Cross-Categorial Restrictions on Measure Phrase Modification

Yoad Winter

Technion – Israel Institute of Technology

May 29, 2004

1 Introduction

Spatial and temporal Measure Phrases (MPs) such as *ten meters, five years* etc. appear with various linguistic items, including locative prepositions, scalar dimensional adjectives and comparatives, and show certain systematic contrasts in these domains. Some examples are given below.

(1)	a.	Prepositions:	ten meters *behind/outside/*near/*on* the house
	b.	Adjectives:	ten meters *wide/*narrow/deep/*shallow*
			five years *old/*young/long/*short*
	c.	Comparatives:	ten meters *wider/narrower/deeper/shallower* than...
			five years *older/younger/longer/shorter* than...

These constructions raise obvious questions about their proper semantic interpretation and the origins of the marked differences in their acceptability. But MP modification of adjectives in the positive form as in (1b) raises an additional complication: in the acceptable cases of MP modification with adjectives, the meaning of the adjective is quite different than what it means without the MP. For instance, a child who is *five years old* is definitely not *old* under any normal interpretation of the word. Any theory of MP modification should explain this "neutralizing" effect that MPs have on the interpretation of the adjective. While the basic contrast that (1b) exemplifies has received quite a lot of attention in the literature about adjectives (Cresswell (1976), Seuren (1978), Bierwisch (1989), Kennedy (2000), among others), this last question about the neutrality of modified adjectives has not been given a satisfactory account, certainly not within a cross-categorial theory of MP modification.

This paper develops a uniform analysis of MP modification that relies on the *Modification Condition* of Zwarts (1997) and Zwarts and Winter (2000). This condition is originally designed to capture the differences between various prepositions as illustrated in (1a). Zwarts' basic proposal is this: for a preposition to be modified by an MP it has to be *upward monotone*, where the relevant notion of monotonicity is defined within a formal semantic analysis that employs *vector spaces*. Intuitively, a vector can be conceived of as a directed line segment that points from one location in space to another. In the proposed vector space semantics the preposition *outside* is classified as upward monotone because if x is outside A and then gets further away from A, it remains outside A. In more technical terms: when a vector that points to x is in the denotation of *outside* A, then also any lengthening of this vector is in the denotation of *outside* A. By contrast, the preposition *near* is not upward monotone: when x is near A and then gets further away from A, it does not necessarily remain near A. Zwarts and Winter (2000) argue that while upward monotonicity of prepositions correctly describes differences in acceptability of MP modification, it does not provide a satisfactory explanation of such differences. Their refinement of Zwarts' original account requires a preposition to be upward as well as downward monotone for it to be modifiable by an MP. Zwarts and Winter argue that since all prepositions are downward monotone, this additional downward monotonicity condition is descriptively vacuous. Therefore, in the Zwarts/Winter proposal the value of downward monotonicity in accounting for the acceptability of modified prepositions is *only* explanatory.

One of the main claims of the present article is that the downward monotonicity restriction has a real descriptive value when it comes to the semantics of MP modification with adjectives.[1] It will be shown that under the proposed analysis, the only way for an adjective to be upward monotone is in case it is a "positive" member of an antonymous pair (e.g. *old* vs. *young*). In order to further become downward monotone, the *standard value* of the adjective comes into play. As in other theories, a standard value is a degree on a scale that is associated with the adjective: the minimal degree on the scale that is needed in order to qualify as being in the denotation of the positive form of the adjective. For instance, the standard value of *old* is the minimal age (=the minimal degree on the age scale) that is considered *old* in the given context. As we shall see, for "positive" adjectives like *old* to become downward monotone, and thus satisfy Zwarts and Winter's modification condition, the standard value has to become zero. According to this value anything is considered *old*, which gives a straightforward account of the lack of "value judgements" in expressions such as *five years old*.

This possibility to state a general modification condition that correctly accounts for a variety of cross-categorial modification phenomena, is taken as a strong argu-

[1]With respect to adjectives the term MP *modification* is not theoretically neutral, since there is a tradition (see Heim 2001) where MPs such as *ten meters* or *five years* as in (1b) and (1c) are treated as arguments, rather than modifiers, of the positive or comparative adjective. However, for a cross-categorial theory of the phenomena in (1) it seems natural to assume, like Kennedy (1999) and others, that MPs are modifiers, since with PPs as in (1a) they are unlikely to be arguments of the preposition.

ment in favor of Faller's (2000) motivation to develop a cross-categorial theory of MP modification. To state generalizations across categories, we will make use of the semantically richest domain of these categories – the spatial domain of prepositions, which in the Zwarts/Winter proposal is a collection of vector spaces. However, while vector space semantics is a useful tool for expressing cross-categorial observations, it is not claimed to be necessary for treating the semantics of adjectives and comparatives *per se*. As it turns out, the basic "interval" ontology of adjectives, proposed among others in Bierwisch (1989) and Kennedy (2000), is very much similar to the application of vector ontology to the domain of positive and comparative adjectives.

The paper is organized as follows. Section 2 briefly reviews some basic notions in Vector Space Semantics and Section 3 modifies Faller's analysis of degree adjectives and comparatives. After this cross-categorial mechanism of MP modification is introduced, Section 4 studies the restrictions on MP modification within this framework. It addresses the implications of Zwarts/Winter's modification condition for the domain of adjectives and comparatives, and the resulting notion of adjective (*un*)*boundedness* is discussed. Some finer distinctions between adjectives are addressed, especially in relation to effects on MP modification created by the property of *scale exhaustivity*, which classifies adjectives according to which parts of the scale they can potentially cover.

2 Basic notions in Vector Space Semantics

Intuitively speaking, vectors can be conceived of as directed line segments in space. Vectors together with some operations on them form together a *vector space*. Vector Space Semantics (VSS), as introduced in Zwarts (1997) and Zwarts and Winter (2000), assumes that the main ontological primitive in the semantics of spatial ex-

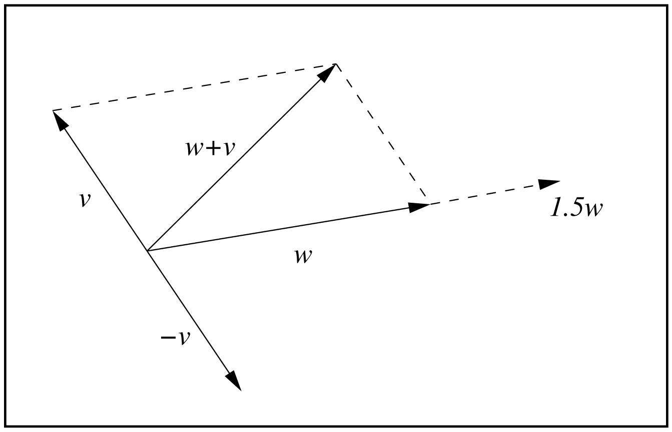

Figure 1: vectors

pressions is a vector space V over the real numbers $\mathbf{R}$. Formally, this means that for V the following constants and operations are defined:

- An addition operator $+$ on elements in V.
- A zero element 0 in V that satisfies $v + 0 = v$ for every element v in V.
- An opposite element $-v$ for each element v in V, which satisfies $v + (-v) = 0$.
- A scalar multiplication operator ('$\cdot$') between real numbers in $\mathbf{R}$ and elements in V, such that for all real numbers $s \in \mathbf{R}$ and elements $v \in V$: $s \cdot v$ is an element in V.

Figure 1 illustrates two vectors v and w, their vector sum $v + w$, an opposite vector $(-v)$ to v, and a scalar multiplication of w by 1.5. These notions and their algebraic properties define the structure of the vector space V. To define a metrics for distances in V, we also assume a *norm function* $|\ |$ that sends every vector v in V to a non-negative scalar in $\mathbf{R}$. This function guarantees for any scalar s and

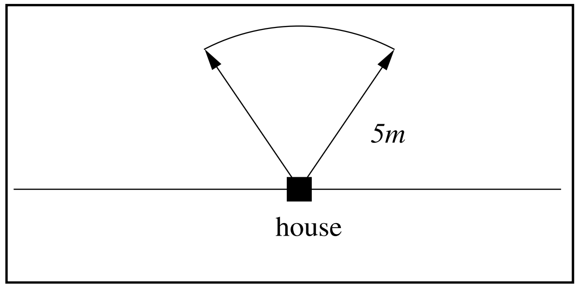

Figure 2: five meters behind the house

vector v that $|s \cdot v|$ is equal to $|s| \cdot |v|$, where $|s|$ is s's absolute value and $|v|$ is v's norm. Suppose, for instance, that for the vector w in Figure 1 we have $|w| = 4$. It follows then that $|1.5 \cdot w| = 1.5 \cdot 4 = 6$.

These basic notions are sufficient for developing the part of VSS that is relevant for the purposes of this paper. For extensive surveys on the mathematics of vector spaces see Lang (1977) or any other introduction to Linear Algebra.

Vectors spaces are useful for dealing with MP modification in a simple compositional way. Given a vector space V, we assume that an MP like *five meters* denotes the set of vectors in V with norm $5m$, where m is some positive constant for *meters*. We further assume that a PP like *behind the house* is associated with the set of vectors that go from the house to points behind it. Consequently, we can treat the modified prepositional phrase *five meters behind the house* as the intersection of these two sets of vectors, which is the set of vectors that point from the house to points that are five meters behind it. A graphical illustration of this analysis of MP modification is given in Figure 2, and the fact that it is obtained using a simple intersective procedure is one of the main arguments in favor of VSS.

Faller (2000) argues that the same kind of simplicity can be retained if VSS is used for treating MP modification of adjectives in the positive (e.g. *five meters* *tall*) or in the comparative (e.g. *five meters taller than Bill*). The intuitive basis for Faller's claim is quite clear: if *tall* (or *taller than Bill*) represents a set of vectors that describes the lengths that are considered *tall* in the given context (or the set of lengths that are longer than than Bill's height, respectively) then modification using *five meters* can work with adjectives in the same way it works with PPs. Of course, for adjectives , unlike spatial PPs, a one-dimensional vector space that models a *scale* of the relevant degrees (for height, age etc.) may be sufficient. However, the application to the domain of adjectives of the same formal apparatus that is used for modeling with spatial PPs is useful in the formulation of a uniform modification mechanism across categories. As we shall see, the basic assumptions of the VSS treatment of adjectives are similar to those of theories that are based on intervals.

When vectors are used in the description of PPs, one aspect that is especially important in the Zwarts/Winter proposal is the fact that they determine a *relative position*. For instance, in a simple sentence such as *the bird is above the house*, the bird is located relative to the house. Traditionally the house is called the *reference object* and the bird is the *located object*. The reference object can vary from PP to PP, even within the same sentence and when locating one and the same object. Consider for instance the following sentence.

