

Article

A Dynamic Typology of Adjectives: Measurement Theory and Syntactic Interaction

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Abstract

Traditional degree semantics approaches have aimed to pin down the inherent class of adjectives. This paper presents a novel dynamic perspective, where the classification of an adjective is dynamic and syntactically dependent. Using measurement theory and fuzzy set analysis, the proposed framework defines dynamic patterns of adjective classes with a set of axioms and integrates these patterns with syntactic structures to explain the flexibility and constraints observed in adjectival expressions. Employing Mandarin data, the paper illustrates how different syntactic constructions select specific adjective classes, thereby affecting their distribution and interpretation. This approach not only accommodates cross-linguistic variations but also provides a more comprehensive understanding of the semantics of adjectives.

Keywords: measurement theory; adjective taxonomy; fuzzy set

1. Introduction

Approaches to gradability and evaluativity have often treated adjectives with the precision of a jigsaw puzzle: each word is treated as a clearly defined piece with fixed shape, fitting neatly into syntactic structures that expect a certain form. In this view, adjectives are assigned fixed lexical properties of gradability and evaluativity, and their corresponding distribution and interpretation across syntactic environments are treated as lexical and deterministic (e.g., Schwarzschild [1], Kennedy and McNally [2], Breakstone [3]). While contextualist approaches acknowledge that meaning can vary with use (e.g., Rett [4], Rothschild and Segal [5]), the dynamic ways in which adjectives systematically shift interpretation across constructions are rarely treated as central to semantic composition.

Natural language shows that the reconfiguration of adjectival interpretation is the norm rather than the exception. Consider the adjective “tall”: in predication (e.g., “She is tall”), “tall” indicates the subject is relatively tall (evaluative). Meanwhile, in equatives (“She is as tall as Nancy”) or comparatives (“She is taller than Nancy”), the same adjective becomes neutral, as both individuals could, in fact, be short (non-evaluative). Charles Travis’s (1989) [6] example with “green” makes this point even sharper: even when syntax remains constant, the word sense can shift. “My maple leaves are green” can hold true for leaves painted green when referring to their appearance but false when judged by their ability to photosynthesize. Although the surface form ostensibly conveys the same message, its truth conditions shift depending on the context. Such observations align with Waismann’s (1945) [7] notion of language’s “open-texture,” where terms adapt to unforeseen cases in seemingly limitless ways.

Such variations are typically modeled as distinct lexicalized senses associated with different compositional patterns (e.g., [1,2]). Complementary pragmatic accounts instead



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appeal to inference or contextual indexing to derive interpretation variation (e.g., [3–5]). A related line of construction-based research (e.g., [8,9]) attributes such flexibility to conventionalized form–meaning pairings, where constructions themselves contribute interpretive content. Yet these approaches, though insightful, face limits. Lexical encoding alone cannot explain the productive flexibility with which adjectives shift meaning across syntactic environments, while unconstrained contextual or constructional reasoning risks overgeneration. Thus, what remains largely underinvestigated is the systematic relation among these contextually conditioned readings—how a single adjective can dynamically realign its scalar profile as it enters different syntactic environments.

Given above, this paper proposes a shift in perspective: from a jigsaw puzzle model of adjectives to a Tetris model. In Tetris, each piece starts off in a neutral, ambiguous orientation. It is not meaningful on its own until it enters a context—the falling grid—that constrains and determines how it must be positioned. Similarly, I argue that adjectives begin with scale potential, not fixed scale type. Their final interpretation—whether binary or gradient, ordinal or ratio—is shaped by syntactic structures that select or coerce specific orientations. This compositional interface model thus incorporates insights from both lexical and construction-based traditions while offering a unified account of how syntax regulates scalar interpretation in Mandarin and beyond.

This Tetris-like interaction between adjectives and syntax is formalized in a dynamic typology grounded in measurement theory [10] and fuzzy set semantics [11]. In the past decade, measurement theory has been applied in formal semantic analysis of adjectival constructions such as measure phrase distribution (e.g., *5 ft tall* vs. **5 lbs heavy*) [12], inter-adjective comparatives (e.g., *John is taller than Mary is smart*) [13], and differential comparatives (e.g., *5 inches taller*) [14]. Unlike previous approaches, rather than assuming adjectives come predefined with a measurement scale, the current framework models them as multifaceted and underdetermined until context determines the appropriate reading.

This paper addresses two questions in the semantic research of adjectives: How to determine the scale potential of an adjective in one language? What formal principles govern when and how adjectives shift between scalar types? To answer these, I propose two key principles: The Contextual Membership Principle (CMP) explains when an adjective can shift between binary (nominal) and gradient (non-nominal) interpretations based on context. The Hierarchical Precision Principle (HPP) licenses transitions across scalar types—ordinal, interval, and ratio—if such shifts reduce semantic vagueness or are required by compositional coherence. These principles combine to yield a formal, predictive model for understanding adjective interpretation across constructions and languages.

Mandarin Chinese provides an ideal testbed for this theory. Unlike English, Mandarin features overt syntactic distinctions (e.g., nominal predication vs. adjectival predication) that shape adjective interpretation. These constructions offer a clear view of: (1) how different syntactic forms promote various scalar interpretation of adjective, (2) which adjectives resist certain configurations due to lexical constraints? and (3) how metaphor or coercion can enable otherwise blocked combinations.

The paper proceeds as follows. Section 2 presents Mandarin and English syntactic data that motivate this dynamic view. Sections 3 and 4 introduce the formal measurement-theoretic framework and scale-shifting principles. Section 5 applies the theory to Mandarin, showing how syntax and semantics interact to yield preferred interpretations. While the paper primarily employs Mandarin data, the framework aims to account for universal generalities of adjectival expressions.

2. Syntactic Structures Can Change Semantic Scales

The observation that a single adjective can vary in interpretation depending on context is not new (e.g., [5,6,15,16]). Mandarin provides a typologically revealing case, as it exhibits a dedicated predicative structure for adjectives such as *zhong* ‘heavy’. This construction typically involves *hen* ‘very’, which is known as a bleached intensifier in predicative adjective constructions.¹ On the other hand, a distinct structure *shi...de* is employed for another group of modifiers such as *mutou* ‘wooden’. As shown by the contrast in (1), *mutou* ‘wooden’ is acceptable with *shi...de* (1a) but not *hen* (1b), whereas *zhong* ‘heavy’ only appears naturally with *hen* (1b).

- (1) a. zhe ba yizi shi {mutou/#zhong} de
this CL chair be wood/heavy de
Intended: ‘This chair is wooden/#heavy.’
b. zhe ba yizi hen {*mutou/zhong}
this CL chair very wood/heavy
Intended: ‘This chair is *wooden/heavy.’²

At first glance, the two constructions seem to mark distinct modifier types, echoing traditional accounts that classify *mutou* ‘wooden’ as a “distinguishing word” rather than an adjective ([18,19] a.o.). However, even within this tradition, Zhu (1982) [18] observed that *shi...de*-licensed “distinguishing words” are classificatory in meaning: they encode category membership rather than degree. As a matter of fact, similar combinations such as *very wooden* are likewise infelicitous in English. These cross-linguistic parallels point to the deeper semantic property of gradability, the capacity of a predicate to combine with degree morphology (e.g., *very*, *more*).³

The distributional contrast in (1) and (2) thus reveals that syntax interacts directly with gradability. Adjectives such as *xin* ‘new’ are acceptable with both constructions (2a). More importantly, the interpretation differs between the two sentences (2b). In the former, *xin* ‘new’ indicates binary membership, where a secondhand book cannot be considered new. In the latter, it denotes graded membership, where the secondhand book can be relatively new compared to other secondhand books.

