Attributive Measure Phrases in Mandarin: Monotonicity and Distributivity

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Abstract. This paper investigates the interpretation of measure phrases (MPs) in attributive constructions in Mandarin. Contra Schwarzschild [1], we argue that the attributive position is not bound to a non-monotonic reading for MPs, and that Mandarin attributive MPs are subject to both monotonic and non-monotonic readings, which are to be recast as a contrast between object-level and kind-level readings. The alleged non-monotonic reading for attributive MPs is argued to be a result of the distributivity effect [2, 3]. It is observed in Mandarin that attributive MPs always have a distributive reading on monotonic and non-monotonic readings, which originate from two different sources. We propose that on the monotonic reading, the attributive MP distributes over the predicate Classifier-Noun, which denotes a set of non-overlapping individuals, and that the apparent non-monotonic reading is a consequence of the (sub)kind reading, such that the property expressed by MP is distributive over the instantiation set of the relevant (sub)kind. As far as their semantics is concerned, we claim that attributive MPs on the non-monotonic reading are intersective adjectives, which compose with NPs via Heim and Kratzer's [4] rule of Predicate Modification, but attributive MPs on the monotonic reading compose with NPs with functional application, as induced by the predicativizer *de*, whereby they denote degrees serving to saturate the degree argument associated with the semantics of dimensional adjectives, which is at type <d, et>.

Keywords: Measure phrase · Monotonicity · Attributive constructions · (Sub)kind · Distributivity

This study is supported by the Fundamental Research Funds for the Central Universities (Project NO.: 2020QNA107). This paper is a substantially revised version of my 2019 paper written in Chinese [10], in which the issue of distributivity was not touched at all. Among other things, the current version makes two major changes/improvements. First, we tease apart the relation between monotonicity and distributivity. Second, monotonic and non-monotonic MPs are argued to be composed in two different ways, either by the rule of Predicate Modification or Functional Application. I would like to express my gratitude to the anonymous reviewers, whose critical comments help to improve the readability of the paper. I am solely responsible for the errors.

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1 The Issue: The Syntactic Dependence of Measure Predicates on Monotonicity

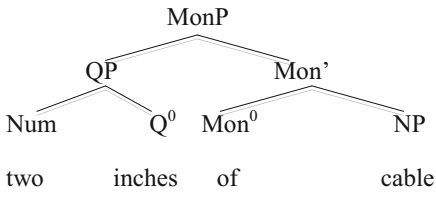
Measure predicates (MPs hereafter), consisting of a numeral followed by a measure word like *meter*, denote degrees of entities along a certain dimension associated with the measure word. MPs are available in a wide range of syntactic contexts, and two of such contexts are pseudopartitives and attributive constructions, as exemplified by (1) and (2) respectively [1, 5, 6]. In pseudopartitives, the MP is realized as a part of the extended functional projection above NP, such as the QP or NumP; in attributive constructions, the MP functions as an attributive modifier to the head noun.

(1) a. two inches of cable (pseudopartitives)
b. three pounds of beef
c. six ounces of gold

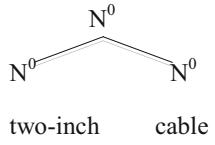
(2) a. two-inch cable (attributive constructions)
b. 100 degree water
c. 18 carat gold

According to Schwarzschild [1], monotonicity plays a crucial role in nominal syntax with MPs. It is argued that syntactic positions of MPs determine their interpretations with respect to (non-)monotonicity. Specifically, pseudopartitives are syntactically projected into a Monotonic Phrase (MonP), where the preposition *of* is realized as the head Mon^0 and the MP is surfaced as its specifier. MPs in attributive constructions are realized below the MonP and become part of noun compounds. According to Schwarzschild [1], MPs in pseudopartitives are interpreted with a monotonic reading, whereas those in attributives are read with a non-monotonic reading only. The structural ambiguity of the MP *two inch(es)* is illustrated by the syntactic trees in (3).

(3) a.



b.



The notions of monotonic and non-monotonic predicates can be defined as in (4) and (5) in a simplified way [1, 2, 7, 8]. Accordingly, the MP *two inches* in the pseudopartitive construction *two inches of cable* measures the length of the cable, which tracks a part-whole relation of entities denoted by NP, so two inches of cable plus two inches of cable would be four inches in total. In contrast, the MP *two-inch* in the expression *two-inch cable* specifies the diameter of the cable, which remains constant and non-monotonic.

(4) If $Meas_{DIM}$ is monotonic, then:
$\forall x \forall y \forall z[x = y \sqcup z \wedge \neg OVERLAP(y,z) \rightarrow Meas_{DIM}(x) = Meas_{DIM}(y) + Meas_{DIM}(z)]$
"If $Meas_{DIM}$ is extensive, then if x is the sum of y and z, and y and z do not overlap, the measure of x is the result of adding the measures of y and z."

(5) If $Meas_{DIM}$ is non-monotonic, then: $\forall x \forall y[\ x \sqsubseteq y \rightarrow Meas_{DIM}(x) = Meas_{DIM}(y)]$
"If $Meas_{DIM}$ is non-monotonic, then if x is part of y, x and y have the same measure."

One of the advantages of this account is that it successfully captures that measure words like *inch*, *meter* and *kilo* are different from those like *carat* for purity and *degree* for temperature. The former are called 'extensive' measures and the latter 'non-extensive' measures [8]. For Schwarzschild, extensive measures are subject to both monotonic and non-monotonic readings, but non-extensive ones can only have a non-monotonic reading. As shown in (6), extensive measures like *inch* are available in both pseudopartitives and attributive constructions, but non-extensive measures like *degree* and *carat* are only permitted in attributives but not in pseudopartitives.

(6) a. two inches of cable — a'. two-inch cable
b.* fifty degrees of water — b'. fifty-degree water
c.*18 carats of gold — c'. 18-carat gold

Nevertheless, it is highly controversial whether monotonicity is the decisive factor responsible for the above contrast. The first issue arising is concerned with whether attributive MPs are allowed for a non-monotonic reading only. This problem is particularly prominent for extensive measure words. Can extensive MPs retain their default monotonic function in attributive positions? For instance, Kennedy [9] points out that attributive MPs do not seem to require non-monotonicity in all the cases. The MP *60 min* in the attributive position in (7b) has a similar monotonic reading as the one in (7a), both of which denote the actual duration of the analysis.

(7) a. 60 minutes of analysis
b. a 60 minute (long) analysis

Second, what is the correlation between non-monotonicity and distributivity for attributive MPs, if there is any? It is noted in Schwarzschild [1] that the property expressed an attributive MP is always distributive, such that it distributes either over atomic entities consisting the relevant plural entity or over the parts of an entity denoted by a mass noun (recall the examples in the second column in (6)). To rule out the monotonic reading for attributive MPs, Schwarzschild [1] claims that non-monotonic MPs entails distributivity but monotonic MPs fail to pass the test of distributivity. In contrast, Rothstein [10], McKinney-Bock and Pancheva [3] both argue for the opposite position that non-monotonicity for attributive MPs is independently determined by distributivity of such predicates.

This study addresses these two controversies by focusing on the usages of MPs in attributive constructions in Mandarin. We confine ourselves to the expression "Numeral-Classifier-MP-*de*-Noun", in which the MP followed by the modification marker *de* occupies the adnominal position and then is preceded by a true numeral and a true classifier, as illustrated in (8).

(8) a. ta ji-le yi tong 1.5-sheng de niunai.
he squeeze-PFV one CL_{bucket} 1.5 liter Mod milk
'He milked a bucket of milk, which measures 1.5 liters.' (Non-monotonic)

b. ta mai-le yi ping 1.5 sheng de niunai.
he buy-PFV one CL_{bottle} 1.5 liter Mod milk
'I bought a 1.5-liter bottle of milk.' (Non-monotonic)

As will be argued, attributive MPs, such as *1.5-sheng* '1.5-liter' in (8), are potentially ambiguous between monotonic and non-monotonic readings. Hence, our answer to the first question is opposed to Schwarzschild's syntactically motivated proposal. We claim that the syntactic position of MPs does not always decide their readings to be monotonic or non-monotonic, and that the attributive position is not reserved for non-monotonic MPs.

Concerning the second question, we argue that the apparent ambiguity between monotonic and non-monotonic readings for MPs should be recast as the distinction between object-level and kind-level readings in Mandarin. In these two contexts, the effect of distributivity on attributive MPs has its roots in two sources: the apparent non-monotonic reading is a consequence of the (sub)kind reading in that the property expressed by MPs is distributive over the instantiation set of the relevant subkind, and on the monotonic reading, the attributive MPs distributes over the predicate Classifier-Noun, which denotes a set of non-overlapping individuals.

The remainder of the article is organized as follows. Section 2 offers a brief review on two semantic accounts of (non-)monotoicity of MPs in attributive constructions, namely, Rothstein [2] and McKinney-Bock and Pancheva [3]. In Sect. 3, we examine the usages of MPs in attributive constructions in Mandarin, which are shown to be subject to both monotonic and non-monotonic readings. The semantics of monotonic and non-monotonic MPs in attributives are worked out in Sects. 4 and 5 respectively. The article is wrapped up in Sect. 6 by summarizing the main arguments made in the paper.

