifications readily illustrates the complexity of applying the *BE* function to quantifiers. However, in the case of existential quantifiers like the denotation of the noun phrase *a trumpeter*, it leads to a simple result: the expression *be a trumpeter* ends up denoting the same *et* predicate as the noun *trumpeter*.[8] This happens because, in any situation, similarly to our example of situation *S* above, the singletons $\{y\}$ within the existential quantifier for *a trumpeter* are precisely the singletons $\{y\}$ where y is a trumpeter.

Partee's Type-Shifting Strategy

Although Partee (1987) embraces the main foundational assumptions of PTQ, in one respect her proposal is substantially different from Montague's. In PTQ all NPs are treated as quantificational, and quantificational only. Thus, if predicates or entities come in handy for analyzing certain NP occurrences, this can only happen in PTQ by virtue of the meaning of the NP's syntactic environment, and not due to the NP meaning itself. For instance, the PTQ analysis in (9) treats the expression *be a trumpeter* as denoting a predicate. This is due to the analysis of the English copula *be*, but the "predicative" NP receives the same quantificational treatment of NPs in argument positions.

In contrast to PTQ, Partee lets NPs have entity and predicate denotations on top of their quantificational analysis. These different readings are derived using operators

[7] On the vexing question of whether universal quantifier denotations of NPs like *every trumpeter* can ever appear as arguments of *BE* in predicate constructions, see Sect. "Critical Comments".

[8] Formally: $\lambda y.\mathbf{trumpeter}(y)$ describes the same function as **trumpeter**. In the Lambda Calculus this fact is generally captured using the *η-conversion*.

that Partee refers to as *type-shifting principles*—here, in short, *type-shifters* (TSs). For instance, in agreement with traditional accounts, Partee assumes that proper names initially denote entities. Thus, a sentence like *Berg smiled* immediately receives the intuitive analysis **smile**(**berg**), without PTQ's intermediate step in (5). At the same time, following the proposal in (Partee and Rooth, 1983), Partee allows all entity-denoting NPs to be shifted to quantifiers using the following operator:

(10) $LIFT = \lambda x_e.\lambda P_{et}.P(x)$

This function sends every entity x to the quantifier that holds of all predicates holding of x. For instance, for the entity **berg** we have:

(11) $LIFT(\mathbf{berg}) = (\lambda x_e.\lambda P_{et}.P(x))(\mathbf{berg}) = \lambda P_{et}.P(\mathbf{berg})$

This is the same quantifier that the extensional PTQ analysis in (4) assumes as the lexical denotation of the proper name *Berg*. In this way, all proper names in Partee's proposal are potentially ambiguous between entities and the quantifiers they denote in PTQ.

Type-shifting is also used in Partee's analysis of predicative NPs. Following Williams (1983), Partee proposes that in *be* constructions like (1b), quantificational NPs are shifted to predicates. To do that, Partee still uses Montague's *BE* function, though not as the meaning of the English copula. Following Williams, Partee (2004, p. 212) assumes that the copula *be* requires the expression following it to be of type et. This triggers the application of *BE* in copular sentences like (1b). Thus, Partee employs Montague's *BE* as a TS that applies to the NP's quantificational meaning and turns it into a predicate. The resulting analysis is identical to the PTQ analysis (9), but it is derived in a different way.

To summarize, we have seen two major elements in Partee's analysis of NPs:

1. **Non-quantificational denotations**: in addition to quantifiers, NPs can also denote entities and predicates.
2. **Type-shifting**: an entity-denoting NP can be mapped to a quantifier using the type-shifter *LIFT*; a quantifier-denoting NP can be mapped to a predicate using the type-shifter *BE*.

This proposal modifies one of the central principles of Montague's program: the matching between syntactic categories and semantic types. As a follower of the categorial tradition (Ajdukiewicz, 1935; Bar-Hillel, 1953; Lambek, 1958), Montague assumed a close link between the syntactic category of an expression and its semantic role in the sentence. In the PTQ-style grammar architecture, we are always able to predict the semantic type of an expression from its syntactic category. Officially, we refer to this principle as follows:

(12) **Category-Type (C-T) Matching Principle**: *If we assign a syntactic category C to an expression α, then the semantic type of α is predictable from C.*

According to this principle, any occurrence of an expression of category *NP* must have the same semantic type. This rigid assignment of types to categories gives compositional semantics a pleasingly restrictive architecture. Once we have decided on the workings of syntactic categories, we have little room to hesitate about the types of objects they denote. Specifically, according to the C-T Matching Principle, once we have decided to treat some NPs as quantificational, then all the expressions bearing the *NP* category should receive a quantificational treatment. Partee renounces this C-T matching. Instead, she allows the same NP to have denotations of different types when it appears in different syntactic positions.

