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The Semantics of Measure Phrases[*]

Kimiko Nakanishi

University of Pennsylvania

1. Measure Phrases in Japanese

Languages use so-called measure phrases to express amount in noun phrases. In Japanese, classifier phrases (e.g., *five-classifier*) and measure phrases (e.g., *three liters*) are used for this purpose.[1] For example, in *five-classifier students*, the amount of relevant students is indicated by the classifier phrase *five-classifier*. In *three liters of water*, the denotation of *water* is measured by the measure phrase *three liters*. In the following, the term **measure phrases** (hence **MPs**) includes both classifier phrases and genuine measure phrases. MPs in Japanese can be adjacent to the host noun, or the measured noun, and form a nominal constituent with it, as in (1a) and (2a). I call such MPs **non-split MPs**. MPs can also 'split' from their host noun, i.e., they can be separated from the host noun, as in (1b) and (2b).[2] I call such MPs **split MPs**.[3] Sentences with non-split MPs are called **non-split MP constructions**, and ones with split MPs **split MP constructions**.

(1) a. Non-split MP construction ([host noun + MP]-CASE):

[*Gakusei*	**go-nin**]-ga	paatii-de	utatta	(koto)[4,5]
[student	five-CL]-NOM	party-at	sang	(the fact that)

'(the fact that) five students sang at the party'

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[1] Numerals in languages such as Japanese and Chinese must be followed by a classifier (Downing 1996, Chierchia 1998, Cheng and Sybesma 1999). A classifier is a morpheme that indicates the semantic class of the host noun in terms of shape, size, animacy, etc. For example, in *five-classifier pens*, the classifier carries some semantic information of *pens* like being inanimate, thin, and long.

[2] Any quantifier (*all*, *most*, *many*, etc.) can split, although this paper focuses on split MPs only.

[3] MPs in Japanese that are not adjacent to their host noun are generally called floating quantifiers (FQs). I use the more general term "split MPs", since the analysis in this paper extends to MPs in other languages such as MPs in German split topicalization (Nakanishi 2002; see also section 5 below).

[4] In Japanese, matrix sentences are subject to some pragmatic restrictions. Since such restrictions do not occur in embedded clauses, *koto* 'the fact that' is added to create an embedded environment.

[5] The following abbreviations are used in this paper:
ACC=accusative case marker, ASP=aspectual marker, CL=classifier, COP=copula, GEN=genitive, NM=nominalizer, NOM=nominative, PASS=passive, PAST=past tense, REFL=reflective

b. Split MP construction (host noun-CASE … MP):
Gakusei-ga paatii-de **go-nin** utatta (koto)
student-NOM party-at five-CL sang

(2) a. [*Mizu* **san-rittoru**]-ga tukue-nouede koboreta (koto)
[water three-liter]-NOM table-on spilled
'Three liters of water spilled on the table'
b. *Mizu*-ga tukue-nouede **san-rittoru** koboreta (koto)
water-NOM table-on three-liter spilled

There have been a large number of studies on the relation between non-split and split MP constructions. One of the main goals has been to figure out whether these two constructions are transformationally related. Most notably, Inoue (1978) argued that they are not, based on examples such as (3), which shows that split MPs can be acceptable even when their non-split MP counterparts are unacceptable.[6]

(3) a. * John-ga [*juu-mon-no mondai* **go-mon**]-o kinoo toita (koto)
John-NOM [10-CL-COP question 5-CL]-ACC yesterday solved
'John solved five of the ten questions yesterday'
b. John-ga *juu-mon-no mondai*-o kinoo **go-mon** toita (koto)
John-NOM 10-CL-COP question-ACC yesterday 5-CL solved

Furthermore, recent studies have shown that the two constructions are not semantically equivalent, which cannot be straightforwardly captured by the transformational approach, and have argued that split MPs are VP-adverbs (Fukushima 1991, Fujita 1994, among others).[7] The goal of the present paper is to explore in detail the semantic differences between the two. I argue that the differences exist because split/non-split MPs differ in the domains of their measurement. In particular, I claim that non-split MPs measure the amount of individuals in the extension of the nominal predicate, whereas split MPs measure the amount of the events in the extension of the verbal predicate. In other words, non-split MPs measure in the nominal domain, whereas split MPs measure in the verbal domain. Importantly, the present analysis reveals that there is an algebraic parallelism between the nominal and the verbal domain. Furthermore, I argue that this analysis can be extended to cross-linguistic data.

The organization of this paper is as follows. Section 2 shows that split/non-split MPs are subject to semantic restrictions on the nominal domain. Section 3 shows that only split MPs are subject to semantic restrictions on the verbal domain. In section 4, I argue that split MPs measure in the verbal domain, while non-split MPs measure in the nominal domain. Section 5 is the conclusion and the discussion on cross-linguistic issues.

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[6] In most of the previous studies including Inoue (1978), (i) is used as a non-split MP:

(i) [**Go-nin**-no *gakusei*]-ga paatii-de utatta (koto)
[five-CL-COP student]-NOM party-at sang
'Five students sang at the party'

This construction does not show semantic restrictions relevant to this paper (cf. footnote 8 below), thus I use the construction presented in (1a) as a non-split MP construction instead of (i) (cf. Terada 1990).

[7] In section 4, I discuss whether the present analysis is compatible with the adverb approach.

2. The Monotonicity Constraints on the Nominal Domain

In this section, I show that split/non-split MPs are subject to semantic restrictions on the nominal domain. I account for this fact by using Schwarzschild's (2002) monotonicity constraints.

2.1. Data

Let us start our discussion by examining a curious restriction on MPs. As shown above, MPs in Japanese can be used either as non-split or split MPs. However, there is some restriction, as shown in (4) and (5): MPs like *san-rittoru* 'three liters', but not MPs like *san-do* 'three degrees', can be used as non-split or split MPs.[8]

(4) a. [*Mizu* **san-rittoru**]-ga tukue-nouede koboreta (koto)
[water three-liter]-NOM table-on spilled
'Three liters of water spilled on the table'
b. *Mizu*-ga tukue-nouede **san-rittoru** koboreta (koto)
water-NOM table-on three-liter spilled (= (2))

(5) a. * [*Mizu* **san-do**]-ga tukue-nouede koboreta (koto)
[water three-degree]-NOM table-on spilled
'Three-degree water spilled on the table'
b. * *Mizu*-ga tukue-nouede **san-do** kobore-ta (koto)
water-NOM table-on three-degree spilled

The question to be addressed is why *three degrees* is inappropriate in the non-split and split MP constructions. In particular, why 'water whose volume is three liters' can be expressed by using split/non-split MPs, while 'water whose temperature is three degrees' cannot. This question is answered by applying Schwarzschild's (2002) analysis on English pseudopartitives to the Japanese data.