2 Two Semantic Accounts for (Non-)Monotonicity of MPs

This section reviews two existing accounts which challenge the non-monotonicity restriction of MPs in attributive constructions. Contra Schwarzschild [1], Rothstein [2] argues that the projection of the so-called MonP is not syntactically but semantically determined by the availability of 'extensive' measure function for measure words [8]. One of the consequences is that it is actually possible for attributive MPs to receive both a monotonic reading and a non-monotonic reading. McKinney-Bock and Pancheva [3] also argue that attributive position is not reserved for non-monotonic readings by examining behaviors of various types of adjectives. It is concluded that non-monotonicity of attributive MPs follows from the effect of distributivity, but not vice versa.

2.1 (Non-)extensive Measure Functions

According to Schwarzschild [1], as indicated by the structure (3a), it is the head *of* in Monotonic Phrases that is responsible for assigning the quantity property expressed by

the MP to individuals in the denotation of nouns. This syntactically motivated approach to monotonicity tried to account for the following two relevant facts. First, measures like *karat* and *degree* fail to be licensed in pseudopartitives, and they are restricted in attributive constructions; second, measures like *inch* or *kilo* exhibit the same non-monotonicity property as *karat* and *degree*, when they are used as attributive modifiers. The two facts are exemplified by (9) and (10) respectively.

(9) a. 18-karat gold a '.* 18-karat of gold
b. 20 C° degree water b '.* 20 C° degree of water

(10) a. two inches of wire a'. the two-inch wire
b. three pounds of cherries b'. the three-pound cherries

It is assumed that the dimension associated with the measure *karat* is not monotonic with the stuff gold, because the PURITY of any proper part of it will always remain the same. The unacceptability of (9b') also reflects the fact that temperature is not monotonic with respect to water. If the 5 ounces of water in the bottle measures 20°, then its subparts will also measure 20°. Similarly, the measure *inch* in the pseudopartitive construction tracks the monotonic dimension of length, as in (10a), but it measures the diameter of wire in the attributive construction in (10a'), where it does not track a part-whole relation to wire. The properties denoted by non-monotonic MPs are distributive over parts of entities in the NP denotation. For plural entities, each singular atom consisting the plural entity shares the same property denoted by the MP, and for mass nouns, the property holds of any subpart of the relevant entity. For Schwarzschild, the distributivity effect observed is due to the monotonic interpretation of the MPs.

However, Champollion [11] showed that the same measure word *degree* for temperature is fairly acceptable in pseudopartitives as in the example (11), where the relevant measure function, e.g. *temperature-increasing*, maps any warming event to the number of degrees of warming that it causes. Nouns like *global warming* can be categorized as 'scalar nominals' in the sense of Kennedy [9], which are compatible with the alleged 'lexically' non-monotonic MPs.

(11) a. The scientists from Princeton and Harvard universities say just *two degrees Celsius of global warming*, which is widely expected to occur in coming decades, could be enough to inundate the planet. [11]
b. 6 degrees of separation [9]

We learn from the examples in (11) that the alleged intrinsically non-monotonic measure words can, in fact, be licensed in monotonic constructions, when some contexts are construed in an appropriate way. This suggests that the monotonic or non-monotonic measure function cannot be lexically determined by the measure words themselves. It is less likely to be syntactically determined either. If it were the case, some independent mechanism is still called for to explain how the same measure word *degree* is analyzed with different syntactic status in these two situations. As far as the monotonic reading is concerned, Ladusaw [12] suggests that the partitive *of*, as in 'some of the students', denotes the function from a divisible entity, i.e. an entity that has part structure, to a property that is true of parts of that entity, as formalized in (12). However, Schwarzschild

assumes that the monotonic *of* in pseudopartitives is distinct from the partitive *of*. It is thus ruled out the possibility that it is the preposition *of* that is responsible for assigning a part-whole structure onto the noun denotation in pseudopartitives.

(12) *of* in partitives: $\lambda y \lambda x.\ x \leq y$

The strict mapping of attributive MPs onto a non-monotonic reading was criticized in Rothstein [2], who suggested that it is the semantics of the MP that determines its property of being monotonic or non-monotonic. It is proposed that it is the availability of extensive measure function of measure words that makes them possible in pseudopartitives. The contrast between *inch* and *degree* is suggested to be a distinction between extensive and non-extensive measure functions in the sense of Krifka [8]. The measure word *inch* denotes an extensive measure operation, and *length*, the dimension on which inch operates, is extensive, whereas *degree* which maps an entity onto a degree of heat is not extensive, and *temperature* is a non-extensive dimension. Accordingly, non-extensive measure words in (9a-b) are disallowed in pseudopatitives due to the lack of extensive measure functions. However, as shown in (11), it is possible for the alleged non-monotonic measures like *degree* to be used in monotonic constructions. The measure word *degree* in examples of (11) is assumed to denote an extensive measure function then. This further supports that the monotonicity function is neither lexically nor syntactically specified but semantically dependent.

Rothstein [2] argues against the syntactic account that (non-)monotonicity of measure predicates is determined by their syntactic positions, and propose that non-monotonicity is a consequence of the distributive interpretation of MPs. We already know that the MP *two pound* in *two-pound apples* distributes over atomic apples and has a *two-pound-per-apple* reading. But in this case, "non-monotonicity is met trivially, since atoms in the denotations of count nouns are assumed to have no parts" (ibid: 12). The difference of MPs like *two pound(s)* in pseudopartitives and attributives is more illustrative in cumulative contexts, where they differ in cumulative entailments.

(13) a. If a and b are in the denotation of the predicate *(exactly) two pounds of apples*, then a⊔b is not in the denotation of the predicate *two pounds of apples*.
b. If a and b are in the denotation of the predicate *(exactly) two-pound apples*, then a⊔b is also in the denotation of the predicate *(exactly) two-pound of apples*.

The MP *two pounds of apples* denotes the set of pluralities of apples in the denotation of apples which weigh two pounds, as in (14a). Obviously two such quantities cannot together weigh two pounds, thus the cumulative entailment in (13a) holds. In (13b), the attributive MP *two-pound* distributes over atomic apples in the denotation of the count noun apples and gives us the set of atomic apples which each weigh two pounds, as in (14b).[1] Therefore, it is not surprising that the increasing of the quantity of apples in the denotation of two-pound apples does not affect the measure value of each apple in the set.

[1] The semantics in (14b) was simplified by getting rid of the derivation from the root meaning of nouns to a set of atomic individuals.

(14) a. $\{x_{pl}: x_{pl} \in \text{APPLES}\} \cap \{x_{pl}: \text{MEAS}(x) = <2, \text{POUND}>\}$, it denotes the intersection of the set of pluralities of apples and the set of entities which weigh 2 lbs.
b. $\{x: x \in \text{APPLES} \wedge \text{MEAS}(x) = <2, \text{POUND}>\}$, it denotes the set of atomic individuals which are (each) apples and which (each) weigh 2 lbs.

The account of (non-)extensive measure function predicts that the monotonic interpretation is not ruled out at all in attributive constructions. The monotonic reading of attributive MPs in English is supported by the evidence given below (adapted from Rothstein 2019).

First, additive attributive measures decrease incrementally. If the attributive were a non-monotonic predicate, (15) would be unexpected.

(15) If A is a two-pound apple, then half of A weighs one pound.

Second, we can see the effects of monotonicity in attributive predicates in accumulation entailments. Accumulation entailments are entailments of the form in (16).

(16)	a. Three two-pound apples is six pounds of apples.	TRUE
	b. Three 500 meters skeins yarn is 1500 meters of yarn.	TRUE
	c. Three ten dollar tanks of gas is thirty dollars-worth of gas.	TRUE

Attributive MPs discussed here are clearly monotonic, because they contribute the measures though which the measure of the overall quantity is computed. Non-monotonic MPs do not show any of these effects.

2.2 Deriving Non-monotonicity from Distributivity

McKinney-Bock and Pancheva [3] also cast doubt onto the non-monotonicity constraint of MPs in attributive constructions. By examining the behaviors of adjectives, they reach the same conclusion that attributive modifiers are not bound to having the non-monotonic reading and its apparent non-monotonicity is attributed to distributivity.

Schwarzschild [1] suggests that when a MP combines with a substance noun in attributives, they express (possibly complex) non-monotonic dimensions, which are understood as properties distributive over atomic individuals, such as weight or price per (standard) unit, as exemplified by (17).

(17)	a. 3 pound cherries:	WEIGHT PER CHHEEY
	b. 20 pound paper:	WEIGHT PER STANDARD UNIT
	c. $72 oil:	PRICE PER STANDARD UNIT

For Schwarzschild [1], the non-monotonic reading of attributive MPs entails the distributivity effect, but McKinney-Bock and Pancheva [3] suggest that non-monotonicity follows from the independently determined distributivity of the relevant predicates. But McKinney-Bock and Pancheva's [3] arguments are mainly built upon the properties of adnominal adjectives in attributive constructions.

When the dimensional adjective *heavy* is used in the predicate position (18a), it has either a collective reading or a distributive reading, which means that the boxes are heavy

as a group or each box is heavy. But, in the case of (18b), the attributive *heavy* passes the non-monotonicity requirement: the weight of individual boxes does not track the part-whole relation among boxes. The attributive *heavy* is obligatorily interpreted with a distributive reading. It is called a 'stubbornly distributive' adjective in Schwarzschild [1].