(2) The bird is above the house and below the cloud.

To capture this possibility of using different reference objects in different PPs, Zwarts and Winter use *pairs* of vectors in their analysis of the locative PP: one vector locates the reference object, another determines the position of the located object relative to the reference object's position. Consider the schematic analysis of sentence (2) in Figure 3. The arbitrary 0 point represents the zero element in the vector space V of the spatial ontology. The pair of vectors $\langle w1, v1\rangle \in V \times V$ describes the location of the bird $\mathbf{b}$ relative to the location of the house $\mathbf{h}$: $w1$

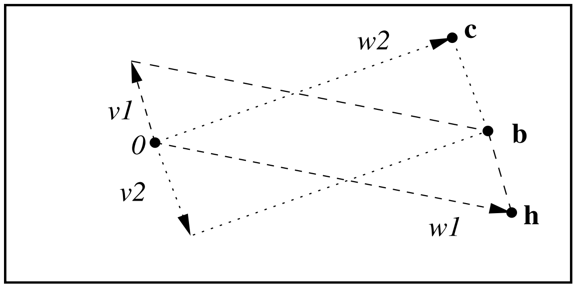

Figure 3: the bird is above the house and below the cloud

describes the location of $\mathbf{h}$, whereas $v1 + w1$ is the vector describing the location of $\mathbf{b}$. In other words: $v1$ is the vector that describes the position of $\mathbf{b}$ relative to $w1$. Similarly, the pair of vectors $\langle w2, v2 \rangle$ describes the location of the bird $\mathbf{b}$ with respect to the cloud $\mathbf{c}$.

This example illustrates that pairs of vectors allow us different perspectives on located objects using different reference objects. This is reflected in the fact that given a vector $w \in V$, the pairs in $\{w\} \times V$ can be viewed as a vector space: the vector space formed by the reference object that w locates. Formally, this is stated as follows.

Fact 1 *Given a vector space V, display the Cartesian product $V \times V$ (the set of pairs of elements from V) as $\cup_{w \in V} V_w$, where $V_w = \{w\} \times V$ (the set of vector pairs $\langle w, v \rangle$, where the vector w is given). For any vector $w \in V$, the set V_w is a vector space with a zero vector $\langle w, 0 \rangle$ and the natural operations that are defined by:*

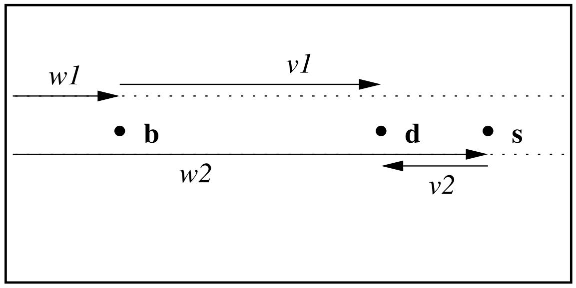

Figure 4: the desk is five cm. wider than the box and two cm. narrower than the shelf

$$
\begin{aligned}
\langle w, v_1\rangle + \langle w, v_2\rangle &= \langle w, v_1 + v_2\rangle \\
-\langle w, v\rangle &= \langle w, -v\rangle \\
s \cdot \langle w, v\rangle &= \langle w, s \cdot v\rangle \\
|\langle w, v\rangle| &= |v|.
\end{aligned}
$$

Thus, $V \times V$ is a collection of vector spaces V_w, where the “reference” of each vector in V_w is determined by the vector w. We therefore refer to the elements in $V \times V$ as *located vectors*.

As we saw in the discussion of sentence (2), located vectors are useful for treating locative PPs. Faller points out that they are also useful for treating the comparative. For instance, consider the following sentence.

(3) The desk is five cm. wider than the box and two cm. narrower than the shelf.

Here the desk’s width is measured once relative to the width of the box and once relative to the width of the shelf. This is illustrated in Figure 4, where the located vector $\langle w1, v1\rangle$ measures the desk’s width **d** relative to the width **b** of the box and $\langle w2, v2\rangle$ measures **d** relative to the width **s** of the shelf. As we shall see later in this paper, located vectors are also useful for describing the semantics of adjectives in the positive.

Since it is convenient to have explicit types for the denotations we use, we employ a standard typed model that allows function types (formed by '$\rightarrow$') and product types (formed by '$\bullet$'), and where the basic types are e (for entities), t (for truth-values) and v (for vectors). Officially, we define the set of types and their corresponding domains as follows.[2]

Definition 1 *The set of* **types** *is the smallest set* TYPE *that satisfies:*

$\{e, t, v\} \subset \mathrm{TYPE}$*;*

if $\tau \in \mathrm{TYPE}$ *and* $\sigma \in \mathrm{TYPE}$ *then* $(\tau \rightarrow \sigma) \in \mathrm{TYPE}$*;*

if $\tau \in \mathrm{TYPE}$ *and* $\sigma \in \mathrm{TYPE}$ *then* $(\tau \bullet \sigma) \in \mathrm{TYPE}$.

Definition 2 *For any type in* TYPE *the corresponding* **domain** *is defined by:*

D_e *is an arbitrary non-empty set;*

$D_t = \{0, 1\}$ *with the numerical partial order '$\leq$';*

D_v *is a vector space* V *over* **R** *with norm* $|\ |$*;*

$D_{\tau \rightarrow \sigma} = D_\sigma^{D_\tau}$*;*

$D_{\tau \bullet \sigma} = D_\sigma \times D_\tau$.

The functional constructor '$\rightarrow$' and unnecessary parentheses are often left out. Some examples for useful types follow.

vt:	a (characteristic function of a) set of vectors
$v \bullet v$:	a located vector
$(v \bullet v)t$:	a (characteristic function of a) set of located vectors

[2] In Zwarts and Winter (2000) a slightly different convention for vector types is used: vectors are conceived as 'points' of type p and located vectors as 'vectors' of type v, where the semantic connection between the two types is made by the assumption $D_v = D_p \times D_p$, without using general product types.

3 The interpretation of dimensional adjectives and comparatives in Vector Space Semantics

The problem of MP modification is the main motivation for the semantics that Zwarts and Winter propose for locative PPs. This section shows that similar problems to those that motivate the vector treatment of locative PPs also motivate a similar treatment of adjectives in the positive and the comparative. Their interpretation process within VSS will be developed, which will lay the grounds for the analysis of the conditions on MP modification in the following section.

Modified constructions such as *ten meters outside the house*, *ten years old* and *three kmh. faster* involve at least four different questions to be dealt with:

1. *Interpretation*: How can these modified constructions be simply analyzed on a par with other modification constructions?

2. *Conditions on acceptability*: What are the origins of the unacceptability of expressions such as **ten meters in the house*, **three years young* or **ninety kmh. fast*?

3. *Neutralization*: In constructions such as *three years old*, *one inch long* etc., what explains the loss of the "value judgement" part of the adjective meaning?

4. *Cross-categorial aspects*: Can answers to the above questions be given within a unified cross-categorial framework?

While many works address some of these questions, there is no systematic framework that attempts to answer them all. Cresswell (1976) proposes a compositional account of MP modification with adjectives, but his account of the distinction between *six feet tall* and **six feet short* is by means of a stipulation that distinguishes the kind of degrees that *tall* and *short* relate to; Klein (1980) gives an account of modification that is not based on degrees, but like Cresswell's account it does not attempt to explain the source of this opposition; Seuren (1978) proposes a condition that defines the adjectives that allow MP modification, but his account, which will be discussed in more detail later in this paper, does not follow from general principles and does not explain why MPs should function as "neutralizers"; for Kennedy (2000), the difference between adjectives like *tall* and *short* lies in the different kind of entities they denote, but, while Kennedy's ontological primitives (positive and negative *extents*) are very similar to vectors, the exact compositional interpretation process and the "neutralizing" effect of MPs on adjectives like *long* are not explicitly accounted for.

From a typological point of view, it is important to mention that problems of MP modification with adjectives are part of a more general attempt in the literature on lexical semantics to characterize the difference between antonyms in various classes of adjectives. Bierwisch (1967) and Lehrer (1985) give various tests for classifying a "marked" member of antonymous pairs of adjectives, where modification by MPs, when available, is one criterion that distinguishes the marked from the unmarked member of the pair. In Cruse (1976,1986:ch.9) a distinction is made between three groups of adjectives with respect to various "neutralizing" effects. Cruse does not explicitly discuss MP modification, but the data he treats, concerning *how* questions, raise issues related to neutralization effects with adjectives. In a question like "*how tall is John?*", the adjective *tall* is neutralized, and the question does not imply that John is tall. By contrast, in the question "*how short is John?*", to the extent that it is acceptable, the adjective is not neutralized: the question does imply that John is short. Most other dimensional adjectives that invoke scaled properties show a similar behavior. However, Cruse shows pairs of adjectives such as *hot* and *cold*, where *how* questions do not neutralize the adjective: both questions "*how hot/cold is it*?" imply that it is hot/cold, respectively. These adjectives do not allow MP modification, and in this paper I am especially concerned with MP modification across categories, and not with the general typology of antonymous adjectives. Hence, the application of the proposal to a wider range of adjectives that do not necessarily undergo MP modification will be left for further research.

The works that were mentioned above do not address the cross-categorial aspect of MP modification. Faller (2000) proposes a novel systematic account of MP modification across categories based on Zwarts/Winter's VSS. However, Faller does not try to substantially address the restrictions on the modification process or its "neutralizing" effect on adjectives.[3] In this section, Faller's proposal will be modified in a way that will enable us in the next section to also use it in order to account for the restrictions on MP modification and its "neutralization" effect.

3.1 Degree adjectives and comparatives

As mentioned in Section 2, Zwarts' account of MP modification with locative PPs treats modification as a standard *intersective* process. In a PP structure like (4) below, the set of (located) vectors that the P' denotes is simply intersected with the set of vectors that the MP denotes.

(4) [$_{\text{MP}}$ two meters] [$_{P'}$ outside the house]

Faller (2000) observes that the same kind of interpretation can apply with modified adjectives in the positive and the comparative, after vectors are properly introduced into the semantics of adjectives. Consequently, Faller proposes that structures as in (5) and (6) below should be analyzed using intersection of sets of vectors, similarly to the VSS analysis of the PP structure in (4) above.

[3] Following an early draft of the present work, Faller briefly mentions an account that essentially uses the considerations that will be employed in Section 4.

