TWICE VERSUS TWO TIMES IN PHRASES OF COMPARISON

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ABSTRACT

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The interaction of factor phrases—things like *half*, *twice*, and *three times*—with degree constructions such as comparatives (i.e., comparisons of the form *–er* or *more…than*) and equatives (comparisons of the form *as…as*) is an area that has seldom been touched upon. While much has been written about comparatives in general, and some has been written about adverbial versions of these factor phrases (in sentences such as *John went to the store twice today*), degree-related factor phrases have been largely neglected. In particular, the distinction between factor phrases like *twice*, which combine only with equatives, and phrases like *two times*, which combine with both equatives and comparatives, has been overlooked. I will thus be examining these factor phrases as they relate to degree constructions. I will argue that for many factor phrases, like *twice* and *half*, Bierwisch (1989)'s prediction that they interact only with equatives holds true, while in cases of the form *n times* this prediction breaks down. I will also argue that factor phrases like *twice* involve a maximality operator, while factor phrases like *two times* simply involve an existential operator.

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TABLE OF CONTENTS

Twice Versus Two Times in Phrases of Comparison

1 Introduction

The interaction of factor phrases—things like *half*, *twice*, and *three times*—with degree constructions such as comparatives (i.e., comparisons of the form *–er* or *more…than*) and equatives (comparisons of the form *as…as*) is an area that has seldom been touched upon. While much has been written about comparatives in general, and some has been written about adverbial versions of these factor phrases (in sentences such as *John went to the store twice today*), degree-related factor phrases—those which interact with adjectives like *tall* and *nimble*—have been largely neglected. In particular, the distinction between factor phrases like *twice*, which combine only with equatives, and phrases like *two times*, which combine with both equatives and comparatives, has been overlooked.

This thesis will therefore take a detailed look at these factor phrases as they relate to phrases of comparison. I will argue that for many factor phrases, like *twice* and *half*, Bierwisch (1989)'s prediction that they interact only with equatives holds true, while in cases of the form *n times*—which, though a single basic form, is far more common than other factor phrases—this prediction breaks down. I will also argue that FPs like *twice* involve a *max* operator, while FPs like *two times* simply involve an existential operator.

Section 2 will outline the basic problem. Section 3 will discuss earlier writings about factor phrases, adjectival comparison, and degrees in general. Section 4 will provide a syntactic structure and denotations for the pertinent factor phrases, as well as showing how they work compositionally in sentences. This section will also discuss a couple puzzles that are still

unresolved. Section 5 will conclude the thesis, while providing a possible direction for further research.

2 The Problem

Look at the following sentences.

(1) John is as tall as Mary.

(2) John is taller than Mary.

(3) John is the tallest.

(1) through (3) all involve types of adjectival comparison, specifically that of height. The construction of (1) is an equative. (2) is a comparative construction, and (3) is the superlative. (3) is given here simply to complete the paradigm; I will not deal with this form any further.

The meanings of (1) and (2) are very similar. (2) is a true statement if and only if the height of John exceeds the height of Mary. (1) is true if John's height is greater than or equal to Mary's height. While that is not immediately intuitive, a sentence like (4),

(4) You must be as tall as this line to ride the rollercoaster.

shows this to be true. Thus, the only difference semantically between (1) and (2) is whether the relation is either greater than or greater than or equal to.

However, despite this similarity, there are different patterns. For instance, while comparatives can take bare measure phrases like *three feet*, equatives cannot.

(5) John is three feet taller than Mary.

(6) *John is three feet as tall as Mary.

(7) *John is as three feet tall as Mary.

Some phrases, however, can combine with both comparatives and equatives. These include factor phrases like *two times*.

(8) John is two times taller than Mary.

(9) John is two times as tall as Mary.

Yet not all factor phrases behave this way.

(10) John is twice as tall as Mary.

(11) *John is twice taller than Mary.

(12) The red shirt is twice as expensive as the blue shirt.

(13) *The red shirt is twice more expensive as the blue shirt.

On the surface, *twice* and *two times* appear to be identical in meaning—corresponding roughly to the meaning $y=2x$, where y is the measure of the first thing (so in the case of (8), John's height) and x, the measure of the second (Mary's height). So what would account for this difference? Why is (8) acceptable and (11) unacceptable?

Before I answer that question, let's take a step back and look at what's already been written about comparative adjective phrases, degrees, and factor phrases.

3 Previous Research

3.1 Gradable Adjectives

Looking back at (1) and (2),

(1) John is as tall as Mary.