- (2) a. zhe ben shu {shi xin de/hen xin}
this CL book {be new de/very new}
‘This book is new.’
b. zhe ben ershou shu {*shi xin de/hen xin}
this CL secondhand book {be new de/very new}
‘This secondhand book is new.’

In this light, Mandarin *shi...de* and *hen...de* can be seen as morphosyntactic reflections of two semantic types: non-gradable versus gradable. Moreover, similar context-dependent gradability alternations are found in English color adjectives [15], but Mandarin makes such alternations overtly visible in syntax, as in (2), demonstrating that syntactic structure can actively regulate scalar interpretation even for the same adjective.

The interaction between syntax and gradability thus illustrates how interpretive dimensions traditionally viewed as lexical can in fact be compositionally constrained. A parallel phenomenon involves evaluativity, which is the dependence of an adjective’s interpretation on a contextual standard. Like gradability, evaluativity interacts systematically with syntactic structure [3,4]. As shown in (3), *tall* in (3a) denotes a relation to a contextual standard (i.e., ‘taller than the contextual norm’), while it yields a neutral interpretation in (3b). However, this shift is not only syntactically conditioned but also lexically constrained, as *short* remains context-sensitive in the same construction (3c), where it implies that she is short. More interestingly, evaluativity exhibits a systematic correlation between its cancelability

(3b–3c) and an adjective’s syntactic distribution (e.g., *5ft tall* vs. **5ft short*) [25]. This pattern mirrors how the semantic dimension of gradability is encoded in Mandarin syntax as in (2).

- (3) a. She is tall. [Evaluative]
 b. She is as tall as her. [Non-evaluative]
 c. She is as short as her. [Evaluative]

Previous analyses have generally explained such flexibility within a static lexical framework, in which each adjective is associated with a fixed sense or a set of discrete senses that determine its syntactic distribution and interpretation. This view includes accounts of gradability framed in terms of lexical ambiguity (e.g., [2]) or homonymy (e.g., [1]), as well as analyses of evaluativity that treat the property as lexically inherent (e.g., [3]). Despite their differences, these approaches share the assumption that the distribution of gradability and evaluativity is determined by the adjective’s inherent lexical specification. Other proposals attribute interpretive variation to contextual parameterization (e.g., [5]) or pragmatic inference (e.g., [4]), yet the systematic relationship among these related senses remains unexplained.

Crucially, the flexibility of adjectival interpretation is not a free-for-all. While their meaning may appear context-sensitive or indeterminate, the range of shifts they undergo is systematic and constrained. For instance, sense shifts in gradability are not symmetric: shifting from a non-gradable to a gradable interpretation is marked, often requiring metaphor or contextual coercion (e.g., “very American” can only be interpreted in terms of cultural stereotype instead of nationality). This markedness is reflected in morphosyntax: gradable senses have extra morphosyntactic encoding—such as the degree modifier “very”—while non-gradable uses do not. Evaluativity shows a parallel asymmetry: non-evaluative readings are cross-linguistically marked and restricted to specific lexical items. Developmental data further support these markedness hierarchies: children acquire gradable and non-evaluative readings later than their unmarked counterparts (e.g., [26–28]).

Together, these facts suggest that adjective meanings are not merely polysemous but reflect structured conceptual hierarchies. Moreover, the cross-linguistic patterns shown with Mandarin and English data supports the Tetris view: adjectives begin as underdetermined in their distinct scalar profile, and syntactic constructions act as selection mechanisms that determine their interpretation. Some adjectives (e.g., *xin* “new”, *tall*) are rotatable across contexts, while others (like *mutou* “wooden”, *short*) are more rigid and only fit in specific syntactic frames (**hen mutou* “very wooden”, **5ft short*). In other words, syntax exerts selective pressure, and when an adjective’s semantic properties resist reorientation, the sentence becomes infelicitous.

Building on this, I propose that adjectives possess latent scale potentials that correspond to measurement-theoretic categories. Syntactic constructions and pragmatic goals select from these potentials, and adjectives must either align with the selected scale or undergo coercion (e.g., metaphor, reinterpretation) to fit. The remainder of the paper formalizes this hypothesis. Sections 3 and 4 introduces the taxonomy of scale types and truth-value systems that underlie these interpretations, along with two principles—CMP and HPP—that govern how and when scale shifts are licensed. Section 5 returns to the Mandarin data to show how these principles explain observed patterns of felicity and constraint in adjectival constructions.

3. Nominal Scale and Gradability: Axiom and Dynamics

Ever since the discussion by Stevens [10] on measurement scales of human response, measurement theory has served as a powerful framework for understanding how different kinds of data encode structure in psychology. This idea has been fruitfully extended by researchers such as Sassoon (2010) [12] and van Rooij (2011) [13] to the analysis of adjectives.

Within this framework, a core typological distinction among adjectives is between nominal and non-nominal scales, corresponding to the traditional contrast between non-gradable and gradable adjectives. Nominal adjectives denote category-like properties and are typically interpreted as non-gradable. These adjectives return binary truth values, exhibit morphosyntactic resistance to degree morphology, and align with entity-based conceptual structures. Non-nominal adjectives, by contrast, map entities to ordered or measurable degrees along a scale. This section presents the measurement-theoretic, morphosyntactic, and developmental motivation for distinguishing nominal-scale adjectives as a fundamental scale for adjectives within the broader typology of adjectival meaning.

3.1. Definition and Distinctiveness Axiom

In the measurement-theoretic framework, the contrast between gradable and non-gradable adjectives is captured by the distinction between nominal and non-nominal scales. Nominal-scale adjectives encode binary properties, corresponding to a semantic type $\langle e, t \rangle$, where truth is invariant across contexts. This is formalized by the proposed Distinctiveness Axiom, as defined below:

Distinctiveness Axiom. *is met iff for any x , if in some context C , $A_C(x) = t$, then for all contexts, $A_C(x) = t$, $t \in \{0, 1\}$.*

While the Distinctiveness Axiom captures the context-invariant, binary nature of nominal-scale adjectives, non-nominal scales depart from this behavior by allowing truth to vary continuously with degree and contexts. To formally represent this contrast in evaluation, I adopt a dynamic truth value evaluation model.⁴ In this framework, a proposition is true if its evaluation is a member of the set T_{pos} . For nominal scale predicates, truth values are binary; for non-nominal predicates, truth holds when the evaluated value succeeds or meets ($\succeq$) the contextual threshold τ , which may vary across speakers.

$$T_{pos} = \begin{cases} \{1\} & \text{if } t \text{ is binary} \\ \{t | t \succeq \tau\} & \text{if } t \text{ is continuous} \end{cases}$$

This scalar distinction naturally derives the gradability contrast: nominal scales, confined to binary truth evaluation, support only judgments that classify entities into unordered, discrete, contextually invariant categories, while non-nominal scales, defined over continuous degrees, support comparative and gradience operations.

