Yasutada Sudo

The semantic role of classifiers in Japanese

Abstract: In obligatory classifier languages like Japanese, numerals cannot directly modify nouns without the help of a classifier. It is standardly considered that this is because nouns in obligatory classifier languages have 'uncountable denotations', unlike in non-classifier languages like English, and the function of classifiers is to turn such uncountable denotations into something countable (Chierchia 1998a,b, Krifka 2008, among many others). Contrary to this view, it is argued that what makes Japanese an obligatory classifier language is not the semantics of nouns but the semantics of numerals. Specifically, evidence is presented that numerals in Japanese cannot function as predicates on their own, which is taken as evidence that the extensions of numerals in Japanese are exclusively singular terms. It is then proposed that the semantic function of classifiers is to turn such singular terms into modifiers/predicates. It is furthermore claimed that the singular terms denoted by numerals are abstract entities (cf. Rothstein 2013, Scontras 2014a,b), and proposed that the reason why they cannot have modifier/predicate uses in obligatory classifier languages like Japanese is because the presence of classifiers in the lexicon blocks the use of a type-shifting operator that turns singular terms denoted by numerals into predicates (cf. Chierchia 1998a,b).

Keywords: classifier, numeral, semantic parameter, Japanese

1. Introduction

Japanese is a typical *obligatory classifier language* in which a classifier is required in order for a numeral to modify a noun phrase, as illustrated in (1).[1] The relevant classifier here is -*rin,* which is used for counting flowers.

(1) ichi*(-rin)-no hana
one-cl-gen flower

[1] In Sudo (to appear) I raise some exceptional examples where classifiers are optional such as (i):

(i) san-zen-*(nin)-no* *heetai*
3-1000-cl-gen soldier
'3,000 soldiers'

It appears that such examples involve high and/or approximate numeral, and only occur in a certain non-colloquial register. While the exact nature of these exceptions needs further research, it is safe to say that they are exceptions, rather than the rule. In addition, an anonymous reviewer raises examples like *san-kazoku* 'three families' and *roku-daigaku* 'six universities' that do not require a classifier. As far as I can see, such examples are all compounds (as suggested by the reviewer's use hyphenation), which is evidenced by the fact that they all have accent patterns typical of compounds. Since compounding allows types of semantic composition that are not observed at the phrasal level, these cases should be treated separately from phrasal cases, to which we confine our attention in this paper.

'one flower'

It is standardly considered in the current literature that one of the factors that distinguish obligatory classifier languages like Japanese from non-classifier languages like English is the semantics of nouns (e.g. Borer 2005, Bunt 1985, Chierchia 1998a,b, 2010, Krifka 2008, Li 2011, Nemoto 2005, Rothstein 2010, Scontras 2013, 2014b). The idea is that nouns in obligatory classifier languages generally have denotations that are somehow incompatible with direct modification by counting modifiers like numerals, which include not only nouns that denote substances but also those nouns that correspond to count nouns in other languages, e.g. *hana* 'flower'.

Although this idea is appealing, I argued in Sudo (to appear) that nominal denotations in Japanese are not so different from those in non-classifier languages like English. In particular, I observed that there are counting modifiers that may appear without classifiers (some of which are incompatible with classifiers) but are nonetheless only compatible with nouns denoting countable objects. These modifiers include *tasuu* 'numerous' and *nan-zen-toiu* 'thousands, for example. Such counting modifiers show that Japanese nouns come in two varieties: those whose denotations are compatible with counting, which I call *countable nouns* (e.g. *hana* 'flower'), and those whose denotations are incompatible with counting, which I call *uncountable nouns* (e.g. *ase* 'sweat'). A direct consequence of this observation is that it should not be the semantics of nouns that requires classifiers with numerals, contrary to the standard view, since countable nouns are perfectly compatible with non-numeral counting modifiers in the absence of classifiers (see Watanabe 2006, Cheng & Sybesma 1999, Bale & Barner 2009 for related ideas).