2.2. Schwarzschild's (2002) Monotonicity Constraints

2.2.1. The Constraint on Measure Functions

Schwarzschild (2002) shows that pseudopartitives in English such as *three liters of water* is sensitive to some semantic restrictions in that not all MPs can be used in this construction. In particular, like Japanese examples, *three liters*, but not *three degrees*, is acceptable in this construction, as shown in (6).

(6) a. three liters of water
b. *three degrees of water (cf. three-degree water)

[8] 'Three degrees' can be combined with 'water' in the following way (cf. footnote 6 above):

(i) [**San-do**-no *mizu*]-ga tukue-nouede koboreta (koto)
[three-degree-COP water]-NOM table-on spilled
'Three-degree water spilled on the table'

Schwarzschild accounts for this contrast by appealing to the semantics of the measure function μ. For Schwarzschild, μ is a measurement scheme such as 'volume' or 'temperature'.[9,10] He argues that μ is **monotonic** relative to the measured element if and only if it tracks part-whole structures of the element: a measurement scheme is monotonic if and only if a measure obtained for an element x is larger than a measure obtained for a proper subpart of x. For example, 'volume' is monotonic for water, since, if a quantity of water has a certain volume, proper subparts of it will have lower volumes. 'Temperature', however, is not monotonic for water, since, if the water has a certain temperature, it is not necessarily true that proper subparts of it will have lower temperatures. Formally, the measure function μ is monotonic relative to the denotation of the host noun if it satisfies the following condition:

(7) μ is monotonic relative to domain I iff:
For individuals x, y in I:
If x is a proper subpart of y, then $\mu(x) < \mu(y)$ (Schwarzschild 2002a)

Schwarzschild captures the contrast in (6) by claiming that the measure function in pseudopartitives has to be monotonic relative to the part-whole structure expressed by the noun. Since 'volume', but not 'temperature', is monotonic relative to water, *three liters of water* is acceptable, but not *three degrees of water*.

2.2.2. The Constraint on the Host Noun

Schwarzschild further shows that monotonicity can account for the following contrast:

(8) a. two hours of work, seven pounds of meat
b. *two hours of job, ??seven pounds of baby
(cf. a two-hour job, a seven-pound baby)

In English, *work* and *meat* are mass nouns. Mass nouns are generally considered to have part-whole structures. For example, if you have a big chunk of meat, then any smaller chunk of that big piece is still meat. Thus, the measure function can be monotonic relative to mass nouns as long as the condition in (7) is met. In contrast, *job* and *baby* are singular count nouns. The extensions of singular count nouns are considered to be atomic. For instance, a smaller part of the baby, say a toe, is not a baby. A measure function cannot be monotonic relative to singular count nouns, since there is no part-whole structure to work off of. For this reason, *job* is not compatible with pseudopartitives, and *baby* evokes a gruesome interpretation only. Schwarzschild further assumes that plural

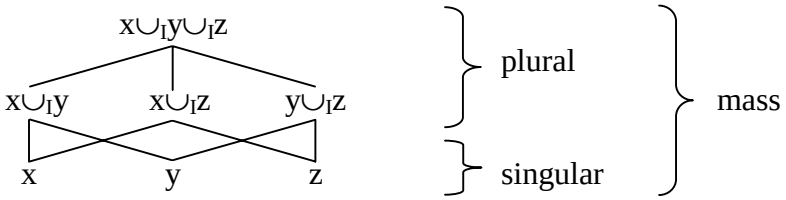
[9] Previous studies on MPs do not abstract measure functions from MPs (for example, Krifka 1989). However, such approaches cannot straightforwardly account for the fact that MPs are cross-categorial (Jackendoff 1977). Instead, Schwarzschild separates measure functions from MPs and claims that measure functions map entities to intervals on a scale. His analysis successfully offers a uniform semantics of MPs. In Nakanishi (2002), I have shown that this analysis applies to the semantics of split/non-split MPs.

[10] The choice of measure functions can be dependent on context (Schwarzschild 2002b). For example, the measure function of the MP *three inches* can be 'depth' or 'length', depending on context: it is 'depth' in *three inches of snow piled up*, whereas it is 'length' in *John bought three inches of wire*.

count nouns behave like mass nouns, since they come with a part-whole structure given by the plural-part structure. Thus, his analysis would predict that plural count nouns can be used in pseudopartitives just like mass nouns. Indeed, this prediction is borne out as is clear from examples such as *two kilos of marbles* and *four pounds of coffee beans*.[11]

A standard way to represent the extension of nouns that have a part-whole structure is to use a lattice of individuals (Link 1983). Take a set containing elements in the figure in (9), where x, y, and z are atomic individuals, $\cup_I$ is an individual sum operator, and the lines indicate the part-of relation.

(9)



Out of this lattice of individuals, we can define the denotations of singular count nouns, plural count nouns, and mass nouns. A singular count noun like *table* will denote a subset of the atomic elements at the bottom of the lattice, that is, x, y, and z. The denotation of a plural count noun like *tables* will be a subset of the non-atomic elements in the structure such as $x\cup_I y$.[12] Finally, the denotation of a mass noun like *furniture* will make no distinction between atomic elements and non-atomic ones, and will correspond to a subset of the set of individuals in the entire lattice. For example, if there are tables x, y, and z, and there is nothing but tables which can be considered as furniture in a relevant context, the denotations of *table*, *tables*, and *furniture* are as follows:

(10) a. Singular count nouns: $[\![\text{table}]\!] = \{ x, y, z \}$
a. Plural count nouns: $[\![\text{tables}]\!] = \{ x\cup_I y, x\cup_I z, y\cup_I z, x\cup_I y\cup_I z \}$
a. Mass nouns: $[\![\text{furniture}]\!] = \{ x, y, z, x\cup_I y, x\cup_I z, y\cup_I z, x\cup_I y\cup_I z \}$

We consider that the extension of a noun is a lattice of individuals if some members of the denotation of nouns are a proper-subpart of some other members of the denotation of nouns. For example, in the denotation of *tables* and *furniture*, $x\cup_I y$ is a subpart of another member $x\cup_I y\cup_I z$. In the case of the denotation of *table*, there is no such part-of relation. Thus, the extensions of plural count nouns and of mass nouns are a lattice of individuals, while the extension of singular count nouns is not, which is summarized in (11).

