

The Partee Paradox. Rising Temperatures and Numbers

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Abstract

The chapter explains the “Partee paradox”— the observation that *the temperature is rising* and *the temperature is ninety* does not entail *ninety is rising*—and the solution it received in formal semantics. It is shown that the predication in *the temperature is rising* takes an “individual concept” argument and involves an “intensional verb” of a kind; it states a change of the value of a time-dependent function. Constructions known as “concealed questions”—for example *know the price*—are shown to be closely related. Partee’s observation and the phenomenon of concealed questions are taken as the point of departure into taking a closer look at the three components of the constructions: intensional verbs, individual concept nouns, and the definite article. The construction provides a bridge to a general theory of types of noun and their interaction with definiteness. In addition, the particular class of functional nouns and concepts figures in the center of Barsalou’s cognitive theory of concept modeling. Thus the understanding of the puzzle is connected to fundamental issues of semantics and cognition.

Keywords

Partee paradox – Intensional verb – Individual concept – Functional concept – Concealed question – Definiteness – Barsalou Frames

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0. Before we go into the matter

The so-called Partee paradox is concerned with a special construction that, at a first glance, does not look different from the ordinary subject-VP construction; it is exemplified by sentences like (1):

(1) *The temperature is rising.*

Crucially, this construction requires a special logical type of subject argument for the verb. This type is different from the ordinary type e (= individual) that we assume for the usual subject-VP construction, like in the sentence *the rocket is rising*.

In order to focus on the issue of the logical type of the subject argument in the construction, we will first keep to the simplest case of predication, about a single argument. This will be achieved by restricting the discussion to examples with singular definite subject NPs. The strategy is comparable with using for the usual subject-VP construction examples with proper names or personal pronouns in the subject position.

The first three sections are dedicated to the discussion of the logical type of the subject argument in this and related constructions. In section 4.2, we will take a look at other types than singular definite NPs in such sentences.

Tackling with Partee's puzzle triggered a cascade of semantic explorations and theoretical developments. These include the distinction between extensional and intensional verbs of certain types (section 2) and between different logical types of noun (section 3); the latter inspired an alternative approach to definiteness and nominal determination in general (section 4); in addition, the characteristic type of noun in these constructions can be linked to a fundamental theory of cognitive representation based on "frames" in the sense of Barsalou's (section 5).

1. Partee's paradox and Montague's solution

1.1 Leibniz' Law

Consider the following three sentences, assuming a context where Rachel has exactly one roommate:

- (2) a. *Rachel's roommate is in the café.*
b. *Rachel's roommate is Monica.*

c. *Monica is in the café.*

The sentences form a valid logical entailment: if (2a) and (2b) are true, so is (2c). (The horizontal line indicates that the sentence below it, the conclusion, logically follows from those above it, the premises.) The entailment seems trivial; if Rachel's roommate and Monica are the same person, stating something about Rachel's roommate is equivalent to stating the same about Monica. The entailment is due to a general rule, known as Leibniz' Law¹, that holds for predicate logic in general:

- (3) Leibniz' Law
a. $P(x)$
b. $x = y$

c. $P(y)$

In (3), 'P' is a one-place predicate term, for example, *is in the café*, and the two expressions *x* and *y* represent individual terms, that is, terms for individuals, the kind of thing predicates normally predicate about. If one takes *is* in (2b) as expressing identity, (2b) is a statement of the form (3b). Leibniz' Law forms the background for what became to be known as 'Partee's paradox' ².

1.2 Partee's paradox

Barbara Partee is credited³ for the following apparent counterexample to Leibniz' Law:

- (4) Partee's paradox
The following is not a valid entailment:
- a. *The temperature is rising.*
 - b. *The temperature is ninety.*
-
- c. *Ninety is rising.*

This entailment clearly is invalid: the number 90, or the temperature value 90 degree Fahrenheit meant here, are fixed things that cannot rise. However, *is not the temperature is rising* a statement of the form $P(a)$, that is a predication about some individual, the temperature, and *is not the temperature is ninety* an identity statement, something like $t=90$ °F, with *t* short for *the temperature*? If Leibniz' Law does not hold in this case, is Leibniz' Law false? The latter is a consequence one would not want to accept. Leibniz' Law is so fundamental to elementary predicate logic and everything building on it, for example, set theory, that predicate logic would plainly break down if Leibniz' Law were abandoned. Leibniz' Law must not only be upheld, it cannot be allowed any exception.

Various suggestions were made in order to defend Leibniz' Law in view of Partee's (apparent) paradox; they all amount to the result that (4) is not really of the general form given in (3). Some argued that the conclusion (4c) *ninety is rising* is a semantically anomalous sentence. Jackendoff (1979) objected that *the temperature is ninety* is not an identity statement of the form $x=y$ but rather a statement localizing the temperature at some point of the Fahrenheit scale.⁴ However, these and similar objections against the nature of (4b) and (4c) can be met by versions of Partee's paradox like the following:

- (5) a. *The temperature in Chicago is rising.*
b. *The temperature in Chicago is the same as the temperature in Sidney.*
-
- c. *The temperature in Sidney is rising.*

Clearly, (5b) is an identity statement, and (5c) is not anomalous. And clearly, the temperature in Sidney need not rise with the temperature in Chicago. Still, the *temperature* examples are fraught with the problem that temperature values are abstract entities which might ontologically and logically not be of the same kind as usual individuals that we encounter as "normal" referents of natural language NPs, entities like persons, objects and others. Some arguments against the paradox have been brought forward along these lines. However, there are also instantiations of Partee's paradox that involve reference to ordinary individuals:

- (6) a. *The president of the US will change in 2021.*
 b. *The president of the US is Melania Trump's husband.*

 c. *Melania Trump's husband will change in 2021.*

In order to obtain an instance of Partee's paradox, the sentences in (6a) and (6c) depend on a certain reading of the verb *change*: the paradoxical effect is only achieved if *change* is taken in the sense 'be replaced'. While (6c) is, of course, possible given the truth of (6a) and (6b), it is not a necessary logical consequence. In another reading of *change*, roughly 'become different', the entailment in (6) is valid. Translation into German helps to disambiguate the two readings; rendering *change* as *wechseln* yields the paradox reading, while *sich ändern* allows for both readings of *change*. So, here we are with a water-proof version of Partee's paradox:

- (7) a. *Der Präsident der Vereinigten Staaten wird 2021 wechseln.*
 b. *Der Präsident der Vereinigten Staaten ist der Ehemann von Melania Trump.*

 c. *Der Ehemann von Melania Trump wird 2021 wechseln.*

Partee's paradox is, hence, not bound to predications about abstract entities like temperatures or prices etc. and to numerical values or measures; it is more general in nature and calls for an answer. I want to note that there are examples with 'abstract' nouns that leave no doubt either:

- (8) a. *The number of students in his seminar on modal logic will grow.*
 b. *The number of students in his seminar on modal logic is two.*

 c. *Two will grow.*

1.3 Montague's solution

Montague in PTQ offers the following solution to the puzzle: Partee's first two sentences – *the temperature is rising* and *the temperature is ninety* – are not about the same thing; they are not like 'P(x)' and 'x=y', but actually instantiate 'P(x)' and 'z=y' where z is different from x; obviously, 'P(x)' and 'z=y' do not entail 'P(y)'. In the sentence *the temperature is ninety*, Montague argues, the referent of the subject NP is the temperature value in the given context of utterance, in particular the temperature value at the given point in time. In the sentence *the temperature is rising*, however, the subject NP does not refer to the value at the given moment. The sentence states a change of the temperature, and a change cannot be stated with respect to one point in time – one needs to refer to at least two points in time. Given a certain point in time t_0 , *the temperature is rising (at t_0)* roughly means that there is a point in time t_1 before t_0 and a point in time t_2 after t_0 such that the temperature value at t_2 is higher than the temperature value at t_1 and the temperature value monotonically changes upwards between t_1 and t_2 . Thus, if we relate (1b) *the temperature is ninety* to a particular time t_0 and thereby refer to the particular temperature value at that time, we have to relate (1a) *the temperature is rising* to an extended time interval around t_0 and to more than one temperature value, respectively. To be more precise, (1a) expresses a predication about the temporal *course* of the temperature value around the given point in time t_0 .