(18) a. The boxes are *heavy*. [collective or distributive]
b. The *heavy* boxes sat in a corner. [distributive]

McKinney-Bock and Pancheva [3] propose that the distributive reading and the collective reading of gradable adjectives can be differentiated by different comparison classes to be chosen in the context. On the distributive reading, (19) has the meaning that 'boxes that are heavy for a prototypical box', which can be represented as a covert pronominal element C, as sketched in (19b). In addition to the distributive reading (20b), the predicative *heavy* also has the collective reading, which is understood as 'the weight of the pile of boxes is compared to contextually relevant prototypical entities', as illustrated by (20c).

(19) the heavy boxes
a. ||heavy||= $\lambda D_{<d,t>}$ λx. x's weight $\in$D, where D represents degree intervals.
b. [$_{DP}$ the [$_{NP}$ [POS C] [$_{NP}$ D-heavy boxes]]], where the variable C stands for the comparison class, Pos in combination with C introduces standard of comparison.
c. ||C||= $\lambda x.\exists D$[x is a D-heavy prototypical box]

(20) The boxes are heavy.
a. the boxes are [$_{AP}$ [POS C] [$_{NP}$ D-heavy]]
b. ||C||= $\lambda x.\exists D$[x is a D-heavy prototypical box]
c. ||C||= $\lambda x.\exists D$[x is a D-heavy prototypical entity]

If the property of (non-)monotonicity is determined syntactically, it is expected that adjectives or other forms of predicates are expected to have a non-monotonic reading only when occurring in attributive constructions. This prediction is falsified by the following facts (adapted from McKinney-Bock and Pancheva [3]).

First, when the adjective *heavy* modifies collective mass nouns like *traffic* and *jewelry*, it is interpreted collectively. *Heavy* in (21a) measures the density of vehicles, and the most prominent reading of (21b) is that the overall quantity of jewelry is heavy. These examples clearly pose a problem for the link between attributive syntax and the semantics of non-monotonicity.

(21) a. The *heavy* traffic was unbearable.
b. The *heavy* jewelry weighed down the bride.

Second, in addition to the distributive adjective *heavy*, collective adjectives like *numerous*, *plentiful*, and *sparse*, can also be used attributively. The semantics of *numerous* requires a plurality measured along a cardinality dimension that is not necessarily precise. The example (20) only requires the cardinality of protesters to be large enough, but it is not expected to know the exact number of protesters.

(22) The *numerous* protesters overwhelmed the counter-protesters.

Unfortunately, McKinney-Bock and Pancheva [3] only discussed (non)monotonicity of adjectives, and left untouched the property of MPs in attributive constructions. It is dubious whether these two types of phrases, i.e. attributive APs and MPs, are supposed to have the same behavior with respect to monotonicity. At least, as far as attributive QAs (Quantity Adjectives) are concerned, such as *many* and *much*, they are monotonic in a way that does not seem tied to their syntax [13].[2] We will explore in the following sections whether attributive MPs are constantly distributive.

In sum, this section offers an overview of Rothstein's [2] and McKinney-Bock and Pancheva's [3] accounts on (non-)monotonicity of attributive modifiers, which examine the behaviors of MPs and adnominal adjectives respectively. According to Rothstein [2], the monotonic reading of MPs is determined by the extensive function denoted by measures, which is available both in pseudopartitives and attributive constructions. The crucial argument made in McKinney-Bock and Pancheva [3] is that non-monotonicity of attributive adjectives like *heavy* follows as a consequence of distributivity. Both accounts are in favor of the view that modifiers in the attributive position receive a monotonic reading or a non-monotonic reading: the former depends on the measure function to be extensive or non-extensive, and the latter on the adjective to be distributive or collective.

3 (Non-)Monotonic MPs in Mandarin: the Facts

This section first shows how pseudopartitives and attributive constructions are realized in a classifier language like Mandarin. It will then be followed by the discussion on the ambiguity of attributive MPs with respect to monotonicity in this language. A caution is in place here that we will be focusing only on the use of extensive measure words like *meter* and *pound* in attributive positions in this study.

3.1 MP-*de*-N as Pseudopartitives or Attributive Constructions

In Mandarin, measure predicates can directly merge with a noun to generate pseudopartitive constructions, such as MP-N in (23). Besides, the modification marker *de* can also intervene between MP and N, which results in the expression MP-*de*-N.[3] The phrase MP-*de*-N is structurally ambiguous between pseudopartitives and attributive constructions, as exemplified by (24) [14–16].

(23) ta mai-le liang bang rou.
she buy-PFV two pound meat
'She bought two pounds of meat.' [pseudopartitive construction]

[2] Schwarzschild (2006) treats such QAs as *many* and *much* to be realized high in some functional projection, e.g. at or above MonP.

[3] The modification marker *de* is able to turn any phrasal elements into attributive modifiers, which is schematized as "XP-*de*-NP".

(24) ta mai-le liang bang de rou.
she buy-PFV two pound Mod meat
a. 'She bought two pounds of meat.' [pseudopartitive construction]
b. 'She bought some two-pound meat.' [attributive construction]

Under the pseudopartitive reading, the MP *liang-bang* in (23) and (24a) measures the overall weight of meat to be two pounds, regardless of whether *de* is present or absent. On the attributive reading, in (24b) *liang bang* specifies the meat to be the one that comes in the unit of two pounds, or "the meat that is sorted in accordance with two pounds" in Tang's [14] terms.

According to Tang [14] and Jiang [15], MP-*de*-N in (25) is associated with two distinct syntactic structures under pseudopartitive and attributive readings: the former has the structure of [$_{\text{MeasP}}$ Num-Meas (*de*) [$_{\text{NP}}$ N]] and the latter [$_{\text{NP}}$ [$_{\text{MeasP}}$ Num-Meas *de*] N]. This structural difference predicts that MP-*de*-N can be embedded in a canonical classifier phrase, i.e. Num-Cl-MP-*de*-N, only when the MP is interpreted with an attributive reading. The presence of Num-Cl before the MP impedes the availability of the monotonic reading for MP-*de*. It follows that MPs *sanbang-de* in (25a) and *wubang-de* in (25b) are attributive modifiers and are interpreted non-monotonically.

(25) a. liu ge san-bang de yingtao [15]
six CL three-pound Mod cherry
'six cherries, each of which weigh three pounds'
b. ta mai-le liang bao wu-bang de rou. [14]
she buy-PFV two $\text{CL}_{\text{parcel}}$ five-pound Mod meat
'She bought two parcels of meat that were sorted in accordance with five pounds.'

According to Tang [14] and Jiang [15], when the MP is used as an attributive modifier, it behaves like a 'classifying' adjective, which expresses properties that are able to establish subtypes of entities. Jiang [15] suggests that *san bang de yingtao* 'three-pound cherry' in (25a) refers to 'a complex kind or concept', but, unfortunately, this was not reflected in the English translation. Example (25a) is supposed to mean 'the three-pound cherry'. The term used by Tang 'sorted in accordance with' has the same effect as Jiang's [15] 'complex kind or concept' in that (25b) refers to a certain type of meat available on the market.

In this study, we will leave aside the pseudopartitive construction and focus solely on the attributive use of measure phrases, i.e. the MP in the construction "Num-Cl-MP-*de*-N". We refer readers to Li and Rothstein [17] for the discussions on the pseudopartitive expression "MP-*de*-N" in detail. We will address the following two questions concerning attributive MPs in Mandarin: (i) how can we relate the subkind reading discussed in Tang [14] and Jiang [15] to the non-monotonic reading proposed in Schwarzschild [1]? (ii) is it possible for the MP in MP-*de*-N to have a monotonic reading? If the answer is positive, how are the two monotonic readings in attributives and pseudopartitives distinguished from each other?

3.2 Ambiguity of Attributive MPs in Mandarin

In this subsection, we defend the view that the attributive position is not reserved for non-monotonic MPs in Mandarin. As will be shown, attributive MPs, as the one in [Num-Cl-[[MP-*de*]N]], are ambiguous between monotonic and non-monotonic readings. We propose that the ambiguity of attributive MPs between monotonic and non-monotonic readings should be recast a contrast between object-level and subkind-level readings in Mandarin. As a result, the apparent 'non-monotonic' reading is a consequence of the kind reading in Mandarin, whereas monotonic MPs in attributives express properties distributive over the atomic set denoted by Cl-N.

In English, attributive MPs can optionally co-occur with dimensional adjectives, such as *two meter (tall)* in (26a). This suggests that attributive MPs are not adjectives, but they are rather the degree arguments of (possibly implicit) adjectival or measure functional heads [9]. It is also suggested that attributive MPs, along with the dimensional adjective followed, have the same analysis they would have in predicative positions, where they denote properties of individuals, as in (26b).

(26) a. a *two-meter (tall)* man
b. ||two-meter tall|| = λx. tall (x)=2m

If this analysis in (26) is on the right track, there is no reason to believe that attributive MPs are required to be interpreted with a non-monotonic reading. As shown in (27), the MP *60* min can be used for the noun analysis either on its mass use or its count use, which leads to pseudopartitives and attributive constructions [9]. What's important here is that the same MP receives a monotonic reading in both constructions, which means that the duration of analysis lasts 60 min.