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[11] Pseudopartitives with plural count nouns are not always acceptable, as in ??*twenty kilos of babies*. This fact cannot be explained by the monotonicity constraint on the host noun: *babies* has a part-whole structure, thus the monotonicity constraint is satisfied. I suspect that the unacceptability is caused by some pragmatic reasons. In general, individual babies are not measured by 'weight', but by 'unit' using numerals. Thus, when 'weight' is used to measure babies, we tend to imagine a situation where some parts of babies are measured, which leads us to a gruesome interpretation. If we create a context where individual babies can be measured by 'weight', *twenty kilos of babies* should sound better. For example, suppose that a nurse has to move babies to a doctor's room using a big cart and that the cart can carry elements up to twenty kilos. Then we might be able to say 'A nurse has to carry twenty kilos of babies by cart'.

[12] Some researchers include a set of atomic elements in the denotation of plural count nouns. Nothing in the present analysis hinges on this choice (cf. footnote 14).

(11) Lattice of Individuals in the Nominal Domain

	With a lattice		No lattice
Nominal Domain	Mass Nouns (*furniture*, *water*)	Bare Plural Count Nouns (*tables*)	Singular Count Nouns (*table*)

In terms of monotonicity, plural count nouns and mass nouns can satisfy the monotonicity constraint on the host noun, since their extensions are a lattice, i.e., they have a part-whole structure. In contrast, singular count nouns cannot satisfy monotonicity, since their extension is not a lattice.

2.2.3. Summary of Schwarzschild (2002)

In sum, Schwarzschild argues that pseudopartitives must satisfy the two monotonicity constraints. The first constraint is on the host noun: the host noun must have a part-whole structure. This accounts for the contrast between *two hours of work* and **two hours of job*. The second constraint is on measure functions: the measure function must be monotonic relative to the given part-whole structure (cf. (7)). This accounts for the contrast between *three liters of water* and **three degrees of water* is not.

2.3. Applications to the Japanese Data

Let us go back to the contrast between *san-rittoru* 'three liters' and *san-do* 'three degrees' in Japanese, which is repeated in (12) and (13).

(12) a. [*Mizu* **san-rittoru**]-ga tukue-nouede koboreta (koto)
[water three-liter]-NOM table-on spilled
'Three liters of water spilled on the table'

b. *Mizu*-ga tukue-nouede **san-rittoru** koboreta (koto)
water-NOM table-on three-liter spilled (= (4))

(13) a. * [*Mizu* **san-do**]-ga tukue-nouede koboreta (koto)
[water three-degree]-NOM table-on spilled
'Three degree water spilled on the table'

b. * *Mizu*-ga tukue-nouede **san-do** kobore-ta (koto)
water-NOM table-on three-degree spilled (= (5))

The data show that MPs like *san-rittoru* 'three liters', but not MPs like *san-do* 'three degrees', can be used in the split/non-split MP constructions. This contrast is the same as the one in English pseudopartitives. For this reason, I propose to extend Schwarzschild's analysis to Japanese split/non-split MPs and claim that both constructions are subject to the monotonicity constraints on the nominal domain. This claim will be slightly modified later in section 4. As discussed in section 2.2, there are two monotonicity constraints, one on the host noun and the other on measure functions. In the following, I examine how these two constraints apply to the Japanese data.

I first examine the constraint on the host noun, that is, the host noun must have a part-whole structure to which the measure function can apply in a monotonic fashion. It

is generally assumed that nouns in Japanese denote kinds of type <e>. Chierchia (1998) claims that the type-shifting $^{\cup}$-operator assigns a mass denotation to the predicate counterpart of a kind, thus the extension of Japanese nouns is mass. Since the extension of mass nouns is a lattice of individuals, all nouns in Japanese have a part-whole structure. It follows that the constraint on the host noun is always satisfied in Japanese.[13]

The other constraint to be examined is on measure functions, i.e., measure functions μ must be monotonic relative to the given part-whole structure denoted by the host noun. The contrast in (12) and (13) is that *san-rittoru* 'three liters', but not *san-do* 'three degrees', can be used in the split/non-split MP constructions, which is the same contrast as English pseudopartitives in (6). Thus, the same account as English applies to Japanese: the measure function for *three liters* is 'volume' and it is monotonic with respect to water. In contrast, 'temperature', which is the measure function for *three degrees*, is not monotonic for water. It follows that only 'volume' can satisfy the monotonicity constraints. As for classifier phrases, their measure function is considered to be something like 'object unit', since classifier phrases denote the number of specimens of a kind expressed by the host noun (cf. Krifka 1995). 'Object unit' is always monotonic relative to the host noun. For example, if *hon* 'book' has a certain object unit (say, in *ten-classifier books*, 'object unit' is ten), then every proper subpart of it will have a lower object unit (in *three-classifier books*, 'object unit' is three). Thus, split/non-split classifier phrases always satisfy the monotonicity constraint on measure functions.

2.4. Summary

I have claimed that both non-split and split MPs are subject to the monotonicity constraints on the nominal domain. The constraints are summarized in (14).

(14) Monotonicity constraints on the Nominal Domain (cf. Schwarzschild 2002)

a. Constraint on the Host Noun
The host noun must have a part-whole structure, i.e., the extension of the host noun must be a lattice of individuals.

b. Constraint on Measure Functions
The measure function μ must be monotonic relative to the given part-whole structure, i.e., a lattice of individuals (as defined in (7)).