In the present paper I pursue an alternative explanation for the obligatory use of classifiers with numerals in Japanese. The main idea is that it is the semantic properties of numerals, rather than nouns, that require classifiers in modification contexts (see Krifka 1995, Bale & Coon 2014 for similar views). Empirical motivation for this view comes from data showing that numerals in Japanese cannot function as predicates on their own, and require classifiers to do so. In order to make sense of this observation, I will develop an analysis where numerals in all natural languages denote abstract entities by default, which are singular terms and hence cannot function as predicates or modifiers. I propose that classifiers turn such singular terms into predicates/modifiers. In order to account for the difference between obligatory classifier languages and non-classifier languages, furthermore, I follow Chierchia's (1998a,b) idea in assuming that natural language is equipped with a phonologically silent operator, the $^{\cup}$-operator, which turns such singular terms into predicates/modifiers, but its use is blocked in languages that have phonologically overt lexical items that play the same or a related role. In the present case, the relevant phonologically overt lexical items are the classifiers. Consequently, languages with classifiers have to employ classifiers in order to use numerals as predicates/modifiers, while in non-classifier languages, numerals have a dual status as singular terms and predicates/modifiers.

The present paper is organized as follows. In Section 2, I will lay out the core theoretical assumptions and proposals. In Section 3, I will present data motivating the analysis proposed in Section 2. The analysis will be extended in Section 4 with the dual of the $^{\cup}$-

operator, the $^{\cap}$-operator, which accounts for further data of classifiers in Japanese. Finally, I will conclude in Section 5.

2. Numerals and Classifiers

2.1 Numerals

Let us start with the main theoretical proposal of the paper. Firstly, I assume that the extensions of numerals in all natural languages are singular terms by default, which are abstract objects of type n (contrary to Ionin & Matushansky 2006; cf. Rothstein 2013).[2] Anticipating the later discussion, I will intensionalise the denotations in what follows. Then, the intension of *roku* 'six' in Japanese will be a constant function from possible worlds to an object of type n, as in (2), and *six* in English is assumed to have an identical intension. I use Arabic numerals to represent objects of type n.

(2) $[\![\text{roku}]\!] = [\![\text{six}]\!] = \lambda w_s.\ 6$

Rothstein (2013) is an important predecessor of this idea. She assumes that numerals have multiple semantic functions which are systematically related via type-shifting rules, and the type-n interpretation is only one of them. I adopt this view later on, but one crucial difference between our analyses is that she does not seem to consider the type-n denotation to be the default. As we will see, this assumption is crucial for my account of the obligatory use of classifiers in obligatory classifier languages.

2.2 Classifiers

Secondly, I assume here without argument that in Japanese (and possibly in other obligatory classifier languages), a numeral and classifier form a constituent to the exclusion of the noun phrase (Krifka 1995, Fukui & Takano 2000, Doetjes 2012). Thus, I assume the structure of (1) to be something along the lines of (3).[3]

(3) [ichi-rin]-no hana
[one-CL]-GEN flower
'one flower'

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[2] For the purposes of the analysis to be developed here, it is not necessary to make commitments about the ontological status of objects of type n. Here I follow Rothstein (2013) among others and assume that they are of a separate semantic type than objects of type e, but they could alternatively be regarded as a sub-type of type e. I thank an anonymous reviewer for discussion on this point.

[3] Some authors assume that classifiers combine with nouns first, before combining with numerals (e.g. Chierchia 1998b, Krifka 2008, Scontras 2013, 2014b, Watanabe 2006). The reason why this is not adopted here is because the analysis to be presented below will be considerably simpler with the structure like (3). Also, this syntax matches the surface structure more directly, at least in Japanese: In Japanese a numeral and a classifier form a single phonological word to the exclusion of the noun. I leave it open how to reconcile the analysis of classifiers proposed here with the alternative syntax of classifiers.

Following the standard assumption in the literature on plurality, the denotation of a countable noun like *hana* 'flower' is assumed to be as in English, except that the number is underspecified. Therefore, it contains all individuals that count as single flowers and their individual-sums (or i-sums).

Since *ichi* 'one' denotes an object of type n, it cannot directly modify the noun *hana.* I claim that the role of the classifier *-rin* is specifically to turn the type-n object into a modifier. Recall that this particular classifier *-rin* is used for counting flowers and flowers only. I assume that this sortal restriction is a presupposition.[4] Thus, the intension of *-rin* looks like (4). Metalanguage predicates like **flower** are assumed to be only true of atomic individuals, and ***flower** is the closure of **flower** under i-sum formation $\sqcup$, i.e. *P(x) is true iff either P(x) is true, or $x=y\sqcup z$ and both *P(y) and *P(z) are true.