(5) [$_{\mathrm{MP}}$ two meters] [$_{A'}$ tall]

(6) [$_{\mathrm{MP}}$ two meters] [$_{A'}$ taller than Mary]

Faller's semantics is similar in many respects to the interval semantics of adjectives in Bierwisch (1989) and Kennedy (2000), among others.[4] There are two main differences between the proposal developed below and Faller's system. First, while Faller uses one scale structure for pairs of antonyms such as *tall-short*, *old-young* etc., the present proposal follows Kennedy (2000) and makes a distinction between different directions of scales for antonymous adjectives. As will be explained below, from this treatment follows a unified account of antonymous adjectives using the same formal scheme and possible scale *values*, despite the different scale *structure*. Second, Faller treats an adjective in its positive form (e.g. *tall*) as a concealed comparative relative to a given standard value (i.e. "taller than the given height standard"). By contrast, the proposal below distinguishes between the positive and the comparative by associating positives with located vectors whose first coordinate is the zero vector. The standard value does not appear as a "point of reference" in the proposed treatment of the positive.

We first use VSS to define the familiar notion of *scales*. In this definition a scale consists of two elements: (i) a unit vector (=a vector of norm 1) that determines the "dimension" that is measured by the adjective; and (ii) a set of real numbers that specify the legitimate values along this dimension.

[4]Kennedy uses a notion of intervals that he calls *extents*, and argues that it is preferable to the more common ontology of *degrees*, which is similar to ontologies of points in spatial semantics. Kennedy's arguments for extents come mainly from phenomena that he calls *cross-polar anomaly*, as in unacceptable sentences of the form ?*Alice is shorter than Carmen is tall*. According to Kennedy, such unacceptabilities show that the entities in the denotation of *short* should be different than those in the denotation of *tall*. While the present account is compatible with this claim, I will not try to account here for cross-polar anomalies using the mechanism that is proposed in this paper.

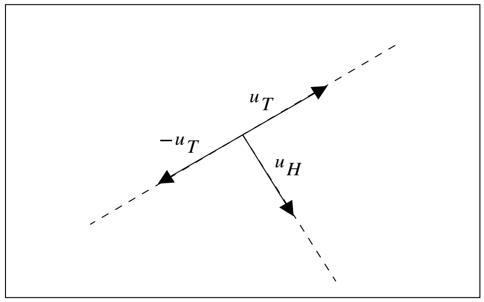

Figure 5: scales

Definition 3 *Let V be a vector space over* $\mathbf{R}$ *with a norm function* $|\ |$. *Let $U \subset V$ be a (finite) set of unit vectors that are called* **scale units**. *A pair $S = \langle u_S, X_S \rangle$ where $u_S \in U$ and $X_S \subseteq$* $\mathbf{R}$ *is called a* **scale** *over V and U. The set of* **values** *of a scale S is the set of vectors $\{t \cdot u_S : t \in X_S\}$.*

Figure 5 illustrates three scales: a height scale, determined by the unit vector u_H and the set $(0, \infty)$ of the positive real numbers; a time scale (e.g. for the adjective *early*) with unit vector u_T and the set of all real numbers; an "opposite" time scale (e.g. for the adjective *late*) with unit vector $-u_T$ and the same set of all real numbers. As a result, these two time scales have the same set of scale values but using opposite unit vectors. Note that the vector space V is not necessarily the same vector space that is used for treating spatial locative prepositions. Furthermore, degree adjectives such as *old* or *early/late* are obviously not spatial but temporal, and can be modified by temporal MPs. In Subsection 4.2 some other scale structures of various adjectives will be discussed.[5]

Scalar theories of adjectives in the positive have to assume that their denotation is sensitive to contextual factors. For instance, even when two people are of the

[5]For two recent works on scale structures that is motivated by different data than those discussed here, see Kennedy and McNally (1999) and Rotstein and Winter (2004).

same height, one of them can be considered tall while the other is considered not tall. Whether a person is considered *tall* or not may depend on his/her sex, age, profession, point of view of the speaker and other extra-semantic factors.[6] For the purposes of this paper, we can follow many works on adjectives and assume that the semantics of the positive is defined relative to a certain *standard value*. We further assume that this standard is in the *closure* of (the values of) the relevant scale.[7] For instance, the height scale H is the pair $\langle u_H, (0,\infty)\rangle$ – the height unit vector and the positive real numbers. The height standard value is $t \cdot u_H$, for some t in the closure of $(0,\infty)$, which is denoted by $\overline{(0,\infty)} = [0,\infty)$ – the non-negative real numbers. Note that here, the standard value can be the zero vector, which is not a value of the height scale.

We assume that an adjective A in the positive form is associated with a set of *located* vectors, of the form $\langle z_S, w\rangle$. The vector z_S represents the *zero value* for the adjective A: the minimal amount of A-ness relative to the scale S. The vector w represents the actual amount of A-ness of an entity in A's denotation, which must be "greater" than the standard vector d_S. We assume that both vectors z_S and d_S can be determined by the context. However, for any given adjective, only one of these values is contextually determined. Thus, we use one parameter, which we denote c_S (the *contextual parameter*), and adopt the following assumption:

(7) **The standard/zero value convention**: For a given scale S: $d_S = c_S$ iff $z_S = 0$, and $z_S = c_S$ iff $d_S = 0$, where c_S is some vector in the closure of

[6]See Kamp (1975) and Klein (1980) for classical works on these phenomena, and Kennedy (1999) for a more recent theory, including a comprehensive survey of relevant literature.

[7]A set $A \subseteq \mathbf{R}$ is *closed in* $\mathbf{R}$ iff for every $x \in \mathbf{R} \setminus A$ there is $\delta > 0$ s.t. $\{y \in \mathbf{R} : |y - x| < \delta\} \subseteq \mathbf{R} \setminus A$. The *closure* $\overline{A}$ of a set $A \subseteq \mathbf{R}$ is the minimal closed set in $\mathbf{R}$ that contains A. Note that $\overline{(a,b)} = \overline{[a,b)} = \overline{(a,b]} = \overline{[a,b]} = [a,b]$, $\overline{(a,\infty)} = \overline{[a,\infty)} = [a,\infty)$, and $\overline{(-\infty,b)} = \overline{(-\infty,b]} = (-\infty,b]$ for any $a,b \in \mathbf{R}$, and that $\overline{(-\infty,\infty)} = (-\infty,\infty)$. It is easy to show that the closure of the values in a scale $\langle u_S, X_S\rangle$ is the set $\{t \cdot u_S : t \in \overline{X_S}\}$, where $\overline{X_S}$ is the closure of X_S in $\mathbf{R}$.

S.

The empirical implications of this convention will be clarified as we go along.

An adjective in the positive is associated with a set of located vectors, determined by its scale S and the d_S and z_S parameters. The located vectors are those with a first coordinate z_S and a second coordinate of vectors "longer" than the standard vector d_S. To define this notion of "longer than a vector", it is convenient to adopt the following standard presentation in Linear Algebra, of the scalar $c(v, w)$ connecting to one another two vectors v and w that go in the same direction:

(8) Let V be a vector space with $v, w \in V$ s.t. $v \neq 0$. If there is $t \in \mathbf{R}$ s.t. $w = t \cdot v$, then (provably) this t is unique, and we denote $t = c(v, w)$.

For an adjective associated with a scale S, we define now the *adjective set* of located vectors relative to S and the parameters d_S and z_S:

Definition 4 (adjective set) *Let $S = \langle u_S, X_S \rangle$ be a scale, and let d_S and z_S be the standard and zero values, respectively. The* adjective set *A of located vectors relative to S, d_S and z_S is defined by:*

$$A = \{\langle z_S, t \cdot u_S \rangle : t > c(u_S, d_S) \wedge t \in X_S\}.$$

Let us exemplify how this definition works using Figure 6. For the antonyms *tall* and *short* we assume the scales $H = \langle u_H, (0, \infty) \rangle$ and $-H = \langle -u_H, (-\infty, 0) \rangle$ respectively ('H' stands for 'height'). This means that the sets of values of these two scales, obtained by multiplication of the unit vector u_H/$-u_H$ by a positive/negative scalar, respectively, are the same. For simplicity we can assume that the standard value for both scales is also the same and denote it by $d_H = d_{-H}$.[8] Assume that

[8]This assumption is true only in situations where there is only one height that is considered neither tall nor short. Of course, in more realistic situations we have to assume different height standards $t_0 \cdot u_H$ and $-t'_0 \cdot u_h$ for *short* and *tall* respectively, where $t_0 < t'_0$.

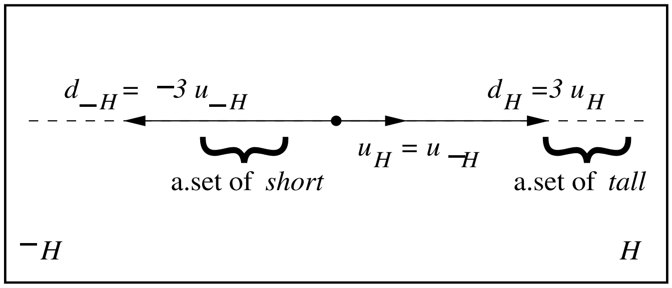

Figure 6: adjective sets of *tall* and *short*

$z_H = z_{-H} = 0$, and that the standard vector d_H of *tall* is $3 \cdot u_H$, hence the standard vector d_{-H} of *short* is also $3 \cdot u_H$, which is equal to $(-3) \cdot u_{-H}$. Consequently, $c(u_H, d_H) = 3$ and $c(-u_H, d_H) = -3$. According to Definition 4, the resulting adjective sets of *tall* and *short* are the following, as also shown in Figure 6.

(9) $\mathbf{tall}' =$

$\{\langle 0, t \cdot u_H \rangle : t > c(u_H, d_H) \wedge t \in (0, \infty)\} =$

$\{\langle 0, t \cdot u_H \rangle : t > 3 \wedge t \in (0, \infty)\} =$

$\{\langle 0, t \cdot u_H \rangle : t > 3\}$

(10) $\mathbf{short}' =$

$\{\langle 0, t \cdot (-u_H) \rangle : t > c(-u_H, d_H) \wedge t \in (-\infty, 0)\} =$

$\{\langle 0, t \cdot (-u_H) \rangle : t > -3 \wedge t \in (-\infty, 0)\} =$

$\{\langle 0, t \cdot u_H \rangle : 0 < t < 3\}$

There is nothing too surprising about these results: they involve sets of vectors for dimensional adjectives which are very much parallel to the set of degrees that other scalar theories assume. The non-trivial part in this analysis is the derivation of the adjective sets for antonyms like *tall* and *short* from one general definition of adjective sets. Although the meanings of the adjectives *tall* and *short* are both defined in terms of the same scale values and the same standard value, their adjective sets are different, because the scales for *tall* and *short* have opposite unit vectors. In general, we adopt the following convention for antonymous adjectives.

(11) **The antonymy convention**: If A_1 and A_2 are antonymous degree adjectives, then their respective scales are $S = \langle u_S, X_S \rangle$ and $-S = \langle -u_S, \{-t : t \in X_S\} \rangle$. The adjectives A_1 and A_2 have the same standard and zero values, denoted by d_S and z_S respectively. Both are vectors in the closure of S (=closure of $-S$).