Partee considers some empirical advantages of her approach over the PTQ analysis. First, as Partee (2004, p. 207) mentions, proper names are among the NPs that license singular anaphoric expressions in discourse, as in (13a) below. By contrast, singular NPs like *every trumpeter* do not easily license such discourse anaphoric relations with singular pronouns (13b).

(13) a. Berg came in. He looked tired.
b. Every composer came in. *He looked tired.

Following Kamp (1981) and Heim (1982), Partee assumes that only entity-denoting NPs contribute "discourse referents".[9] Thus, only entity-denoting NPs appear as antecedents of anaphors such as "he" in (13). Proper names in Partee's system lexically denote entities. She proposes that this accounts for the acceptability of examples like (13a). Definite and indefinite NPs like *the/a composer* also appear in discourse anaphora, similarly to proper names. To account for such effects, Partee's system also allows definites and indefinites to denote entities.[10] By contrast, NPs like *every composer* usually fail to denote entities in Partee's system, even after type-shifting.[11] Partee sees this as the reason for the unacceptability of examples like (13b).[12]

Another motivation for Partee's proposal comes from predicative NPs. Montague's work only treats predicative uses of NPs in copular sentences like (1b). However, Partee points out that other constructions also require predicative meanings of NPs. For example:

(14) Berg considers Mary *a trumpeter*.

[9] On Kamp's article see Chap. 11.

[10] Definites can be interpreted as entities using the *IOTA* type-shifter (see below). As for indefinites, (Partee, 2004, p. 216–7) tentatively proposes to replace PTQ's treatment by free variables over entities as in (Kamp, 1981) and (Heim, 1982).

[11] Partee's *LOWER* type-shifter (see below) maps quantifiers to entities, but it is only defined for quantifiers that have single entities as their "basis", i.e. quantifiers that can be described as the result of applying *LIFT* to some entity. This is not generally the case for NPs like *every composer*. Further, shifting *every composer* to a predicate is possible using *BE*, but that predicate cannot always be shifted further to an entity using Partee's TSs, since the available strategy (the *IOTA* type-shifter, see below) requires the predicate to hold of only one entity.

[12] In situations with only one composer Partee's system treats the universal NP *every composer* as possibly referring to that composer. Partee does not fully analyze the status of discourses like (13b) in such situations. On this problem and other limitations of Partee's treatment of universal NPs see Sect. "Critical Comments".

In (14), Berg's attitude is described as taking the noun phrase *a trumpeter* to be a predicate that holds of the entity for *Mary*. In this kind of sentence, the syntactic and the semantic treatment should explain how the verb *consider* combines with the small clause *Mary a trumpeter*.[13] While PTQ does not analyze such sentences, Partee proposes to treat them by letting the verb *consider* select for a predicate of type *et* as one of its arguments. Partee's *BE* operator shifts the quantificational denotation of *a trumpeter* to the required *et* type in the same way as in copular sentences like (1b). As further evidence for this account, Partee (2004, p. 207) points out that indefinites like *a trumpeter* can appear in coordinations with adjectives and adjective phrases. This is illustrated by the following examples:

(15) a. John is competent in semantics and *an authority on unicorns*.
b. Mary considers John competent in semantics and *an authority on unicorns*.

Coordinations as in (15) cannot be accounted for using the PTQ methods. This is because adjectives are a *prima facie* case of predicates, or, as in PTQ, predicate modifiers. Such denotations—of types *et* and $(et)(et)$ respectively, cannot be coordinated with quantifiers under the PTQ analysis. PTQ's treatment of coordination (which has been standard in formal semantics ever since) requires the two conjuncts to be of the same type. Thus, cases like (15) are problematic for Montague's uniform quantificational analysis of indefinite NPs. Partee's proposal easily deals with such coordinations as an instance of the predicative reading of indefinites that she derives using the *BE* operator.