(4) $[\![\text{-rin}]\!] = \lambda w_s.\ \lambda n_n.\ \lambda x_e\text{: }{*}\mathbf{flower}_w(x).\ |\{y \sqsubseteq x\text{: }\mathbf{flower}_w(y)\}|=n$

In words, this classifier ensures that x is a single flower or an i-sum consisting of flowers via the sortal presupposition, and counts the number of singular flowers in x.

I assume that (4) combines with a numeral via (Extensional) Functional Application, yielding a function of type (s,(e,t)).

(5) *Functional Application*
If $[\![A]\!]$ is of type (s,(σ,τ)) and $[\![B]\!]$ is of type (s,σ), then $[\![A\ B]\!] = [\![B\ A]\!] = \lambda w_s$: $w\in\text{dom}([\![A]\!])\ \&\ w\in\text{dom}([\![B]\!])\ \&\ [\![B]\!](w)\in\text{dom}([\![A]\!](w)).\ [\![A]\!](w)([\![B]\!](w))$.

I follow Heim & Kratzer (1998) in assuming that functions of type (s,(e,t)) can serve as nominal modifiers via Predicate Modification.

(6) *Predicate Modification*
If A and B are both of type (s,(e,t)), then $[\![A\ B]\!] = \lambda w_s.\ \lambda x_e\text{: } w\in\text{dom}([\![A]\!])$ & $w\in\text{dom}([\![B]\!])\ \&\ x\in\text{dom}([\![A]\!](w))\ \&\ x\in\text{dom}([\![B]\!](w)).\ [\![A]\!](w)(x)=[\![B]\!](w)(x)=1$.

For instance, the denotation of (1) is computed as follows (the genitive suffix *-no* is assumed to have no semantic contribution here).

(7) a. $[\![\text{roku}]\!] = \lambda w_s.\ 6$
b. $[\![\text{roku-rin}]\!] = \lambda w_s.\ \lambda x_e\text{: }{*}\mathbf{flower}_w(x).\ |\{y \sqsubseteq x\text{: }\mathbf{flower}_w(y)\}|=6$
c. $[\![\text{roku-rin-no hana}]\!]$
$= \lambda w_s.\ \lambda x_e\text{: }{*}\mathbf{flower}_w(x).\ |\{y \sqsubseteq x\text{: }\mathbf{flower}_w(y)\}|=6\ \&\ {*}\mathbf{flower}_w(x)$

Other classifiers can be given similar analyses. Different classifiers have different sortal presuppositions and count different kinds of individuals, as in (8).

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[4] See McCready (2009) for an alternative analysis of the sortal restriction as a conventional implicature. As far as I can see this theoretical choice is inconsequential for the purposes of the present paper.

(8) a. $[\![\text{-nin}]\!] = \lambda w_s.\ \lambda n_n.\ \lambda x_e$: $^*\mathbf{human}_w(x)$. $|\{y \sqsubseteq x: \mathbf{human}_w(y)\}|=n$
b. $[\![\text{-hiki}]\!] = \lambda w_s.\ \lambda n_n.\ \lambda x_e$: $^*\mathbf{small}_w(x)$ & $^*\mathbf{animal}_w(x)$. $|\{y \sqsubseteq x: \mathbf{animal}_w(y)\}|=n$

There are also classifiers that count non-atomic individuals, e.g. *-kumi* 'pair', which counts the number of pairs, and *-daasu* 'dozen', which counts sets of twelve objects. They can be analyzed as in (9). Since these classifiers have no sortal restrictions, they have no presuppositions. Here, y_i and y_j range over $y_1, \ldots, y_n$.