The reason why degree adjectives such as *tall* and *wide* are treated in the proposed definition as located vectors of the form $\langle 0, v \rangle$ is the general semantics of MP modification. As observed above, MP modification with prepositions and comparatives is *relative*. Thus, in sentences with locative PPs or comparatives like *A is ten meters outside the house* or *A is ten meters wider than the house*, the actual location or width of *A* is determined relative to the location or width of the house. By contrast, when something is *10cm. wide*, it is invariably *10cm. wider than zero*. Hence, for sake of generality it is convenient to treat adjectives like *wide* with a zero vector that describes this fact. But this is not for sake of generality alone. As we shall see in Subsection 4.2, MP modification with adjectives such as *early* and *late* should be treated as relative, in contrast to the adjectives *tall* and *wide*.

According to the same principles, a comparative such as *ten meters wider than the house* is described using a set of located vectors $\langle w, v \rangle$ where w is a vector in the width scale that describes the house's width, and v is a vector that satisfies $|v| = 10m$. In general, a comparative *more/less A than x* is treated using a set of located vectors $\langle w, v \rangle$. Assume that the scale for the adjective *A* is $S = \langle u_S, X_S \rangle$. The w vector is a value of S that describes the dimension of *x* in this scale.[9] The

[9]For the exact process that determines w, see below.

v vector is any multiplication of the unit vector by a positive scalar, in case the comparative item is *-er* or *more*, and by a negative scalar, in case the comparative item is *less*. Formally, the following definition treats the comparative items *more A...than* (or *A-er...than*) and *less A...than* as functions from vectors in the relevant scale to sets of located vectors. The comparative functions $\mathbf{more\_A'}$ and $\mathbf{less\_A'}$ are consequently treated as functions of type $v((v \bullet v)t)$ that are defined as follows.

Definition 5 (comparative functions) *Let $S = \langle u_S, X_S \rangle$ be a scale for an adjective A, and let w be a value in S.*

The comparative $\mathbf{more\_A'}(w)$ is defined as the set of located vectors $\{\langle w, t \cdot u_S \rangle \in V \times V : t \in (0, \infty)\}$.

The comparative $\mathbf{less\_A'}(w)$ is defined as the set of located vectors $\{\langle w, t \cdot u_S \rangle \in V \times V : t \in (-\infty, 0)\}$.

For example, consider the set of vectors that this definition derives for comparative forms with *tall* and *short*, where the vector in the height scale that describes John's height is denoted by $h_{\mathbf{j'}}$.

(12)
$$\begin{array}{lcccl} [\![\text{taller than John}]\!] & = & \mathbf{more\_tall'}(h_{\mathbf{j'}}) & = & \{\langle h_{\mathbf{j'}}, t \cdot u_H \rangle : t \in (0, \infty)\} \\ [\![\text{shorter than John}]\!] & = & \mathbf{more\_short'}(h_{\mathbf{j'}}) & = & \{\langle h_{\mathbf{j'}}, t \cdot -u_H \rangle : t \in (0, \infty)\} \\ & & & = & \{\langle h_{\mathbf{j'}}, t \cdot u_H \rangle : t \in (-\infty, 0)\} \\ [\![\text{less tall than John}]\!] & = & \mathbf{less\_tall'}(h_{\mathbf{j'}}) & = & \{\langle h_{\mathbf{j'}}, t \cdot u_H \rangle : t \in (-\infty, 0)\} \\ [\![\text{less short than John}]\!] & = & \mathbf{less\_short'}(h_{\mathbf{j'}}) & = & \{\langle h_{\mathbf{j'}}, t \cdot -u_H \rangle : t \in (-\infty, 0)\} \\ & & & = & \{\langle h_{\mathbf{j'}}, t \cdot u_H \rangle : t \in (0, \infty)\} \end{array}$$

These derived sets of vectors capture the equivalences between *taller* and *less short* and between *shorter* and *less tall*. Note that the located vectors $\langle w, v \rangle$ in the set for the comparatives *shorter than John* and *less tall than John* do not guarantee that $w + v$ is a legitimate value of the height scale. Whenever the value of the parameter $t \in (-\infty, 0)$ makes the vector $t \cdot u_H$ longer than John's height $h_{\mathbf{j}'}$, the sum $h_{\mathbf{j}'} + t \cdot u_H$ will fall below zero – outside the values of the scale. This fact is semantically harmless, as we shall presently see, but it has desirable effects for the account of the conditions on MP modification, as we will see in Section 4.

3.2 The interpretation process

Zwarts and Winter (2000) propose a compositional system for analyzing (possibly modified) locative PPs in VSS. Faller (2000) extends this system for degree adjectives and comparatives. Both proposals involve processes that derive sets of located vectors for locatives (e.g. *above the house*) and comparatives (e.g. *wider than the house*) by first mapping an e-type denotation of the reference object (e.g. *the house*) to a vector that describes its location or dimension. Zwarts and Winter use a *location function* of type $e(vt)$, which maps entities to sets of vectors that describe their location in space. For describing dimensions of entities on a scale S, Faller (2000), and the present work as well, uses a function dim_S of type ev. This *dimension function* maps each entity x to a value in the scale S. For instance, if *John* denotes the entity $\mathbf{j}'$, then $dim_H(\mathbf{j}')$ describes John's height (which was earlier denoted by $h_{\mathbf{j}'}$). To guarantee that John's height is the same in the scale H (of *tall*) and in the scale –H (of *short*), we adopt the following convention.

(13) **The dimension-antonymy convention**: For any entity x, for any two opposite scales S and $-S$, $dim_S(x) = dim_{-S}(x)$.

This convention entails that if John's height (i.e. his relevant dimension for *tall*) is represented by the vector v in the scale H, then John's "opposite height" (his relevant dimension for *short*) is represented by the same value, on the scale $-H$.

Locatives such as *above the house* and comparatives such as *wider than the house* are treated using vectors in a similar manner, by applying the following three steps:

(i) First, the e-type individual that the reference object (e.g. *the house*) denotes is mapped into its location or dimension in the relevant scale by the location or dimension function.[10]

(ii) The locative or comparative expression applies to this location or dimension and derives a set of located vectors.

(iii) A set of entities is derived from this set of vectors by applying an inverse function to the location/dimension function.

For a detailed description of this process with locatives, see Zwarts and Winter (2000). The "anti-dimension" function dim_S^- is a function of type $((v \bullet v)t)(et)$ (from sets of located vectors to sets of entities) that is defined as follows.

(14) $dim_S^- \; = \; \lambda W_{(v \bullet v)t}.\lambda x_e.\exists w \exists v[\langle w, v\rangle \in W \wedge dim_S(x) = w + v]$

In words: dim_S^- maps any set of located vectors W to the set of entities with an "absolute" dimension in S that corresponds to the "relative" dimension that is described by some located vector in W.

The application of the dim and dim^- operators lead to the following analysis of the sentences below, using the sets of vectors that were assumed for comparatives in (12).

[10] The question of how to compositionally determine the scale S within the dimension function is not addressed in this paper.

(15) Mary is taller than John.

$(dim_H^-(\mathbf{more\_tall'}(dim_H(\mathbf{j'}))))(\mathbf{m'})$

$\Leftrightarrow\ (dim_H^-(\{\langle dim_H(\mathbf{j'}), t\cdot u_H\rangle : t\in(0,\infty)\})(\mathbf{m'})$

$\Leftrightarrow\ \exists t\in(0,\infty)[dim_H(\mathbf{m'}) = dim_H(\mathbf{j'}) + t\cdot u_H]$

(16) John is shorter than Mary.

$(dim_{-H}^-(\mathbf{more\_short'}(dim_H(\mathbf{m'}))))(\mathbf{j'})$

$\Leftrightarrow\ (dim_{-H}^-(\{\langle dim_{-H}(\mathbf{m'}), t\cdot u_{-H}\rangle : t\in(0,\infty)\})(\mathbf{j'})$

$\Leftrightarrow\ \exists t\in(0,\infty)[dim_{-H}(\mathbf{j'}) = dim_{-H}(\mathbf{m'}) + t\cdot -u_H]$

It is easy to verify that these two statements are equivalent given the dimension-antonymy convention, as intuitively required.

The dim^- function is similarly useful for the analysis of simple predicative sentences with degree adjectives in the positive, using the adjective sets that were given in (9)-(10):

(17) Mary is tall.

$(dim_H^-(\mathbf{tall'}))(\mathbf{m'})$

$\Leftrightarrow\ c(u_H, dim_H(\mathbf{m'})) > c(u_H, d_H)$

(18) Mary is short.

$(dim_{-H}^-(\mathbf{short'}))(\mathbf{m'})$

$\Leftrightarrow\ c(u_H, dim_H(\mathbf{m'})) < c(u_H, d_H)$

Let us move on now to the interpretation process of MPs and MP modification constructions. Given a vector space V, we assume that a measure phrase such as (*at least*/*at most*) *ten meters* denotes a subset of located vectors over V with a norm that satisfies the corresponding requirement on its length. Measure units such as *meter* or *year* are assumed to specify constant real numbers, defined relative to the norm of the vector space. The exact way these constants are determined is not our main concern here, but once we allow MPs to denote sets of vectors, it is important to note that they must have a special property: whether or not a vector is in an MP denotation depends solely on its norm. We call such sets of vectors *measure sets*, which are formally defined as follows.

Definition 6 *Given a set of vectors* W *with a norm function* $|\ |$*, we call a set* $M \subseteq W$ *a* **measure set** *over* W *iff for all* $v, v' \in V$*: if* $v \in M$ *and* $|v'| = |v|$ *then* $v' \in M$.

Note that for any vector space V, a set $W \subseteq V \times V$ is a measure set over $V \times V$ iff $W = V \times X$, where X is a measure set over V.

Consider for example the denotation of the measure phrase (*exactly*) *two meters*, where m is some positive real constant:

(19)
$$\begin{aligned} \mathbf{two\_meters'} &= \{\mathbf{v} \in V \times V : |\mathbf{v}| = 2m\} \\ &= V \times \{v \in V : |v| = 2m\} \end{aligned}$$

Whenever a located vector $\mathbf{v}$ is in this set, any vector $\mathbf{v}'$ s.t. $|\mathbf{v}'| = |\mathbf{v}|$ is obviously in this set as well.

We assume that all MPs denote measure sets of located vectors in $V \times V$. This assumption allows us to use intersection for MP modification with PPs, adjectives and comparatives, which are all associated with sets of located vectors in the present system. The following examples illustrate this intersection process with degree adjectives and comparatives.[11]

[11] An anonymous reviewer questions the intersective process with comparatives, in view of examples such as the following.