(27) a. 60 minutes of analysis
b. a 60-minute (long) analysis [9]

We now show that monotonic and non-monotonic readings are equally available for attributive MPs in Mandarin. The example (28) with the MP *100 haosheng* '100 ml' in an attributive position has two possible readings. On the monotonic reading in (28a), it means that the actual volume of milk that was drunk amounts to 100 mls, and this sentence is true only when the whole glass of milk is finished up. On the non-monotonic reading in (28b), it means that the milk that he drank was poured out of the 100-ml bottled ones, where the property denoted by the MP '100 ml' does not track a part-whole relation over the quantity of milk.

(28)	ta	he-le	yi	bei	[[yibai-haosheng	de]	niunai].
	he	drink-PFV	one	Cl_{glass}	100-ml	Mod	milk

a. 'He drank a glass of milk, which measures to be 100 mls.' [Monotonic]
b. 'He drank a glass of the 100-ml milk.' [Non-monotonic]

It is more difficult for attributive MPs to obtain a monotonic reading than a non-monotonic one in some cases. But the monotonic reading becomes available, once the contexts are appropriately construed. Two extra examples are provided in (29) to show the

availability of the monotonic reading in attributive constructions, but the non-monotonic reading is not excluded here.

(29) a. Tian laohan jianshang bei-zhe yi dai 30 gongjin de dami.
Old Tian shoulder.on carry-Dur one Cl_{sack} 30 KG Mod rice
'Old Tian carried a sack of 30-KG rice on his shoulders.'
Literal: 'Old Tian carried a sack of rice on his shoulder, which was 30 KGs.'
b. tamen zao-le yi dong sanbai mi de dalou.
they build-PFV one CL three hundred meter Mod building
'They built a 300-meter (tall) building.'
Literal: 'They built a building, which was 300 meters tall.'

We hypothesize that the contrast of attributive MPs between monotonic and non-monotonic readings should be recast as the distinction between object-level and kind-level predicates in Mandarin. The semantics of MPs under these two readings can be tentatively sketched in (30a–b). We suggest that the attributive MP in (30a) expresses a property of weight that is predicated of entities denoted by the noun, and that the MP in (30b) does not express a measure function of milk but a property that helps to establish a subtype of milk, e.g. the 100-ml type of milk (also see [14, 15]). In this case, the MP does not express the actual amount of milk to be taken.

(30) a. $[[100\ haosheng\ de\ niunai]]=\lambda x.\ milk(x) \wedge \mu_{weight}(x)=100\ ml$
b. $[[100\ haosheng\ de\ niunai]]=\lambda k.\ milk\ (k) \wedge 100\text{-}ml\ (k)$
$= {}^{\cap}(\lambda x.milk(x) \wedge 100\text{-}ml(x))$

The posited object/kind-level ambiguity, which underscores the monotonic and non-monotonic readings associated with attributive MPs, can be justified in the following contexts in Mandarin.

First, the object-level/kind-level readings of the attributive MP affect the truth conditions of sentences. Consider the examples in (31).

(31) ta mai-le wu zhi [si-liang de pangxie],
he buy-Asp five CL 200-gram Mod crab
zong zhongliang liang jin budao yidianr.
total weight two pound less.than a bit
'She bought five 200-gram crabs, but the overall weight is a bit less than 2 pounds.'

Under both monotonic and non-monotonic readings, attributive MPs without any approximators is expected to express exact measurement of entities in the case of English (recall Rothstein's examples from (13) to (16)). However, in Mandarin, it is possible for attributives to have inexact measurements. As shown in (31), it only requires each crab to be close enough to 200 g. We suggest that the statement of (31) is judged to be true only when the MP is interpreted with a kind reading. If the sentence is interpreted with an object reading or the so-called monotonic reading, each crab has to weigh exactly 200 g and the overall weight should be two pounds in an exact sense. In this context, the sentence (31) is then judged to be false. But if '200 g crab' is a general name of crabs

of a certain subtype, in which the MP *200*-g denotes a classifying property to classify crabs, then the approximate interpretation is expected. It is a common practice in the Yangtze Delta area that crabs are sorted into the 100 g type, the 200 g type etc., and the larger they are, the more expensive they become. In this context, it only requires the actual weight of each crab to be close enough to 200 g to instantiate the relevant kind, so the overall weight can be around 2 pounds. Thus the same sentence (31) becomes true in this context. As for the question of how close it is to 200 g, it depends on how fine/coarse-grained the scale it is. We take this evidence in support of the claim that the apparent non-monotonic reading of attributive MPs should be treated as a (sub)kind reading.

The second context to distinguish between the object-level reading and the kind-level reading is concerned with the availability of dimensional adjectives after MPs. The expression "Num-Cl-MP-*de*-N" is ambiguous between an object-level reading and a kind reading, but 'Num-Cl-MP-Adj-*de*-N' has an unambiguous object-level reading and the kind reading is suppressed, when the MP is followed by a dimensional adjective, such as *chang* 'long', *kuan* 'wide', *gao* 'high', *zhong* 'heavy' and *shen* 'deep'.

(32) Scenario A:
Xiaowang mai-le yi kuai [[liang-mi chang de] hongbu]
Xiaowang buy-PFV one CL_{piece} two meter long Mod red cloth
he yi kuai [[san mi chang de] baibu].
and one CL_{piece} three meter long Mod white cloth
'Xiaowang bought an item of 2-meter long red cloth and another item of 3-meter long white cloth.'

(33) Scenario B:
Xiaowang mai-le yi kuai [[liang-mi de] hongbu]
Xiaowang buy-PFV one CL_{piece} two meter Mod red cloth
he yi kuai [[san-mi de] baibu].
and one CL_{piece} three-meter Mod white cloth
'Xiaowang bought an item of 2-meter red cloth and another item of 3-meter white cloth.'

The MPs in (32) are followed by the dimensional adjective *chang* 'long', but those in (33) are not. In the context depicted by (32), the overall length of cloth that was bought is 5 m, a sum of 2 m and 3 m. In contrast, in the context of (33), the overall length of cloth is either five meters or uncertain. The length of cloth becomes uncertain when the MPs are kind-level predicates, since in this context they simply specify which type of cloth and give no information on the actual length that was bought.

The insertion of dimensional adjectives after MPs in Mandarin is different from what's observed in English. As shown in (26) and (27), the insertion of adjectives after MPs does not result in any interpretational differences of the MP in English. For Kennedy [9], they are "much synonymous". Some more examples are provided in (34).

(34) a. a three-meter (long) rope
b. two 1.8 meter (tall) students

Third, object-level MPs in attributive positions differ from kind-level ones in that they allow adverbial modification, such as *duo* 'more', *budao* 'less than' and *ganghao* 'just'.

MPs with approximative modifiers in (35) can only be interpreted with a monotonic reading.

(35) a. yi gen [[san mi duo de] dianxian]
one CL three meter more Mod wire
Possible reading: 'a stretch of wire, which is more than three meters'
Impossible reading: a kind of wire, which is more than three meters'
b. yi gen [[san mi budao de] dianxian]
one CL three meter less Mod wire
Possible reading: 'a stretch of wire, which is less than three meters'
Impossible reading: a kind of wire, which is less than three meters'
c. yi gen [[ganghao san mi de] dianxian]
one CL just three meter Mod wire
Possible reading: 'a stretch of wire, which is exactly three meters'
Impossible reading: a kind of wire, which is exactly three meters'

Last but not least, these two types of attributive MPs are confined to some word order restriction. They must co-occur in the order of "$MP_{Object\ level}$ - $MP_{Kind\ level}$ -NP", not the other way round. Example (36) means that the watermelon belongs to the five-kilo type and that the overall quantity of each sack measures fifty kilos.

(36) ta mai-le liang madai [wushi gongjin de]$_{Monotonic}$[wu gongjin de]$_{Nonmonotonic}$ xigua.
she buy-PFV two CL_{sack} fifty kilo Mod five kilo Mod watermelon
'She bought two fifty-kilo sacks of five-kilo type watermelons.'

Adopting our second diagnostic that dimensional adjectives can only follow the object-level MPs, it follows that only the first MP that follows the classifier can be followed by dimensional adjectives, and the one immediately preceding the noun cannot.

(37) a. ta mai-le liang madai [wushi gongjin zhong de] [wu gongjin de] xigua.
she buy-PFV two CL_{sack} fifty kilo heavy Mod five kilo Mod watermelon
'She bought two fifty-kilo sacks of five-kilo type watermelons.'
b.?ta mai-le liang madai [wushi gongjin de] [wu gongjin zhong de] xigua.
she buy-PFV two CL_{sack} fifty kilo Mod five kilo heavy Mod watermelon
'She bought two fifty-kilo sacks of five-kilo type watermelons.'
c.*ta mai-le liang madai [wushi gongjin de zhong] [wu gongjin zhong de] xigua.
she buy-PFV two CL_{sack} fifty kilo Mod heavy five kilo heavy Mod watermelon
'She bought two fifty-kilo sacks of five-kilo type watermelons.'

The co-occurrence of the two types of attributive MPs in Mandarin suggests that they are possibly realized in two distinct syntactic positions. We assume that the MP close to NP functions as adnominal adjectives and the one close to the classifier act as "pre-classifier" modifiers in terms of the scope of modification. The underlying structural relation of these two MPs in classifier phrases can be represented as: [$_{NumP}$ Num [$_{ClP}$ MP1 [$_{ClP}$ CL [$_{NP}$ MP2 [$_{NP}$ N]]]]], where MP1 and MP2 act as ClP adjunct and NP adjunct respectively. The reason why MP1 follows the classifier but does not precede it is

probably due to phonological reasons. It was discussed in Li [18] that only a limited set of dimensional adjectives are allowed to appear between numeral and classifier, which are required to be used in bare forms, namely, neither degree modifiers nor the modification marker *de* is allowed. Compared with those bare adjectives, MPs are structurally more complex and phonologically heavier. This might well be the reason for their right dislocation.