(9) a. $[\![\text{-kumi}]\!] = \lambda w_s.\ \lambda n_n.\ \lambda x_e.\ \exists y_1 \ldots y_n[x = y_1 \sqcup \ldots \sqcup y_n\ \&\ \forall y_i[|\{z \sqsubseteq y_i: \mathbf{atomic}_w(z)\}|=2\ \&$ $\neg \exists y_j[y_i \Diamond y_j\ \&\ y_i \neq y_j]]]$
b. $[\![\text{-daasu}]\!] = \lambda w_s.\ \lambda n_n.\ \lambda x_e.\ \exists y_1 \ldots y_n[x = y_1 \sqcup \ldots \sqcup y_n\ \&\ \forall y_i[|\{z \sqsubseteq y_i: \mathbf{atomic}_w(z)\}|=12\ \&$ $\neg \exists y_j[y_i \Diamond y_j\ \&\ y_i \neq y_j]]]$

'$x \Diamond y$' means x and y do not overlap, i.e. $x \Diamond y$ is true iff $\{z: z \sqsubseteq x\} \cap \{z: z \sqsubseteq y\} \neq \emptyset$. This condition is necessary, in order to not count the same atomic individual multiple times. Specifically, it prevents four books from forming six pairs, rather than two pairs.

2.3 Type-Shifting

According to the above idea, classifiers turn numerals into modifiers. But then, what about non-classifier languages like English where numerals directly modify nouns? Following Rothstein (2013), I assume that objects of type n have corresponding properties. Or to put it differently, we regard objects of type n as abstract entities that are systematically related to a certain kind of functions (cf. Chierchia 1985, Chierchia & Turner 1988, Rothstein 2013). For example, the property correlate of 6 is the property of having six members. Following Chierchia, I use the $^{\cup}$-operator as the map from constant functions of type (s,n) to the corresponding properties, as in (10).[5]

(10) $^{\cup}(\lambda w_s.\ 6) = \lambda w_s. \lambda x_e.\ |\{y \sqsubseteq x: \mathbf{atomic}_w(y)\}|=6$

In English, the $^{\cup}$-operator is used to combine a numeral with a noun, which is triggered by $^{\cup}$-Shifted Predicate Modification.

(11) *$^{\cup}$-Shifted Predicate Modification*
If $[\![A]\!]$ is of type (s,n) and $[\![B]\!]$ is of type (s,(e,t)), then $[\![A\ B]\!] = [\![B\ A]\!] = \lambda w_s.\ \lambda x_e$: $[\![A]\!] \in \text{dom}(^{\cup})$ & $w \in \text{dom}(^{\cup}[\![A]\!])$ & $x \in \text{dom}(^{\cup}[\![A]\!](w))$ & $w \in \text{dom}([\![B]\!])$ & $x \in \text{dom}([\![B]\!](w))$. $^{\cup}[\![A]\!](w)(x)=[\![B]\!](w)(x)=1$.

Concretely, the meaning of *six flowers* will be computed as follows.

[5] Chierchia (1998a,b) assumes that the $^{\cup}$-operator applies directly to kinds, while I assume that it applies to constant functions of type (s,n). This technical difference is immaterial, given that there is a one-to-one mapping between objects of type n and constant functions of type (s,n). The same remark applies to the $^{\cap}$-operator introduced below.

(12) a. $[\![\text{six}]\!] = \lambda w_s.\ 6$
b. $[\![\text{six flowers}]\!] = \lambda w_s.\ \lambda x_e.\ |\{y \sqsubseteq x: \mathbf{atomic}_w(y)\}|=6\ \&\ {}^*\mathbf{flower}_w(x)$

If $^{\cup}$-Shifted Predicate Modification (11) is available in Japanese too, it will overgenerate, as the same derivation as (12) will become available. I follow Chierchia's (1998a,b) insights here and assume that $^{\cup}$-Shifted Predicate Modification is only available as a last resort. That is, if there are overt lexical items in the language that incorporate the function of a silent operator, the use of these overt lexical items becomes obligatory. In this case, the silent operator is the $^{\cup}$-operator and the overt lexical items are classifiers. What blocks the derivation like (12) in Japanese is, therefore, the presence of classifiers in the lexicon. Thus, the cross-linguistic variation between obligatory classifier languages and non-classifier languages boils down to the lexical inventory of functional items.[6]

3. Numerals as Predicates

The analysis proposed above makes testable predictions. In particular, numerals should always denote singular terms in Japanese, due to the presence of classifiers in the lexicon, and hence should not be able to function as predicates, not just not as modifiers. We observe in this section that this is indeed the case.