In his semantic theory, Montague distinguishes between extensions and intensions, adopting these notions from Carnap (1947[1988]). They are defined on the following general background (see also Article REPRESENTING INTENSIONALITY). Truth values of sentences and referents of NPs depend on an "index" that consists of two components, a point in time and a "possible world". Pragmatically, a time-

world index can be thought of as a context of utterance in which, along with a time of reference, all facts that may bear on the truth-value of any sentence are fixed. For example, the referent of the NP *the president of the US* in the real world was Barack Obama at all times between Jan 20, 2009, 12 p.m. and Jan 20, 2017, 12 p.m., while it is Donald Trump since then (for the time being); in a different possible world, Hillary Clinton might have been the present referent of that NP.

Leaving aside details of Montague's formal treatment, we may define the notions of **intension** and **extension** for definite NPs such as *the temperature* and *Donald Trump* as follows: at a given time-world index, the *extension* is the referent of the NP in that world, for example, Donald Trump as we know him and the (value of) the temperature as it happens to be in that moment in that world, say 90 °F.⁵ The *intension*, however, of a definite NP is what determines its extension at every time-world index. In Montague's theory, and generally in formal semantics, intensions are modeled as functions that return for every index the extension at that index. For example, for indices based on the real world, the intension of *the president of the US* is a function that returns for every time from April 30, 1789 till today the US president at that time; for the NP *the temperature*, the intension is a function that depends not only on time but also on the location referred to (assuming that *temperature* is taken in the sense 'temperature of the air outdoors'). Distinguishing between intension and extension, we obtain that *the temperature is ninety* is an identity statement about the *extension* of *the temperature* at the given index, while *the temperature is rising* is a predication about the *intension* of *the temperature*. Thus, the two premises of the original paradox have the following logical forms:

- | | | | | |
|-----|----|----------------------------------|--|------------------|
| (9) | a. | <i>the temperature is rising</i> | is-rising(intension(<i>the temperature</i>)) | P(intension(x)) |
| | b. | <i>the temperature is 90</i> | extension(<i>the temperature</i>) = 90 | extension(x) = y |

These two statements are not such that Leibniz' Law would apply; the argument of P in the first premise is the intension of x, but the thing equated with y in the second premise is the extension of x. Given the definitions of intension and extension, it is clear that two expressions may have the same extension, but different intensions. The two crucial NPs in (1) and (9) are *the temperature* and *ninety*. The intension of *the temperature* is a function that returns different values for different times (and worlds; the intension of *ninety* [°F] returns the same fixed temperature value at every index whatsoever. The two intensions are different, even if for a given index they may happen to return the same value, that is if the present temperature actually is ninety °F. Therefore, the same predication about the two intensions – 'is rising' – constitutes two different statements which may differ in truth-value. In fact, the predication 'is rising' can be true or false of the intension of *the temperature*, but it cannot be true of the intension of *ninety*, for the principal reason that the value of the intension of *ninety* [°F] is always the same. In the case of the president example in (7), both intensions, the one of *der Präsident der Vereinigten Staaten* and the one of *der Ehemann von Melania Trump*, have changing values and they are clearly different. The predication *wird 2021 wechseln* yields different statements that can be true or false for either one.

Montague's solution amounts to the view that the construction instantiated by *the temperature is rising* is an **intensional construction**, in the sense of Carnap (1947[1988]: 46ff), while *the temperature is ninety* is **extensional**. A construction is extensional with respect to a certain part, if that part can be replaced by every other expression with the same extension, without changing the truth-value of the sentence. Clearly, this is the case for any construction that is a predication about the extension of the NP. For example, *NP is in the café* is a sentence that makes a predication about the contextually given extension of the subject, describing their momentary whereabouts. If in the given context Rachel's roommate actually is Monica, the NPs *Rachels's roommate* and *Monica* have the same extension, and

it doesn't make a difference in truth-value if we refer to the argument of the predication by one NP or the other. The situation is different if the predication concerns the *intension* of the subject NP. Substitution with an arbitrary NP of the same extension may yield a different predication and hence affect the truth-value. Constructions of this kind are called **intensional**. We now see that the scheme of Leibniz' Law can be used as a test for checking if a given construction is extensional or intensional with respect to an NP position. The constructions in (1a), (5a), (7a), and (8a) are intensional with respect to the subject NP, while the construction in (2a) is extensional, and the construction in (6a) has an extensional and an intensional reading.

The constructional context in the Partee examples essentially consists in a verb (*rise, change, wechseln*); therefore these verbs themselves are called **intensional verbs**, or more precisely, subject-intensional verbs. The vast majority of verbs, including the prototypical examples, are extensional with respect to the subject argument, in fact with respect to all their arguments. Therefore we obtain valid instances of Leibniz' Law such as in (2) above or in (10):

- (10) a. *The president of the US is sleeping.*
 b. *The president of the US is Melania Trump's husband.*

 c. *Melania Trump's husband is sleeping.*

From a pragmatic point of view, it may of course matter which NP to choose in a given context for reference to a particular individual; but the fact remains that the truth-value does not change as long as the referent is the same.

We will leave Montague's treatment here. It has been discussed and criticized in various ways (see Lasersohn 2005, Schwager 2007, and Romero 2008 for reviews of the sparse literature and for further discussion). In the formal semantics literature that developed from PTQ by extending Montague's approach to a widening range of phenomena, intensionality of the *rising temperature* type was not maintained as part of the general approach.⁶ This has several reasons. Montague applied a basic principle according to which syntactic and semantic composition go hand in hand: for example, there is one syntactic rule for combining verbs with a subject NP, and there is one uniform rule for interpreting this combination. This forced him to apply the technique of "generalizing to the worst case"⁷: Since there are verbs that apply to the intension of the subject, the interpretation rule must state that the verb in general takes an intension as its subject argument. If a verb happens to be extensional, it applies to the intension and a meaning postulate is added to the system that states that only the given value of the intension (i.e. the extension) matters for this verb. An analogous complication arises with the nouns involved. Montague had to assume that nouns denote sets of so-called individual concepts rather than sets of individuals although most nouns intuitively do denote just this. Again, the generalization to intensions requires meaning postulates for every 'normal' noun to the effect that they essentially refer to individuals. Furthermore, at a closer look, it turns out that most verbs that have this kind of intensional use, also have extensional uses. I mentioned an extensional reading of intransitive *change* in connection with the *president* example in (5); *rise* and *grow*, too, obviously have extensional uses, as in *the rocket rises*, *the child has grown* etc. This makes an adequate treatment even more complicated. In view of all these issues and of the apparent marginality of the phenomenon, the mainstream development in formal semantics chose not to include intensional constructions of the rising-temperature type.

What remains as the crucial point for the discussion here is the fact that the *rising-temperature* construction exhibits a certain type of intensionality: as opposed to the usual logical type of verb argument, the crucial argument of the construction is of an intensional type: a function from time-

world indices to individuals. In Montague's system of logical types, individuals are of a type called "e" (for 'entity') and world-time indices, of type "s". The type of arguments of intensional verbs as in the *rising-temperature* construction is $\langle s,e \rangle$ in Montagovian notation, which stands for the type of functions from the set of indices to the set of entities. Following Carnap (1947:41), Montague calls this type of thing "individual concept" ⁸. Thus, intensional verbs like *rise* in the *rising-temperature* construction take arguments of type $\langle s,e \rangle$, while the type of the arguments of extensional verbs is simple e.

It turned out that this simple construction raises several fundamental semantic questions. These concern:

- The verb: Which verbs exhibit this type of intensional use?
- The noun: Which nouns can enter this construction?
- The article: Most examples contain the definite article. Is this necessarily so?

2. Intensional verbs

2.1 Time-intensional verbs

I want to call the particular type of intensionality in the rising-temperature examples **time-intensionality**. What is at issue in the examples discussed is the fact that the referent of the NPs in the intensional construction may change with time. Of the two components of an "index" – the given time and the world – only the time component is involved. We will see soon that there is another type of construction that is similar, but is not related to the time component but to the world component (section 2.2).