The scopal difference between these two types of attributive MPs is also illustrated by the English translation, where monotonic attributive MPs modify the classifier, and non-monotonic ones modify the noun. A similar pattern is also observed in English in Rothstein [2]. But it should be noted that the adnominal MP does not have a kind reading at least in the context of (38).

(38) a. I bought a *two-kilo* bag of flour.
b. I bought two *two-kilo* crates of *two-kilo* watermelons.

To sum up, in contrast with Schwarzschild [1], we claim that the attributive position is not reserved for non-monotonic readings for MPs. Relying on the four diagnostics shown above, we suggest that attributive MPs can be interpreted either with an object-level reading or a kind level reading, which appears parallel to a monotonic or a non-monotonic reading in a loose sense. What is more important is that subkind-level and object-level MPs appear to take two distinct syntactic positions, although in Mandarin they appear linearly in the sequence of Num-Cl-MP-*de*-N. As will be argued later, monotonic and subkind-level MPs at the attributive position modify two types of nominal phrases, namely, NP or ClP/NumP. They are either adnominal modifiers or pre-classifier modifiers.

4 Deriving the Monotonic Reading of Attributive MPs

The task of this section is to work out the compositional semantics of the object-level reading of MPs in attributive positions, i.e. being monotonic. We propose that on the object-level reading, MPs are projected as part of the functional phrase DegP, distinct from its projection into AP on the kind-level reading. This is empirically motivated by the fact that the presence of dimensional adjectives after MPs triggers an unambiguous object-level reading. The relevant examples are repeated in (39).

(39) a. yi kuai san-mi de bu
one CL three-meter Mod cloth
'a piece of three-meter cloth' [kind-level: non-monotonic]
OR 'a piece of cloth, which measures three meters' [object-level: monotonic]
b. yi kuai san-mi chang de bu
one CL three-meter long Mod cloth
'a piece of cloth, which measures three meters' [object-level: monotonic]

In the post-Abenian generative syntax, it has become a standard assumption that there is the functional projection DegP above the lexical projection of Adjective Phrases [19–21]. This articulated structure can accommodate the fact that either degree words or

MPs can appear before adjectives. As shown in (40), degree words are realized as Deg^0, and MPs fall in the specifier position of DegP [21].

(40) a. John is [$_{DegP}$ [$_{Deg}$ quite [$_{AP}$ tall]]].
b. John is [$_{DegP}$ [$_{MP}$ 1.80 meters] [$_{Deg}$ [$_{AP}$ tall]]].

Following the degree-based analysis of adjectives pioneered in Cresswell [22], adjectives are argued to denote the function from degrees to properties. They are of the semantic type <d, et>. The expression MP-Adj is suggested to denote a degree predicate, which relates an individual x to x's degree along a certain dimension (see Kennedy 1997 for the "measure function" account as an alternative). As a first approximation, the semantics of degree phrase "MP-Adj" can be represented in (41).

(41) a. $||\text{tall}||_{<d, et>}$: $\lambda d \lambda x.\ \text{HEIGHT}(x) \geq d$
b. $||1.8 \text{ meters tall}|| = ||\text{tall}||\ (||1.8 \text{ meters}||) = \lambda x.\ \text{HEIGH}(x) \geq 1.8 \text{ meters}$

Next we extend the semantics of the degree phrase in (41) to attributive MPs on the monotonic reading. We suggest that the degree phrase MP-Adj at the predicate position can be converted into an attributive modifier by the modification marker *de*, which denotes the function from properties to property modifiers. As will be argued later on, in the shifting process, the effect of distributivity can be captured by assuming that the property denoted by attributive modifiers intersects with the comparison class provided in the context, i.e. a set of atomic individuals denoted by Classifier-Noun in our case.

Monotonic MPs can be composed in complex ways by introducing various range adverbials or approximatives, such as *duo* 'more', *budao* 'less', *ganghao* 'exactly' and *zuoyou* 'approximately'. Note that such modifiers either precede or follow the MP linearly, and their positional difference does not concern us too much.

(42) a. yi kuai **ganghao/budao** san mi chang de bu.
one CL exactly/less than three meter long Mod cloth
'a piece of cloth, which measures exactly/less than three meters'
b. yi kuai san mi **duo/zuoyou** chang de bu.
one CL three meter more/approximately long Mod cloth
'a piece of cloth, which measures more than/about three meters.'

Landman [23] argues that numeral expressions like the *n* noun can be represented as the *r n* noun in its complete form, where *n* is a number expression and *r* is an expression denoting numeral relations like *more than*, *less than*, *at least* etc. On Barwise and Cooper's [24] analysis, the *r n* is analyzed as a partial determiner (of generalized quantifier type). In contrast, Landman [23] suggests that the constituent structure of the *r n* noun should be [[$_{Det}$ the][$_{NP}$ *r n* noun]], and not [[$_{Det}$ the *r n*][$_{NP}$ noun]], where the numeral expression *n* is analyzed as an intersective adjective. And the relation between *r* and *n* can be represented as follows:

(43) *r n* → $\lambda x.\ |x|$ r n , of type <e, t> ,
the set of sums whose cardinality stands in relation r to number *n*.

the set of sums whose cardinality stands in relation r to number *n*.

We, following Landman [23], propose that attributive MPs denote properties of degrees equal to the value specified by MP on the monotonic reading, and that approximatives denote a degree relation like =, >, <, ≈. Complex MPs like those in (42) are of the type <d, t> as well, if we consider approximatives or hedges as predicate modifiers.

(44) a. ||*san-mi*|| = λd. d=3 meters
b. ||*san-mi duo*|| = λd. d >3 meters
c. ||*san-mi zuoyou*|| = λd. d≈3 meters

We take the predicative meaning of MPs as its default, whereby they denote a set of degrees along a certain dimension. Following Partee's [25] type-shifting principles, we suggest that the predicative reading of MPs can be mapped onto arguments either by lifting them into GQs, i.e. at type <<d,t>, t> or lowering them into degree terms at type d. The implementation of the shifting of MP from <d,t> to type d is suggested in Kotek [26] and Grosu and Landman [27], who suggest that a maximality operator, such as the definite article *the*, is able to pick out the unique degree from the degree set in the relevant context.

(45) a. $\|\text{the}\|_{\langle\langle d,t\rangle d\rangle} = \lambda f_{\langle d,t\rangle}$: there is exactly one contextually salient d: f(d)=1, the unique d in the context such that f(d)=1
b. ||the 9kg that your bag weighs||= the unique d in the context such that weigh (your bag, d) ≥ d ∧ d=9kg

In the case of attributive MPs on a monotonic reading, we suggest that the MP be interpreted as a name for a degree at type d, such that it serves to saturate the degree argument of the adjective and turns it into a predicate of individuals. It is thus proposed that a nominalization operator NOM, as notated ^, is employed to shift the degree predicate to a degree name, as in (46). This operator is comparable to Chierchia's [28] DOWN operator ∩.

(46) **Step 1: Nominalization**
a. ||*san-mi*||= λd. d=3 meters
b. d=NOM (λd. d=3 meters) =^λd. d=3 meters
= 3 meters
c. ||*san-mi chang*|| = ||*chang*|| (||*san-mi*||)
=λdλx. length (x)=d (d=3 meters)
=λx. length (x)= 3 meters

The second step is to turn the measure predicate into a predicate modifier, which is achieved obligatorily by the modification marker *de*. Heim and Kratzer [4] propose that noun phrases modified by restrictive modifiers are composed by the rule of 'Predicate Modification', which intersects the properties denoted by the modifier and the head noun. However, when attributive MPs are interpreted with a monotonic/object-level reading, they compose with nouns by the rule of functional application. We suggest that the marker *de* undertakes the role of being a type-shifter coercing properties into a function of properties. This implies that attributive MPs are derived from their predicative uses, when they are interpreted with an object-level reading or a monotonic reading.

(47) **Step 2: Shifting from predicate to predicate modifier**

a. $\|de\| = \lambda P \lambda Q \lambda x.P(x) \wedge Q(x)$

b. $\|san\text{-}mi\ chang\ de\| = \|de\|\ (\|san\text{-}mi\ chang\|$

$= \lambda Q \lambda x.\ \text{length}\ (x) = 3\ \text{meters} \wedge Q(x)$

According to Schwarzschild [1], attributive MPs are interpreted with a non-monotonic reading only, which gives rise to the distributive reading of the nominal phrase. However, the distributivity constraint is also observed for attributive MPs on the monotonic reading. It will be argued that the effect of distributivity is derived by two independent mechanisms in these two contexts. As argued earlier, attributive MPs precede the head noun at the surface structure on both monotonic and non-monotonic readings, they are realized in syntactically different ways. Attributive MPs are adnominal modifiers on the non-monotonic reading, but they are pre-classifier modifiers on the monotonic reading. In the latter case, attributive MPs scope over Cl-N but not over NP, which denotes a set of entities that do not overlap with each other. This is exactly the source of distributivity for attributive MPs on the monotonic reading.