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[13] There is a contrast between a mass-like noun *niku* 'meat' and a count-like noun *akanboo* 'baby':

(i)	a.	[*niku*	**nijuk-kiro**]-o		b.	*niku*-o	…	**nijuk-kiro**
		[meat	twenty-kilo]-ACC			meat-ACC		twenty-kilo
		'20 kilos of meat'						
(ii)	a.	??[*akanboo*	**nijuk-kiro**]-o		b.	?? *akanboo*-o	…	**nijuk-kiro**
		[baby	twenty-kilo]-ACC			baby-ACC		twenty-kilo
		'20 kilos of baby/babies'						

The contrast between (i) and (ii) is not necessarily an argument for the existence of the mass-count distinction in Japanese, since the oddness of (ii) can be attributed to some pragmatic reasons that explain the oddness of English *twenty kilos of babies* (see footnote 11). Both Japanese *akanboo* 'baby' and English plural *babies* denote a lattice, i.e., they have a part-whole structure, hence the monotonicity constraint on the head noun is technically met.

The first constraint accounts for the contrast between mass and plural count nouns on the one hand and singular count nouns on the other. The constraint is satisfied with the former but not the latter, since the former has a part-whole structure, while the latter does not. This constraint is always satisfied in Japanese, assuming that all nouns are mass. The second constraint accounts for the contrast between 'volume' and 'temperature'.

3. The Monotonicity Constraints on the Verbal Domain

In this section, I first show that split MPs are subject to a semantic restriction on the verbal domain, while non-split MPs are not. I claim that such restriction is captured by the monotonicity constraints on the verbal domain. The present claim attests that there is an algebraic parallelism between the nominal and the verbal domain.

3.1. Data

We saw in the previous section that split/non-split MPs behave in the same way in terms of monotonicity on the nominal domain. However, they show a striking contrast with respect to the verbal domain in that non-split MPs can combine with any verbal predicate, whereas split MPs are sensible to which verbal predicate they combine with. As shown in (15a) and (16a), non-split MPs are compatible with any verbal predicate. In contrast, *pile up* is compatible with split MPs, as in (15b), while *destroy John's house* is not, as in (16b). This finding holds for classifier phrases as well, as shown in (17) and (18).

(15) a. [*Yuki* **san-ton**]-ga yane-noueni tumotta (koto)
[snow three-ton]-NOM roof-on piled up
'Three tons of snow piled up on the roof'

b. *Yuki*-ga yane-noueni **san-ton** tumotta (koto)
snow-NOM roof-on three-ton piled up

(16) a. [*Yuki* **san-ton**]-ga kinoo John-no ie-o ositubusita (koto)
[snow three-ton]-NOM yesterday John-GEN house-ACC destroyed
'Three tons of snow destroyed John's house yesterday'

b. * *Yuki*-ga kinoo **san-ton** John-no ie-o ositubusita (koto)
snow-NOM yesterday three-ton John-GEN house-ACC destroyed
(cf. Gunji and Hashida 1998:46)

(17) a. [*Hako* **juk-ko**]-ga tukue-noueni tumiage-rare-ta (koto)
[box ten-CL]-NOM desk-on pile up-PASS-PAST
'Ten boxes were piled up on the desk'

b. *Hako*-ga tukue-noueni **juk-ko** tumiage-rare-ta (koto)
box-NOM desk-on ten-CL pile up-PASS-PAST

(18) a. [*Hako* **juk-ko**]-ga kinoo John-no tukue-o ositubisita (koto)
[box ten-CL]-NOM yesterday John-GEN desk-ACC destroyed
'Ten boxes destroyed John's desk yesterday'

b. * *Hako*-ga kinoo **juk-ko** John-no tukue-o ositubisita (koto)
box-NOM yesterday ten-CL John-GEN desk-ACC destroyed

The observation here is that split MPs are subject to a restriction on the verbal domain, whereas there is no restriction for non-split MPs. I propose to extend the monotonicity constraints on the nominal domain to the verbal domain and argue that split MPs have to satisfy monotonicity constraints on the verbal domain, while non-split MPs do not. As discussed above, there are two monotonicity constraints on the nominal domain, i.e., a constraint on the host noun and a constraint on measure functions. In the following, I examine how these two constraints can be applied to the verbal domain.

3.2. The Constraint on the Verbal Predicate

I first examine the difference between *pile up* and *destroy John's house*. Intuitively, *pile up*, which is an incremental event, has uniform part-whole structures such that a subevent of a piling up event is still a piling up event. In contrast, *destroy John's house* does not have uniform part-whole structures, since a subevent of the predicate *destroy John's house* is not a destroying-John's-house event. This intuition is tied to the atelic-telic distinction (cf. Vendler 1957, Verkuyl 1972, Dowty 1979): *pile up* is an atelic predicate, that is, a predicate whose denotation has no set terminal point, while *destroy John's house* is a telic predicate, that is, a predicate whose denotation includes a terminal point. One of the tests to see the telicity of verbal predicates is to combine the verbal predicates with durative adverbs such as *for two hours* and time span adverbs such as *in two hours*. Telic verbal predicates are compatible with time span adverbs, but not with durative adverbs. The opposite claim holds for atelic verbal predicates.

(19) a. Telic: Tom destroyed John's house *for two hours / in two hours.
b. Atelic: The snow piled up for two hours / *in two hours.

Previous studies have shown analogies between the atelic-telic distinction in verbal predicates and the mass-count distinction in nouns (ter Meulen 1984, Bach 1986, Krifka 1989, among others): mass nouns are like atelic predicates, and count nouns are like telic predicates. In the previous section, I argued that what matters for monotonicity is whether or not the relevant noun has a part-whole structure. I discussed above that a part-whole structure on the nominal domain can be represented as a lattice of individuals. This analysis applies to the verbal domain if we introduce Davidsonian event arguments (Davidson 1967) and further assume that events can also form a lattice (Krifka 1989, among others). That is, a verbal predicate will be considered to have a part-whole structure when its extension is a lattice of events. Under such a view, the extension of atelic predicates is a lattice of events, while the extension of telic predicates is not.

Let us go back to the two verbal predicates at issue, that is, *pile up* and *destroy John's house*. The monotonicity constraint on the verbal predicate says that the verbal predicate must have a part-whole structure. I argue that split MPs must satisfy this constraint. *Pile up* has a part-whole structure, thus it is possible for the measure function to apply monotonically. In contrast, *destroy John's house* lacks such a structure, hence monotonicity fails. I also argue that non-split MPs are not subject to this constraint on the verbal predicate. For this reason, non-split MPs are compatible with any verbal predicate.