(i) The suitcase is 0-3lbs heavier than the box.

(ii) Jack is less than 2 years older than Jill.

The reviewer claims that in (i) the suitcase need not be heavier than the box, and that in (ii) Jack is not necessarily older than Jill. The speakers I consulted were not sure about these judgements, and I was not able to find conclusive evidence for either intersective or non-intersective MP modification

(20) *five feet tall*:

$$\mathbf{five\_feet}' \cap \mathbf{tall}'$$
$$= \{\mathbf{v} \in V \times V : |\mathbf{v}| = 5f\} \cap \{\langle 0, t \cdot u_H \rangle : t > c(u_H, d_H)\}$$
$$= \{\langle 0, t \cdot u_H \rangle : t = 5f \wedge t > c(u_H, d_H)\}$$

(21) *two cm. taller than John*:

$$\mathbf{two\_cm}' \cap \mathbf{more\_tall}'(dim_H(\mathbf{j}')))$$
$$= \{\mathbf{v} \in V \times V : |\mathbf{v}| = 2cm\} \cap \{\langle dim_H(\mathbf{j}'), t \cdot u_H \rangle : t > 0\}$$
$$= \{\langle dim_H(\mathbf{j}'), t \cdot u_H \rangle : t = 2cm\}$$

Sentences with modified adjectives and comparatives are treated like the sentences without modifiers (17) and (15):

(22) Mary is five feet tall.

$$(dim_H^-(\mathbf{five\_feet}' \cap \mathbf{tall}'))(\mathbf{m}')$$
$$\Leftrightarrow\ (dim_H^-(\{\langle 0, t \cdot u_H \rangle : t = 5f \wedge t > c(u_H, d_H)\}))(\mathbf{m}')$$
$$\Leftrightarrow\ dim_H(\mathbf{m}') = 5f \cdot u_H \wedge 5f > c(u_H, d_H)$$

(23) Mary is two cm. taller than John.

$$(dim_H^-(\mathbf{two\_cm}' \cap \mathbf{more\_tall}'(dim_H(\mathbf{j}'))))(\mathbf{m}')$$
$$\Leftrightarrow\ (2cm \cdot u_H) + dim_H(\mathbf{j}') = dim_H(\mathbf{m}')$$

Note that the analysis in (22) as stated above is not an adequate paraphrase of the sentence. This sentence (unlike the simpler sentence *Mary is tall*) does not require that Mary's height is above any positive standard. Thus, we must assume that for evaluating this sentence the relevant standard d_H should be zero. The principles that underly this relaxation of 'value judgment' requirements with adjectives in MP constructions are introduced in the next section.

---

using such examples. If conclusive evidence for a non-intersective process are found, they might impose significant modifications in the interpretation procedure that is proposed in this section.

4 Boundedness and the modification condition

The previous section introduced an interpretation procedure for degree adjectives in the positive and and comparative forms, possibly modified by MPs, which following Faller (2000) is based on the Zwarts/Winter VSS analysis of locative PPs. In this section it will be shown that this revision of Faller's (2000) system also accounts for many of the factors that affect the grammaticality of MP modification with these items, based on the *modification condition* of Zwarts (1997) and Zwarts and Winter (2000). Moreover, the same condition explains why adjectives in the positive are neutralized when modified by MPs. Following Zwarts/Winter, the proposed account will distinguish between *bounded* and *unbounded* adjectives and prepositions, which is directly captured by the *monotonicity* of the set of vectors that these items are associated with. It is observed that only *unbounded* adjectives can become upward and downward monotone, which is the case when their standard value is set to zero. After giving this analysis of MP modification, it will be observed that even though the antonym of a bounded adjective is often an unbounded adjective, two antonymous adjectives can be both bounded or both unbounded, in correlation to the acceptability of MP modification. Using the uniform method of deriving adjective sets that was introduced in the previous section it will be shown that different boundedness properties of adjectives are a direct result of different scale structures. Following Seuren (1978) a notion of scale *exhaustivity* will be introduced, and it will be argued that it is responsible for some systematic contrasts in the acceptability of MP modification with unbounded adjectives.

4.1 The modification condition for prepositional phrases

The *modification condition* (MC) that was proposed by Zwarts/Winter is a principle that accounts for the (un)acceptability of MP constructions with prepositional phrases such as *two meters outside/*near the house*. Intuitively, the principle classifies prepositions like *outside* as "unbounded" in the following sense. If it is given that *John is outside the house* then John can be at any distance from the house. By contrast, if *John is near the house* then John's distance from the house is bounded (by some contextual standard of "nearness"). Zwarts/Winter's formal definition of this distinction is based the following two definitions of *ordering* and *monotonicity* in VSS.

Definition 7 (vector ordering) *For any two vectors* v, w *in a vector space* V *over* $\mathbf{R}$, $v \leq w$ *iff there is* $s \geq 1$ *in* $\mathbf{R}$ *s.t.* $w = s \cdot v$.

Thus, two vectors v and w are comparable when they "point in the same direction". In this case w is considered "greater" than v if it is a lengthening of v. Using this natural partial ordering of vectors, we can standardly define the notion of upward (downward) monotone sets of vectors as being sets that are closed under lengthening (shortening) of their members. Formally:

Definition 8 *A set of vectors* $A \subseteq V$ *is* **upward (downward) monotone** *iff for all vectors* $v \in A$ *and* $w \in V$, *if* $v \leq w$ $(v \geq w)$ *then* w *is in* A.

Consider for instance the set of vectors associated with the prepositional phrase *outside the house*. As we saw, in VSS it is taken to be the set of all located vectors that start on the house and point outwards. This is an upward monotone set of vectors: any lengthening of a vector that points from the house outwards leads to another such vector. By contrast, this is not the case for the prepositional phrase *near the house*: if v is a vector that points from the house outwards to a point that is in proximity to the house, there are still lengthenings of v that do not have this property. Thus, the set of vectors associated with this PP is not upward monotone. Note that both sets of vectors are *downward* monotone: shortening a vector that points outside (or near) the house leaves us with a vector that points outside (near) the house.[12]

As shown by Zwarts (1997), upward monotonicity of prepositions is a central factor that governs the possibility to modify them using MPs. In VSS, those prepositions that appear felicitously with MPs lead to upward monotone sets of vectors, and vice versa. Zwarts' generalization about upward monotonicity as a precondition for the acceptability of MP modification is empirically well-motivated, but it comes without an explanation why MP modification should be sensitive to upward monotonicity and not to other semantic properties (e.g. downward monotonicity). Zwarts and Winter (2000) try to answer this question by using a more general modification condition, which requires downward monotonicity as well as non-emptiness of the modified set of vectors, in addition to upward monotonicity. Formally, Zwarts and Winter's condition is the following.

(24) **The Modification Condition**: An expression that is associated with a set of vectors W can be modified by an MP only if W is non-empty, upward and downward monotone and does not contain zero vectors.[13]

Zwarts and Winter's explanation of this generalization relies on a simple observation: any set of vectors W satisfies the MC if and only if for every non-empty measure set M with no zero vectors: $M \cap W$ is not empty. Trivially: if a set

[12] In fact, Zwarts (1997) argues that <u>all</u> locative prepositions are closed under shortening in this way.

[13] In Zwarts and Winter (2000), zero vectors did not play a role in the definition of the MC. However, comparatives clearly are not associated with zero vectors: if x is heavier than y then the difference between x's and y's "weight vectors" cannot be the zero vector. Thus, the alternative statement of the MC below does not take into account MPs that modify a given set of vectors and include only zero vectors (e.g. *zero meters*), for such MPs would lead to an empty set when intersected with the set of vectors associated with comparatives. See also footnote 11.

contains vectors of all positive lengths (i.e. it is non-empty, upward and downward monotonic and does not contain zero vectors) then its intersection with a non-empty measure set without zero vectors (=a non-empty set of vectors that contains all the vectors of specified positive lengths) will be non-empty as well. The intuition behind this statement of the MC is that modification using MPs is possible only if the modified set of vectors guarantees that for *any* MP that denotes such a non-empty measure set of non-zero vectors, the modification process (=intersection of the two sets) would not lead to an empty set.[14]

As an illustration for this reasoning, consider for instance the contrast between the acceptable prepositional phrase *two meters outside the house* and the unacceptable prepositional phrase **two meters near the house*. As we saw, the set of vectors associated with the constituent *outside the house* is upward monotone but the set associated with *near the house* is not. Thus, for any non-zero value of *N*, the set of vectors for the prepositional phrase *N meters outside the house* is non-empty. By contrast, even though the intersection of the set of vectors for *N meters* and *near the house* may be non-empty (depending on *N* and the standard of "nearness"), it is guaranteed that *some* MP can nullify this intersection (e.g. *two hundred kilometers*). Consequently, MP modification is ruled out. For further elaborations on the semantic restrictions on MP modification of PPs see Zwarts and Winter (2000). In Sections 4.2 and 4.3, we will see that the MC can be used to similarly govern MP modification with adjectives in the positive and the comparative. In Section 4.4, we will have a closer look at the MC in relation to "scale exhaustivity".

[14]This reasoning is quite similar to the "no triviality" rule of thumb underlying Barwise and Cooper's (1981) account of *there* sentences. For a discussion of this point see Subsection 4.5 below.

4.2 Bounded adjectives vs. unbounded adjectives

After having reviewed the MC for prepositions, we can now see that a similar condition is applicable to adjectives. Consider first the adjective sets of *tall* and *short* as defined in (9) and (10), which are restated below.

(25) $\mathbf{tall}' =$

$\{\langle 0, t \cdot u_H \rangle : t > t_0\}$

(26) $\mathbf{short}' =$

$\{\langle 0, t \cdot u_H \rangle : 0 < t < t_0\}$

The adjective *short* is associated with a *bounded* set of vectors – a set with a supremum ($t_0 \cdot u_H$) and an infimum (0).[15] By contrast, the adjective set of *tall* is an *unbounded* set of vectors – a set that has an infimum ($t_0 \cdot u_H$) but no supremum. We henceforth use the terms *bounded adjectives* and *unbounded adjectives* to refer to this contrast. In Section 4.3 we will see the strong relationships between boundedness and the Modification Condition. For the time being, note that MP modification is possible with the unbounded adjective *tall* (cf. *five feet tall*) but not with the bounded adjective *short* (cf. **five feet short*).

One kind of entailments that distinguishes between bounded and unbounded adjectives is the following:

(27) John's height is five feet $\Rightarrow$ No one is more than five feet *shorter* than John.

By contrast, there is no entailment in the following case.

(28) John's height is five feet $\not\Rightarrow$ No one is more than five feet *taller* than John.

[15] Recall that supremum/infimum are the least upper bound/greatest lower bound respectively of sets in a partially ordered domain.