Importantly, these motivations for using entities and predicates as NP denotations do not undermine the quantificational treatment. As Partee mentions, Montague's quantificational analysis is still required for NPs in conjunctions like *King John and every peasant* or *a student I know and every teacher*, where a proper name or an indefinite is conjoined with a universal NP. Since the prominent reading of universal NPs is quantificational, standard treatments of conjunction require that the other conjunct is also analyzed as a quantifier. With proper names like *King John*, this quantificational analysis is obtained using the *LIFT* operator from (Partee and Rooth, 1983). As for indefinites like *a student I know*, Partee considers two methods to derive their quantificational reading: either they initially denote quantifiers as in (2), or, as in (Kamp, 1981) and (Heim, 1982), they are treated as free variables ranging over entities, which are shifted to quantifiers (Partee, 2004, p. 216).

In addition to the *LIFT* and *BE* type-shifters, Partee introduces five other extensional operators between entities, predicates and quantifiers. Two of these TSs map predicates to quantifiers:

(16) $A = \lambda P_{et}.\lambda B_{et}.\exists x_e.P(x) \wedge B(x)$
(17) $THE = \lambda P_{et}.\lambda B_{et}.\exists x_e.\forall y_e.(P(y) \leftrightarrow y = x) \wedge B(x)$

[13] For a review of small clauses and theoretical proposals for their syntactic treatment see Citko (2011).

The A operator is the same function that generates the existential quantifier analysis of indefinites in (2). However, in addition to its use as the lexical meaning of the indefinite articles *a* and *some* in English, the A operator is also used as a TS. Similarly, the *THE* operator maps every predicate P to Montague's quantificational analysis of definites. For instance, the sentence *the trumpeter smiled* is analyzed as follows:

$$
\begin{aligned}
&(\mathit{THE}\ (\mathbf{trumpeter}))(\mathbf{smile}) \\
=\ &((\lambda P_{et}.\lambda B_{et}.\exists x_e.\forall y_e.(P(y) \leftrightarrow y{=}x) \wedge B(x))(\mathbf{trumpeter}))(\mathbf{smile}) \\
&\qquad \triangleright \text{ by definition of } \mathit{THE} \\
=\ &(\lambda B.\exists x.\forall y.(\mathbf{trumpeter}(y) \leftrightarrow y{=}x) \wedge B(x))(\mathbf{smile}) \qquad \triangleright \text{ simplification} \\
=\ &\exists x.\forall y.(\mathbf{trumpeter}(y) \leftrightarrow y{=}x) \wedge \mathbf{smile}(x) \qquad \triangleright \text{ simplification}
\end{aligned}
$$

In words: there exists a unique trumpeter x, and x smiled.

The *THE* operator implements the truth-conditional (aka. Russellian) analysis of definites. Partee also uses a TS from predicates to entities, the *IOTA* operator, which models the presuppositional (aka. Strawsonian) analysis of definites. The *IOTA* operator maps a predicate P to an entity c if c is the only entity of which P holds, otherwise it is undefined. Formally:

(18) $$\mathit{IOTA} = \lambda P_{et}.\begin{cases} c_e & \text{if } P \;=\; \lambda y_e.y{=}c \\ \text{undefined} & \text{otherwise} \end{cases}$$

For instance, the formula *IOTA*(**trumpeter**) derives an entity as the denotation of *the trumpeter* when the set of trumpeters includes only one member. Otherwise, this Strawsonian treatment leaves the denotation undefined. For a review of Russellian and Strawsonian analyses of definites in philosophy of language and formal semantics, see (Heim, 2011).

Partee recognizes some mathematical properties of the *BE*, *A* and *THE* operators, and claims that the "naturalness" of these properties helps to explain why in different languages, these functions "may be encoded either lexically or grammatically or not explicitly marked at all" (Partee, 2004, p. 204). This is an important part of her proposal, which deserves some elaboration.

Unlike English, in many languages there is no direct expression of (in)definiteness or predication similar to the English use of the words *the*, *a* and *be*.[14] Consider for instance the following sentences in Polish and Hebrew:

(19) Anna je jabłko
Anna eat apple

[14] Additionally, many languages only optionally express concepts of (in)definiteness and predication, or express them using morphological processes rather than single words. See (Dryer, 2013a, 2013b, Stassen, 2013) for cross-linguistic overviews of these phenomena.