There are examples in which telic predicates are compatible with split MPs:

(20) a. *Hako*-ga tukue-kara **juk-ko** yuka-ni otita (koto)
box-NOM desk-from ten-CL floor-to fell
'Ten boxes fell from the desk to the floor'

b. *Gakusei*-ga kinoo **juu-nin** *Harii Pottaa*-o yomi-oeta (koto)
student-NOM yesterday ten-CL *Harry Potter*-ACC read-finished
'Ten students finished reading *Harry Potter* yesterday'

The predicates *fall from the desk to the floor* and *finish reading Harry Potter* are telic in that they have a terminal point. Even so, split MPs can be used with these predicates. I propose that this is because telic predicates can be sometimes pluralized by applying an operation of semantic pluralization * introduced by Link (1983) (cf. Landman 1989, 2000). The extension of pluralized verbal predicates includes a set of atomic events and their plural sums, as exemplified in (21).[14]

(21) *FALL TO THE FLOOR [a set of atomic falling to the floor events and their plural sums]

When telic predicates are pluralized, they can form a lattice of events. Thus, the MPs in (20) can satisfy the monotonicity constraints. However, not all telic predicates can be pluralized. For example, *destroy John's house* cannot be pluralized, since the destroying-John's-house event can occur only once. As a result, it is impossible to obtain plural sums of the destroying-John's-house event. I call telic predicates that cannot be pluralized **singular telic predicates** as opposed to **plural telic predicates**.

Given the discussion so far, the distinctions among nominal predicates and among verbal predicates are completely parallel, as shown in (22).

(22) The Parallelism between the Nominal and the Verbal Domain

	With a lattice		No lattice
Nominal Domain	Mass Nouns (*furniture, water*)	Bare Plural Count Nouns (*tables*)	Singular Count Nouns (*table*)
Verbal Domain	Atelic Predicates (*pile up*)	Plural Telic Predicates (**fall to the floor*)	Singular Telic Predicates (*destroy John's house*)

The present analysis is supported by the following examples:

(23) a. * *Otoko*-ga kinoo **san-nin** John-no hahaoya-o korosita (koto)
man-NOM yesterday three-CL John-GEN mother-ACC killed
'Three men killed John's mother yesterday'

b. *Otoko*-ga kinoo **san-nin** John-no hahaoya-o koros-ootosita (koto)
man-NOM yesterday three-CL John-GEN mother-ACC kill-tried
'Three men tried to kill John's mother yesterday'

[14] As mentioned in footnote 12 above, it is not crucial for the present analysis whether or not the extension of pluralized verbal predicates includes a set of atomic events.

c. *Otoko*-ga kinoo **san-nin** John-no hahaoya-o nagutta (koto)
man-NOM yesterday three-CL John-GEN mother-ACC hit
'Three men hit John's mother yesterday'

Kill John's mother is a singular telic predicate, since there cannot be multiple killing-John's-mother events. This means that *kill John's mother* cannot have a part-whole structure. Indeed, (23a) is unacceptable, violating the monotonicity constraint on the verbal predicate. *Try to kill John's mother* or *hit John's mother*, however, can be pluralized. With a part-whole structure, the monotonicity constraint on the verbal predicate can be satisfied, as supported by the acceptable examples in (23b) and (23c).

Furthermore, the present analysis can account for the observation in some previous studies that split MP constructions allow a distributive reading, but not a collective reading (Terada 1990, Ishii 1999, among others). The non-split MP construction in (24a) allows both readings, while the split MP construction in (24b) has a distributive reading only.

(24) a. [*Gakusei* **san-nin**]-ga mitibata-de hon-o hirotta (koto)
[student three-CL]-NOM street-on book-ACC found
'Three students found a book on the street'
√distributive, √collective

b. *Gakusei*-ga mitibata-de **san-nin** hon-o hirotta (koto)
student-NOM street-on three-CL book-ACC found
√distributive, ??collective

Following Landman (1989, 2000), I assume that a collective predication is a singular predication, and a distributive predication is a plural predication. It means that the extension of the collective reading is an atomic event, while the extension of the distributive reading is a lattice of events. In our example, the collective reading denotes a single event of finding a book, while the distributive reading denotes a multiple events of finding a book. With these assumptions, the above contrast naturally follows from the current analysis that split MPs must satisfy monotonicity on the verbal predicate. The collective reading is unavailable since, in this reading, there is no part-whole structure where a measure function applies to monotonically. In contrast, the distributive reading is available since this reading has a part-whole structure. Non-split MPs are not subject to monotonicity on the verbal predicate, thus they allow both readings.

Another set of data which follows from the present analysis comes from split MPs whose host noun is the object. So far, the data have been limited to split MPs whose host noun is the subject. We have seen that subject-oriented split MPs are sensitive to which verbal predicates they combine with. The relevant data is repeated in (25). In contrast, object-oriented split MPs seem to be compatible with any verbal predicate, as in (26).

(25) a. *Yuki*-ga yane-noueni **san-ton** tumotta (koto)
snow-NOM roof-on three-ton piled up
'Three tons of snow piled up on the roof' (=(15b))

b. * *Yuki*-ga kinoo **san-ton** John-no ie-o ositubusita (koto)
snow-NOM yesterday three-ton John-GEN house-ACC destroyed

'Three tons of snow destroyed John's house yesterday' (=(16b))

(26) a. John-ga *mikan*-o kinoo **san-ton** tumiageta (koto)
John-NOM orange-ACC yesterday three-ton piled up
'John piled up three tons of oranges yesterday'

b. John-ga *mikan*-o kinoo **san-ton** tubusita (koto)
John-NOM orange-ACC yesterday three-ton destroyed
'John destroyed three tons of oranges yesterday'

According to the syntactic structures proposed in Fujita (1994), subject-oriented split MPs syntactically combine with VP, whereas object-oriented split MPs combine with the verb only.[15] Any verb by itself can be pluralized, hence both *tumiageru* 'pile up' and *tubusu* 'destroy' can have a part-whole structure. As a result, monotonicity on the verbal domain is always satisfied with object-oriented split MPs.