This opposition supports the intuition that the adjective *short* is bounded whereas *tall* is an unbounded adjective.[16] Some more examples for pairs of adjectives that are bounded and unbounded (respectively) are *low-high, young-old, narrow-wide, long-short* (in both spatial and temporal usages), *shallow-deep* and *weak-strong*. In all these cases, the unbounded adjective licenses MP modification and the bounded adjective rules it out:

(29) a. The tree is twenty feet high/*low.

b. The boy is five years old/*young.

c. The box is ten cm. wide/*narrow.

d. The road is one km. long/*short.

e. The visa is three months long/*short.

f. The well is one meter deep/*shallow.

g. The crowd is 2,000 strong/*weak.

Although antonymous adjectives usually show the bounded-unbounded opposition, there are also some cases in English where this kind of contrast does not

[16] As an anonymous referee points out, this kind of entailments only indirectly supports the classification. The entailment holds for an adjective *A* iff it is guaranteed that for any choice of x, the set of vectors associated with the modified comparative *MP more A than x* is mapped by the anti-dimension function to the empty set. This trivially happens for MPs with big enough values when the set of vectors associated with the *un*-modified comparative *more A than x* is bounded. However, as will be mentioned below, in the present proposal such sets of vectors are always unbounded. In fact, the entailment in (27) is explained because the *height scale* is bounded from below, so the anti-dimension function generates an empty set (of type et) for *more than five feet shorter than John* even though the set of located vectors (of type $(v \bullet v)t$) that is associated with the same expression is not empty. Thus, the present proposal characterizes an adjective A as bounded or unbounded only according to the boundedness of A's *scale* S in the direction of the unit vector u_S. For sake of presentation I ignore this subtle point in the rest of the article.

hold. As was pointed out by Teller (1969) and Kennedy (2000), among others, pairs of adjectives such as *early-late, fast-slow* (in their temporal use) and *flat-sharp* have certain special properties when compared to other pairs of antonymous adjectives. One of these special properties (not mentioned by Teller or Kennedy) is that *both* adjectives in each of these pairs are semantically unbounded. Consider for instance the following examples with the adjectives *fast* and *slow*.

(30) a. My watch is five minutes fast/slow $\not\Rightarrow$ No watch is more than five minutes faster than my watch.

b. My watch is five minutes fast/slow $\not\Rightarrow$ No watch is more than five minutes slower than my watch.

This indicates that both *fast* and *slow* are classified as unbounded in their temporal usage.[17] In correlation to that, both adjectives can be modified by MPs under their temporal interpretation:

(31) My watch is five minutes fast/slow.

Similar observations hold for the pairs of adjectives *early-late* and *flat-sharp*. Therefore, these four adjectives are also classified as unbounded. As expected, MP modification is possible with these adjectives as well:

(32) My train is five minutes early/late.

(33) My C is 30 Hz flat/sharp.

In addition to these pairs of unbounded adjectives, there is (at least) one antonymous pair of adjectives – the antonyms *full* and *empty* – where both adjectives are bounded: a *full* container cannot become much fuller, and an empty container

[17] Of course, in addition to this temporal usage, the adjectives *fast* and *slow* are also used for measuring speed (as in e.g. *my car is fast*/*slow*). This usage will be discussed in Section 4.4.

cannot become much emptier. Accordingly, both *empty* and *full* are unacceptable modified by MPs:[18]

(34) *The container is three liters empty/full.

Now that we have characterized pairs of adjectives in terms of their boundedness properties, we can see how these properties follow from their different scale structures. What is attractive in Definition 4 of adjective sets and the antonymy convention (11), is that these definitions allow us to account in a unified manner for the three possibilities of (un)boundedness as resulting from the different *scale parameters* of different adjectives. Unlike previous works on adjectives, this allows us to locate the sources of various differences between the set of degrees that are associated with various adjectives. Recall that Definition 4 employs three differ-

[18]The case of *full* and *empty* is quite singular among the dimensional adjectives. Two anonymous referees doubt whether *full* and *empty* are gradable to begin with. However, to account for expressions such as *much fuller/emptier* or *completely full/empty*, some notion of scalar gradability is convenient. Indeed, for some reason comparative forms like *two liters fuller/emptier* are degraded in their grammaticality as compared to *much fuller* or *much emptier*. However, the web also documents the following usages of numeral MPs:

(i) A dry year in 2000 left U.S. Bureau of Reclamation reservoirs *619.4 billion gallons emptier* in October than one year earlier.

(ii) ...her stomach now *nearly two quarts fuller* than it had been before and much warmer.

(iii) ...the tin of chocolate-coated caramel popcorn Severus had bought on impulse last week at a specialty confectioner's in Chicago had accompanied them to the porch, and was now – inexplicably – *several inches emptier*.

This is not the end of the story, however: the web also reveals the following usage of *MP full*, which is not expected by the present proposal:

(iv) When I have made this soup my 12 quart kettle has been about *10 quarts full* when the soup is done.

ent parameters when it determines the set of vectors associated with an adjective: the *scale* $S = \langle u_S, X_S \rangle$, the *standard value* d_S and the *zero value* z_S, with the restriction in (7) that one of the latter two parameters is zero. For pairs of bounded-unbounded adjectives such as *short-tall*, *young-old* etc. we have assumed that the standard value is contextually determined and the zero point is fixed as a nominal zero. Let us assume now that with unbounded-unbounded pairs of adjectives like *early-late*, the situation is the opposite one: the standard value is fixed as zero and the "zero value" is contextually determined. Consider first the following inference with *wide*.

(35) Box A is 3 feet wide; Box B is 6 feet wide;
$\Rightarrow$ Box B is (3 feet) wider than box A.

Similar entailments do not hold with *early* and *late*:

(36) Train A is 3 minutes early/late; Train B is 6 minutes early/late;
$\not\Rightarrow$ Train B is (3 minutes) earlier/later than train A.

The entailment in (35) is accounted for by our assumption that the "zero value" for *wide* is constantly zero. By contrast, the "zero value" for *early* and *late* is contextually determined (for instance, for a train it may describe the expected time of arrival). The standard value for *early* and *late* is zero by the convention in (7). If we assume that the adjective set associated with *late* is defined relative to a temporal scale $\langle u_T, (-\infty, \infty) \rangle$, it follows from the antonymy convention that the scale for the adjective set of *early* is $-T = \langle -u_T, (-\infty, \infty) \rangle$. This directly accounts for MP modification with both *early* and *late*, since applying Definition 4 leads to the following adjective sets, which are both unbounded.

(37) $\mathbf{late}' =$
$\{\langle z_T, t \cdot u_T \rangle : t > c(u_T, d_T) \wedge t \in (-\infty, \infty)\} =$
$\{\langle z_T, t \cdot u_T \rangle : t > t_0\}$

(38) $\mathbf{early}' =$

$$\{\langle z_T, t \cdot (-u_T)\rangle : t > c(-u_T, d_T) \wedge t \in (-\infty, \infty)\} =$$
$$\{\langle z_T, t \cdot u_T\rangle : t < -t_0\}$$

Here, the unboundedness of both *early* and *late* follows directly from our general definitions of adjective sets, the assumption that the relevant temporal scale is unbounded from both ends, and from the context-dependence of the zero value.

The analysis of the bounded adjectives *empty* and *full* is also derived from Definition 4 of adjective sets. We assume that the scale for *empty* and *full* is relative to the line segment $S = [0, 1]$ – the real numbers t s.t. $0 \leq t \leq 1$ – and the unit vector u_C. Further, we assume that the standard values for *empty* and *full* are $t_0 \cdot u_C$ and $t_1 \cdot u_C$, where $0 < t_0 < t_1 < 1$, and t_0 and t_1 are close to 0 and 1 respectively.[19]

(39) $\mathbf{full}' =$

$$\{\langle 0, t \cdot u_C\rangle : t > c(u_C, t_1 \cdot u_C) \wedge t \in [0, 1]\} =$$
$$\{\langle 0, t \cdot u_C\rangle : t_1 < t \leq 1\}$$

(40) $\mathbf{empty}' =$

$$\{\langle 0, t \cdot (-u_C)\rangle : t > c(-u_C, t_0 \cdot u_C) \wedge t \in [-1, 0]\} =$$
$$\{\langle 0, t \cdot u_C\rangle : 0 \leq t < t_0\}$$

Both sets are bounded, in correlation with the unacceptability of MP modification with both *empty* and *full*.

The three possibilities of boundedness in antonymous pairs – bounded-unbounded ('$+-$'), bounded-bounded ('$++$') and unbounded-unbounded ('$--$') – are summarized in Table 1, with the standard and zero values for each type of adjective pair.

[19]The assumption that $t_0 \neq 0$ and $t_1 \neq 1$, which may seem unmotivated at first blush, is in fact motivated by the lack of synonymy between *empty* and *completely empty* and between *full* and *completely full*.

boundedness	example	scale values	standard value	zero value
$+-$	*short-tall*	$\{t \cdot u_S : t \in (0, \infty)\}$	variable	0
$++$	*empty-full*	$\{t \cdot u_S : t \in [0, 1]\}$	variable	0
$--$	*early-late*	$\{t \cdot u_S : t \in (-\infty, \infty)\}$	0	variable
$--$	comparatives	–	0	variable

Table 1: possible boundedness properties in adjective pairs

Why do only scales that are unbounded from both sides exhibit a variable, context-dependent, zero parameter? The reason may be that in scales that are bounded from one side, this is a "natural" zero point of the scale. However, when a scale is unbounded, as it is the case with the temporal scale for *early* and *late*, the nominal zero point is only arbitrary, so the actual point in time that is considered as the "zero" point may vary according to the context. When this contextual variability is present, the standard value becomes redundant and can be set as constantly zero, as required by the convention in (7).

Note that in the proposed treatment, the comparative forms of all adjectives (either bounded or unbounded) behave most similarly to pairs of *unbounded* adjectives. Consider for instance the sets of vectors for *taller* and *shorter* in (12), and compare these sets to the scheme in Definition 4 of adjective sets. The sets associated with both *taller* and *shorter* are unbounded (non-empty and upward+downward monotone), and the "zero value" is the height of the reference object within the comparative (e.g. *John* in *taller/shorter than John*). The "standard value" is assumed to be zero, and the set of scale values is assumed to be $\{t \cdot u_H : t \in (-\infty, \infty)\}$ (which properly contains the set of legitimate height values). The sets of vectors for other comparative forms are assumed to be similar, independently of the (un)boundedness of the adjective. Accordingly, all comparatives univocally appear with MPs, independently of whether their positive form allows MP modification (viz. *five feet shorter* vs. **five feet short*).