Polish: 'Anna is eating the/an apple' (Bielec, 1998, p. 270)

(20) dani ha-more le-matematika
Dani the-teacher to-Math
Hebrew: 'Dani is the math teacher' (Doron, 1983, p. 71)

Partee assumes that cross-linguistically, nouns and verbs are of the same predicate type as in English. Sentences as in (19) and (20) then require some additional "semantic glue". For instance, the Polish noun *jabłko* ('apple') in (19) must be shifted to an entity (using *IOTA*) or to a quantifier (using *THE* or *A*). In (20), a Russellian quantificational reading of the Hebrew noun phrase *ha-more le-matematika* ('the math teacher') can be mapped to a predicate using the *BE* operator (8). A Strawsonian entity denotation of that definite can be mapped to a predicate using Partee's *IDENT* operator.[15]

With respect to *BE*, *A* and *THE*, Partee claims that the mathematical properties of these operators make them natural candidates for providing the necessary "glue". Thus, she sees these operators as *universal type-shifters*: semantic operators that may be used in any language whenever the meanings of the words (or morphemes) in an NP are not sufficient for interpreting it. This is why, according to Partee, in any language where sentences like (19) are acceptable, they can only be interpreted as definite or indefinite, and not, say, as universal statements like "Anna is eating every apple". Similarly, the *BE* operator is used to explain why (20) can only be interpreted as claiming that Dani is the math teacher, and not, say, as the negative statement "Dani is not the math teacher": the *BE* operator is part of Partee's scheme of "natural" type-shifters, whereas a putative negative TS is not.

We can summarize these ideas as follows:

(21) **Natural Type-Shifting Principle**: *Some central semantic concepts, including (in) definiteness and predication, involve mathematical definitions that allow them to be conveyed using phonologically silent TSs rather than overt linguistic elements.*

Partee's article suggests that a principle of this sort can be extended to other areas in semantic theory, including the following:

1. *Nominalization operators*: Following Carlson (1980) and Chierchia (1984), Partee proposes that bare plurals like *dogs* (as in *dogs bark*) and proper names like *blue* (as in *blue is my favorite color*) have entity denotations.[16] These entities are derived by an operator *NOM* applying to the basic predicative denotations of the common noun *dogs* and the adjective *blue* respectively. Importantly, *NOM*, and its inverse *PRED*, are intensional TSs: they operate on property denotations of nouns and adjectives, rather than on extensional functions of type et.

[15] The *IDENT* operator maps any entity x to the predicate describing the singleton $\{x\}$. In formula: $IDENT = \lambda x_e.\lambda y_e.y = x$.

[16] On (Carlson, 1977), which covers central aspects of (Carlson, 1980), see Chap. 4.

2. *Plurals*: Following (Link, 1983), Partee assumes that plurals like *the boys* have entity denotations that represent "groups" from an entity domain having a mereological structure.[17] Partee introduces two TSs that are used for plurals—*LINK*, and its inverse *DELINK*. She proposes that they regulate the semantic relations between Link's groups and quantifier denotations of plurals as in (Barwise and Cooper, 1981). In this way, Partee aims to capture ambiguities as in *the three boys ate a pizza*, where the distributive interpretation (one pizza per boy) is derived by the quantificational denotation of the NP, and the collective interpretation (one pizza for all the boys together) is derived using its group reading.
3. *Definites*: As mentioned above, Partee's account takes all definite NPs like *the king* to be ambiguous between the quantificational reading *THE*(**king**) and the entity reading *IOTA*(**king**) obtained by the *IOTA* type-shifter. The quantificational reading is responsible for sentences where definites do not give rise to presuppositions: when there is no unique king, the definite quantifier *THE*(**king**) simply does not hold of any predicate. By contrast, the entity reading of definites is presuppositional: when there is no unique king, the denotation *IOTA*(**king**) is undefined. The *IOTA* operator is another TS that Partee considers as natural, hence potentially universal.

Although these and other possible implications of the Natural Type-Shifting Principle (21) are not developed in detail in Partee's article, this principle is one of its most influential contributions. As formal semantics has become more ambitious in its cross-linguistic tenets, principles in the spirit of (21) occupy a central place in contemporary work, with the usual controversies that characterize the search for universals in cross-linguistic research (Von Fintel and Matthewson, 2008, pp. 154–156).

Figure 19.1 summarizes the operators in Partee's proposal. Except for the *THE* operator, each "raising" operator—from entities to predicates and quantifiers, and from predicates to quantifiers—has a corresponding "lowering" operator that inverts it. For instance, the *BE* operator "undoes" the effects of the *A* operator due to the following fact:

(22) For any predicate P: $BE(A(P)) = P$.