It is suggested that attributive MPs express measure properties over atomic entities in the denotation of Cl-N on the monotonic reading. This is evidenced by the examples in (48). When the attributive MP is embedded in a standard classifier phrase headed by the classifier *madai* 'sack' (48a) or *ke* 'classifier for plants' (48b), the properties denoted by the monotonic MPs, such as 'fifty kilo' and '30 meter' are predicated of the constituent Cl-N. This guarantees the distributive reading of the MP, such that members in the set of atomic individuals denoted by *madai xigua* 'sack of watermelon' or *ke shu* 'Cl tree' are supposed to have the property of being 50 kilos and 30 m respectively.

(48) a. ta mai-le liang madai [wushi gongjin de] xigua.
she buy-PFV two CL_{sack} fifty kilo Mod watermelon
'She bought two sacks of watermelons, each sack of which weighs fifty kilos.'

b. menkou you liang ke [sanshi-mi gao de] shu.
door front have two CL 30 meter tall Mod tree
'There are two 30-meter tall trees in front of the door.'

The reason why Mandarin resorts to classifiers to derive an atomic set is suggested to be due to its noun semantics. Mandarin nouns are different from English counterparts in that the former has mass denotations and the latter makes a mass/count distinction. Following Chierchia [28], we assume that classifiers are argued to be type-shifters from kind denotations to sets of atomic individuals, where the atomic structure of entities is spelled out explicitly by classifiers, as in (49b). As a consequence, the property expressed by MP-Adj-*de* is predicated of Cl-N, which denotes a set of entities intersecting with atomic units, as in (49c).

(49) **Step 3: Applying the property to an atomic set**

a. $\|shu\|_k$: $TREE_k = {}^{\cap}\lambda x.\ tree(x)$

b. $\|ke\ shu\|_{<e\ t>} = \|ke\|_{<k,<e,t>>}\ (\|shu\|_k) = \lambda x.\ ATOM_{plant}(x) \wedge Instantiation\ (x, TREE_k)$

c. $\|ke\ san\ mi\ gao\ de\ shu\| = \|san\ mi\ chang\ de\|\ (\|ke\ shu\|)$

$= \lambda x.\ ATOM_{plant}\ (x) \wedge Instantiation\ (x, TREE_k) \wedge length\ (x) = 3\ meters$

The denotation of Cl-N in Mandarin is analogous to count nouns in English, both of which denote sets of atomic individuals. Borer [29] proposes that Mandarin classifiers are realized in the same syntactic position as the plural marker *-s* in English, both of which are realized as the Dividing head. It thus follows that the properties denoted by MPs operate below the projection of NumP, e.g. below the number morphology in English.

(50) a. two [tall student]s
b. two [1.8 meter student]s

Li [18] proposes that classifiers either denote the function of counting or measuring entities, and they are associated with two distinct syntactic structures. It is suggested that counting classifiers have a counting structure: [NumP [ClP [NP]]], where they stand in a head-complement relation cyclically, whereas measuring classifiers have the measure structure: [Num-Meas [NP]], where the numeral and the measure word forms a constituent first, before merging with the noun. Our semantics in (49) correctly predicts that the monotonic reading is not available for attributive MPs when they are embedded in a true measure phrase (distinct from true classifier phrases in structures). It goes for the structure: [[Num-Meas [MP-NP]], where the classifier forms a constituent with the numeral, and the measure word in Num-Meas is resistant to being scoped over the MP. This prediction is born out by the example in (51), where the classifier position is filled in by measure words like *kilo*, and MPs are restricted to a non-monotonic reading. We suggest that measure words are not endowed with an individuation function and they do not denote sets of atoms in any case and there are no atomic entities available, to which the attributive MP can apply, to yield a monotonic reading at the object level.

(51) ta mai le liang gongjin [wu gongjin de] xigua.
he buy PFV two kilo five kilo Mod watermelon
a. 'He bought two kilos of the five-kilo type watermelon.'
b. Impossible: 'He bought two kilos of watermelon, which measures five kilos.'

To wrap up, in Mandarin, MPs appearing in adnominal positions can have a monotonic reading, which is seen as an object-level interpretation in a more precise sense. Although MPs appear before nouns, they scope over the constituent of Cl-N in terms of their modification relation, which results in the effect of distributivity. It is suggested that attributive MPs on the monotonic reading are part of the DegP and they serve to saturate the degree argument associated with the semantics of dimensional adjectives, which is at type <d, et>.

5 Non-monotonic Reading of Attributive MPs as a Subkind Reading

Non-monotonic MPs are adnominal modifiers, which directly modify the noun that follows. The crucial question to be asked is whether the non-monotonic reading can be treated as a subkind reading. Our answer is that Mandarin and English show parametric

differences in that the alleged monotonic reading should be considered as a subkind reading in Mandarin but not in English, which underscores the difference of their noun semantics. In other words, we argue that the contrast between monotonic and non-monotonic readings should be recast as an ambiguity between object-level and kind-level denotations in Mandarin.

5.1 Non-monotonic MPs as Classifying Adjectives

Adjectival modification comes into two types in Mandarin. It is either the case that adjectives can be juxtaposed to the head noun, i.e. 'Adj-N' or that the modification marker *de* intervenes between the adjective and the head noun, as in the form of Adj-*de*-N, as shown in (52) [30].

(52)	a. baiyun	a'. jiebai-de	yun	
	cloud	white-Mod	cloud	'white cloud'
	b. xiaomao	b'. xiao-de	mao	
	kitten	small-Mod	cat	'small cats'

It has been assumed by many [31–33] that the *de*-less Adj-N expressions are compounds and Adj-*de*-N are analyzed as phrases or relative clauses. If *de* insertion can be taken as diagnostic for the phrasehood of the nominal expression, then MP-*de*-N is definitely a phrase but not a compound.

One of the evidence in support of the phrasal status of MP-*de*-NP is concerned with NP ellipsis. As shown in (53), MP-*de*-NP always allows NP ellipsis, regardless of whether the MP is interpreted monotonically or non-monotonically. This suggests that the head noun has to be a maximal projection, e.g. being NP in our case [34].

(53) Pangxie, ta mai-le liang zhi [si-liang de] he yi zhi [liu-liang de]].
crab he buy-PFV two CL 200-gram Mod and one CL 300-gram Mod
'As for crabs, she bought two 200-gram ones and a 300-gram one.'
OR 'As for carbs, she bought two weighing 200 grams each and one weighing 300 grams.'

OR 'As for carbs, she bought two weighing 200 g each and one weighing 300 g.'

Landman [23] suggests that numerals like *three* can have an adjective use, under which it expresses the cardinality property of being three. Being a numerical adjective, *three* can alternate its position with other adjectives, as exemplified in (54).

(54) a. *Fifty* ferocious lions were shipped to Artis.
b. Ferocious *fifty* lions were shipped to Artis.

As shown in (55), non-monotonic MPs can also flip-flop its positions with other attributive modifiers. We thus assume that MPs can be treated as an adjectival modifier in a similar way as the English *three*, which denote properties true of the individuals in the denotation of the head noun.

(55) a. yi bu 64G-de xinkuan shouji
one CL 64G-Mod new cellphone
b. yi bu xinkuan 64G-de shouji
one CL new 64G-Mod cellphone

The facts exhibited by (53) and (55) suggest that attributive MPs on a non-monotonic reading are syntactically analogous to attributive adjectives. In contrast with monotonic attributive MPs, we claim that non-monotonic attributive MPs are subject to a sub-kind reading but not to an object-level reading. In other words, the distinction of attributive MPs between monotonic and non-monotonic readings is constrained by the sortal distinction between kinds and objects in the denotation of Ns.

It has been claimed since Zhu [35] that there are two different *de*'s involved in the sequence of Modifier-*de*-Modifiee, namely, the predicativizer *de* and the nominalizer *de* (also see [36] for a recent account). According to Huang [37], the former only marks expressions of type <e, t> and the latter denotes the function from an expression of type <e, t> to an individual-denoting expression at type *e*. We suggest that the particle *de* following attributive MPs, as in MP-*de*-NP, are of different status under the monotonic and non-monotonic readings. Specifically, the marker *de* following the monotonic MP is a predicativizer, as defined in Sect. 4, and the one following the non-monotonic MP is a nominalizer.

It is not our primary task to offer a detailed syntactic analysis to tease apart these two *de*'s in the expression MP-*de*-NP. We simply show that monotonic and non-monotonic MPs show different requirements on the presence of *de* in their predicative uses, if we assume that the attributive uses of MPs are derived from their predicative uses in both cases. In the monotonic context of (56), the marker *de* is needed only in attributives and it is not allowed in predicative positions; in the non-monotonic context of (57), the marker *de* is needed obligatorily both in predicative positions and attributive constructions.

(56) a. yi kuai san mi chang *(de) bu.
one CL three meter long DE cloth
'a three-meter piece of cloth wire.' [attributive MP: monotonic]
b. zhe kuai bu you san mi chang (*de).
this CL cloth have three meter long DE
'This piece of cloth reaches three meters long.' [predicative MP: monotonic]

(57) a. zhe kun san-haomi *(de) dianxian shi wo-de.
this Cl_{roll} 3-millimeter DE wire be mine
'This roll of 3-mm wire is mine.' [attributive MP: non-monotonic]
b. zhe kun dianxian shi san-haomi *(de).
this Cl_{roll} wire be 3-millimeter DE
'This roll of wire is of 3-mm.' [predicative MP: non-monotonic]

According to Zhu [38] and Huang [37], it is the signature property for the nominalizer *de* to appear in both predicative and attributive positions. Non-monotonic MPs behave in the same way as non-gradable adjectives, such as *golden*, *male*, *true* regarding the obligatory presence of *de*. Compare (57) with (58).