The contrast between *wooden* and *happy* illustrates this difference (4) and (5): *wooden* systematically reject degree morphology, indicating compliance with the Distinctiveness Axiom and access to a nominal scale (4). In contrast, non-nominal *happy* readily admits degree morphology and comparative syntax (5).

(4) Nominal scale: *wooden*

- a. * The table is very wooden.
- b. # This table is more wooden than that one.
- c. # This table is as wooden as that one.⁵

(5) Non-nominal scale: *happy*

- a. The child is very happy.
- b. Alice is happier than Bob.
- c. Alice is as happy as Bob.

3.2. Scale Shift Between Nominal and Non-Nominal Scales

Although the nominality of adjectives is often treated as fixed, empirical evidence shows that some adjectives exhibit scale flexibility: they can participate in both categorical

and gradient interpretations, depending on syntactic environment and contextual inference. These shifts are not arbitrary, but follow systematic and asymmetric patterns.

The empirical asymmetry is formalized by the Contextual Membership Principle (CMP), which specifies when and how an adjective may shift between nominal and non-nominal interpretations.

Contextual Membership Principle (CMP): A change in the truth value type of an adjective is permissible if and only if one of the following conditions is met:

- *Nominal to Non-Nominal Shift:* If an adjective changes from nominal to non-nominal, there must be a contextual or lexical interpretation that induces gradient membership of the adjective (either through coercion or metaphor).
- *Non-Nominal to Nominal Shift:* If an adjective changes from non-nominal to nominal, there must be a context that supports a well-defined membership boundary.

When an adjective shifts from a nominal to a non-nominal scale, the interpretation must accommodate intermediate degrees of membership. Such shifts are typically achieved through coercion, where a reinterpretation is forced, or through metaphor, where a new meaning is assigned to the adjective that allows for degrees. For instance, the adjective *wooden* normally denotes a discrete material category. Yet in the Mandarin expression *hen mu* ‘very wooden’, it metaphorically describes slow-witted individuals, an interpretation that introduces gradience where the literal sense does not. Likewise, in the English phrase *a very wooden performance*, the adjective no longer refers to material composition but to the stiffness varying by degree, thereby shifting to a non-nominal scale. Similarly, the adjective *American*, which categorizes nationality with a binary truth value, can acquire a continuous, culturally construed interpretation in *This Canadian is very American*, where the property is evaluated along a sociocultural dimension rather than a categorical one.

By contrast, adjectives associated with non-nominal scales more readily support both scalar and categorical readings, provided that context or syntax licenses the shift: the adjective *new* implies a well-defined boundary when contrasted with *second-hand*. If *new* means ‘not existing before,’ the predicate yields a binary truth value. Similarly, the Mandarin adjective *gao* ‘tall’ usually operates on a non-nominal scale, indicating various degrees of height and rejecting the *shi...de* construction. Yet in comparison contexts, the taller of two entities may be classified as *gao* ‘tall’, establishing a sharp, invariant boundary for *gao* ‘tall’ and thereby license the nominal expression *shi gao de*. Such context-induced boundary formation is cognitively and morpho-syntactically less marked, reflecting a natural shift from gradient to categorical evaluation arises through contextual contrast (e.g., *new*) or comparison (e.g., *tall*).

3.3. Linguistic Prediction

This proposal predicts that adjectives can alternate between binary and gradable interpretations only when the syntactic environment or contextual inference licenses a compatible scale structure. Two falsifiable predictions follow:

- (a) **Selector Sensitivity:** An adjective shifts scale *iff* a *selector* (functional head or contextual/pragmatic cue) *demand*s the corresponding truth-type and the shift is CMP-licensed.
- (b) **Directionality Asymmetry:** Nominal to non-nominal shifts are marked and require additional interpretive work (e.g., coercion or metaphor), while non-nominal to nominal shifts occur naturally when contrastive or comparative contexts impose categorical boundaries.

Prediction (a) is borne out by the Mandarin example with *xin* ‘new’ in (1), where the adjective can in principle be associated with distinct truth types (i.e., binary and continuous) but the reading is syntactically determined rather than freely distributed.

The prediction (b) is consistent with observed cross-linguistic asymmetries: nominal-scale adjectives resist degree morphology (*#very wooden*, *#more wooden*) and coercing them into scalar environments often results in marked or metaphorical interpretations (e.g., *very wooden performance*, *very American*), while non-nominal ones can adopt categorical readings when boundary-defining contexts arise (*new* vs. *second-hand*). Over time, frequent coercion may yield lexicalized metaphorical senses (e.g., *so dead*, *very pregnant*), showing that CMP predicts both productive and conventionalized shifts.

3.4. Developmental Asymmetry

Developmental data further support the hierarchical and directional predictions of CMP. Evidence from language acquisition suggests that children initially interpret adjectives in non-relational, categorical ways, consistent with nominal scale structures. For example, young children grasp predication before employing intensifiers [29].

A hallmark of this developmental trajectory is overextension of comparative morphology for intensification. Even after acquiring the comparative form, children may use it for simple predication or intensification, as demonstrated in several studies (Clark 1970 [26]; Gathercole 1979, 1983 [30,31], as cited in Gathercole 2008 [29]). Example (6) illustrates this phenomenon, where the 4-year-old child uses “sweeter” to mean “sweet” in context.

(6) *Saul:4;3.15* (from Gathercole [29])

S: Sadie’s sweet, and I’m sweeter than her, and you’re sweeter than me, and Daddy’s sweeter than you.

M: Wow! *I just thought we were all sweet.*

S: *We are!* Didn’t you hear what I was saying? *We’re all sweeter!*

This reflects an intermediate phase where children recognize but have not yet distinguished scalar syntax from categorical meaning. These findings underscore the markedness of scalar interpretation, and the cognitive cost of constructing or acquiring a scalar structure. It thus corroborates the CMP hierarchy: nominal interpretation is developmentally primary, while gradable interpretation requires an additional representational layer that supports continuous evaluation. The directionality of acquisition mirrors the typological hierarchy predicted by the theory—nominal precedes non-nominal in both cognitive and morphosyntactic markedness.

4. Non-Nominal Scales and Evaluativity: Axioms and Dynamics

Building on prior measurement-theoretic analyses of adjectival meaning [12,13], this section addresses non-nominal scales each corresponding to a distinct degree structure that underlies gradable interpretation. These three scales capture the cross-linguistic variation in adjectival distribution and interpretation in constructions such as differential comparatives, ratio comparatives, and measure phrase modification [12,32]. The framework developed here further shows how these scale types naturally extend to explain evaluativity, that is, whether an adjective conveys a context-dependent or neutral interpretation.

Unlike the nominal scale, non-nominal scales are characterized by inherent ordering and can be modeled by a membership function according to fuzzy set theory. This paper focuses on two axioms from previous approaches using fuzzy set theory [11] to differentiate among these scale types. It also proposes a scale shifting rule that governs the dynamic change of non-nominal scales. This approach also highlights how scale dynamics associated with adjectives can be influenced by perceptual, cultural, and linguistic factors, supporting both cross-linguistic commonalities and differences.

4.1. Axioms with Non-Nominal Scales

Bilgiç and Türkşen (2000) [11] discuss the importance of two axioms in constraining fuzzy scale types: the Archimedean Axiom and the Bounded Axiom.