2.1.1 Extensional vs. intensional uses

In Löbner (1979), an attempt was undertaken to determine which German verbs have time-intensional uses; the investigation was based on the collection from standard German dictionaries of about 14,000 verbs in Mater (1966). As it turned out, almost all verbs with time-intensional uses are time-extensional in other uses, and the latter appear to be the basic ones.⁹ To see the point, let us consider the following example:

(11) *Oh, Johnny's girlfriend has grown a lot recently.*

This is an extensional use of *grow*. The sentence can only mean that there is a time in the recent past when the person who is Johnny's present girlfriend was much shorter than she is now. We are talking of the same person now and before. (11) cannot be said, at least not seriously, if Johnny now has a different girlfriend than in the past, and the new girlfriend is a lot taller than the former one. The verb *grow* when applied to a concrete physical object *x*, for example, a person, in its resultative perfect function to be assumed here, roughly means that the height (or size) of *x* is now greater than *x*'s height (or size) was before. In its extensional use, *grow* requires that the subject referent be physically the same individual within the relevant time interval.

The intensional use of *grow* as in example (8) with the growing number of students in a seminar entails the opposite: the referent of the subject NP *must not* be the same at the two times of comparison. Still, there must be a close semantic connection between the extensional and the intensional use. After all, *grow* in both cases intuitively has a very similar meaning. The predication *x grows* seems to mean something like 'x increases in size or height' and we may interpret *Rachel has*

grown as in (12b):

- (12) a. *Rachel has grown.*
b. 'Rachel's height has increased'

The height of a person is one out of an unlimited array of aspects, or dimensions, of persons; the predication concerns just one of these dimensions, while others are not talked about. It might be the case that an increase in height is accompanied by an increase in weight, but this may or may not be the case and would be expressed by *she has put on weight*, concerning a different dimension of the subject referent's body.

If we compare (12a) to an intensional use of *grow*, we realize that the situation is different. The interpretation of the sentence *the number of students has grown* is (13b); (13c) also appears a possible paraphrase, if a bit artificial; (13c) is parallel to (12b).

- (13) a. *The number of students has grown.*
b. 'the number of students has increased'
c. 'the height of the number of students has increased'

The number of students does not have several logically independent dimensions; it has just one dimension to it: its height or amount. Actually, 'number' in the sense of 'number of' can be considered a dimension itself, of entities that have a cardinality, like sets or groups. Therefore, if the number of students grows, the value of the 'number of' dimension does not remain the same number; it is replaced by a different number.

In a recent approach to this type of construction, Fleischhauer and Gamerschlag (2014) argue that change of state verbs like *rise* or *grow* have a different, more abstract, meaning in their intensional uses. While they lexically fix a scale (or dimension) like *height* or *size* in their extensional use, they leave the scale open in intensional uses; the dimension of change is then denoted by the subject noun itself. (Compare the case of *the temperature is rising* where it is the head noun *temperature* that provides the dimension of change). The only requirement for the subject term is that it denote things that can be ordered by some ordering relation: smaller or greater heights, weights, numbers, etc. This approach corresponds to the more natural paraphrase in (13b).

In the following, I will not relate to the German verbs of the original study Löbner (1979), but to their English counterparts. In most cases, the English equivalents of German intensional verbs have intensional uses, too, and vice versa. We classify the intensional verbs according to their meanings in extensional use.

2.1.2 Semantic subclasses of verbs with time-intensional uses

Verbs of change and motion. Time-intensional verbs of the type of *rise* and *grow* have basic extensional uses that express a change of their subject argument in some dimension (*grow*) or a change of location (*rise*). They allow for intensional use with abstract nouns like *price*, *temperature*, or *number* that denote the dimension of change. They do not have intensional uses with concrete nouns.

- (14) a. concrete: *The hedge grew.* extensional
b. abstract: *The productivity grew.* intensional

Intensional verbs may exhibit various alternations (in the sense of Levin 1993). For example, we have subject-intensional intransitive *increase* and object-intensional transitive *increase*. In (15), *raise* is

object-intensional and subject-extensional:

- (15) *The New Zealand government is to **raise** THE EXCISE TAX ON CIGARETTES by 50 cents per pack to help contain the public health costs of smoking.* (BNC: ECO 105)

The verbs *grow* and *rise* are representative of two subclasses of time-intensional verbs, *change* represents a third one:

- (16) a. Verbs of motion
rise fall drop jump leap proceed recede tend converge ...
b. Verbs of change in a specific dimension
grow shrink increase decrease double reduce cheapen improve worsen accelerate ...
c. Verbs of change in a dimension not fixed by the meaning of the verb
change modify vary ...

Only in their extensional uses, the verbs in (16b) relate to a specific scale. The data quoted in (17) to (19) illustrate time-intensional uses of these verbs. Verbs of motion exhibit different degrees of accommodation to intensional use. Frequently used verbs include such for primarily vertical or forward motion like *fall* and *leap* in (17):

- (17) Verbs of motion
a. *THE DOW JONES INDEX **fell** 61.94 to 3,213.55, its lowest since November.* (BNC: AJ9 386)
b. *In December 1979 and January 1980, by contrast, when the Soviet Union invaded Afghanistan, THE GOLD PRICE **leapt** from \$470 per ounce to \$850 within a month.* (BNC: ABH 3325)

In the examples, the subject NP specifies the intension that is the argument of the time-intensional predication, while further adjuncts of the verb specify the resulting or former extension, or the difference between the two.

Verbs that in their extensional use lexically specify a particular scale, like *accelerate* the scale of speed, may require particular sorts of subject arguments when used intensionally; one cannot accelerate a temperature or a price, but *accelerate one's pace* is possible. In this regard, their intensional meaning is not detached from the scale specification inherent to their extensional uses.

- (18) Verbs of change in a specific dimension
a. *As I **accelerated** MY PACE I asked myself what I was doing here, and I didn't know the answer.* (BNC: AOU 1598)
b. *The most common way of **cheapening** THE COST is to **reduce** THE AMOUNT OF NICKEL, which is the most expensive of the three metals in EPNS.* (BNC: AOC 947)
c. *He had **shortened** THE DISTANCE BETWEEN HIMSELF AND GALLAGHER.* (BNC: B1X 2665)

The third subclass also includes verbs that express the absence of change such as *remain* or *stay*. They do not relate to a specific dimension, neither in their extensional use, nor in their intensional use. They can therefore be combined with a wide range of NPs that specify a dimension on their own part. Note that in the case of verbs that express the absence of change, a change must nevertheless be logically possible: under normal circumstances, it would be pointless to say of something like, for example, the

sum of 2 and 7 that it “remains the same” or “stays at 9”. All examples in (19) pass the intensionality test in the same way as constructions with *rise* etc.

- (19) Verbs of change in a dimension not fixed by the meaning of the verb
- a. *THE NAME will **change** but THE PROFESSIONAL SERVICE **remains the same**.* (BNC: HS3 176)
 - b. *Not only must you spray regularly, but it's a good idea to **vary** THE BRAND OF SPRAY that you use; the nasty wee beasties soon develop resistance if you use the same one over and over again, and that's something worth taking the time to avoid.* (BNC: AOG 2017)
 - c. *'Madeira is a volcanic island and THE TEMPERATURE **stays** at roughly seventy degrees all year round,' Kay told her, 'so it's just perfect.'* (BNC: JXW 2337)

2.1.3 Verbs of exchange and role

The German verb *wechseln* in the reading given in (7a) *der Präsident der Vereinigten Staaten wird 2021 wechseln* does not belong to the classes mentioned. Its English equivalent *change*, in the replacement meaning, groups with verbs that can be characterized as verbs of exchange and role:

- (20) *On Friday, Tsipras **replaced** THE COUNTRY'S ENERGY MINISTER AND LABOR MINISTER. He also **named** A NEW GOVERNMENT SPOKESMAN, according to Reuters. In addition to those changes, EIGHT OTHER MINISTER OR DEPUTY MINISTER POSITIONS were **changed**.*
(International Business Times, July 17, 2015, <http://www.ibtimes.com/greek-debt-crisis-prime-minister-tsipras-culls-cabinet-rebel-ministers-who-voted-2014230>)

The use of *change* here replicates the one in (6a) *the president of the US will change in 2021*, although with a transitive version of the verb. *Replace* is object-intensional, too, and so is *name*.