(58) a. na ge xingzhe-de/nan-de haizi milu le.
that CL awake-DE/male-DE child lost PRF
'That child awake/ the male student got lost.'
b. na ge haizi shi xingzhe-de/nan-de.
that CL child be awake-DE/male-DE
'That child is awake/ is male.'

The contrast between (56) and (57) strongly suggests that for monotonic MPs, the marker *de* comes into play only when the MP is required to be shifted as an attributive modifier, but the one after non-monotonic MPs is persistently present, regardless of its syntactic positions. This difference is sufficient for us to treating these two *de*'s differently. In view of its similarity with non-gradable adjectives, we propose that non-monotonic MPs in predicative positions denote functions from individuals to truth values, and they have the semantics of intersective adjectives in attributive constructions, where they intersect with nouns (see Landman's 2004 semantics of numerals).

It was argued earlier that on the monotonic reading, attributive MPs are composed with the head noun by the rule of functional application, where the marker *de* is claimed to be the functor of type <et, <et,et>>. As for non-monotonic MPs, we suggest that they compose with the head noun by Heim and Kratzer's [4] rule of Predicate Modification by conjoining two entities of the type e (or k for kinds). In particular, we adopt Huang's [37] proposal that nominal modification is a case of conjunction/intersection, which requires sameness of types, which is generalized to the conjunction of nominalized properties: if the head noun (the modifiee) is of type e, the modifier must also be of type e. Its definition is illustrated by (59).

(59) Definition of nominal modification [37]
a. $x \wedge y = nom\ (\lambda z[pred(x)(z) \wedge pred(y)(z)])$
b. xin shu → xin ∧ shu 'new book'

One of main motivations for Huang [37] to treat both attributive modifiers and the head noun to be of type e is attributed to Chierchia's [28] claim that bare nouns in Mandarin are kind terms. We, following Huang [37], suggest that the semantics of attributive MPs on a non-monotonic reading be tentatively represented in (61), where non-monotonic MPs in attributives are assumed to be classifying modifiers operating at the kind level. The details will be worked out in Sect. 5.2.

(60) a. yi kuan san-haomi de dianxian
one CL_{roll} 3-mm DE wire
'a roll of 3-mm wire'
b. $\|$san-haomi-de dianxian$\| = \cap(\lambda x.\ 3mm(x) \wedge wire(x))$

5.2 Non-intersective MPs as Kind Modifiers

This subsection attempts to justify non-monotonic MPs in attributives to be a kind modifier in Mandarin. We will also discuss the parametric differences between Mandarin

and English. We claim that NPs with non-monotonic MPs are kind terms in Mandarin, and the counterparts in English are property-denoting, unless its bare nouns are in plural forms.

Schwarzschild [1] argues that attributive MPs cannot be interpreted as picking out a kind. At least, this is claimed to be the case in English. Schwarzschild claims that "if by 'kind' we mean 'natural kind' then *200 lb polar bear* should be unacceptable, since this is no such species. If on the other hand, we mean by 'kind' something more general, something akin to 'property', then it's hard to understand why *20 lb honey* cannot pick out portions of honey that have the property of weighing 20 pounds."

It is suggested in Chierchia [28] that "kinds are generally seen as regularities that occur in nature". The tern 'kinds' not only refers to biological ones and well-established ones, but also to artifacts and complex things, as long as we can "impute to them a sufficiently regular behavior" (ibid). We argue that in English, attributive MPs do not express natural kinds or well-established kinds, but they can express ad hoc kinds. This is reminiscent of the contrast between *the coke bottle* and *the blue bottle* made in Krifka [39]. In appropriate contexts depicted in (61), complex NPs with attributive MPs can be construed as kind expressions, which are expressed by the syntactic forms of bare plurals or definite singulars.

(61) a. 200 lb polar bears have a lower risk of heart attack.
b. The 20 lb honey sells better than the 10 lb one.

On the basis of the intuition in (60), we propose that non-monotonic attributive MPs in Mandarin express classifying properties that help to establish subkinds. Recall the examples in (25). Jiang [15] suggests that *san bang de yingtao* 'three-pound cherry' in (25a) refers to "a complex kind or concept", which is expressed as "sorted in accordance with…" in Tang's [14] terms. The same MP-*de*-N can be preceded either by the demonstrative phrase *na zhong* 'that kind' (62a) or *na-gen* 'that individual' (62b). In the former, the MP *san haomi* '3 mm' specifies the property that defines a subkind of wire, which most naturally refers non-monotonically to the diameter of the wire to be 3 mm; in the latter, the same MP describes the property of the that particular stretch of wire, which is intended to refer to its length in a monotonic sense.

(62) a. na zhong san haomi de dianxian
that kind three-millimeter Mod wire
'that 3-mm kind of wire'
b. na gen san haomi de dianxian
that CL three-millimeter Mod wire
'that 3-mm wire'

Paul (2005, 2010) argues that a modifier without the subordinator *de* is interpreted as a defining property, whereas a modifier with *de* expresses an accessory property. According to Paul [40], "with the *de*-less modification structure, a new subcategory is established, which must present a natural, plausible class in the sense of Bolinger [41]." In the modification structure with *de*, a property is encoded as an accessory one, in the

sense that this property is presented as not instrumental in establishing a new subcategory of N.

We propose that both *de*-less and *de*-marked adjectives can help to establish kinds, but two different sorts of kind entities are involved: *de*-less adjectives help to establish well-established kinds and it happens at the N^0 level, whereas *de*-marked adjectives can establish *ad hoc* kinds (or not so well-established kinds), namely, kinds based on contextually given properties and it happens at the NP level.

In Mandarin, well-established kinds and *ad hoc* kinds can be distinguished by different question types employed. Carlson [42] suggests that *what N* asks for the identity of subkind entities and it serves as the same function as which kind of N. However, in Mandarin, *which kind of N* can be answered by both well-established and ad hoc kinds, but *what N* can be answered by well-established kinds only.

(63) A: ni mai-le nazhong pingguo? B: Fushi pingguo /zuotian de pingguo.
you buy-PFV which kind apple Fuji apple /yesterday Mod apple
'Which kind of apple did you buy?' 'Fuji apples'. / 'Yesterday's apples.'

(64) A: ni mai-le shenme pingguo? B: Fushi pingguo /#zuotian de pingguo.
you buy-PFV what apple Fuji apple /#yesterday Mod apple
What apples did you buy?' 'Fuji apples. /'#Yesterday's apples.'

As shown in (65), MP-*de*-N can only serve an answer to the question imposed by *na zhong* 'which kind' but not by *shenme* 'what'.

(65) A: ni mai-le *na zhong / #shenme* pingguo? B: er-liang de pingguo.
you buy-PFV which kind/ what apple 100-gram Mod apple
'Which kind of apple do you buy?' 'The 100-gram apple.'

The Mandarin expression MP-*de*-N is analogous to *the big bottle* discussed in Krifka [39]. We thus suggest that MP-*de*-N denote *ad hoc* kinds, but not well-established kinds. "What counts as kind is not set by grammar, but by the shared knowledge of a community of speakers" [28]. Roughly, we suggest that *ad hoc* kinds can be modeled as a set of entities in the intersection of nouns and attributive modifiers, which are characterized with "a sufficiently regular behavior" in the relevant context (ibid).

An extra piece of evidence in support of the correlation of the presence/absence of *de* with the distinction between well-established and *ad hoc* kinds is substantiated by the following fact exemplified by (66). The marker de after the MP can sometimes be omitted under a non-monotonic reading, which would possible lead to a compound, but the omission of *de* after the MP is never possible under a monotonic reading. In other words, *ad hoc* kinds can well be turned into established kinds, which are accompanied by the omission of the marker *de* after the MP at the syntactic level.

(66) a. 32G (de) neicun-ka
32 G Mod memory card
'32G memory cards'
b. 400 mi (de) paodao
400 meter Mod athletic track
'400-meter athletic tracks'
c. shuangren (de) chuang
double:person Mod bed
'double beds'

Before working out the semantics of non-monotonic MPs, we adopt Chierchia's [28] semantics on Mandarin nouns. He claims that Mandarin is an argumental language and its bare nouns are born as arguments by making reference to kinds, and that the corresponding predicative meaning can be derived from the kind term, i.e. a process of predicativization. The kind reading and the predicative reading of the bare noun *dianxian* 'wire' can be represented as in (68).

(67) a. Bare nouns as kind terms: $||\text{dianxian}||_k = \text{WIRE}_k = {}^{\cap}\lambda x.\ \text{wire}(x)$
b. Predicativization: $||\text{dianxian}||_{<e,t>} = {}^{\cup}\text{WIRE}_k = {}^{\cup}{}^{\cap}\lambda x.\ \text{wire}(x)$

We now propose that attributive MPs can directly modify such NPs by ascribing kind-level properties to the kind entity, from which we derive a set of subkind entities. In particular, we adopt Huang's [37] 'conjunctive composition' on complex NPs in Chinese (Heim and Angelika 1998: predicate modification).