Similarly, the *IOTA* operator "undoes" *IDENT*:

(23) For any entity x: $IOTA(IDENT(x)) = x$.

Similarly, Partee introduces an invert operator to *LIFT*, which is defined as follows:

(24) $LOWER = \lambda Q_{(et)t}.\begin{cases} c & \text{if } Q = LIFT(c_e) \\ \text{undefined} & \text{otherwise} \end{cases}$

[17] On Link's article, see Chap. 17.

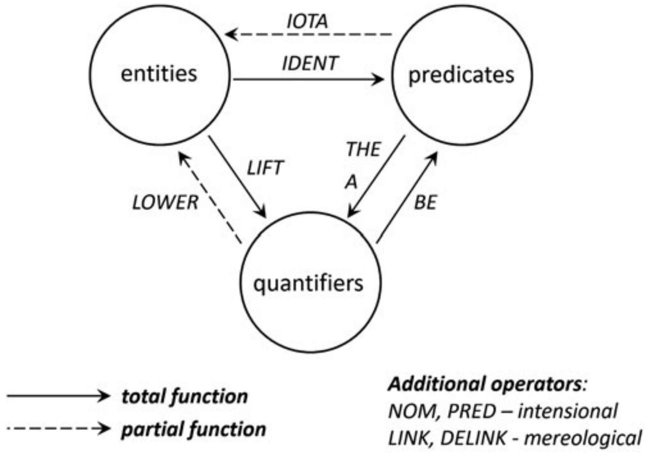

Fig. 19.1 Partee's operators

In words: the *LOWER* operator maps a quantifier Q to an entity c if Q is the lifted version of c, and is undefined otherwise. Thus, the *LOWER* operator trivially "undoes" the effects of *LIFT*.

Partee goes over these and other mathematical properties of her proposal. However, it is important to note that her work is not intended as a minimalist mathematical model of the relevant phenomena. The array of operators in Fig. 19.1 lacks the parsimony and generality that we might expect from such a model.[18] The value of Partee's proposal is in its empirical implications and broader programmatic outlook, to which we now turn.

Critical Comments

Partee's paper modifies the matching between syntactic categories and semantic types, which is one of PTQ's central principles (12). Developing the type-shifting strategy of (Partee and Rooth, 1983), Partee proposes a comprehensive reorganization of semantic theory, which has ramifications for some of the most central issues involving NP interpretation: the semantic distinction between argument NPs and predicate NPs, mass and count, singular and plural, definites and indefinites, genericity, quantification, presupposition, anaphora, and nominalization. This broad ambition is presented using programmatic ideas that are not easy to test, or more

[18] For instance: as mentioned above the *THE* operator cannot be inverted; the *BE* lowering is a total function, whereas other lowering operations are partial; the *NOM*/*PRED* and *LINK*/*DELINK* operators require additional ontological assumptions that are not incorporated into the quantificational domain; etc.

concrete proposals that are quickly sketched without full development. Partee is of course aware of this unavoidable limitation of her contribution, and she duly makes caveats about "the wealth of research these suggestions need to be tested against and integrated with" (Partee, 2004, p. 211). Indeed, some of Partee's proposals have come under closer scrutiny.

One of the central ideas in Partee's paper is that all NPs may in principle have predicative readings. The *BE* operator is defined for all quantifiers, and since Partee adopts Montague's idea that all NPs have quantificational readings, we might expect all NPs to also have predicate denotations and appear in predicative positions. This expectation is not borne out. For instance, as illustrated by (25) below, universal NPs are often unacceptable in predicative positions:[19]

(25) ?Berg is every composer.

Partee's system interprets (25) using the following predicative denotation of the noun phrase *every composer*:

(26) $BE(\mathbf{every}(\mathbf{composer}))$
$$= \begin{cases} \mathbf{composer} & \text{if } \mathbf{composer} = (\lambda x.x = c) \text{ for some entity } c \\ \lambda x.\bot & \text{otherwise} \end{cases}$$

The predicate in (26) corresponds to the singleton $\{c\}$ if there is a unique composer c, otherwise it corresponds to the empty set. Consequently, Partee's treatment expects sentence (25) to be true if Berg is the unique composer, and false otherwise. However, since sentence (25) is hardly acceptable, it is unclear if it has this interpretation. Addressing this problem, Partee (2004, pp. 214–5) claims that with certain NPs, predicative readings are ruled out for pragmatic reasons. She argues that sentences like (25) are unacceptable because a sentence like *Berg is the (only) composer* would be a more natural alternative that describes the same situations.