- (21) Verbs of exchange and role
- a. verbs of replacement and exchange
change exchange substitute replace ...
 - b. Verbs of removing [See Levin 1993: 122]
remove oust fire banish ...
 - c. Verbs of installing
name install appoint ...

Verbs of exchange and role take concrete arguments in intensional use, but do not seem to occur with abstract arguments like *temperature* or *price*. The nouns in question denote roles and offices, but they are not restricted to denoting persons. One may also change/exchange/replace one's clothes, one's car, one's bed etc. (See (22a)), that is objects that play a particular role in their users' life (22a).

- (22) a. *She **changed** HER SHOES, did her hair, dabbed her neck with Chanel and slammed the bedroom door.* (BNC: HNK 730)
b. *Who would normally **replace** THE MATHS TEACHER?* (BNC: ARJ 1180)

Verbs of installing are special in taking indefinite arguments, a feature to be discussed later:

- (23) a. *She takes him to a tailor (hence the gorgeous green suit and bowler hat), **hires** A TUTOR and even buys him a car.* (BNC: A9T 471)

- b. *THE PRESIDENT is **elected** by the Knesset every five years, and **appoints** A PRIME MINISTER on the basis of distribution of power between parties in the Knesset.* (BNC: HL4 4854)

2.2 World-intensional verbs and so-called concealed questions

There is a second class of cases to which Partee's paradox applies; this class has nothing to do with change in time:

- (24) a. *Sue doesn't know the price of the second volume.*
 b. *The price of the second volume is the same as the price of the first volume.*

 c. *Sue doesn't know the price of the first volume.*

Clearly, (24a) and (24b) do not logically entail (24c) – Sue need not know that the second volume costs the same as the first. Thus, *know* in (24a) and (24c) is object-intensional. The phenomenon was investigated extensively for German in Löbner (1979) and simultaneously, and independently, discussed in Heim (1979) who introduced the term 'concealed questions' (henceforth CQ). The label is due to the fact that this type of intensional construction can be paraphrased with an interrogative clause replacing the NP:

- (25) *Sue doesn't know what the price of the second volume is.*

The construction is not restricted to abstract nouns like *price*. We also have a CQ reading for sentences such as (26):

- (26) *Sue doesn't know the capital of Vanuatu.*

With concrete nouns as object, *know* also has the extensional reading 'be familiar or acquainted with'. The verb is not intensional in sentences like *Sue knows Port Vila* or *Sue knows this movie*.

CQ constructions relate to the fact that, for a given time, other referents than the ones actually given are possible. The price might be as it actually is, or some other amount of money; the temperature might be higher or lower; and the capital of Vanuatu might be any town Sue doesn't even know the name of. If, for a given time, things are different, we are dealing with a different world among the possible worlds. Recall that "possible worlds" are just possible constellations of facts. If some facts are different than in a given, or assumed, world then we do are not part of the same world. Different worlds need not be dramatically different, like a world in which Donald Trump would not have been elected US president. They might differ just a little bit, like the same world, but just the price of a liter milk in a certain shop being 2 cents more, or the temperature being 1 °F lower. Thus, alternative referents, at a given time, for expressions such as *the price of the second volume* or *the capital of Vanuatu* belong to different possible worlds. Seen from this perspective, the construction *know the price of the second volume* means something like *know of the price of the second volume that it is the price in the actual world, rather than some other price in some other possible world*. Thus CQs deal with alternative extensions of the NP in different worlds, but at the given time. They predicate about intensions that may take different values under different circumstances.

Since possible worlds are supposed to determine the truth-values of the infinitely many sentences of a language, they represent infinitely much information. Naturally, no ordinary language user ever knows all facts of this or any other possible world. We always only know a tiny finite subset of what makes up the world. The rest of the actual world might be this way or that – in infinitely many ways.

Ignorant as we are by our very nature, we are therefore always faced with an infinite choice of possible worlds. In view of this general situation, CQ constructions with verbs of knowing, telling etc. serve elementary communicative needs for dealing with our limited knowledge of the complex world we live in.

We will call this variant of intensionality 'world-intensionality'. Like time-intensional verbs, world-intensional verbs may also be subject-intensional:

(27) *Insp Bill Blanchard said THE NUMBER **shocked** and **disturbed** them.* (BNC: K4W 7024)

There are also verbs with two world-intensional arguments:

(28) *THE WEATHER **influences** THE ACTUAL LOCATION OF THE RABBITS and it helps determine whether they are underground or on the surface.* (BNC: BNY 1420)

In Löbner (1979), about 1,000 German verbs were identified that allow for world-intensional uses. They can be categorized into four major classes:

(29) Verbs with world-intensional uses

a. Epistemic verbs

know learn forget determine discover prove confirm estimate measure document tell predict anticipate indicate show ...

b. Attitude verbs

accept reject criticize welcome want demand request ...

c. Verbs of emotional effect

surprise shock irritate amuse bewilder ...

d. Verbs of control and relation

influence depend on affect vary with be related to justify dictate fix ...

Data are abundant:

(30) Epistemic verbs

a. *The figure in front of the diagonal is the percentage of chromium content, the number after **indicates** THE PERCENTAGE OF NICKEL.* (BNC: 0C 919)

b. *When he found that his theory exactly **predicted** THE PATH OF MERCURY, he was beside himself with happiness for days.* (BNC: NW 3619)

c. *Berserk with rage, he had called her a slut and worse and **demanded** THE NAME OF THE FATHER.* (BNC: FSC 509)

d. *It is quite common in talking about teaching to **focus** on what the teacher does and to **forget** THE EFFECT THIS MAY HAVE ON THE LEARNER.* (BNC: FUA 1386)

(30d) is a nice example as it exhibits an interrogative clause (*what the teacher does*) and an intensional NP (*the effect this may have on the learner*) in parallel constructions with world-intensional verbs.

(31) Attitude verbs

a. *After all the outsider chose to engage in the share transaction and **accepted** THE PRICE OFFERED.* (BNC: ECD 993)

- b. *The letter called for implementation of constitutional guarantees, freedom and justice, and **criticized** THE GOVERNMENT'S HANDLING OF THE ECONOMY.* (BNC: CJS 434)
- (32) Verbs of emotional effect
- a. *The French were sufficiently **worried** by THE RAPIDITY OF GERMAN INDUSTRIALISATION and by THE QUALITY OF THEIR WARES that by the 1890s they had begun to invest in Russian railways, coal, steel and textiles as a way of controlling and reducing German competition.* (BNC: BN2 515)
- b. *THE PRICE **surprised** him: you get a lot of car for just over £20,000, if only in terms of its length, which is the same as a Mercedes 260E and a couple of inches more than the 5-series BMWs.* (BNC: ED9 1735)
- (33) Verbs of control and relation
- a. *THE END **justifies** THE MEANS.* (BNC: A03 485)
- b. *Hydrocarbon inclusions show strong luminescence, THE COLOUR **varying with** THE GRAVITY OF THE OIL.* (BNC: H9S 1639)
- c. *The importance of format and condition, with even such small matters as THE PRESENCE OR ABSENCE OF SILK TIES **affecting** THE VALUE.* (BNC: CCB 585)

3. Intensional NPs: individual and functional concepts and nouns

3.1 Four conceptual types of noun: individual and sortal, functional and relational

The second part of the rising-temperature construction and CQs that is of special interest is the intensional argument NP. The intensional argument expression in *the temperature is rising* is the definite NP *the temperature*; in the meaning that first comes to mind, *temperature* is taken in the sense ‘temperature of the air outdoors’.¹⁰ From the beginning of the discussion about Partee’s example, it was recognized that the noun *temperature* is different from ordinary nouns such as *rat* or *apple*. In its extensional use, *temperature* refers to abstract values on a temperature scale, these values depending on time. Thus, there is a function “temperature” that returns for every time *t* the temperature at *t*. Montague called the corresponding function an “individual concept” (IC), that is a function from time-world indices to individuals. There is no such function for ordinary common nouns.