4.3 The “neutral” interpretation of modified adjectives

It was observed above that only unbounded adjectives license MP modification. It will now be seen that this generalization follows from the Modification Condition (MC) of Zwarts and Winter (2000) for prepositional phrases. Furthermore, we will see that the MC also derives the “neutral” interpretation of adjectives when they are modified by MPs. Consider first the contrast between *five feet tall* and **five feet short*. By saying that the interpretation of *tall* in *five feet tall* is “neutral” we mean that being five feet tall does not entail being tall. Kennedy (2000) captures this by assuming that the height standard for adjectives in modified structures must be zero. When this is the case, any entity x with measurable height will be in the extension of *tall*. Consequently, x is considered *five feet tall* if and only if x has a measurable height and x's height is five feet, with no requirement that x is tall.[20] However, Kennedy's assumption that the standard value of an adjective becomes zero when it is modified by an MP is stipulated *ad hoc*, with no obvious account of why this should be so.

Under the present view, the ”zero standard” requirement in MP modification constructions is a direct consequence of the Modification Condition. Recall that the height standard d_H is defined by $t_0 \cdot u_H$, and consider again the adjective sets $\mathbf{tall}'$ and $\mathbf{short}'$ in (25) and (26). We observe the following distinction between these two sets of vectors:

[20] Of course, if we assumed that the standard of *tall* was set to zero ”once and for all”, then x *is five feet tall* would entail x *is tall* after all. But such an assumption would be ill-motivated: because standard values are highly context-sensitive it is quite likely that they change within the entailment, especially in cases like the one in question, where the consequent would be tautological without this standard value change.

- The set of vectors $\mathbf{tall}'$ is upward monotonic for any height standard (i.e. any value of t_0), and it is downward monotonic only if $t_0 = 0$ (i.e. the height standard is zero), in which case $\mathbf{tall}'$ covers the whole height scale.

- The set of vectors $\mathbf{short}'$ is downward monotonic for any value of t_0, and it is (trivially) upward monotonic only if $t_0 = 0$, in which case $\mathbf{short}'$ is empty.

In general, unbounded adjectives satisfy the Modification Condition (i.e. they are both upward and downward monotone) only when the standard value is zero. By contrast, bounded adjectives can become upward monotone only in the trivial case where they are false of any entity, hence they cannot satisfy the MC under any standard value without leading to a contradictory statement. Thus, the MC explains why unbounded adjectives such as *tall* can be modified by MPs whereas bounded adjectives such as *short* cannot. Furthermore, when unbounded adjectives are modified by MPs, the MC accounts for their "neutral" interpretation. Note that according to the proposed account, adjectives in unbounded-unbounded pairs are always interpreted as "neutral", since their standard value is *uniformly* zero. Indeed, *3 minutes early* entails *early*, *30Hz flat* entails *flat* etc., which is accounted for since the standard value does not change in the modified construction.

4.4 Exhaustive scales and MP modification

As observed by Seuren (1978) and Kennedy (2000), among others, many pairs of degree adjectives do not allow MP modification at all, even though the opposition between the adjectives in each pair is similar to the bounded-unbounded opposition. Consider for instance the following unacceptable examples.

(41) a. *This car goes 100 kmh. fast/slow.

b. *This parcel is two pounds heavy/light.

c. *This pen is five dollars expensive/cheap.

However, similar to other adjectives, the comparative forms of these adjectives can be modified by MPs, as the following examples illustrate.

(42) a. This car goes 100 kmh. faster/slower than that car.

b. This parcel is two pounds heavier/lighter than that parcel.

c. This pen is five dollars more expensive/cheaper than that pen.

What can be the origin of the uniform unacceptability of the modified constructions in (41) as opposed to other pairs of bounded-unbounded adjectives? A possible explanation, discussed by Seuren and Kennedy, is that the scales of adjectives such as *fast* and *expensive* do not exhaust all the physically legitimate values. This claim can be supported when considering the comparative form. For instance, a stationary object (e.g. a house) cannot be said to be *slower* than a moving object (e.g. a car); something that is available for free (e.g. air) cannot be said to be *cheaper* than things that have price (e.g. gasoline), etc. By contrast, the scales of dimensional adjectives that are MP-modifiable normally exhaust the physically possible degrees. For instance, an object that has no height or a person that has no age do not exist in a physical sense. Hence, the scales of adjectives like *tall*/*short* and *old*/*young* exhaust the values of the possible relevant degrees. Also the scales of doubly-unbounded pairs of MP-modifiable adjectives like *early*/*late* can be shown to exhaust the physically possible values. For instance, if a train arrived on time, and hence is neither *early* nor *late*, it may still be considered *earlier* (or *later*) than other trains. This indicates that the zero value is part of the *early*/*late* scale as well.

Let us see how the exhaustivity property can be used to revise the Modification Condition so that it covers non-exhaustive scales too. Recall the alternative formulation of the MC, which was given above in the discussion of (24):

(43) **The Modification Condition** (alternative formulation): A set of vectors W satisfies the MC iff for every non-empty measure set M with no zero vectors: $M \cap W$ is not empty.

In order to capture the behavior of adjectives with non-exhaustive scales we have to change this formulation of the MC at two points:

- Instead of *non-zero* vectors in M, we should allow M to contain any vector of *admissible* length. We say that a located vector $\mathbf{v} = \langle v, w \rangle$ is admissible relative to a scale S if $v + w$ is in S or if $v + w$ is a possible value of the dimension that S describes. Especially, the zero vector $\langle 0, 0 \rangle$ is admissible relative to the speed scale (although $0 + 0 = 0$ is not in it) but not relative to the height scale.

- Instead of referring to the set of located vectors W itself, we refer to its *closure* $\overline{W}_S$ in the relative scale S. This notion is defined as follows:

  $$\overline{W}_S = \{\langle v, w \rangle \in \overline{W} : v + w \in S\}$$

  For instance, the closure of the set of located vectors associated with the comparative *faster than* x includes $\langle v, 0 \rangle$ where v is x's speed (a non-zero vector), but the closure of the adjective set of *fast* does not contain the located vector $\langle 0, 0 \rangle$, even when the speed standard is zero, since the zero vector is not in the speed scale.

With these two adjustments, we get the following revision of the MC.

(44) **The Modification Condition** (revised version): A set of located vectors W satisfies the MC relative to a scale S iff for every non-empty measure set M that contains only admissible values relative to S: $M \cap \overline{W}_S$ is not empty, where $\overline{W}_S$ is the closure of W in S.

Let us see how this revised version of the MC accounts for the (un)acceptability of the following cases.

(45) This man is five feet tall.

(46) This man is five feet taller than John.

(47) *This car goes 100 kmh. fast.

(48) This car goes 100 kmh. faster than that Jaguar.

In sentence (45), the zero vector $\langle 0, 0\rangle$ is not admissible relative to the height scale. When the height standard is zero, the closure of the set of vectors $\mathbf{tall}'$ in the height scale is equal to itself, and contains all the vectors of positive lengths in the scale. Hence, for each measure set M with only admissible (=non-zero) vectors, $\mathbf{tall}'$ and M have a non-empty intersection. In sentence (46), assume that $h_{\mathbf{j}'}$ is John's height. The closure of the set associated with *taller than John* is the set of vectors $\{\langle h_{\mathbf{j}'}, t \cdot u_H\rangle : t \geq 0\}$ (containing a zero vector $\langle h_{\mathbf{j}'}, 0\rangle$). Hence, again, for each measure set M with only admissible (=non-zero) vectors, this closure and M have a non-empty intersection.

By contrast, in sentence (47), the zero vector $\langle 0, 0\rangle$ *is* admissible relative to the speed scale. However, even when the speed standard is set to zero, the closure of $\mathbf{fast}'$ in the speed scale does not contain this zero vector (which is not in the speed scale), hence there is an admissible vector that is not in this closure, and sentence (47) is ruled out. However, when we move on to (48), assume that the speed of the Jaguar is $s_{\mathbf{j}'}$. As in (46), the closure of the set associated with *faster than that Jaguar* is the set of vectors $\{\langle s_{\mathbf{j}'}, t \cdot u_S\rangle : t \geq 0\}$ (containing a zero vector $\langle s_{\mathbf{j}'}, 0\rangle$). Hence, for each measure set M with only admissible (zero and non-zero) vectors, this closure and M have a non-empty intersection.

The revised MC in (44) applies to modified locatives in a similar way that it applies to the comparative *faster than*. For instance, the phrase *outside the house* is associated with the set of located vectors $\langle v, w\rangle$, where $|w| > 0$ and v is the house's location. The closure of this set (in $V \times V$) contains the located zero vector $\langle v, 0\rangle$. Since any located vector describes a legitimate location is space, we can assume that all located vectors are admissible. Consequently, the closure of the set of vectors for *outside the house* has a non-empty intersection with any admissible MP denotation of admissible (=zero and non-zero) values.

The revised version of the modification condition in (44) ends up similar in some aspects to Seuren's (1978) account of the difference between different *scales*. For Seuren, only scales that are unbounded from above and exhaustive lead to adjectives that allow MP modification. Seuren does not distinguish theoretically between the adjectives in an antonym pair, and stipulates that only the "positive" adjective can be modified. However, in pairs such as *early-late*, the distinction between the "positive" and the "negative" adjective vanishes, and both of them allow MP modification. Seuren also does not explain why MPs should have a neutralizing effect on the adjective they modify. Thus, in effect, instead of applying the Seuren's conditions to the scale, the present treatment applies similar conditions to the *adjective set* (of vectors), with the additional requirement, borrowed from Zwarts and Winter's modification condition, that the modified adjective should be downward monotone.

4.5 On the formal nature of triviality filters

It was claimed above that the reasoning behind the proposed Modification Condition is quite similar to Barwise and Cooper's (1981) account of *there* sentences. This section elaborates on the parallelism between the principles that underly the two accounts. Barwise and Cooper propose that the acceptability of *there* sentences is governed by whether they express contingent statements or not. Consider for instance the following sentences.

(49) There is some man in the room.

(50) ?There is every man in the room.

Barwise and Cooper propose that sentence (49) is OK because, under their semantics of the *there* construction, the statement it expresses is contingent – one that can be either true or false – equivalent to *some man is in the room*. By contrast, under Barwise and Cooper's account, sentence (50) is odd because it turns out to be equivalent to the semantically trivial statement *every man in the room exists*, which is patently true under any model.[21]

Keenan (1987) points out that Barwise and Cooper's reasoning cannot be used as a general grammatical principle: more often than not, semantic triviality does not lead to any syntactic unacceptability. For instance, tautologies like *every table is a table* and contradictions like *some table is not a table* are uninformative but perfectly well-formed. Thus, theories like Barwise and Cooper's that rely on a grammatical filter of semantic triviality should specify the constructions that are subject to this filter. The present work suggests that MP modification, like existential *there*, is among the constructions whose grammaticality is sensitive to semantic triviality.