Archimedean Axiom is met iff for any $a, b \in A$ there exists a positive integer m such that $a^{(m)} \succ b$ where $a^{(m)}$ is recursively defined as $a^1 = a$, $a^{(m)} = a \oplus a^{(m-1)}$.

Bounded Axiom is met iff there exist u and e in A such that: for all $a \in A$, $u \succ e$, $u \precsim a$ and $a \precsim e$.

(cited from Bilgiç & Türkşen (2000) Appendix Definition 3 [11])

Archimedean Axiom states that for any two elements a and b in a set A , you can find a positive integer m such that applying a recursive binary operation to a m times will exceed b . For example, if a is 1 foot and b is 10 feet, adding 1 foot repeatedly will eventually surpass 10 feet. If this axiom is accepted, it allows for an interval scale where differences between elements can be meaningfully measured, it does not depend on whether the scale has a true zero point.

Bounded Axiom states that there exist two elements, u and e , in a set A , where u is an upper bound and e is a lower bound. For example, in a set of heights, u could be the tallest height and e the shortest. If the lower bound is satisfied, a ratio scale becomes available, allowing for meaningful measurements with a true zero point, enabling comparisons of absolute magnitudes, such as height and weight. The relationship between the two axioms and the scales is summarized in Table 1.

Table 1. Properties of Different Scales.

Scale	Archimedean	Lower Bounded
Ordinal	–	–
Interval	+	–
Ratio	+	+

The capacity of an adjective to satisfy the two axioms depends on three major factors:

- Perceptual Properties:** If an adjective denotes a mono-dimensional and visual property, visual stacking can support the Archimedean Axiom without relying on real numbers. e.g., stacking lengths or heights visually is straightforward compared to stacking loudness levels.
- Cross-Cultural Influences:** A more industrialized culture, or specific occupations within a culture, can provide more real number measurement systems (such as inches, Fahrenheit, or Celsius) that support the Archimedean and Bounded Axioms. Real numbers can easily support recursive functions and sometimes include zero, facilitating precise measurements.
- Linguistic Integration:** The introduction of a measurement system to a society can lead to the creation or incorporation of new lexical items, resulting in cross-linguistic effects. e.g., both *leng* ‘cold’ and *di* ‘low’ can describe perceptual temperature in Mandarin, but only *di* ‘low’ satisfies the Archimedean Axiom. In contrast, in English, both *cold* and *low* are acceptable for describing temperature differences, highlighting a cross-linguistic difference induced by lexical idiosyncrasy. This distinction is illustrated by the awkwardness of using *leng* ‘cold’ but the acceptability of *colder* in the following sentence:

- (7) jintian bi zhousan {**leng/di*} wu du.
 today compare Wednesday {*cold/low*} 5 degrees.
 ‘Today(’s temperature) is 5 degrees {*colder/lower*} than Wednesday.’

4.2. Scale Shifting with Non-Nominal Scales

Analyses of non-nominal adjectives divide between comparison-class approaches [33,34] and degree-based accounts. The latter motivated by constructions that quantify over degrees such as differential comparatives and measure phrases modification [35–37]. However, degree-based analyses also raise a foundational issue of whether degrees should be treated as primitive [38]. The contrast between these approaches reveals an underlying hierarchy of precision in adjectival interpretation, ranging from qualitative comparison to quantitative measurement. The present approach shows that a measure-theoretic framework may reconcile this tension by associate measurement scales to adjectival interpretations dynamically.

Following Van Rooij [39], the present account assumes that scale type determines the precision with which degree operations can be made, and that fuzziness corresponds to tolerance zones where small differences are not discriminated. This paper proposes a Hierarchical Precision Principle (HPP), which adds a dynamic component: rather than treating scale type as fixed, it models how syntactic and pragmatic factors can trigger scale strengthening when required for interpretation. The HPP licenses shift to a stronger measurement scale if it can reduce fuzziness or be required for semantic coherence, provided that a stronger scale is available. In this hierarchy, ratio scales are considered stronger than interval scales, which in turn are stronger than ordinal scales. The availability of these scales is determined by the Archimedean Axiom and the Bounded Axiom, as detailed in the preceding section.

Hierarchical Precision Principle (HPP): a scale shift is permissible iff both of the conditions below are met:

- At least one stronger, more precise scale is available;
- The shift must reduce fuzziness of the proposition or is required by semantic coherence of the proposition.

Following Takeuti and Titani [40], fuzziness can be understood as the degree of indeterminacy at the boundary of a predicate's positive truth region $T_{pos} = \{t \mid t \lesssim \tau\}$. It characterizes how sharply truth values separate just above and below the threshold: the smoother or flatter this transition, the greater the fuzziness. Two mechanisms naturally reduce fuzziness.

First, by the Archimedean property, any weak order $\lesssim$ on A admits a numerical representation $d : A \rightarrow \mathbb{R}$. The truth region $T_{pos} = \{t \mid t \lesssim \tau\}$ can therefore be expressed as a numerical cut $d \geq \theta$. Under a purely ordinal comparison, the boundary between true and false cases is determined only by order precedence, leaving a wider set of borderline instances whose status at τ is indeterminate. When the same relation is mapped onto an interval scale, each t can be distinguished from τ by a measurable difference $d - \theta$, reducing that zone of indeterminacy. This means the ordinal relation exhibits greater fuzziness, while the interval comparison with a sharper numerical boundary corresponds to a crispier set with lower fuzziness.

Second, eliminating a contextual threshold further reduces fuzziness. If τ varies with discourse or comparison class, the effective boundary of T_{pos} fluctuates across contexts, widening the uncertain region. Replacing τ with a fixed or absolute standard (e.g., zero) collapses this variability, narrowing the boundary zone and yielding a crisper truth partition. The HPP application below formally describes the operations of fuzziness reduction.

HPP Application: If HPP is applied, then the continuous truth value t is overridden by the stronger scale, reducing fuzziness. Specifically:

- If shifted to interval scale, t is saturated by d and τ mapped to degree threshold θ .
- If shifted to ratio scale, t is saturated by 1 and $t > \tau$ set to $|I| > 0$.

4.3. Linguistic Prediction

The axioms and HPP together yield three general predictions about how scale structure and fuzziness reduction determine the distribution of gradable adjectives.

- (a) Scale hierarchy per adjective: Each adjective encodes a set of admissible scale types determined by the axioms: If the Archimedean Axiom holds, an interval scale is licensed; if the Bounded Axiom additionally holds, a ratio scale becomes available; otherwise, only an ordinal scale is accessible. In other words, the hierarchy is implicational: access to a higher scale entails access to all lower scales.
- (b) No downward shifts: Within a proposition, a scale can only move up the hierarchy (from ordinal to interval to ratio). Downward shifts are never licensed. Once a higher scale is required, reinterpreting the adjective on a weaker one is blocked because the weaker scale cannot satisfy the compositional requirements of the structure. This predicts a compatibility-based distribution: expressions selecting stronger scales will exclude adjectives whose denotation provides only weaker ones.
- (c) Scale-activation prediction: An adjective's interpretation activates the weakest scale sufficient for compositional coherence. A shift to a stronger scale (interval or ratio) occurs only if it reduces fuzziness—that is, if the stronger scale provides a measurable degree or an absolute standard that sharpens the truth boundary of the proposition.