In PTQ Montague assumed that the lexical noun *temperature* denotes a set of individual concepts that return temperature values. The definite article in *the temperature is rising* would pick out the (supposedly) only IC at the given time-world index, and this would be “the temperature”. What the early accounts did not reflect is the fact that if the noun *temperature* is analysed as denoting a set of ICs, then there is necessarily only one IC in the extension of the noun. Furthermore, this single IC in the denotation of the noun must be the same for all time-world indices with the same world.¹¹ This observation was first made in Löbner (1979), and it gave rise to the following characterization of *temperature* in its nonrelational sense:

- (34) For the noun *temperature*, there is a function f_{temp} from time-world indices to temperature values. If the NP *the temperature* is used extensionally, it refers to the value $f_{temp}(t, w)$ of that function at the given time-world index $\langle t, w \rangle$. If the NP *the temperature* is used intensionally, it refers to the individual concept f_{temp} .

According to this approach, *temperature* represents a special type of noun: its meaning is an individual concept.¹², namely the corresponding function from time-world indices to an appropriate type of value. For every index there is exactly one referent – the temperature at this index – and this holds

independently of, and prior to, the use of the definite article. This property gave rise to the notion of **individual noun** (IN): an individual noun is a noun that has an individual concept as its meaning. Individual nouns are inherently unique, and they are not relational. Most nouns are not relational; among them the majority is not inherently unique. For these **sortal nouns** (SN), there is no such corresponding function; rather, there is a one-place property such that the extension of the noun at an index is the set of all individuals that exhibit this property; there may be zero, one, or more such individuals.

In the examples and attestations in (4) to (33), most intensional nouns are relational: they determine their referent in relation to a possessor.¹³ Accordingly, these nouns either come with an explicit possessor specification as indicated, or the possessor is to be understood from context. Three of these nouns in the examples above – *distance* (18c), *effect* (30d) and *handling* (31b) – have two relational arguments, either explicitly specified, or understood from the context. With one exception, the expression *minister [positions] or deputy minister positions* in (20), the head nouns are inherently unique: relative to a given possessor argument, the referent is uniquely determined, there can be only one. These nouns represent the conceptual type of **functional noun** (FN): relational and inherently unique. Like all relational nouns, the meaning of a functional noun not only provides an open possessor argument, but also specifies the relation between the possessor and the referent. The price of x is what one has to pay for x, the name of x is what x is called, the foot-gear of x is what x wears on their feet, the temperature of x is how warm x is, and so on. A relational noun without this uniqueness condition is called **relational noun** (RN; “relational” in the narrower sense excluding functional nouns). Thus, there are four basic types of noun: sortal (nonunique and nonrelational), individual (unique and nonrelational), relational [in the narrower sense] (nonunique and relational), and functional (unique and relational). Their respective meanings are sortal concepts (SC), individual concepts (IC), relational concepts (RC), and functional concepts (FC).¹⁴

In the appendix, a table is compiled that lists all intensional NPs in the above examples that serve as argument terms for intensional verbs. The first columns of the table display the determination of the intensional NP, its head noun with its concept type, and the status of the type assignment. There are four cases of intensional NPs with an IC head noun: *temperature* [= *of the air*] (twice), *Dow Jones index*, and *gold price*; in each case, the concept type IC is due to the lexical meaning of the head noun, and hence classified ‘lex[ical]’. In all but the IC cases mentioned and the one exception of *positions* in (20), the concept type entry is FC. For most of these noun tokens, the FC status is due to their lexical meaning; lexical FNs are *cost*, *price*, *value*, *number (of)*, *percentage*, *temperature* (in its general, relational sense), *rapidity*, *distance*, *path*, *name*, *brand*, *end*, *means*, *color*; *president*, *prime minister*; *handling*. In the cases classified as ‘ctx’, the FC status is owed to the context. As usual when a word is used in context, noun meanings can be shifted to a required concept type by a variety of conceptual shifts. It is instructive to have a closer look at the four cases marked as contextual.

The notion *tutor* used in (23a) is lexically relational and not inherently unique: there may be more than one tutor for a given possessor. In the case of (23a), we will assume that there has been no further tutor when the tutor referred to was hired because otherwise it would have been more felicitous to say ‘hires another tutor’. It is open in (20) whether the ‘new government spokesman’ is the only government spokesman at that time, of the Greek government. The new spokesman might be the successor of the former spokesman, or the new spokesman might be additional. In any event, there is a unique individual concept that is predicated about; *tutor* and *new government spokesman* function as FC expressions in the given context. Notably, the two nominals are used with the indefinite article. This is due to the fact that they specify the respective intensional argument of a verb of installing; this type of verb takes an IC/FC argument without commitment to the presupposition of existence because

the reference of the argument NP is established by the very event expressed. With the replacement reading of (20), existence of a referent of *government spokesman* before and after is presupposed by *new*, but not, of course, the existence of a referent of new government spokesman.

The noun *shoes* in (22a) is an ordinary sortal noun by lexical meaning. In the constructional context given – *x changes x’s shoes* – the interpretation of *shoes* is not just the sortal concept ‘shoes’, but the functional concept ‘shoes x is wearing’ because it is the shoes you are wearing which you change when you change your shoes, not any other shoes of yours. This concept is inherently unique and relational, hence an FC. As for (22b) – *Who would normally replace the maths teacher?* – there is a functional meaning variant of *maths teacher* with the pupil(s) as possessor argument. This concept can be coerced into an IC in two ways: (i) it can be implicitly related to a specific student or a set of students, (ii) we can abstract away from the particular pupil(s) and relate the referent to the employing institution.

If a functional noun is provided with an IC possessor – either by explicit specification or by retrieval from context – the compositional result is an individual concept.¹⁵ In most of the data quoted, the possessor NP is an IC NP, that is a definite NP.¹⁶ If explicit, and if the possessor is left to the context, it is presumed to be uniquely determined, too; otherwise the definite article could not be used with the functional head noun. If a functional noun is used as the head of an argument term, the possessor needs to be determined one way or other because the potential referents of the NP depend on the possessor.

There are a couple of apparent exceptions: *number of students in my seminar on modal logic* in (8a) and *percentage of nickel* (32a). These nominals form IC expressions despite of the fact that the possessor NPs appear to be indefinite.¹⁷ The phenomenon is in need of further investigation. In any event, we observe that the whole NPs denote individual concepts.

3.2 Conclusion on the type of argument of time- and world-intensional verbs

We may state, at this point, the following generalization:

- (35) In the argument position of a time-intensional or world-intensional predication about a single definite case, the intensional NP denotes an individual concept.

From this observation, we can draw the conclusion that time- and world-intensional verbs predicate about individual concepts; the logical type of their arguments is $\langle s,e \rangle$. If the intensional NP refers to a singular case and its IC status is not due to special conditions in the given context, the argument is the intension of the respective nominal. By contrast, extensional verbs predicate over arguments of type e . If we do not adhere to Montague’s strategy of generalizing to the worst case, we may assume that there are two different composition rules for extensional and intensional predication: extensional predication applies to arguments of logical type e , and intensional predication to arguments of type $\langle s,e \rangle$. We can then consider the extensions of individual nouns to be of logical type e and one-place functional nouns of type $\langle e,e \rangle$, while sortal nouns are $\langle e,t \rangle$ and one-place relational nouns proper are $\langle e,\langle e,t \rangle \rangle$. Of course, this step requires the assumption of as many syntactic categories of nouns.¹⁸

	<i>nonunique</i>	logical type	<i>unique</i>	logical type
<i>nonrelational</i>	sortal	$\langle e,t \rangle$	individual	e
<i>relational</i>	relational	$\langle e,\langle e,t \rangle \rangle$	functional	$\langle e,e \rangle$

Table 1: Conceptual types and logical types of nouns and concepts

A remark is due to the extent that not all nominals of type e lend themselves to the intensional constructions discussed. One such type is proper names. Proper names are considered to have the same extension, that is bearer of the name, at all indices. Their intensions are constant functions; they neither change with time, nor are there alternative extensions in different possible worlds (at least this is the received view on proper names). Therefore proper names defy both time-intensional and world-intensional constructions. Thus what constitutes the simplest case of argument terms for extensional verbs in examples such as *Mary loves John*, is not available for intensional constructions.