This pragmatic reasoning faces some problems. One problem is pointed out by Winter (2001, pp. 143–5), considering cases like the following:

(27) If Beethoven was the only pianist present at the premiere of his 4th Piano Concerto,[20] then

a. *every pianist at that premiere* was among the performers.
b. ?the soloist was *every pianist at that premiere*.

[19] I am ignoring here the use of universal NPs in case like *this house has been every color*, where the only valid interpretation is "every color x is such that the house has been (colored) x". Partee (2004, p. 219) refers to this kind of effect as the "Williams puzzle", and treats it straightforwardly by letting the quantifier *every color* take sentential scope. The resulting predication over the *entity-referring* variable "(the color) x" is independent of the issues that I mention above, which involve Partee's general mapping of *quantifiers* to predicates.

[20] Beethoven's notable concert of 22 December 1808 featured the public premieres of his 4th Piano Concerto (with the composer as soloist), 5th and 6th Symphonies, and Choral Fantasy.

This example shows an asymmetry between argument positions (27a) and predicate positions (27b). Sentence (27a) is somewhat scholastic but acceptable, and in the given context, it does not have any implication that there was more than one pianist at the premiere. This is not the case for the predicative NP in (27b), which is as unacceptable as (25). If the unacceptability of (25) was only pragmatic, we should have expected this unacceptability to be pragmatically suspended in (27b) in the same way it is in (27a).[21]

The syntactic-semantic restrictions on predicative NPs are another source of problems for Partee's proposal. As shown in Doron's (1983) study of Hebrew, there are important differences in distribution even among the NPs that easily appear in predicative positions. Specifically, unlike Hebrew definites as in (20), proper names cannot appear in predicative positions without a copula.[22] Furthermore, Doron points out that English clauses that omit the copula (as in (15b) above), show similar distinctions to those in Hebrew. Consider for instance the following examples:

(28) a. I considered Mary a champion/the champion/*Sue.
b. I considered Mary to be a champion/the champion/Sue.

The contrast in (28) involves a predicative environment where the *be* copula is required with proper names, but not with definite and indefinite NPs. Partee's account does not distinguish proper names from other descriptions: denotations of all three kinds of NP can be mapped to predicates. The unacceptability of *Sue* in (28a) shows that there are restrictions on the predicative readings of proper names that do not follow from Partee's paradigm. More generally, Partee's paper follows PTQ and analyzes simple English sentences of the form NP_1 *is* NP_2 and small clauses as in (28) as involving two quantifiers (or entities) that are hammered into the sentence using logical operators (*BE* or *IDENT*). This approach avoids the traditional distinction between "predicative" usages of *be* (*Cicero is an orator*) and "equative" usages of *be* (*Cicero is Tully*). Observations by Doron, Geist (2007), Mikkelsen (2005) and others pose serious challenges for this approach.

Another critical point about Partee's proposal concerns the central role it gives to entity-denoting NPs. Partee motivates the use of entities as NP denotations by linguistic tradition, as well as by the special status of "referential NPs" (proper names, definites and simple indefinites) with discourse anaphora as in (13). However, while we may concede Partee's claim that certain semantic operators on NPs need entities as their input, we should also note that under Partee's other assumptions this is not

[21] Another potential problem for Partee's shifting of quantifiers to predicates is observed in (Landman, 2004, p. 30), concerning examples with predicative plurals like *the people at the meeting were at most 30 deaf composers*. While such examples may perhaps not be fully acceptable, Landman shows that any theory that would like to treat them using TSs on quantifiers would face serious complications, since *no* function can derive sensible predicative meanings from standard quantificational denotations of NPs like *at most 30 deaf composers*.

[22] For instance, (i) below is ungrammatical, and does not mean "Dan is Mr. Blum":
(i) * dan adon blum
Dan Mr. Blum

conclusive motivation for introducing entities as NP denotations. Partee's *LOWER* operator allows us to emulate any necessary operation on entities by adjusting it to PTQ-like quantifiers, leaving the result undefined when the quantifier cannot be associated with a unique entity.[23] This shows a weakness of Partee's argument for entity-denoting NPs.