The table in (27) summarizes the data on verbal predicates.

(27) Restrictions on Verbal Predicates

Verbal Domain	With a lattice		No lattice
	Atelic	Plural Telic	Singular Telic
non-Split MPs	√ [no constraint]	√ [no constraint]	√ [no constraint]
Split MPs	√	√	*

Non-split MPs are compatible with any predicate since they are not subject to monotonicity on verbal predicates. Split MPs are compatible only with predicates whose extension is a lattice of events. This is because split MPs are subject to the monotonicity constraint that verbal predicates must have a part-whole structure.

3.3. The Constraint on Measure Functions

We have seen that one of the monotonicity constraints, i.e., the constraint on the verbal predicate, successfully accounts for the relevant data. Another constraint is on measure functions: measure functions must be monotonic relative to the given part-whole structure, i.e., a lattice of events. A question arises as to how we can apply the measure function to a lattice of events. Consider the example in (28).

(28) *Yuki*-ga yane-noueni **san-ton** tumotta (koto)
snow-NOM roof-on three-ton piled up
'Three tons of snow piled up on the roof' (=(15b))

We would like to say that the measure function 'weight' is monotonic relative to the lattice of the piling up event. However, 'weight' cannot directly measure the piling up event, since the event per se does not have weight. Instead, some argument of the event,

[15] Syntactic tests such as pseudoclefting, VP-preposing, and *do so* substitution show that subject-oriented split MPs and object-oriented split MPs are adjoined in different syntactic positions (cf. Miyagawa 1989, Fujita 1994; see also Nakanishi 2002, in press).

yuki 'snow' in this case, has weight. Thus, we need a mechanism that maps the piling up event to its agent *yuki* 'snow' and that 'weight' applies to *yuki* 'snow', instead of the piling up event.

In fact, a similar mismatch is observed in Krifka (1989) in examples with temporal adverbials like 'for three hours' in (29).

(29) He slept for three hours.

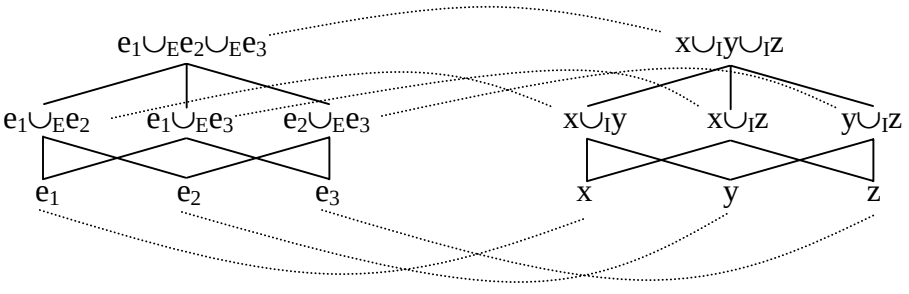
We want to say that *for three hours* measures the sleeping event. However, *for three hours* cannot directly measure the sleeping event since the event is not a time-interval. Rather, *for three hours* indirectly measures the sleeping event by measuring a run time of the event. Krifka (1989) proposes to measure events by measuring time-intervals related to the events. This can be done by assuming that there is a mapping from events to event run times. Formally, Krifka assumes that there is a homomorphism h from the lattice of events to the lattice of event run times, where $h(x \cup_E y) = h(x) \cup_T h(y)$.

(30) $E \xrightarrow{h} T$ where $h(x \cup_E y) = h(x) \cup_T h(y)$

I propose to extend this idea to the Japanese data. In particular, I argue that there is a mapping from events to individuals and that measure functions indirectly measure events by measuring individuals related to the events. For example, in (28), the piling up event is mapped to *snow*. As I discussed earlier, *pile up* has a part-whole structure, and this structure is mapped to *snow*. That is, subparts of the piling up events are mapped to subparts of *snow*. Thus, the amount of *snow* increases as the piling up event proceeds. This argument is formalized in the following way: suppose that there is a homomorphism h from a lattice of events E denoted by the verbal predicate to a lattice of individuals I denoted by the host noun.[16] (32) is a homomorphism that preserves a lattice from E to I:[17]

(31) $E \xrightarrow{h} I$ where $h(x \cup_E y) = h(x) \cup_T h(y)$

(32)

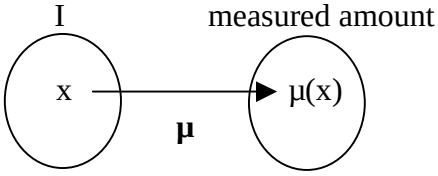


[16] Events are related to individuals which have a measurement scheme denoted by the relevant measure function. In other words, we have to find some individuals in a sentence that can be measured by the relevant measure function. I believe that this is done by syntax, assuming that the homomorphism is identical to neo-Davidsonian thematic roles and that arguments are associated by the neo-Davidsonian method in the syntax (cf. Kratzer's (1996) Voice P that introduces an external argument). Such an analysis captures the fact that the host noun of MPs is restricted to arguments (Inoue 1978, among others).

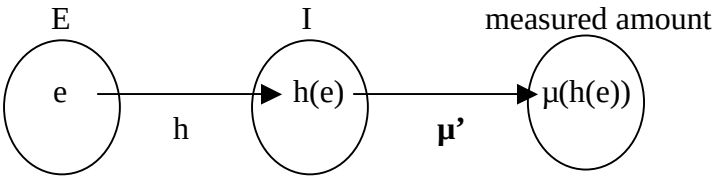
[17] For simplicity, I use a case of isomorphism.