4. Rising temperature and determination

4.1 Individual and functional concepts and definiteness

As noted above, there is a third component of the intensional constructions that is of special interest: the definite article. We saw in the discussion of the examples that, with the exception of verbs of installing where the presupposition of existence is not given, intensional predicates about a single concrete case take IC arguments. A look at the table in the appendix shows that in all these cases, the determination of the intensional NP is definite. IC NPs are inherently unique, and if existence of a referent is given, they also fulfill the second presupposition required for definites, the presupposition of existence, that a referent of the definite NP exist. Thus, definiteness in these cases is not accidental, but systematic.

The observation that individual and functional concepts are inherently unique led to the theory of definiteness proposed in Löbner (1985) and further expanded in Löbner (2011). It will be sketched here very briefly; for argumentation see there. The basic idea is this: individual and functional nouns yield a conceptually unique description of the referent by their very meaning: the meaning of *US president* is such that, in a given context, it can apply to exactly one person – the one person presently in that office. Since the referent of the noun is uniquely determined, it will be normally used with the definite article if we refer to one US president. Thus, the conceptual nature of individual nouns can be taken as an indication of what the function of the definite article is: it marks the whole NP as an expression that uniquely describes its referent. This is why marking INs that are used to refer to a single referent as definite is functionally redundant. The observation gave rise to the theory that not only NPs with IC heads are conceptually unique, but definite NPs in general: they all constitute individual concepts. If a nominal is conceptually unique, like *temperature [of the air]*, *Dow Jones Index*, or *president of Russia*, its use with definite determination results in a **semantic definite**, that is an NP that provides a unique description of its referent by virtue of its semantics even without definite determination. IC nouns with definite article or FC nouns with possessive pronouns, among other cases, are semantic definites.

If the head noun of a definite NP is not inherently unique, the condition for conceptual uniqueness must be retrieved from the given context. This is the case with deictic or anaphoric definite NPs such as those in (36a) and (36b), respectively:

- (36) a. deictic: *Pass me **the salt**, please.* (pointing to some salt)
 b. anaphoric: *I stumbled out of the hotel and into the middle of the road, narrowly missing being killed by a taxi. I remember the screech of the horn and the blur of **the car** as it passed in front of me.* (BNC: A0F 953)

With deictic NPs, the relevant IC-in-context would be something like, in the case of (36a), ‘salt here which speaker is pointing at and addressee can pass to speaker’. With anaphoric definites, the lexical sortal concept of the head noun is enriched with the information about the referent of the antecedent

as it is given in the preceding text. For (36b), this would yield the concept ‘car and taxi by which I narrowly missed being killed when I stumbled out of the hotel and into the middle of the road’. The concept links its referent car to the narrator and what happened to them at a certain time in a certain situation. This results in a unique conceptual description of the common referent of the anaphoric definite *the car* and its indefinite antecedent *a taxi*. Such definites, which crucially draw on additional conditions given in the context of use, are called **pragmatic definites** in Löbner (1985, 2011). The distinction between semantic and pragmatic definites, and the integration of both into a uniform account of definiteness in terms of conceptual uniqueness, is what distinguishes the theory from other approaches.¹⁹

In a second step, this approach to definiteness was expanded to a theory of nominal concept types and determination in general, also including indefinite, absolute, and relational determination. The theory in Löbner (2011) starts out with the idea that the two basic binary features that distinguish the four nominal concept types – conceptual uniqueness and conceptual relationality – also capture the function of the four basic types of determination. Definite determination indicates conceptually unique reference; indefinite determination indicates reference that is conceptually less than unique; absolute determination yields nonrelational reference; and relational (possessive) determination, relational reference.

4.2 Intensional verbs with argument NPs other than singular definites

Individual and functional nouns have a unique referent if the index argument and the possessor argument (for functional nouns) are uniquely determined. Nevertheless, they can be used for plural reference or quantification if their referents are linked to a plurality of arguments of the noun: the temperatures at various places or times, the presidents of different countries or at different times, and so on. Consider the following attestations:

- (37) a. *If brought to trial, she can expect a long prison sentence, followed by ‘re-education through labour’ in a camp in Qinghai — ‘China’s Siberia’ — an Area [sic] like the Sahara desert, in the west of the country, where the climate is notorious for its boiling heat in summer and freezing TEMPERATURES in winter.* (BNC: A8D 34)
- b. *Diem was assassinated and in the space of 1962–64, South Vietnam had THREE PRESIDENTS.* (BNC: H8W 722)
- c. *De Klerk said that in his recent meetings with the PRESIDENTS [sic] of Zaïre, Mozambique, Côte d’Ivoire and Zambia, all had agreed that South Africa should play a positive part in regional cooperation and development.* (BNC: HKR 14)

In (37a), *freezing temperatures* refers to the temperatures at different times over winter and at different places in the region. (37b) is about the presidents at different times of the same country, while (37c) relates to the presidents at the same time of different countries.

This way of expressing reference to a plurality of cases is also possible if the predication is intensional. The attestations in (38a,b) have plural functional nouns with varying possessor arguments; the example in (39) contains a world-intensional predication on an individual noun relating to varying times and places.

- (38) a. *However, SOME PRICES continue **rising**, particularly for foodstuffs such as bacon.* (BNC: HJO 13017)

- b. *Sinhalese, of status equivalent to that of a mudaliyar or ratemahatmaya, were **appointed** as PRESIDENTS of the tribunals.*
- (39) *I was **surprised** at the mild TEMPERATURES in St David's and the surrounding areas.*
(BNC: A65 723)

A less straightforward case is provided by occurrences of nonfunctional relational nouns as the ones mentioned above in (20):

- [(20)] *In addition to those changes, EIGHT OTHER MINISTER OR DEPUTY MINISTER POSITIONS were **changed**.*

The intensional NP *eight other minister or deputy minister positions* refers to a set of eight semantically not fully described entities of type $\langle s, e \rangle$ to which the time-intensional predication 'change' is to be applied. The first token of *minister* here is to be taken as elliptical for *minister position*; this is a relational noun with two relational arguments, one for the government the minister position belongs to (in this case the national Greek government) and one for the department the respective minister is in charge of (like Foreign Affairs, or National Defense). Fixing these arguments in a unique way will result in an individual concept. Plural reference is based on a plurality of cases that result from applying the same relational concept to different possessor constellations. This option exists for relational nouns in general: if I refer to my "three daughters", I refer to three cases of individuals who are in the daughter relation to me. However, there is more to the example in (20); fixing the two relational arguments, the government and the department, must result in an individual concept. This requires that in successive governments there are ministers for the same department. The noun *minister position* is not just a relational noun of the usual type, but denotes a collection of individual concepts: positions for threads of persons, as it were, that succeed each other in the same department in the same government.²⁰

We are now in the position to review the preliminary characterization of the type of intensional predications that was given above in (35):

- (40) The arguments²¹ of time-intensional or world-intensional predication are individual concepts.

5. Frames

We observed above that 'temperature', 'price', or 'height' – all functional nouns – denote abstract dimensions of entities. In cognitive psychology, such dimensions are called **attributes**; they serve mental description. According to the theory of concepts and categorization proposed in Barsalou (1992a, 1992b), mental descriptions are exclusively in terms of attributes. A person can be uniquely described in a passport by a selected choice of attributes – like 'name', 'sex', 'nationality', 'date of birth', 'place of birth', 'fingerprint' – and the values they take. Analogously, according to Barsalou's approach, a concept cognitively represents an individual entity, or an entity representative of a category, by means of a nested structure of attributes and the values they take; he calls these structures **frames**. The attributes in frames are not restricted to abstract dimensions like 'height' or 'temperature'; one type of attribute relates to constitutive parts, like 'face' for persons, or to unique correlates like 'owner', 'place of birth', or 'mother'; 'president' is a correlate attribute in the frame describing the US. Crucially, all attributes are functional concepts: inherently unique and relational.²² Conversely, all functional concepts figure in some frame or other. For example, any NP of the form 'FN

with possessor specification' – like *path of Mercury* – denotes an attribute in the frame of the possessor.