Prediction (a–b) jointly derives the empirical distribution patterns in (8–10). As predicted, adjectives differ in the highest scale type they admit: *happy* (8) supports only an ordinal interpretation, *short* (9) extends to interval but not ratio, and *tall* (10) allows access to all three. Downward reinterpretation, which uses a weaker scale in a context that requires a stronger one, results in infelicity (8b, 8c, 9c). This pattern follows directly from the measurement-theoretic axioms. Differential comparatives such as *1.3 degrees happier* require a numerically defined difference, licensed only by the Archimedean Axiom; since *happy* fails to satisfy this axiom, such expressions are ill-formed. Likewise, ratio comparatives such as *2.5 times shorter/taller* presuppose a true zero point, as specified by the Bounded Axiom; adjectives like *short*, which support only interval scales, lack this lower bound and are therefore excluded. Only adjectives like *tall* that satisfy both axioms can appear across ordinal, interval, and ratio contexts. This alignment illustrates how the Archimedean and Bounded Axioms jointly constrain the admissibility of adjectives in comparative constructions, yielding the observed hierarchy of felicity.

(8) *happy*: {ordinal}⁶

- a. Alice is happy.
- b. # Alice is 1.3 degrees happier than Bob.
- c. # Alice is 2.5 times happier than Bob.

(9) *short*: {ordinal, interval}

- a. Alice is short.
- b. Alice is 1.3 feet shorter than Bob.
- c. # Alice is 2.5 times shorter than Bob.

(10) *tall*: {ordinal, interval, ratio}

- a. Alice is tall.
- b. Alice is 1.3 feet taller than Bob.
- c. Alice is 2.5 times taller than Bob.

Similarly, the prediction (a) and (c) jointly yield the interpretive contrasts in (3) (repeated below in (11)). In (11a), the simple positive relies on a contextual threshold τ whose value is left undetermined. Because this contextual uncertainty does not support a clear

numerical comparison, HPP thus does not license a shift to a stronger scale. The adjective therefore remains at the ordinal level, yielding an evaluative interpretation. In (11b), the equative introduces an explicit standard of comparison, eliminating contextual dependence and allowing fuzziness reduction. This supports a shift to an interval scale, where equality can be metrically defined. Since *tall* also satisfies the Bounded Axiom, further application of HPP permits a shift to the ratio scale, removing residual contextual dependence and producing a non-evaluative reading. In (11c), however, *short* fails the Bounded Axiom, as there is no natural zero for “shortness.” The equative in (11c) cannot access a ratio scale, so the interpretation remains context-sensitive. The observed evaluativity asymmetry thus follows as a corollary of the general scale-selection and fuzziness-reduction dynamics imposed by the axioms and HPP.

- (11) a. She is tall. [Evaluative]
 b. She is as tall as her. [Non-evaluative]
 c. She is as short as her. [Evaluative]

These patterns neatly capture polarity asymmetries in evaluativity [4,15,16]. Positive members of antonym pairs (e.g., *tall*) often align with ratio scales, where zero provides a natural lower bound; negative members (e.g., *short*) lack such a bound and thus exhibit greater fuzziness and stronger evaluative bias. The Bounded Axiom therefore supplies a principled, scale-based account of evaluativity effects traditionally attributed to polarity distinctions.

4.4. Developmental Asymmetry

The *ordinal–interval–ratio* distinction reflects a hierarchical structure of scales, which also emerges in developmental patterns of adjective understanding. For instance, young children often first interpret adjectives evaluatively, even in contexts where adult language uses them non-evaluatively, before developing a neutral understanding [29]. For example, children as young as two years old struggle to comprehend the neutral reading of equatives. In (12), the 2-year-old misinterprets “as big as” to mean that Ernie is simply *big*, rather than understanding the comparative neutrality intended. This suggests that the neutral interpretation develops at a later stage than the evaluative reading.

- (12) *Sally:2;4.17* (from Gathercole [29])

[Mother talking for Ernie, who is about 5 inches tall]

M: I can’t write anything with that pen. *It’s twice as big as I am!*

S: *No, you’re little.*

This developmental pattern supports the theoretical hierarchy: evaluative (ordinal) readings are cognitively primary, while non-evaluative (interval/ratio) interpretations require later-acquired notions of precision and boundedness.

5. Mandarin Case Study: Syntactic Structure and Scale Dynamics

Having established that (1) different scales license distinct operations, which are syntactically realized as compatibility across different constructions, and that (2) CMP and HPP jointly predict which interpretation is rendered in a given syntactic environment, we now turn to Mandarin Chinese as a test case.

This section applies the proposed dynamic scale approach to Mandarin, illustrating the framework’s predictions through type-based analysis. Despite focusing on Mandarin, the principles of scale dynamics (Section 3) and semantic types here are applicable across languages, highlighting the framework’s universal relevance.

5.1. Typology of Mandarin Adjectives

This case study selects seven morphosyntactic environments that correspond to specific operations on scales. These serve as tests for the availability of a given scale potential as well as probes to illustrate how CMP and HPP regulate coercion, context constraints, and fuzziness.

(13) a. Predication	<i>shi mutou de</i> be wooden de	'is wooden'
b. Implicit equative	<i>yiyang shi mutou de</i> same be wooden de	'both wooden'
c. Bare comparative	<i>bi ta gao</i> compare her tall	'taller than her'
d. Explicit equative	<i>yiyang gao</i> same tall	'equally tall'
e. Intensifier	<i>hen gao</i> very tall	'very tall'
f. Differential comparative	<i>gao 5 mi</i> tall 5 meter	'5 meter taller'
g. Measure phrase modification	<i>5 mi gao</i> 5 m tall	'5 m tall'

Table 2 summarizes the adjectives discussed in this section, their lexical scale potentials under Measurement Theory, and the syntactic diagnostics that test those potentials. This table directly integrates the theoretical scale hierarchy with empirical diagnostics.

Table 2. Scale types, Measurement-theoretic properties, and corresponding Mandarin diagnostics.

Scale	Axioms Satisfied	Syntactic Diagnostics	Example
Nominal	Distinctiveness	Predication Equative (Implicit)	<i>mutou</i> 'wooden'
Ordinal	–	Intensifier Bare comparative Equative (Explicit)	<i>gaoxing</i> 'happy'
Interval	Archimedean	Differential comparative	<i>ai</i> 'short'
Ratio	Archimedean, Bounded	Measure phrase modification	<i>gao</i> 'tall'

5.2. Case Analyses by Adjective Class

Each subsection below examines how a given adjective's lexical scale potential interacts with these diagnostics. The analysis also shows that classical properties such as gradability and evaluativity, along with coercion and contextual shift naturally follow from the measurement-theoretic hierarchy and the CMP/HPP principles.