With this homomorphism, the measure function μ for the event e applies to h(e), since h(e) has a measurement scheme compatible with the measure function (for example, snow can be measured by 'weight'). As a result, we obtain μ(h(e)). In this mechanism, the measure function indirectly measures events by measuring individuals. I call such measure functions **indirect measure functions μ'** as opposed to regular measure functions, which I now refer to as **direct measure functions μ**. The following figures illustrate the difference between direct and indirect measure functions:

(33) Direct Measure Functions



(34) Indirect Measure Functions



The direct measure function applies to a set of individuals and gives measured amounts.[18] The indirect measure function, on the other hand, applies to a set of individuals which is related to a set of events by a homomorphism h. For indirect measure function μ' to be monotonic relative to events, the following condition must be met:

(35) The indirect measure function μ' is monotonic relative to the domain E iff:
For events e_a, e_b in E:
If $h(e_a)$ is a proper subpart of $h(e_b)$, then $\mu'(h(e_a)) < \mu'(h(e_b))$,
where h is a homomorphism from E to I such that $h(e_1 \cup_E e_2) = h(e_1) \cup_I h(e_2)$

I illustrate how this condition works using the example in (28). The piling up event and *snow* are related by a homomorphism, which is a being-a-theme-of function.[19] For example, $h(e_1)=x$ means that x is the theme of e_1. In the situation illustrated in (32) where there is a homomorphism h from E to I such that $h(e_1 \cup_E e_2) = h(e_1) \cup_I h(e_2)$, the indirect measure function 'weight' is monotonic to the piling up event, since, if $h(e_a)$ is a proper subpart of $h(e_b)$, then 'weight'$(h(e_a))$ is a proper subpart of 'weight'$(h(e_b))$ as well.

In sum, I have shown that a measure function can apply to verbal predicates that do not have a measurement scheme denoted by the measure function. With the help of a homomorphism from a lattice of events to a lattice of individuals, the measure function can indirectly measure events by measuring individuals.

[18] To be precise, following Schwarzschild (2002), I consider that measure functions map entities to intervals on a scale. Since I do not have space to discuss the detailed semantics in this paper, I simply say that measure functions yield measured amounts. See Nakanishi (2002) for the actual analysis.

[19] I consider *pile up* as an unaccusative verb. Thus, the subject *snow* is the theme of the event (cf. footnote 16 above).

3.4. Summary

In this section, I have argued that split MPs are subject to monotonicity constraints on the verbal domain, whereas non-split MPs are not. There are two monotonicity constraints on the verbal domain, which are summarized in (36).

(36) Monotonicity Constraints on the Verbal Domain
  a. The Constraint on the Verbal Predicate
     The verbal predicate must have a part-whole structure, i.e., the extension of the verbal predicate must be a lattice of events.
  b. The Constraint on Measure Functions
     The measure function μ must be monotonic relative to the given part-whole structure, i.e., a lattice of events (as defined in (35)).

The monotonicity constraints on the verbal domain are parallel to the monotonicity constraints on the nominal domain proposed in (14) above. This approach attested that the nominal and the verbal domain are algebraically parallel. I further proposed that there is a homomorphism from a lattice of events to a lattice of individuals.

4. Monotonicity on the Nominal Domain Revisited

In section 2, I showed that the split/non-split MP constructions behave identically in the nominal domain in terms of what kind of host nouns and measure functions can be used. I tentatively claimed that such behaviors are due to the monotonicity constraints on the nominal domain. The last section revealed that the split/non-split MP constructions behave differently in the verbal domain. I argued that this is because the split MP construction has to satisfy the monotonicity constraints on the verbal domain, whereas the non-split MP construction does not. The question I would like to address here is whether the restrictions on the nominal domain for the split MP construction are due to genuine constraints on the nominal domain or whether they can be derived as side effects of the constraints on the verbal domain. In other words, is it sufficient to say that non-split MPs are subject to constraints on the nominal domain, while split MPs are subject to constraints only on the verbal domain? In the following, I examine the data on split MPs that were explained by the monotonicity constraints on the nominal domain and show that they can be derived as a by-product of the constraints on the verbal domain.

The relevant examples are repeated in (37).

(37) a. *Mizu*-ga tukue-nouede **san-rittoru** koboreta (koto)
     water-NOM table-on three-liter spilled
     'Three liters of water spilled on the table' (=(4b))
  b. * *Mizu*-ga tukue-nouede **san-do** kobore-ta (koto)
     water-NOM table-on three-degree spilled
     'Three degree water spilled on the table' (=(5b))

In section 2.3, I accounted for this contrast by appealing to the monotonicity constraints on the nominal domain: for water, the measure function 'volume' is monotonic, but

'temperature' is non-monotonic. This contrast can be captured by the monotonicity constraints on the verbal domain as well, that is, the measure function must be monotonic relative to a lattice of events. Split MPs in (37) apply to the spilling event. Since the event cannot be measured by 'volume' or by 'temperature', we need a homomorphism from the event to the denotation of *water*. Then the measure functions measure water. Since 'volume', but not 'temperature' is monotonic relative to water, only the former is acceptable. Thus, we do not need the monotonicity constraints on the nominal domain to account for the 'volume' vs. 'temperature' contrast.

In sum, I have shown that the monotonicity constraints on the verbal domain alone can capture the monotonic behavior of split MPs in the nominal domain. The following table summarizes the monotonicity restrictions of split/non-split MPs:

(38) The restrictions on MPs

	Nominal domain (Section 2)	Verbal domain (Section 3)
Non-split MPs	monotonic behavior *[due to monotonicity constraints on the nominal domain]*	no restriction
Split MPs	monotonic behavior *[due to monotonicity constraints on the verbal domain]*	monotonic behavior *[due to monotonicity constraints on the verbal domain]*

As a result, a simple picture emerges: both non-split MPs and split MPs are subject to the monotonicity constraints. The difference between them is that non-split MPs measure in the nominal domain, while split MPs measure in the verbal domain. Thus, non-split MPs must obey the monotonicity constraints on the nominal domain, whereas split MPs must obey the monotonicity constraints on the verbal domain.

This simple semantic picture corresponds to the syntax of non-split and split MPs. It is generally assumed that non-split MPs are in the same nominal projection as their host noun, forming a nominal constituent (Terada 1990, among others). Thus, they combine with the nominal predicate directly. As for split MPs, some previous studies claim that they are VP-adverbs syntactically (Fukushima 1991, Fujita 1994).[20] It follows that split MPs, syntactically acting as VP-adverbs, directly combine with the verbal predicate in syntax. Then we can say that the current claim regarding the semantics of split/non-split MPs corresponds to their syntax. Non-split MPs are subject to the semantic constraints on the nominal domain since non-split MPs combine with the nominal predicate in syntax. In contrast, split MPs are subject to the semantic constraints on the verbal domain because, in syntax, split MPs directly combine with the verbal predicate.