In the case of example (6a) – *the president of the US will change in 2021* – the intended time-intensional predication conveys this: in the frame of the US, the attribute 'president' will change its value in 2021. Similarly, if we say that the temperature is rising, we relate to the changing value of the 'temperature' attribute in the frame of the implicit possessor of the temperature.²³ The picture is analogous for world-intensional predications with intensional arguments with FN head nouns. If, for example, someone 'demands the name of the father', what they demand is to learn the value of the attribute 'name' of the value of the attribute 'father' in the frame of the daughter or son implicitly concerned.

In terms of frames, the distinction between extensional and intensional uses of verbs like intransitive *grow* can now be described more clearly, realizing that what was called dimensions is attributes in a frame. In the extensional use of *grow* in (12a) – *Rachel has grown* – the predication applies to a person; the frame for a person has an attribute 'body height', among countless others. The verb *grow* predicates a change of value for this one attribute of the person. A couple of other attributes may change with body height, but most other attributes are unrelated and not affected. Consequently, a change in body height does not replace the very person by some other person. By contrast, in its intensional use like in (13a) – *the number of students has grown* – the subject argument is the number-of-students. This being an abstract entity of a kind, it has only one dimension, its height, or rather, it *is* the dimension the predication applies to.

According to Barsalou's frame approach, frames [may] constitute the universal format of conceptual representation where frames represent objects and categories exclusively in terms of attributes. These can be recursively embedded unlimitedly; think of 'president' as an attribute of the US, the value of this attribute is a person, with an unlimited number of attributes the values of which carry their own attributes, and so on. If Barsalou's approach is correct, that means that all mental description and categorization is in terms of functional concepts.²⁴ And this certainly means that the class of functional nouns is of eminent importance for lexical semantics – because it is for cognitive psychology.

6. Conclusion

Barbara Partee's paradox gave rise to a cascade of observations. The logical problem led to the distinction between plain type *e* entities and the intensional type $\langle s,e \rangle$ entities called "individual concepts". For many verbs, there are two different uses, extensional and intensional, to be distinguished in terms of the type of argument they predicate about: *e* or $\langle s,e \rangle$, respectively. Accordingly, intensional and extensional uses require different types of nominals. This led to the distinction of inherently unique as opposed to the common nonunique nouns, in particular to the identification of individual and functional nouns. Intensionality of the type observed may concern either component of a Montagovian index: the time or the world. If the latter, the intensional NP may (often) be replaced by an interrogative clause; we then are dealing with a concealed question construction.

The distinction of different conceptual types of noun and NP gave rise to a theory of definiteness in which, again, individual and functional concepts play a central role. Finally, it turned out that functional concepts may be *the* concept type that humans use in general in their mental representations.

Thus, we see, it may be worthwhile to take a closer look at what first appears to be the exceptional and marginal, that which does not fit the general picture – it might turn out to open far-reaching new perspectives.

References

- Barker, Chris. 2016. 'Why relational nominals make good concealed questions'. *Lingua* 182: 12–29.
- Barsalou, Lawrence W. 1992a. *Cognitive Psychology*. Lawrence Erlbaum Associates. Hillsdale, NJ.
- Barsalou, Lawrence W. 1992b. Frames, concepts, and conceptual fields, in A. Lehrer, E. F. Kittay (eds.), *Frames, fields, and contrasts: New essays in semantic and lexical organization*. Lawrence Erlbaum Associates. Hillsdale, NJ. 21–74.
- BNC = BNCweb. *British National Corpus online*. <http://bncweb.lancs.ac.uk/>.
- Carnap, Rudolf. 1947[1988]. *Meaning and Necessity*. The University of Chicago Press. Chicago, London.
- Dowty, David R., Robert E. Wall, Stanley Peters. 1981. *Introduction to Montague Semantics*. Kluwer. Dordrecht.
- Fleischhauer, Jens, Thomas Gamerschlag. 2014. 'We're going through changes: How change of state verbs and arguments combine in scale composition'. *Lingua* 141: 30–47.
- Gamerschlag, Thomas, Willi Geuder and Wiebke Petersen. 2014. 'Glück auf, der Steiger kommt – A frame account of extensional and intensional "steigen" '. In D. Gerland et al. (eds.), *Meaning and Grammar of Nouns and Verbs*. Düsseldorf University Press. Düsseldorf. 115–144.
- Heim, Irene. 1979. 'Concealed questions'. In R. Bäuerle et al. (eds.), *Semantics from Different Points of View*. Springer. Berlin, Heidelberg. 51–60.
- Heim, Irene. 2011. 'Definiteness and indefiniteness'. In C. Maienborn et al. (eds.), *Semantics: An International Handbook of Natural Language Meaning*. De Gruyter Mouton. 996–1025.
- Jackendoff, Ray. 1979. 'How to keep ninety from rising'. *Linguistic Inquiry* 10: 172–176.
- Janssen, Theo M. V. (1984). Individual concepts are useful. In F. Landman, F. Veltman (eds.), *Varieties of Formal Semantics*. Foris. Dordrecht. 171–192.
- Laserson, Peter. 2005. 'The temperature paradox as evidence for a presuppositional analysis of definite descriptions'. *Linguistic Inquiry* 36: 127–134.
- Levin, Beth. 1993. *English Verb Classes and Alternations*. The University of Chicago Press. Chicago.
- Löbner, Sebastian. 1979. *Intensionale Verben und Funktionalbegriffe. Zur Syntax und Semantik von wechseln und den verwandten Verben des Deutschen*. Narr. Tübingen.
- Löbner, Sebastian. 1985. 'Definites'. *Journal of Semantics* 4: 279–326.
- Löbner, Sebastian. 2011. 'Concept types and determination'. *Journal of Semantics* 28: 279–333.
- Löbner, Sebastian. 2012. 'Sub-compositionality'. In W. Hinzen et al. (eds.), *The Oxford Handbook of Compositionality*. Oxford University Press, Oxford. 220–241.
- Löbner, Sebastian. 2013. *Understanding Semantics*. 2nd edition. New York, London. Routledge.
- Mater, Erich. 1966. *Deutsche Verben*. Bibliographisches Institut. Leipzig.
- Montague, Richard. 1973. 'The proper treatment of quantification in ordinary English'. In J. Hintikka et al. (eds.), *Approaches to natural language. Proceedings of the 1970 Stanford Workshop on Grammar and Semantics*. Reidel. Dordrecht. 221–242.
- Partee, Barbara. 1997. [With H. Hendriks] 'Montague Grammar'. In Johan van Benthem, Alice ter Meulen (eds.), *Handbook of Logic and Language*. Elsevier. Amsterdam. 5–91.
- Petersen, Wiebke (2007). Representation of concepts as frames. In Jurgis Šķilters et al. (eds.), *Complex Cognition and Qualitative Science. The Baltic International Yearbook of Cognition, Logic and Communication*, University of Latvia. Riga. Vol. 2. 151–170.
- Romero, Maribel. 2008. 'The temperature paradox and temporal interpretation'. *Linguistic Inquiry* 39: 665–667.

Schwager, Magda. 2007. 'Bodyguards under cover: The status of individual concepts'. In M. Gibson, T. Friedman (eds.), *Proceedings of Semantics and Linguistic Theory XVII*. Cornell University. Ithaca, NY. 246–263.

Schwarz, Florian. 2009. *Two Types of Definites in Natural Language*.
http://scholarworks.umass.edu/open_access_dissertations

Crossreferences

SEE ALSO: Chapter *Concealed questions. Knowing the price of milk*.