3.1 Predicative numerals in Japanese

Firstly, numerals can appear in predicative position in identificational sentences, as in (13) and (14). In these sentences, the extensions of the subject DPs are also objects of type n (cf. Rothstein 2013).

(13) kyoo-no okyakusan-no kazu-wa juu-ni-da.
today-GEN guest-GEN number-TOP 10-2-COP
'The number of guests today is twelve.'

(14) ni tasu ni-wa yon-da.
2 plus 2-TOP 4-COP
'Two plus two is four.'

When the subject DP denotes an individual, however, the example becomes unacceptable, as illustrated by (15). Note that the numeral here has the same form as in (13) and (14), so the syntax is not the culprit for the unacceptability here.

(15) * kyoo-no okyakusan-wa juu-ni-da.
today-GEN guest-TOP 10-2-COP

In order to make the example acceptable, a classifier needs to be added as in (16).

(16) kyoo-no okyakusan-wa juu-ni-nin-da.

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[6] One potential problem is optional classifier languages, to which I will come back at the end of the paper.

today-GEN guest-GEN number-TOP 10-2-CL-COP
'The guests are twelve today.'

This is as predicted in the analysis put forward here. Classifiers turn numerals into properties, thereby allowing them to function as predicates.

Similar contrasts are observed with other classifiers, as shown in (17).

(17) a. katteiru doobutsu-no kazu-wa yon-da.
have.as.pets animal-GEN number-TOP 4-COP
'The number of pets (I) have is 4.'
b. katteiru doobutsu-wa yon-*(hiki)-da.
have.as.pets animal-TOP 4-(CL)-COP
'I have four pets.'
(lit.) 'The pets I have are four.'

3.2 Predicative numerals in English

As Rothstein (2013) observes, numerals in English seem to be able to function as predicates, e.g. (18).[7]

(18) a. Soon we will be three.
b. The reasons are four.

Since English by assumption has no lexical items that incorporate the $^{\cup}$-operator, the $^{\cup}$-operator can be used to type-shift the intensions of numerals to properties.[8] For examples in (18), we use the compositional rule, $^{\cup}$-Shifted Functional Application (which is essentially parallel to Rothstein's 2013 account of examples like (18)). There are two versions, depending on which expression serves as the argument.

(19) *$^{\cup}$-Shifted Functional Application* (version 1 of 2)
a. If ⟦A⟧ is of type (s,n) and ⟦B⟧ is of type (s,e), then ⟦A B⟧ = ⟦B A⟧ = λw_s: ⟦A⟧∈dom($^{\cup}$) & w∈dom($^{\cup}$⟦A⟧) & w∈dom(⟦B⟧) & ⟦B⟧(w)∈dom($^{\cup}$⟦A⟧(w)). $^{\cup}$⟦A⟧(w)(⟦B⟧(w)).
b. If ⟦A⟧ is of type (s,n) and ⟦B⟧ is of type (s,((e,t),t)) then ⟦A B⟧ = ⟦B A⟧ = λw_s: ⟦A⟧∈dom($^{\cup}$) & w∈dom($^{\cup}$⟦A⟧) & w∈dom(⟦B⟧) & $^{\cup}$⟦A⟧(w)∈dom(⟦B⟧(w)). ⟦B⟧(w)($^{\cup}$⟦A⟧(w)).

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[7] Here and below, we are not interested in the age-interpretation, which seems to be possible with bare numerals above 10 in Japanese, when the subject is animate.
[8] An anonymous reviewer points out that the verb *to number* seemingly has a function akin to the $^{\cup}$-operator, as in *The apostles numbered 12.* However, its complement is not always of type n, but could be a quantity expression like a modified numeral or an expression like "hundreds", which do not name an object of type n. It is conceivable, therefore, that the complement of *to number* is a predicate/modifier.

As in the case of $^{\cup}$-Shifted Predicate Modification, $^{\cup}$-Shifted Functional Application, which makes use of the $^{\cup}$-operator, is assumed to be unavailable in Japanese, due to the presence of classifiers in the lexicon. Therefore the Japanese counterparts of (18) are unacceptable.