5.2.1. Nominal Scale

Nominal scales permit categorization, which is the fundamental operation of classifying entities into discrete sets without ordering or gradience. In Mandarin, such operations are reflected by the *shi...de* construction, which contrasts sharply with the morphosyntax of non-nominal scales (see Section 2). The syntactic marking thus directly signals the type of truth-value evaluation the adjective supports. Formally, *shi* 'be' selects a function from entities to binary truth values. For example, *mutou* 'wooden' denotes a binary predicate on a nominal scale, yielding categorical truth values:

- (14) a. $\llbracket \text{mutou} \rrbracket = \lambda x. \text{mutou}(x)$
 b. $\llbracket \text{shi} \rrbracket = \lambda G_{\langle e, t \in \{0,1\} \rangle}. \lambda x. G(x) \in T_{pos}$
 c. $\llbracket \text{shi mutou de} \rrbracket = \lambda x. \text{mutou}(x) = 1$

Here, the equative construction, by introducing the positive truth set T_{pos} , correctly yields a binary truth value for the equative, effectively producing an implicit equative construction.⁷ This is formalized below with the Mandarin morpheme *yiyang* ‘same’.

- (15) a. $\llbracket \text{yiyang} \rrbracket = \lambda G. \lambda S. \exists v \in T. [x \in S \rightarrow G(x) = v]$
 b. $\llbracket \text{yiyang shi mutou de} \rrbracket = \lambda S. \exists v \in \{1\}. [x \in S \rightarrow \text{mutou}(x) = v]$
 $= \lambda S. \forall x \in S, \text{mutou}(x) = 1$ [Implicit equative]

Because the predicate operates over a discrete truth domain, it is incompatible with operators that select gradient (continuous) inputs. For instance, intensifiers like *feichang* ‘extremely’ require a continuous truth value between 0 and 1, and thus fail to combine with nominal predicates. Following empirical findings by Hersh and Caramazza [42], a power term is associated with intensifiers that reflects their hierarchical order (e.g., *super* > *very* > NULL > *slightly* in English). Higher power indicates a higher rank in the intensifier hierarchy and increases the slope of the measurement function.⁸

- (16) $\llbracket \text{feichang} \rrbracket = \lambda G_{\langle e, t \in [0,1] \rangle}. \lambda x. G^2(x) \in T_{pos}$

Since nominal predicates cannot supply a $[0, 1]$ -valued input, CMP predicts coercion when a nominal adjective is embedded in a scalar environment. This prediction is borne out by the Mandarin adjective *mutou* ‘wooden’, which undergoes metaphorical reinterpretation when modified by *feichang*, yielding *mu* ‘slow-witted’. The coercion involves both a semantic shift (from material property to cognitive disposition) and a morphological reduction (loss of the second syllable), signaling the activation of a non-nominal scale.

- (17) a. $\text{CMP}(\llbracket \text{mu} \rrbracket) = \lambda x. \text{mu}(x)$
 b. $\llbracket \text{feichang mu} \rrbracket = \lambda x. \text{mu}^2(x) \in T_{pos} = \{t | t \gtrsim \tau\}$
 $= \lambda x. \text{mu}^2(x) \gtrsim_{\text{slow-witted}} \tau$

Overall, nominal adjectives such as *mutou* are licensed in *shi...de* constructions but resist degree morphology unless coerced. Under coercion, they yield non-literal or metaphorical readings consistent with CMP.

5.2.2. Ordinal Scale

Ordinal scales introduce ordering among entities without specifying measurable distance. They permit comparative judgments without implying additive or ratio-based operations. This scale type thus licenses operations such as comparison and equality, but not measurement.

In Mandarin, ordinal relations are expressed through constructions such as bare comparatives and explicit equatives, both of which are compatible with ordering even no numerical quantification is granted. Unlike nominal scales, which merely categorize, ordinal scales evaluate relative ranking of entities, yielding fuzzy but ordered truth values within $[0, 1]$. Formally, bare comparative is formalized with a COMP morpheme (realized in English as *-er*), which defines a precedence relation between two entities along a perceptual or numerical ordering:

- (18) $\llbracket \text{Adj-COMP} \rrbracket = \lambda y. \lambda x. G(x) \gg G(y), \ggg := \begin{cases} \succ_G & \text{if } G_{\langle e, t \in [0,1] \rangle} \\ >_G & \text{if } G_{\langle e, d \rangle} \end{cases}$

Consider the adjective *gaoxing* ‘happy’, which typically realizes an ordinal scale. Bare comparatives such as *Zhangsan bi Lisi gaoxing* ‘Zhangsan is happier than Lisi’ express a relative ordering of happiness values without numerical precision, consistent with the ordinal type.

$$(19) \llbracket \text{gaoxing-COMP} \rrbracket = \lambda y. \lambda x. \text{gaoxing}(x) \succ_{\text{happy}} \text{gaoxing}(y)$$

The equative construction *yiyang gaoxing* ‘equally happy’ likewise denotes that both subjects under comparison are evaluated as having the same extent of happiness, that is, they occupy the same position on the ordinal scale.

$$(20) \llbracket \text{yiyang gaoxing} \rrbracket = \lambda S. \exists v \in \{t \mid t \succ \tau\}. [x \in S \rightarrow \text{gaoxing}(x) = v] \\ = \lambda S. \exists t \succ \tau. \forall x \in S, \text{gaoxing}(x) = t \quad [\text{Explicit equative}]$$

Crucially, ordinal scales cannot support differential comparatives or measure phrase modification, as such operations presupposes a metric structure with additive differences, which are available only at the interval or ratio level. The incompatibility arises as a type mismatch between the expected interval argument of the measure phrase and the truth-value type of the ordinal predicate. This analysis follows Schwarzschild [1], where measure phrases are analyzed as predicates of intervals.

$$(21) \llbracket 5 \text{ ft} \rrbracket = \lambda I. |I| = 5 \text{ ft}$$

Here, as measure phrases denote predicates of intervals, they require a semantic domain that supports additive measurement. For an ordinal predicate G , however, the comparative interval $[t_x, t_y]$ is not well defined, as ordinal scales encode only ordering, not numerical distance. Consequently, differential comparatives are undefined. Likewise, direct measure phrase modification fails, since a single truth value t_x does not support any interval-based measurement. The mismatch thus correctly rules out sentences such as **wu du gaoxing* ‘5 degrees happy’ and **gaoxing wu du* ‘5 degrees happier’.

Yet, ordinal adjectives can surface with nominal-like interpretations in predicative contexts, when contrastive structure licenses a categorical reading in accordance with CMP. Such reinterpretation arises even in the absence of overt comparative morphology. As discussed in Sections 2 and 3, the adjective *xin* ‘new’ typically realizes an ordinal scale, supporting graded evaluations such as ‘relatively new’. However, in contrastive contexts, it can be coerced to a nominal scale, yielding a binary interpretation (‘not existing before’). This shift exemplifies how contextual contrast can trigger a CMP-regulated reduction from an ordinal to a nominal reading, effectively collapsing gradient membership into categorical classification.

$$(22) \quad \text{a. } \llbracket \text{shi xin de} \rrbracket = \lambda x. \text{xin}(x) = 1 \\ \quad \text{b. } \llbracket \text{feichang xin} \rrbracket = \lambda x. \text{xin}^2(x) \succ_{\text{new}} \tau$$

In summary, ordinal scales support ordering but not quantification. They license bare comparative and explicit equative constructions but exclude differential comparatives and measure phrases. The Mandarin data demonstrate how these distinctions manifest syntactically and compositionally, providing a direct reflection of the operations licensed at the ordinal level.

5.2.3. Interval Scale

Interval scales introduce measurable differences between ordered points while lacking a true zero point. They extend the ordinal relation by adding the capacity to evaluate the differences between degrees, allowing judgements about how much greater one value is than another. Accordingly, differential comparison are licensed at this level.