(68) a. **Step 1:** MP denotes a measure property of individuals
$||\text{san haomi}|| = \lambda x.\text{MEAS}^{\text{diameter}}(x) = 3\ \text{mms}$
b. **Step 2:** a measure predicate is turned into an argument by the nominalizer *de*
$||\text{san-haomi de}|| = ||\text{de}||\ (||\text{san haomi}||) = \lambda P[{}^{\cap}\lambda x.P(x)]\ (\lambda x.\text{MEAS}^{\text{diameter}}(x) = 3\ \text{mms}\ )$
$= {}^{\cap}\lambda x.\text{MEAS}^{\text{diameter}}(x) = 3\ \text{mms}$
c. **Step 3:** the subkind entity is derived by "conjunctive composition" [4]
$||\text{san haomi de dianxian}|| = ||\text{san haomi de}|| \wedge ||\text{dianxian}||$
$= {}^{\cap}\lambda x.\ \text{MEAS}^{\text{diameter}}(x) = 3\ \text{mms}\ \&\ {}^{\cap}\lambda x.\ \text{wire}(x))$

6 Conclusions

This paper challenges Schwarzschild's [1] claim that the attributive position is reserved for non-monotonic readings of measure predicates. It was shown that attributive MPs in Mandarin are potentially ambiguous between monotonic and non-monotonic readings. We propose that the apparent monotonic and non-monotonic readings in Mandarin should be recast a distinction between object and kind readings in Mandarin, but such a correlation cannot be established in English. In the case of Mandarin, attributive MPs modify ClPs on the monotonic reading but modify NPs on the non-monotonic reading,

which serve as different sources for the distributivity effect observed in these two contexts. This suggests that distributivity and (non-)monotonicity are independent of each other. It is also suggested that attributive MPs on the monotonic reading denote degrees, and they are part of a DegP, but those on the non-monotonic reading are attributive adjectives and they compose with NPs via Heim and Kratzer's [4] rule of PM [37].

References

1. Schwarzschild, R.: The role of dimensions in the syntax of noun phrases. Syntax **9**, 67–110 (2006). https://doi.org/10.1111/j.1467-9612.2006.00083.x
2. Rothstein, S.: Semantics for Counting and Measuring. Cambridge University Press, Cambridge (2019)
3. McKinney-Bock, K., Pancheva, R.: Why is attributive "heavy" distributive? In: Altshuler, D., Rett, J. (eds.) The Semantics of Plurals, Focus, Degrees, and Times, pp. 81–110. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-04438-1_5
4. Heim, I., Angelika, K.: Semantics in Generative Grammar. Blackwell Publishing, Malden (1998)
5. Jackendoff, R.: X-bar Syntax: A Study of Phrase Structure. MIT Press, Cambridge (1977)
6. Schwarzschild, R.: The grammar of measurement. In: Jackson, B. (ed.) Proceedings of SALTXII, pp. 225–245. Cornell University Press, Ithaca, N.Y. (2002)
7. Krifka, M.: Nominal reference, temporal constitution and quantification in event semantics. In: Bartsch, R., van Benthem, J., van Boas, E.P. (eds.) Semantics and Contextual Expressions, pp. 75–111. Foris Press, Dordrecht (1989)
8. Krifka, M.: Thematic relations as links between nominal reference and temporal constitution. In: Sag, I., Scabolcsi, A. (eds.) Lexical Matters, pp. 29–54. CSLI Publications, Stanford (1992)
9. Kennedy, C.: Measurement in NP: Schwarzschild's "Grammar of Measurement". Northwestern University, Evanston, IL (2003)
10. Li, X.P., Yang, R.: On (non-)monotonicity of attributive measure phrases. J. Foreign Lang. **42**, 60–71 (2019)
11. Champollion, L.: Parts of a Whole: Distributivity as Bridge Between Aspect and Measurement. Oxford University Press, Oxford (2010)
12. Ladusaw, W.: Semantic constraints on the English partitive construction. In: Proceedings of WCCFL, pp. 231–242 (1982)
13. Rett, J.: The polysemy of measurement. Lingua **143**, 242–266 (2014). https://doi.org/10.1016/j.lingua.2014.02.001
14. Tang, C.-T.J.: Nouns or classifiers: a non-movement analysis of classifiers in Chinese. Lang. Linguist. **6**, 431–472 (2005)
15. Jiang, L.J.: Monotonicity and measure phrases in Chinese. In: Proceedings of the Chicago Linguistics Society (2013)
16. Tang, C.-T.J.: Chinese Phrase Structure and the Extended X'-theory. Cornell University dissertation, Ithaca, N.Y. (1990)
17. Li, X.P., Rothstein, S.: Measure readings of Mandarin classifier phrases and the particle de. Lang. Linguist. **13**, 693–741 (2012)
18. Li, X.P.: Numeral Classifiers in Chinese: The Syntax-Semantics Interface. Mouton de Gruyter, Berlin (2013)
19. Corver, N.: The internal syntax of the dutch extended adjectival projection. Nat. Lang. Linguist. Theory **15**, 289–368 (1997). https://doi.org/10.1023/A:1005846812956
20. Kennedy, C.: The Syntax and Semantics of Gradability and Comparison (1997)

21. Zamparelli, R.: Pre-nominal modifiers, degree phrases and the structure of AP. In: Dolci, R. and Giusti, G. (eds.) University of Venice Papers in Linguistics, pp. 138–163 (1993)
22. Cresswell, M.J.: The semantics of degree. In: Partee, B. (ed.) Montague Grammar, pp. 261–292. Academic Press, New York (1976)
23. Landman, F.: Indefinites and the Type of Sets. Blackwell Publishing, Malden (2004)
24. Barwise, J., Cooper, R.: Generalized quantifiers and natural language. Form. Semant. Essent. Readings **4**, 75–126 (2008). https://doi.org/10.1002/9780470758335.ch3
25. Partee, B.: Noun phrase interpretation and type-shifting principles. In: Groenendijk, J., de Jongh, D., Stokhof, M. (eds.) Studies in Discourse Representation Theory and the Theory of Generalized Quantifiers, pp. 115–143. Foris Press, Dordrecht (1987)
26. Kotek, H.: Degree relatives, definiteness and shifted reference. In: Kan, S., Moor-Cantwell, C., Staubs, R. (eds.) Proceedings of NELS. GLSA Publications, Amherst, MA (2011)
27. Grosu, Alexander, Landman, Fred: Strange relatives of the third kind. Nat. Lang. Semant. **6**(2), 125–170 (1998). https://doi.org/10.1023/A:1008268401837
28. Chierchia, G.: Reference to kinds across languages. Nat. Lang. Semant. **6**, 339–405 (1998). https://doi.org/10.1023/A:1008324218506
29. Borer, H.: In Name Only. Oxford University Press, Oxford (2005)
30. Zhu, D.X.: Yufa Jiangyi [Lecture Notes on Grammar]. Commercial Press, Beijing (1982)
31. Duanmu, S.: Wordhood in Chinese. In: Packard, J. (ed.) New Approaches to Chinese Word Formation: Morphology, Phonology and the Lexicon in Modern and Ancient Chinese, pp. 135–196. Mouton de Gruyter, New York & Berlin (1998)
32. Paul, W.: Adjectival modification in Mandarin Chinese and related issues. Linguistics **43**, 757–793 (2005). https://doi.org/10.1515/ling.2005.43.4.757
33. Sproat, R., Shih, C.: Prenominal adjectival ordering in English and Mandarin. Proc. NELS **18**, 465–489 (1988)
34. Lobeck, A.: Ellipsis: Functional Heads, Licensing and Ellipsis. Oxford University Press, New York (1995)
35. Zhu, D.X.: Shuo 'de' [On 'de']. ZhongguoYuwen, pp. 1–15 (1961)
36. Li, Y.-H.A.: Mandarin noun phrases with de from the perspective of Taiwan Southern Min. In: Studies of the Particle de in Chinese, pp. 181–196. Beijing University Press, Beijing (2017)
37. Huang, S.Z.: Property theory, adjectives, and modification in Chinese. J. East Asian Ling. **15**, 343–369 (2006). https://doi.org/10.1007/s10831-006-9002-0
38. Zhu, D.X.: Cong Fangyan he Lishi Kan Zhuangtai Xingrongci [Investigation of adjectives that describe temporary properties from a dialectal and diachronic perspective]. Fangyan, pp. 81–100 (1993)
39. Krifka, M., et al.: Genericity: an introduction. In: Carlson, G.N., Pelletier, F.J. (eds.) The Generic Book. University of Chicago Press, Chicago (1995)
40. Paul, W.: Adjectives in Mandarin Chinese: the rehabilitation of a much ostracized category. In: Hofherr, P., Matushansky, O. (eds.) Adjectives: Formal Analyses in Syntax and Semantics. John Benjamins Publishing Company, Amsterdam (2010)
41. Bolinger, D.: Adjectives in English: attribution and predication. Lingua **18**, 1–34 (1967). https://doi.org/10.1016/0024-3841(67)90018-6
42. Carlson, G.N.: A unified analysis of the English bare plural. Form. Semant. Essent. Readings **1**, 35–74 (2008). https://doi.org/10.1002/9780470758335.ch2