However, this analysis of predicative numerals in English is actually too simple-minded. As pointed out to me by Martin Hackl (p.c.), numerals cannot appear in constructions that are considered to require predicative expressions, e.g. (20b) and (20c) (see also Solt 2015).

(20) a. The guests are three.
b. *The guests look three.
c. *I consider the guests three.

Compare these to the following acceptable sentences (due to an anonymous reviewer), which illustrate the fact that the intended meanings are fine.

(21) a. The guests number three.
b. The guests look to number three.
c. I consider the guests to number three.

Note also that not only numerals, but also other number-related expressions, e.g. *many,* are excluded from these constructions.

This observation is potentially problematic for the above analysis of English where numerals have a dual status as abstract numbers and properties (and hence is as problematic for Rothstein 2013). One way to save the current account of English numerals is to assume that $^{\cup}$-Shifted Functional Application is somehow made unusable in constructions in (20b) and (20c) but not in (20a), although why this should be so is not clear to me. Since English and other non-classifier languages are not of our main interests here, I will leave this issue open for future research.

4. More on Type-n Objects

In the previous section we observed that numerals in Japanese cannot function as predicates on their own. Here, we observe that numeral+classifier can also denote objects of type n. For example, the following sentences, which are parallel to (14) and (17b), are also acceptable (and perhaps more natural than (14) and (17b)).

(21) a. kyoo-no okyakusan-no kazu-wa juu-ni-nin-da.
today-GEN guest-GEN number-TOP 10-2-CL-COP
'The number of guests today is twelve.'
b. katteiru doobutsu-no kazu-wa yon-hiki-da.
have.as.pets animal-GEN number-TOP 4-CL -COP
'The number of pets (I) have is 4.'

The following example further reinforces this point.[9]

(22) ni-rin tasu ni-rin-wa yon-rin-da.
2-CL plus 2-CL-TOP 4-CL-COP
'Two flowers plus two flowers makes four flowers.'

I propose to accommodate these data as follows. Recall that the $^{\cup}$-operator maps intensions of numerals to properties. In addition to it, I also postulate its inverse, the $^{\cap}$-operator, which maps (certain) properties to constant functions of type (s,n) (cf. Chierchia 1998a,b). For instance, when applied to $^{\cup}[\![6]\!]$ it gives back $[\![6]\!]$.

(23) a. $[\![6]\!] = \lambda w_s.\ 6$
b. $^{\cup}[\![6]\!] = \lambda w_s.\ \lambda x_e.\ |\{y \sqsubseteq x: \mathbf{atomic}_w(y)\}|=6$
c. $^{\cap}(\lambda w_s.\ \lambda x_e.\ |\{y \sqsubseteq x: \mathbf{atomic}_w(y)\}|=6) = \lambda w_s.\ 6$

Thus, we have $^{\cap\cup}[\![6]\!] = [\![6]\!]$. It is assumed that the $^{\cap}$-operator is a partial function and is only defined for certain properties. For instance, the property of being a Japanese speaker living in London has no type (s,n) correlate.

I claimed above that the $^{\cup}$-operator is made unusable in obligatory classifier languages like Japanese due to the presence of classifiers in the lexicon. However, since there is no overt lexical item that do the same thing as the $^{\cap}$-operator, nothing prevents it from being used in Japanese. I claim that this is exactly what is going on in (21) and (22). That is, it involves an application of the $^{\cap}$-operator to numeral+classifier.

Specifically, I propose that the domain of type n contains more objects than just plain numbers. In particular, abstract numbers that correspond to properties of having a fixed number of members of specific categories are also objects of type n (see Scontras 2014a,b for a similar analysis developed for the semantics of measure nouns like *amount*). Here is a concrete example. According to the analysis put forward here, numeral+classifier denotes a property. For example *juu-ni-nin* '10-2-cl.human' denotes the property of having twelve humans as parts.