A *DIFF* morpheme is proposed to represent the operation that derives a measurable interval between two degrees. Adjectives with access to interval scales satisfy the Archimedean Axiom, which ensures that such differences can be recursively added and compared. This makes differential comparatives (e.g., *5 ft taller*) compositionally well-formed, as both the adjective and the measure phrase denote compatible types. In Mandarin, this *DIFF* morpheme can be overtly realized as *chu*, as in *gao chu 4 cm* ‘4 cm taller’.

The measure phrase applies directly to the closed interval created by the adjective's DIFF operator, yielding a well-typed composition:

- (23) a. $\llbracket \text{Adj-DIFF} \rrbracket = \lambda y. \lambda x. [G(x), G(y)]$
 b. $\llbracket 5 \text{ ft} \rrbracket (\llbracket ai\text{-DIFF} \rrbracket) = |[d_x, d_y]| = 5 \text{ ft}$

Adjectives that can access interval scales also appear in other degree constructions, though with varying structural requirements. Because of the scale hierarchy, they can freely occur in expressions requiring only ordinal operations, such as bare comparatives or equatives, while the reverse does not hold: adjectives confined to ordinal scales cannot appear in environments that demand interval or ratio structures without coercion. This asymmetry extends naturally to measure-phrase modification, which imposes the strongest requirement in the hierarchy. While differential comparatives depend on a defined difference $\llbracket [G(x), G(y)] \rrbracket$, measure phrase modification (e.g., *5 ft tall*) presuppose a true zero point that allows absolute measurement. On an interval scale, $\llbracket [G(x), G(y)] \rrbracket$ is defined but $|G(x)|$ is not, producing a type mismatch when the measure phrase expects a ratio-scale argument $\langle e, 1 \rangle$ but the adjective provides only an interval type $\langle e, d \rangle$. The unacceptability of forms such as **5 m ai '5 m short'* thus follows, as measure-phrase modification selectively identifies adjectives with true ratio-scale structure.

Adjectives with interval-scale potential exhibit context-sensitive behavior. In intensifier constructions, they surface with ordinal readings because the contextual standard is unspecified; moving to an interval interpretation would not reduce fuzziness when no numerical standard is defined. In comparatives and equatives, however, adjectives that admit a metric (e.g., *ai 'short'*) can shift to an interval structure and compare degree differences; adjectives confined to ordinal structure (e.g., *gaoxing 'happy'*) cannot. When a comparative remains ordinal, it retains contextual dependence, since the ordering is defined only within a given domain (e.g., "x ranks above y in happiness"). This explains why expressions such as *happier than* imply evaluativity: they presuppose a contextual standard. By contrast, when an adjective accesses an interval scale, the comparison is mapped onto a numerical metric with no strict domain restriction (e.g., any extent of shortness can be mapped to a real value) and is no longer tied to a contextual benchmark. Consequently, *shorter than* permits a neutral interpretation, where both individuals may be tall but differ in measurable degree.

- (24) a. $\llbracket feichang \text{ ai} \rrbracket = \lambda x. ai^2(x) \lesssim_{short} \tau$
 b. $\llbracket ai\text{-COMP} \rrbracket = \lambda y. \lambda x. d_x >_{short} d_y$

In equatives, *ai* can fix equality at a specific degree (interval), but because the equative introduces the positive truth set T_{pos} , the construction remains context-sensitive, presupposing a positive relation to the contextual threshold θ .

- (25) $\llbracket yiyang \text{ ai} \rrbracket = \lambda S. \exists v \in \{d \mid d \geq \theta\}. [x \in S \rightarrow ai(x) = v]$
 $= \lambda S. \exists d \geq_{short} \theta. \forall x \in S, ai(x) = d$ [Evaluative]

In all, interval-scale adjectives such as *ai 'short'* participate freely in differential comparatives, while remaining compatible with weaker, ordinal environments. Their ability to alternate between context-dependent and metrically defined interpretations reflects the flexibility predicted by HPP: interval access licenses numerical comparison when required, yet permits ordinal readings in fuzzier contexts.

5.2.4. Ratio Scale

Ratio scales constitute the strongest type of measurement structure, defined by the presence of a true lower bound and the possibility of expressing proportional relations between quantities. The existence of a zero point eliminates the residual fuzziness that

remains at the interval level, permitting operations such as absolute measurement and ratio comparison. In linguistic terms, ratio scales provide the semantic foundation for constructions that explicitly quantify magnitude differences such as measure phrase modification.

$$(26) \quad \llbracket 5 \text{ ft} \rrbracket(\llbracket gao \rrbracket) = \llbracket 1 \rrbracket = 5 \text{ ft}$$

Because *gao* ‘tall’ can access a ratio scale, its interpretation varies systematically with the demands of the selector, as predicted by HPP. In intensifier constructions such as *feichang gao* or *hen gao*, the contextual threshold τ remains underspecified. Since shifting to a higher scale would yield no reduction without a fixed standard of fuzziness and risks truth triviality: on a ratio interpretation, asserting that one’s degree of tallness exceeds zero would always be true. HPP therefore keeps *gao* at the ordinal level, where the truth value depends on a fuzzy, context-sensitive boundary, producing an evaluative reading. In comparatives such as *Zhangsan bi Lisi gao* ‘Zhangsan is taller than Lisi’, HPP licenses a shift to the interval level, where additive comparison becomes possible and reduces fuzziness. In equatives such as *yiyang gao* ‘equally tall’, equality among positive degrees still involves contextual dependence unless the scale is anchored at zero. Because *gao* satisfies the Bounded Axiom, HPP permits a further shift to the ratio level, eliminating contextual variability and yielding a neutral, non-evaluative interpretation. The same ratio structure also underlies measure-phrase constructions like *5 m gao* ‘5 meters tall’, where absolute magnitude is compared relative to a true zero. Thus, the interpretive range of *gao* follows directly from HPP’s principle of minimal sufficient scale selection: ordinal when the threshold is undetermined, interval when metric comparison is preferred, and ratio when compositional coherence or absolute measurement demands it. Formally, these interpretations can be represented as follows:

$$(27) \quad \begin{aligned} \text{a. } \llbracket feichang \text{ } gao \rrbracket &= \lambda x. gao^2(x) \lesssim_{tall} \tau \\ \text{b. } \llbracket gao\text{-COMP} \rrbracket &= \lambda y. \lambda x. d_x >_{tall} d_y \\ \text{c. } \llbracket yiyang \text{ } gao \rrbracket &= \lambda S. \exists v \in \{1 \mid |1| \geq 0\}. [x \in S \rightarrow gao(x) = v] \\ &= \lambda S. \exists 1. |1| \geq 0. \forall x \in S, gao(x) = 1 \quad \text{[Non-evaluative]} \end{aligned}$$

Ratio-scale adjectives such as *gao* ‘tall’ thus display the full range of scale activation predicted by HPP. They appear evaluatively in ordinal environments, metrically in comparatives, and neutrally in equatives or measure phrase constructions. Their ability to satisfy both the Archimedean and Bounded Axioms allows seamless participation across all degree constructions, making ratio-scale adjectives the most compositionally versatile in the hierarchy.

5.3. Mandarin Case Study Summary

This subsection summarizes the empirical results of the Mandarin case study and connects them explicitly to the theoretical predictions of the measurement-theoretic scale hierarchy and the type shifting rules, CMP and HPP.