Lastly, a major controversy surrounds Partee's treatment of uniqueness and existential quantification as stemming from free operators like *THE*, *IOTA*, and *A*. In languages that generally allow bare NPs (cf.~(19)) without (in)definite markers, various restrictions have been observed on the availability of readings that convey uniqueness ("definite" readings) or existential quantification ("indefinite" readings). This has led to an on-going debate on the ways in which languages like Polish and Russian encode uniqueness and existentiality, if at all. While proposals differ on many points, authors generally agree that there is a need to posit strong restrictions on Partee's operators in such languages, or maybe to avoid some of them altogether. Thus, some of these operators might be considered less "natural" than what Partee assumed, to the extent that they are cross-linguistically available. For relevant facts, proposals and discussion, see (Dayal, 2004; Geist, 2010; Borik, 2016; Šimík and Demian, 2020).

Influence on Further Work

Partee's paper has inspired much further research, and it would be impossible to summarize here all the important ideas in these contributions and the ways that they relate to Partee's work. Instead, the non-exhaustive list below mentions some of the areas where Partee's paper has been influential, with relevant references.

1. *Bare nominals and reference to kinds across languages*: Chierchia (1998), Cheng and Sybesma (1999), Dayal (2004), Krifka (2004), and see also Chaps. 4 and 5.
2. *Predicative NPs*: in relation to the semantics of definites (Coppock and Beaver, 2015), plurals (Winter, 2001; Landman, 2004; Champollion, 2016), *there* sentences (McNally, 1998, 2016; Landman, 2004), numerals (Kennedy, 2015), syntax-semantics interface (Zamparelli, 1995; Adger and Ramchand, 2003; Julien, 2005; Mikkelsen, 2005; Geist, 2007), or more general perspectives on type-shifting for various phenomena involving predication (Pustejovsky, 1993; de Swart, 2001).

[23] The *LOWER* operator "retrieves" an entity from PTQ's quantificational denotation of proper names and definites, as well as from Partee's quantificational treatment of indefinites (Partee, 2004, pp. 216–7). Thus, if an operation *op* is defined on entities, we can instead use an operation *OP* on quantifiers by composing *op* with *LOWER*. In formula, for any quantifier Q:

$$OP(Q) = op(LOWER(Q)) = \begin{cases} op(c_e) & \text{if } Q = \lambda P_{et}.P(c) \\ \text{undefined} & \text{otherwise} \end{cases}$$

3. *Predicative nominals as verb modifiers* (aka. *semantic incorporation*): Van Geenhoven (1998), Chung and Ladusaw (2003).
4. *Type-shifting, indefinites and scope*: Hendriks (1993), Reinhart (1997), Winter (1997, 2007), Kratzer (1998), Landman (2004), Charlow (2020).
5. *Unifying Montague Semantics and Dynamic Semantics*:[24] Groenendijk and Stokhof (1990), Chierchia (1995), Muskens (1996), de Groote (2007).

In addition to this direct influence of Partee's article, her work was also one of the first general usages of the idea of type-shifting as introduced by Partee and Rooth (1983). As such, it helped to open the way for new usages of type-shifting in linguistics. For further references and a review of work on type-shifting from a psycholinguistic perspective, see Pylkkänen (2008). In relation to type-shifting in general, it should be mentioned that one of Partee's TSs, the *LIFT* operator, adopted from Partee and Rooth (1983), comes out as a straightforward result in one of the most popular frameworks in type-logical categorial grammar: the Lambek Calculus (Lambek, 1958; Moortgat, 2011). Work on *continuations* in natural language (Barker, 2001; de Groote, 2001; Barker and Shan, 2014) draws on this type-logical tradition as well as on the type-shifting analysis in Partee and Rooth (1983) and Partee (1987). Additionally, much work in Combinatory Categorical Grammar (Steedman, 1997; Jacobson, 2014) employs type-shifting principles.

Given this remarkable popularity of type-shifting as a tool in different grammatical frameworks, it is notable that there has not been much research on the theoretical foundations of Partee's conception of type-shifting and its relation with categorial grammar and continuation-based semantics. Anticipating the linguistic importance of this topic, Partee (2004, p. 224) claimed that this is one of the important areas for further research. I believe that, like many of Partee's proposals in her seminal article, this claim still holds, more than 30 years after its first publication.

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[24] Unifying dynamic approaches to meaning with Montague Semantics was not a central issue in Partee's paper, but hers was one of the first published works to have proposed this direction, following an unpublished version of (Zeevat, 1989). Further on Dynamic Semantics see Chap. 11.

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