(24) $[\![\text{juu-ni-nin}]\!] = \lambda w_s.\ \lambda x_e: {}^*\mathbf{human}_w(x).\ |\{y \sqsubseteq x: \mathbf{human}_w(y)\}| = 12$

Applying the $^{\cap}$-operator to (24), we obtain a constant function of type (s,n) which maps any world to the type-n object that corresponds to the property of having 12 humans. I analyze (21a) as an identificational sentence involving this object of type n. The subject DP of this sentence is assumed to have a type-n object as its extension, and the entire sentence states

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[9] An anonymous reviewer remarks that this example does not sound perfectly felicitous to them. The existence of such speakers is not incompatible with the account put forward here. That is, for such speakers, mathematical expressions such as *tasu* 'add' might be confined to pure objects of type n that contain no counting information. The same reviewer mentions similar restrictions on expressions related to multiplication and division, but they are also amenable to a similar explanation.

that this type-n object and the type-n correlate of (24) are identical. (21b) and (22) can be analyzed analogously.

For the sake of completeness, we extend the compositional rule of $^{\cup}$-Shifted Functional Application with a clause triggering the $^{\cap}$-operator (25c).

(25) $^{\cup}$-Shifted *Functional Application (*version 2 of 2)

a. If $[\![A]\!]$ is of type (s,n) and $[\![B]\!]$ is of type (s,e), then $[\![A\ B]\!] = [\![B\ A]\!] = \lambda w_s$: $[\![A]\!] \in \mathrm{dom}(^{\cup})$ & $w \in \mathrm{dom}(^{\cup}[\![A]\!])$ & $w \in \mathrm{dom}([\![B]\!])$ & $[\![B]\!](w) \in \mathrm{dom}(^{\cup}[\![A]\!](w))$. $^{\cup}[\![A]\!](w)([\![B]\!](w))$.

b. If $[\![A]\!]$ is of type (s,n) and $[\![B]\!]$ is of type (s,((e,t),t)) then $[\![A\ B]\!] = [\![B\ A]\!] = \lambda w_s$: $[\![A]\!] \in \mathrm{dom}(^{\cup})$ & $w \in \mathrm{dom}(^{\cup}[\![A]\!])$ & $w \in \mathrm{dom}([\![B]\!])$ & $^{\cup}[\![A]\!](w) \in \mathrm{dom}([\![B]\!](w))$. $[\![B]\!](w)(^{\cup}[\![A]\!](w))$.

c. If $[\![A]\!]$ is of type (s,(e,t)) and $[\![B]\!]$ is of type (s,(n,τ)) for any type τ, then $[\![A\ B]\!] = [\![B\ A]\!] = \lambda w_s$: $[\![A]\!] \in \mathrm{dom}(^{\cap})$ & $w \in \mathrm{dom}(^{\cap}[\![A]\!])$ & $w \in \mathrm{dom}([\![B]\!])$ & $^{\cap}[\![A]\!](w) \in \mathrm{dom}([\![B]\!](w))$. $[\![B]\!](w)(^{\cap}[\![A]\!](w))$.

5. Conclusions

To summarize, I claimed that the default extensions of numerals in all natural languages are singular terms of type n. They can be turned into properties via the $^{\cup}$-operator, which allows them to function as predicates and modifiers. However, if classifiers are present in the lexicon, the use of the $^{\cup}$-operator is blocked, and the use of classifiers becomes obligatory. On the other hand, the dual of the $^{\cup}$-operator, the $^{\cap}$-operator, has no lexical counterparts, at least in English and Japanese, and it is freely applied to turn certain properties into functions of type (s,n).

A number of further questions arise from this proposal. Firstly, it is certainly expected that the present analysis is applicable to other obligatory classifier languages. In particular, it is expected that numerals in all obligatory classifier languages cannot function as predicates without the help of classifiers. As I have no access to empirical data in other obligatory classifier languages than Japanese at this point, I need to leave this question for another occasion. Secondly, the analysis put forward here does not square well with the existence of optional classifier languages such as Armenian and Hausa (Borer 2005, Bale & Khanjian 2008, 2014, Doetjes 2012). It seems necessary to say that classifiers in these languages somehow do not block the use of the $^{\cup}$-operator. This is left as a potential problem for the analysis proposed here. Thirdly, why is it that there is no overt lexical counterpart of the $^{\cap}$-operator in English and Japanese? This could simply be a lexical accident, and there might well be a language that has such an item. Further research is required to determine whether this is so, but if such a language is found, the theory proposed here makes a testable prediction, namely, the use of the $^{\cap}$-operator will be blocked.

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