The dichotomous division between binary and continuous truth, as determined by syntactic selection, is correctly borne out. As shown in Table 3, nominal constructions (e.g., predication) select nominal-scale adjectives, whereas non-nominal constructions (e.g., intensifiers, comparatives) select non-nominal scales, as predicted by the CMP. Additionally, the HPP predicts that only adjectives with sufficiently strong measurement structures can occur in constructions that explicitly quantify difference. This is likewise supported by the Mandarin data in Table 3. Differential comparatives and measure-phrase modifications act as the most stringent selectors, as both presuppose arithmetic operations over measurable intervals. Differential comparatives, defined by a difference function, require at least an interval scale satisfying the Archimedean Axiom, while measure phrases

additionally demand a true lower bound, corresponding to the Bounded Axiom. The observed pattern aligns precisely: *gaoxing* ‘happy’ (ordinal) is excluded from both, *ai* ‘short’ (interval) appears only in differential comparatives, and *gao* ‘tall’ (ratio) occurs freely in both. These results confirm that scale strengthening proceeds upward, triggered only when required by the selector, while downward shifts are blocked because weaker scales cannot meet the compositional requirements of explicit measurement.

Table 3. Distribution of adjectives regulated by scale structure compatibility.

	<i>mutou</i> ‘Wooden’	<i>gaoxing</i> ‘Happy’	<i>ai</i> ‘Short’	<i>gao</i> ‘Tall’
Predication		#	#	#
Intensifier	#/*			
Bare Comp.	*			
Diff. Comp.	*	*		
MP modif.	*	*	*	

CMP predicts the observed contrasts between nominal and gradable predication. As summarized in Table 4, syntactic selectors such as *shi* and intensifiers (*hen*, *feichang*) determine the required truth-type, and adjectives align with or adjust to these requirements according to their lexical scale potential. The contrast between *mutou/mu* and *xin* illustrates CMP’s directionality asymmetry: *mutou* ‘wooden’ undergoes marked coercion to form *mu* ‘slow-witted’ in a Nominal-to-Non-nominal shift, while *xin* ‘new’ flexibly alternates between categorical (*shi xin de*) and graded (*hen xin*) readings. These patterns confirm that syntactic selection and lexical semantics jointly constrain permissible scale shifts, as predicted by CMP.

Table 4. Dynamics of adjectives with predication and intensifier.

	<i>mutou/mu</i>	<i>xin</i>
Predication	<i>mutou</i> /* <i>mu</i> ‘wooden’	‘not existing before’
Intensifier	* <i>mutou</i> / <i>mu</i> ‘slow-witted’	‘recently’

HPP further predicts that adjectives strengthen their underlying measurement scales only when doing so reduces semantic fuzziness or is required for compositional coherence. As shown in Table 5, the Mandarin data conform to this prediction. Bare comparatives, which express ordering relations, remain ordinal with *gaoxing* ‘happy’ but shift to an interval interpretation with *ai* ‘short’ and *gao* ‘tall’, where additive measurement becomes available. Equatives display a further hierarchy: *gaoxing* retains contextual vagueness on the ordinal scale, *ai* achieves equality at a defined interval degree, and *gao* accesses a ratio scale, yielding non-evaluative readings through its lower bound. Intensifiers, in contrast, require only continuity and therefore stay at the minimal sufficient scale. Overall, the Mandarin patterns confirm that HPP accurately predicts how syntactic environments promote stronger scales only when such shifts reduce interpretive indeterminacy.

Table 5. Interpretation of adjectives with intensifier, bare comparative, and explicit equative.

	<i>gaoxing</i>	<i>ai</i>	<i>gao</i>
Intensifier	$A^e(x) \succsim \tau$	$A^e(x) \succsim \tau$	$A^e(x) \succsim \tau$
Bare Comp.	$A(x) \succ A(y)$	$A(x) > A(y)$	$A(x) > A(y)$
Explicit Equa.	$A(x) \rightarrow t$	$A(x) \rightarrow d$	$A(x) \rightarrow I$

The Mandarin case study provides a clear empirical instantiation of the proposed dynamic typology. CMP and HPP together predict the observed distributional hierarchy

linking syntactic selectors to scale activation. As shown across Tables 3 and 4, the interaction between morphosyntax and lexical scale potential in Mandarin mirrors the model's theoretical architecture. CMP accounts for the directionality of scale shifts in predicative contexts, distinguishing categorical predication with *shi* from graded predication with intensifiers, while HPP captures the systematic strengthening of scales in degree constructions. The gradation from *gaoxing* 'happy' (ordinal) to *ai* 'short' (interval) and *gao* 'tall' (ratio) illustrates the full scale hierarchy predicted by the framework: each adjective appears only in the syntactic environments its accessible scale can support. The Mandarin data therefore not only exemplify but independently support the model's core claim: the scale selection is compositionally determined by the interaction between syntactic requirements and lexical measurement potential.

6. Conclusions

By leveraging measurement theory and fuzzy set analysis, this paper has demonstrated how syntactic structures can dynamically interact with adjectives scales, shaping the distribution and interpretation of adjectives among these expressions. While the focus is on Mandarin, the paper argues that the principles of scale dynamics and the type-based compositional analysis are applicable to other languages. This broader applicability is supported by discussing potential cross-linguistic variations and the universal relevance of the proposed framework as a robust theoretical tool. Future research can extend this approach to other languages.

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Abbreviations

The following abbreviations are used in this manuscript:

CL	Classifier
CMP	Contextual Membership Principle
HPP	Hierarchical Precision Principle

Notes

- ¹ See Grano (2012) [17] for detailed discussion.
- ² The cautious reader may notice the distinction between # and * in (1a) and (1b). This reflects the fact that *zhong* 'heavy' in (1a) is acceptable in a focal or contrastive context, whereas *mutou* 'wooden' requires coercion to combine with the modifier *hen*, and the coerced interpretation ('slow-witted') is restricted to human subjects. This observation is elaborated in Section 3.2, where context-driven scale shifts and coercion are discussed in detail.
- ³ See Zhu [18], Lin and Peck [19], Lü and Rao [20], Paul [21] for traditional classifications of *mutou*-type modifiers as distinguishing words or non-predicative adjectives. The present paper follows Morzycki [22] and others in treating gradability as independent of syntactic category (cf. [15,22–24]) and therefore refers to such modifiers as adjectives for simplicity.
- ⁴ There are well-developed methods for representing multiple truth values (e.g., possible worlds, modality). For simplicity, this paper uses the current denotation, which should be compatible with other models of multiple truths.
- ⁵ Here, # is used in (4b) and (4c) as *wooden* may be accepted by some speakers in a coerced 'material-composition' context.
- ⁶ I acknowledge that sometimes using *100 times happier* is allowed, but real numbers (e.g., 1.5) is used to here to contrast between real ratio comparatives. For these consideration, # is being used to mark the oddness of such expressions instead of *.
- ⁷ See Rett [41] for discussion of implicit and explicit equatives.
- ⁸ The bleached intensifier *hen* in Mandarin is likely due to fewer intensifier hierarchies (*feichang* 'super' > *hen* 'very' > *youdian* 'slightly'), where *hen* has a power of 1.

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