Let us call an expression (semantically) *trivial* if its denotation is constant, and in every model it denotes the minimal (or the maximal) element of its semantic domain. For instance, a contradictory sentence is semantically trivial since the statement it expresses is constantly *false* (the minimal element of the truth value

[21] Under Barwise and Cooper's standard treatment of universal quantification, if there is no man in the room the universal statement is trivially true.

domain). Similarly, a tautological sentence is semantically trivial because it constantly denotes *true* (the maximal element of the truth value domain). Moving on to phrasal categories, a nominal like *non-circular circle*, for instance, is classified as semantically trivial since it denotes the empty set in every model; an adjectival like *known or unknown* is trivial because in any model it (plausibly) denotes the set of all entities. Barwise and Cooper's general principle might simply be formulated as follows:

(51) **Triviality filter** (version 1): An expression to which the non-triviality filter applies is unacceptable if it is trivial.

Assuming that *there* sentences are subject to this triviality filter, sentence (50) is ruled out simply because it is interpreted as a tautology. However, principle (51) does not work well as a general filter for the acceptability of *there* sentences. Consider for instance the following sentence, in contrast to (50).

(52) There is some table that is not a table.

This sentence, which is pragmatically odd, is syntactically well-formed just like (49). However, (52) expresses a contradiction, so according to principle (51) it should have been not only pragmatically odd, but also grammatically unacceptable like (50). To avoid this problem, Barwise and Cooper's non-triviality condition for *there* sentences may be more adequately stated as follows.

(53) **Triviality filter for *there* sentences** (version 2a): A sentence of the form *there is D N'* is unacceptable if it is trivial for every choice of N'.

This version explicitly takes the determiner *D* and not the nominal *N'* as the governor of of *there* insertion acceptability: whether or not the N' leads to triviality is irrelevant for the acceptability of the *there* sentence. According to this principle, sentence (50) is unacceptable because for *any* N' substituted for *man in the* *room* the statement it expresses is tautological. By contrast, sentence (52) is acceptable (although contradictory) because the nominal *table that is not a table* can be replaced by another nominal (e.g. *man in the room*, as in (49)) that renders the sentence contingent.

As an alternative for principle (53) we can adopt the following, more restrictive, triviality filter for *there* sentences.

(54) **Triviality filter for *there* sentences** (version 2b): A sentence of the form *there is D N'* is unacceptable if it is trivial for some non-trivial choice of N'.

Here for the unacceptability of a *there* sentence we don't require that *any* choice of *N'* would render the sentence trivial, only that some non-trivial *N'* would. According to this principle, sentence (50) is now unacceptable because the nominal *man in the room* (as well as many others) is non-trivial but the statement that the sentence expresses is nevertheless tautological. By contrast, sentence (52) is acceptable (though contradictory) because any non-trivial nominal (e.g. *man in the room* as in (49)) instead of the trivial nominal *table that is not a table* would render the sentence contingent.[22]

If we adopt version 2b of the triviality filter for *there* sentences, then the proposed treatment of MP modification can be stated in a similar fashion:

[22] If there was a non-trivial N' that was guaranteed to be non-empty in any model then principle (54) would rule out sentences of the form *there is some N'* as well. But interestingly, it is hard to find such N's. The only way I can think of creating non-trivial N's that are non-empty in every model is using constructions such as *center of this circle*. Under the axioms of geometry, this N' is non-trivial, and denotes a non-empty set under any model where *this circle* has a denotation. However, many semanticists would consider the axioms of geometry to be outside the semantics of natural language proper: there is a marked linguistic difference between phrases like *a circle without a center* and *a circle that is not a circle*.

(55) **Triviality filter for MP modification**: A modification construction of the form *MP X* is unacceptable if for every context: *MP X* is trivial for some non-trivial choice of MP.

Let us see how this formulation accounts for the contrast between *MP tall* and **MP short*. In the first case, there are contexts – those contexts with a zero height standard – in which *MP tall* is non-trivial if *MP* is. Consequently condition (55) does not hold for *MP tall* and such expressions are correctly expected to be acceptable. By contrast, for *MP short*, any context (i.e. any height standard for *short*) leaves some non-trivial MPs that make *MP short* trivial: if the height standard is n feet, then for any $m > n$, the construction *m feet short* is trivial. Consequently condition (55) holds for *MP short*, and such expressions are correctly expected to be unacceptable.

Note that the formulation of the triviality filter for MPs in (55) is on a par with the alternative formulation of the MC in (43). If *MP X* is acceptable, principle (55) expects contexts where any non-trivial *MP* would make *MP X* non-trivial. In such contexts any model must assign *MP X* a non-empty denotation.

I do not attempt here to extend the formulation in (55) to the revised formulation of the MC in (44). Nor do I claim that this formulation represents a definitive unified theory of *there* sentences and MP modification.[23] However, I do believe that for these phenomena, triviality considerations may lead to generalizations that can give more insight into the variations in acceptability that are involved, and the preliminary discussion in this section may point to a possible way of formulating a more general triviality filter.[24]

[23] For instance, the appeal to contexts in (55) has no correlate in (54), although adding such a reference to contexts in (54) may be innocuous, and perhaps even useful.

[24] Thanks to an anonymous reviewer whose remarks on a previous draft initiated the discussion in this section.

5 Conclusions

In this paper it was shown that using fairly simple assumptions, it is possible to extend the empirical coverage of the Modification Condition as proposed by Zwarts and Winter (2000) to apply to MP modification with adjectives in the positive and comparative forms. The compositional procedure from Faller (2000) was modified so that one general scheme derives the denotations of various adjectives as following directly from their different scale structures. Using these scale structures, one type of adjectives was classified as having a constant zero value and a variable standard value. We saw that adjectives of this type come in bounded-unbounded antonymous pairs such as *short-tall* or *young-old*. Another type of adjectives pertains to scale structures that are derived by the whole set of real numbers. These adjectives come in unbounded-unbounded pairs such as *early-late* and *sharp-flat* and have a constant (zero) standard value and a variable zero value. They are similar in their semantic behavior to comparative forms (of all adjectives). We saw that the Modification Condition accounts for the possibility to modify comparatives and *unbounded* adjective positive forms, and it rules out modification with bounded adjectives. Furthermore, the same condition explains why modified adjectives, when acceptable, are "neutralized" by fixing their standard value to be zero.

In addition, we saw that the Modification Condition can be extended so that to account for the unacceptability of MP modification with unbounded adjectives such as *fast, heavy* or *expensive*. By invoking the notion of *exhaustive* scales – scales that cover all the possible degrees in the relevant dimension – it is possible to further relate the scale structure of an adjective to its modification potential with measure phrases. This last extension of the theory may point to other fine distinctions in which scale structure affects the acceptability and interpretation of adjectives. On a different level, the proposed account touches on the question of semantic triviality conditions on acceptability and their general status within linguistic theory. These and other questions of scale structure certainly need further study, but I believe that the present paper has shown the prospects of such studies of scale structure for deepening our understanding of the semantics of adjectives, and its relations with the semantic interpretation of other categories.

Acknowledgements

This research was supported by grant no. 1999210 ("Extensions and Implementations of Natural Logic") from the United States-Israel Binational Science Foundation (BSF), Jerusalem, Israel. Part of the research was carried out during a stay at the Utrecht University, which was supported by an NWO grant no. B30-541. This article is an extended and revised version of a paper that appeared in *proceedings of WCCFL20*. I would like to thank Beth Levin and two anonymous referees of *L&P* for their thorough remarks on a previous version.

References

Barwise, J. and Cooper, R. (1981). Generalized quantifiers and natural language. *Linguistics and Philosophy*, 4:159–219.

Bierwisch, M. (1967). Some semantic universals of German adjectivals. *Foundations of Language*, 3:1–36.

Bierwisch, M. (1989). The semantics of gradation. In Bierwisch, M. and Lang, E., editors, *Dimensional Adjectives*. Springer-Verlag, Berlin.

Cresswell, M. J. (1976). The semantics of degree. In Partee, B., editor, *Montague Grammar*. Academic Press, New York.

Cruse, D. A. (1976). Three classes of antonym in English. *Lingua*, 38:281–292.

Cruse, D. A. (1986). *Lexical Semantics*. Cambridge University Press, Cambridge.

Faller, M. (2000). Dimensional adjectives and measure phrases in vector space semantics. In Faller, M., Kaufmann, S., and Pauly, M., editors, *Formalizing the Dynamics of Information*. CSLI Publications, Stanford.

Heim, I. (2001). Degree operators and scope. In Fery, C. and Sternefeld, W., editors, *A Festschrift* *for Arnim von Stechow*. Akademie Verlag, Berlin.

Kamp, J. A. W. (1975). Two theories about adjectives. In Keenan, E., editor, *Formal Semantics of Natural Language*. Cambridge University Press, Cambridge.

Keenan, E. (1987). A semantic definition of 'indefinite NP'. In Reuland, E. J. and ter Meulen, A. G. B., editors, *The Representation of (In)definiteness*. MIT Press, Cambridge, Massachusetts.

Kennedy, C. (1999). *Projecting the Adjective: the syntax and semantics of gradability and comparison*. Garland Press, New York. A published version of a 1997 UCSC PhD thesis.

Kennedy, C. (2000). Polar opposition and the ontology of 'degrees'. *Linguistics and Philosophy*, 24:33–70.

Kennedy, C. and McNally, L. (1999). From event structure to scale structure: degree modification in deverbal adjectives. In *Proceedings of Semantics and Linguistic Theory, SALT9*.

Klein, E. (1980). A semantics for positive and comparative adjectives. *Linguistics and Philosophy*, 4:1–45.

Lang, S. (1977). *Linear Algebra*. Addison-Wesley, Reading, Massachusetts, second edition.

Lehrer, A. (1985). Markedness and antonymy. *Journal of Linguistics*, 21:397–429.

Rotstein, C. and Winter, Y. (2004). Total adjectives vs. partial adjectives: scale structure and higher-order modification. To appear in *Natural Language Semantics*.

Seuren, P. A. M. (1978). The structure and selection of positive and negative gradable adjectives. In Farkas, D. et al., editors, *Papers from the Parasession on the Lexicon, CLS14*. University of Chicago.

Teller, P. (1969). Some discussion and extension of Manfred Bierwisch's work on German adjectivals. *Foundations of Language*, 5:185–217.

Zwarts, J. (1997). Vectors as relative positions: a compositional semantics of modified PPs. *Journal of Semantics*, 14:57–86.

Zwarts, J. and Winter, Y. (2000). Vector space semantics: a model-theoretic analysis of locative prepositions. *Journal of Logic, Language and Information*, 9:169–211.

Computer Science, Technion, Haifa 32000, Israel

E-mail: winter@cs.technion.ac.il

WWW: http://www.cs.technion.ac.il/~winter