Biographical notes

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Appendix: Table of intensional NPs in the examples (4) to (33)

[CT = concept type, ctx = contextual, (in)def = (in)definite, Det = determination of intensional NP, Dim. = dimension of intensionality, em. = emotional, FC(2) = (2-place) functional concept, IC = individual concept, lex = lexical]

Nr.	Det	head	CT	status	possessor	CT	Verb	Class	Dim.
(4a)	def	<i>temperature</i>	IC	lex	–	–	<i>rise</i>	motion	time
(6a)	def	<i>president</i>	FC	lex	<i>the US</i>	IC	<i>change</i>	change	time
(8a)	def	<i>number</i>	FC	lex	<i>students in ..</i>	plural	<i>grow</i>	change	time
(15)	def	<i>excise tax</i>	FC	lex	<i>cigarettes</i>	plural	<i>raise</i>	change	time
(17a)	def	<i>Dow Jones index</i>	IC	lex	–	–	<i>fell</i>	motion	time
(17b)	def	<i>gold price</i>	IC	lex	–	–	<i>leap</i>	motion	time
(18a)	def	<i>pace</i>	FC	lex	<i>my (I)</i>	IC	<i>accelerate</i>	change	time
(18b)	def	<i>cost</i>	FC	lex	ctx		<i>cheapen</i>	change	time
(18c)	def	<i>distance</i>	FC2	lex	...	IC	<i>shorten</i>	change	time
(19a)	def	<i>name</i>	FC	lex	ctx		<i>change</i>	change	time
(19a)	def	<i>prof. service</i>	FC	lex	ctx		<i>remain</i>	change	time
(19b)	def	<i>brand</i>	FC	lex	<i>spray</i>	mass	<i>vary</i>	change	time
(19c)	def	<i>temperature</i>	IC	lex	–	–	<i>stay at</i>	change	time
(20)	def	<i>energy minister</i>	FC	lex	<i>the country</i>	IC ctx.	<i>replace</i>	replace	time
(20)	indef	<i>new ... spokesman</i>	FC	ctx	ctx	IC	<i>name</i>	install	time
(20)	indef	<i>eight ... positions</i>	RC	lex	ctx	IC	<i>change</i>	change	time
(22a)	def	<i>shoes</i>	FC	ctx	<i>her (she)</i>	IC	<i>change</i>	change	time
(22b)	def	<i>maths teacher</i>	FC	ctx	ctx		<i>replace</i>	replace	time
(23a)	def	<i>tutor</i>	FC	ctx	<i>him (he)</i>	IC	<i>hire</i>	install	time
(23b)	def	<i>president</i>	FC	lex	ctx	IC	<i>elect</i>	install	time
(23b)	indef	<i>prime minister</i>	FC	lex	ctx	IC	<i>appoint</i>	install	time
(24a)	def	<i>price</i>	FC	lex	<i>2nd volume</i>	FC	<i>know</i>	epistemic	world
(26)	def	<i>capital</i>	FC	lex	<i>Vanuatu</i>	IC	<i>know</i>	epistemic	world
(27)	def	<i>number</i>	FC	lex	ctx		<i>shock</i>	em. effect	world
(28)	def	<i>actual location</i>	FC	lex	<i>the rabbits</i>	IC ctx.	<i>influence</i>	control	world
(30a)	def	<i>percentage</i>	FC	lex	<i>nickel</i>	mass	<i>indicate</i>	epistemic	world
(30b)	def	<i>path</i>	FC	lex	<i>Mercury</i>	IC	<i>predict</i>	epistemic	world
(30c)	def	<i>name</i>	FC	lex	<i>the father</i>	IC ctx.	<i>demand</i>	epistemic	world
(30d)	def	<i>effect</i>	FC2	lex	(rel. clause)		<i>forget</i>	epistemic	world
(31a)	def	<i>price</i>	FC	lex	ctx		<i>accept</i>	attitude	world
(31b)	def	<i>handling</i>	FC2	lex	<i>government</i>	IC ctx	<i>criticize</i>	attitude	world
(32a)	def	<i>rapidity</i>	FC	lex	<i>German ..</i>	mass	<i>shock</i>	em. effect	world
(32b)	def	<i>price</i>	FC	lex	ctx		<i>surprise</i>	em. effect	world
(33a)	def	<i>end , means</i>	FC	lex	generic		<i>justify</i>	control	world
(33b)	def	<i>colour</i>	FC	lex	ctx		<i>vary with</i>	control	world
(33c)	def	<i>value</i>	FC	lex	ctx		<i>affect</i>	control	world

¹ Gottfried Wilhelm Leibniz [ˈlaɪpnɪts], German philosopher and mathematician (1646 – 1716).

² Barbara Partee, semanticist, University of Massachusetts, Amherst MA.

³ In Montague (1973: 221); ‘The proper treatment of quantification in ordinary English’ – PTQ for short – is the seminal paper of formal semantics.

⁴ See Romero (2008) and Lasersohn (2005) for more detailed reviews of the literature that tried to evade the paradox by questioning the examples. We will not go into this discussion because it requires a firm background in formal semantics.

⁵ Actually, this is a technical simplification of Montague's formal treatment in PTQ; Montague does not treat definite NPs as individual terms. However, the existence of corresponding individual concepts (in the sense defined below) can be logically derived from his analysis. The crucial point here is not the general design of Montague's PTQ semantics and the particulars of his analysis of the sentences in (4), but the difference in logical type of the argument of the predications in *the temperature is rising* and *the temperature is ninety*, respectively.

⁶ As an exception, Janssen (1984) made a plea for not disregarding individual concepts in the framework of formal semantics.

⁷ The term for this interpretive strategy goes back to Partee (1997: 75). From the point of view of semantic theory, this strategy is problematic in itself; see Löbner (2012) for discussion.

⁸ It should be noted that Carnap's "individual concepts" in this sense are not concepts in the psychological sense of the word: they are neither words nor abstract cognitive entities; they are set-theoretic functions from indices to individuals in the world.

⁹ Nevertheless, I will talk in this article of verbs with intensional uses as 'intensional verbs'.

¹⁰ For the sake of simplicity and of focusing on the argument, we will ignore the fact that there is a more general sense of *temperature* as a relational noun that takes as an argument a physical substance: 'temperature of'.

¹¹ It was observed early on that this feature of Montague's analysis leads to the logical problem that "the temperature" at one time need not be the same individual concept as at another time (Dowty, Wall, Peters 1981: 284f, see Lasersohn 2005 for discussion).

¹² For Montague, and the tradition of formal semantics, meanings are functions from the set of time-world indices to the set of the type of entities that this logical type of expression can denote. In Löbner (2013) and Löbner (2011), I take the position that meanings are concepts. According to this approach, individual concepts are concepts in the sense of cognitive psychology. There is, however, a common denominator of the respective notions of meaning in both types of approach: the meaning of an expression is something that for any time-world index, yields the denotation of the expression, that is the Montague's "extension". The problem at issue here is a logical and ontological problem, not a problem of what entities we consider meanings to be. Both approaches to meaning can deal with it analogously.

¹³ See Barker (2016) for a recent discussion of why relational nouns lend themselves to intensional arguments in CQ constructions.

¹⁴ See Löbner (2011: S. 1.2) for a more elaborate description of these types of noun and types of concept.

¹⁵ Löbner (2011: 301–303, 328f) describes the composition of relational and functional nouns with possessor NPs in terms of concept types. FCs with IC possessor specification yield ICs.

¹⁶ For the claim that definite NPs are IC NPs, see S. 4.1.

¹⁷ Whether the reference of these bare NPs is really indefinite, is questionable. In all the attestations cited, the possessor NPs can be replaced by definite NPs: *number of the students in my seminar on modal logic; percentage of the nickel [content]*.

¹⁸ This treatment was proposed in Löbner (1979: 181ff); Lasersohn (2005) proposes a type ⟨e,t⟩ analysis for *temperature* and *price*.

¹⁹ See Heim (2011) for a survey, but also Schwarz (2009) for an approach advocating essentially the same distinction.

²⁰ For a deeper and more formal discussion of the matter see Schwager (2007).

²¹ Be careful to observe that the arguments of a predication are the things in the world the predication is about – rather than the NPs or other expressions that *specify* the arguments. As we just saw, these NPs may be of various types. For the proper distinction of arguments and argument terms, and predicates and predicate expressions, respectively, see Löbner (2013: 108–111).

²² See Löbner (2013: Ch.12) for a textbook-level introduction to Barsalou frames; Petersen (2007) for the connection between concept types and types of Barsalou frames and a first formal model.

²³ For an explicit frame analysis of time-intensional and extensional German *steigen* 'rise', see Gamerschlag, Geuder, and Petersen (2014).

²⁴ Note that concepts are not to be correlated with words. We may or may not have verbal expressions for the functional concepts we employ in our cognitive system. Functional *nouns* are not functional *concepts* – their meanings are.