I showed above that split MPs can be syntactically treated as VP-adverbs. However, split MPs are semantically different from *san-kai* 'three times', which can be considered as an adverbial element adjoined to VP, as shown in (39):

(39) a. *Gakusei*-ga kinoo **san-nin** piano-o motiageta (koto)
student-NOM yesterday three-CL piano-ACC lifted

[20] Another possibility is to claim that split MPs are secondary predicates (Ueda 1986, Miyagawa 1989, Miyamoto 1994, Takami 1998). Due to a lack of space, I do not consider this possibility here.

'Three students lifted the piano yesterday'

b. *Gakusei*-ga kinoo **san-kai** piano-o motiageta (koto)[21]
student-NOM yesterday three-time piano-ACC lifted
'A student/students lifted the piano three times yesterday'

If the split MP in (39a) is a VP-adverb that modifies a verbal predicate, (39a) should have the same interpretation as (39b) in which the adverb *san-kai* 'three times' is used instead of the split MP. This prediction is not borne out. (39a) means that each of the three students lifted the piano, hence there were three lifting-the-piano events done by three different students (cf. (24) above). (39b), in contrast, could mean that a student or students together lifted the piano three times, hence there were three lifting-the-piano events by the same student or students. Another difference between adverbs and split MPs is the relation to the host noun. Among numerous classifiers in Japanese, a classifier that is compatible with the host noun *gakusei* 'student' is used in the split MP in (39a), implying that there is some connection between the MP and the host noun (cf. footnote 1). If MPs are VP-adverbs, we do not expect to see such a connection, since VP-adverbs are not tied to any particular noun phrase in a sentence.

5. Conclusion and Possible Cross-Linguistic Extensions

In this paper, I argued that split/non-split MPs are different in that non-split MPs measure individuals denoted by the host noun in the nominal domain, while split MPs measure events denoted by the verbal predicate in the verbal domain. In the case of split MPs, we further have to assume that there is a homomorphism from events to individuals. There are several theoretical implications that emerge from the present study on the semantics of split/non-split MPs. First, the present analysis supports the existence of Davidsonian event arguments (Davidson 1967). Second, there is an algebraic parallelism between the nominal and the verbal domain (cf. Krifka 1989, among others).

One very important question for a linguistic analysis is how well it stands up when applied to different languages. So far I have examined German, Korean, Chinese, and Catalan and found that they seem to behave in the same way as the Japanese data. For example, in these languages, non-split MPs are compatible with any verbal predicate, while split MPs are sensitive to which verbal predicate they occur with. The contrast between (40) and (41) is in German, and the one between (42) and (43) is in Chinese.

(40) a. [**Drei** **Tonnen** *Schnee*] häuften sich an.
[three tons snow] heaped REFL on
'Three tons of snow piled up'

b. *Schnee* häuften sich **drei** **Tonnen** an.
snow heaped REFL three tons on

(41) a. [**Drei** **Tonnen** *Schnee*] zerstörten Peters Haus.
[three tons snow] destroyed Peter's house

[21] Bare nouns in Japanese can be interpreted either as singular or plural (cf. Nakanishi and Tomioka 2002).

'Three tons of snow destroyed Peter's house'

b. ?? *Schnee* zerstörten Peters Haus **drei** **Tonnen**.
snow destroyed Peter's house three tons

(42) a. [**Shi-dun** *mutou*] duizai kache shang
[ten-ton wood] pile up truck on
'Ten tons of wood piled up on a truck'

b. *Mutou* you **shi-dun** duizai kache shang
wood exist ten-ton pile up truck on

(43) a. [**Shi-dun** *mutou*] yakua-le kache
[ten-ton wood] destroy-ASP truck
'Ten tons of wood destroyed a truck'

b. * *Mutou* you **shi-dun** yakua-le kache
wood exist ten-ton destroy-ASP truck

These contrasts are accounted for by the monotonicity constraints on the verbal domain: non-split MPs are not subject to the constraints, whereas split MPs must satisfy the constraints. Although I do not have a space to show the data, these languages show the same contrast as Japanese in terms of the monotonicity constraints on the nominal domain. Given that the monotonicity constraints are responsible for German and Chinese MPs as well as Japanese MPs, it might be possible to extend the current analysis to the cross-linguistic data. The working hypothesis is that, in languages which have semantic differences between split and non-split MPs, the differences come from their difference in domains of measurement: non-split MPs measure in the nominal domain, whereas split MPs measure in the verbal domain.

In conclusion, I argued that a potential syntax-semantics mismatch observed with split MPs can be solved by introducing a homomorphism from a lattice of events to a lattice of individuals.[22] Syntactically, split MPs are VP-adverbs that modify verbal predicates, but semantically they seem to measure the denotation of the host noun somehow. Such an observation raises a question of how the two components of grammar, the syntactic and the semantic component, interact with each other. I argued that there is a homomorphism from a lattice of events to a lattice of individuals and that, with the help of the homomorphism, split MPs indirectly measure the verbal predicate by measuring the host noun. Thus, with the proposed mechanism, even when the syntax and the semantics do not seem to correlate with each other, it is possible to maintain a direct interaction between the semantic and syntactic components of sentence grammar. The

[22] The present work on split MPs sheds light on other phenomena involving a potential syntax-semantics mismatch. Some examples are given in (i) and (ii).

(i) A blue-eyed bear is always intelligent. (cf. von Fintel 1994)

(ii) Four thousand ships passed through the lock last year. (cf. Krifka 1990)

The first example comes from the so-called quantificational variability effect: (i) has the interpretation that 'all blue-eyed bears are intelligent', where *always* has the effect of semantically quantifying over *a blue-eyed bear*, although syntactically it modifies the predicate *be intelligent*. Another example is an event-related reading (Krifka 1990): (ii) has the interpretation that 'there were four thousand events of ships' passing through the lock last year' implying that there might be fewer than 4000 ships, although *four thousand* modifies *ships* in syntax meaning there are 4000 ships.

present analysis is faithful to syntax, yet it accounts for a connection between split MPs and their host noun, even though this property seems to contradict the syntax.

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Department of Linguistics
University of Pennsylvania
619 Williams Hall
Philadelphia PA 19104

kimiko@ling.upenn.edu