(2) John is taller than Mary.

we note that they involve the gradable adjective *tall* and the equative and comparative degree constructions, respectively. As Kamp (1975), Klein (1980), Kennedy (1997, 2001) and others point out, gradable adjectives refer to properties. These properties are defined as scales which are themselves defined by the ordering of the objects on that scale. So in (1) and (2), the height of John and the height of Mary are both on the scale of *tall*-ness. By ordering objects such as these on a given scale, we can then make comparisons among those objects. Thus it can be said that, since John's height is greater than Mary's height on the scale of *tall*-ness, (2) is an interpretable and true sentence. As for a sentence like (14),

(14) John is tall.

an independent standard must be introduced into the scale of *tall*-ness, and if it is determined that John's height exceeds this standard, then (14) is true. What that standard is varies from situation to situation, and while (14) may be true if John is four feet tall and he is being compared to the set of people who are four feet tall or less, it will not be true if John is being compared to the set of professional basketball players.

Another thing to note about gradable adjectives is that they can be divided into subcategories determined by whether or not the scale is open or closed at either end. *Tall*-ness, for instance, is closed on the bottom end, where heights are zero, and open on the top end—after all, there is theoretically no limit as to how tall something can be. An adjective like *dry*, on the other hand, is closed on both ends; once something is dry, it cannot become any drier. This is something that can be observed more clearly with adverbs like *completely* or *partly*.

(15) The towel is completely/partly dry.

(16) *John is completely/partly tall.

In (15), *completely* and *partly* combine grammatically with the telic adjective *dry*. But in (16), with atelic *tall*, the sentence is ungrammatical.

3.2 Degrees

Now the classical view of these types of adjectives (for the version Kennedy 1997 calls the "Vague Predicate Analysis", in which adjectives denote functions from objects to truth values, see McConnell-Ginet 1973, Kamp 1975, Klein 1980, van Benthem 1983, and others; for the version he calls the "Scalar Analysis", in which adjectives denote functions from objects to

degrees, see Bartsch & Vennemann 1973, Seuren 1973, Cresswell 1976, Hellan 1981, von Stechow 1984, Heim 1985, and others) is that their scales have domains that are partially ordered in some way, usually through a series of points; thus in (1), the degree of John's height is a point on the scale that is above the degree of Mary's height. If John is six feet tall, then the degree of his height on the scale is a point at six feet. The advantage of thinking about degrees as points is that they are easier to conceptualize and thus easier to manipulate; so in a sentence like (17),

(17) John is three inches taller than Mary.

all that is necessary to find the degree of John's height to take the degree of Mary's height and add three inches to it—each degree is a single point, not a range of them that must be further manipulated.

The disadvantage, though, as Kennedy (1997) points out, is that it becomes very difficult to explain the effects of negative adjectives, such as the following:

(18) *Bob is five feet short.

If degrees are simply points on a scale, then it is not immediately clear why (18) is bad. After all, whether an adjective is positive or negative should have no bearing on the specific points of a scale. Additional machinery must be added to determine the ordering of degrees based on the polarity of the adjective, such that the domain of a negative adjective is reversed from that of its positive counterpart. So if we added another sentence, similar in meaning to (2),

(2) John is taller than Mary.

(19) Mary is shorter than John.

then the ordering of the domains (adapted from Kennedy 1997) would be as in (20):

(20) D_{tall} = {a, b, Mary, c, John}

D_{short} = {John, c, Mary, b, a}

where *a, b,* and *c* are other degrees on the scale. This is workable, but then it becomes unclear why the cross-polar anomaly (i.e., a sentence which compares a positive adjective with a negative adjective) in (21), with the following logical representation, is bad.

(21) *John is taller than Bob is short.

$\exists d[(d(tall))(John) \wedge \neg(d(short))(Mary)]$

As Kennedy (1997) states, there is a function *d* that would cause (21) to be both interpretable and true; the function would partition the domains of the adjectives as in (22).

(22) $pos_d(tall)$ = {Mary, c, John}

$neg_d(tall)$ = {a, b}

$pos_d(short)$ = {b, a}

$neg_d(short)$ = {John, c, Mary}

Thus in (22), the positive domain of the function *d* for *tall* would consist of the elements *Mary, c,* and *John*, while the negative domain would consist of *a* and *b*. Since the ordering of the elements for *short* is simply the reverse of *tall*, the positive domain for *short*, for example, is *b* and *a*—the same elements as the negative domain of *tall*, simply reversed. But if adjectives simply distinguish between positive and negative types based on the ordering of the degree objects within the domain, then (21) becomes acceptable—an outcome that is not desired.

However, Kennedy (1997, 2001), following from Seuren (1978, 1984) and von Stechow (1984), offers a different interpretation. In this version, degrees are not points on a scale but are instead intervals. Thus, instead of degrees representing points, they represent sets of points. Positive and negative degrees differ, therefore, by which subset of the scale they represent. So for a positive degree, for any point contained within the degree, every point below that point is also contained within the degree.

(23) $\text{POS}(S) = \{d \subseteq S \mid \exists p_1 \in d \forall p_2 \in S[p_2 \leq p_1 \rightarrow p_2 \in d]\}$

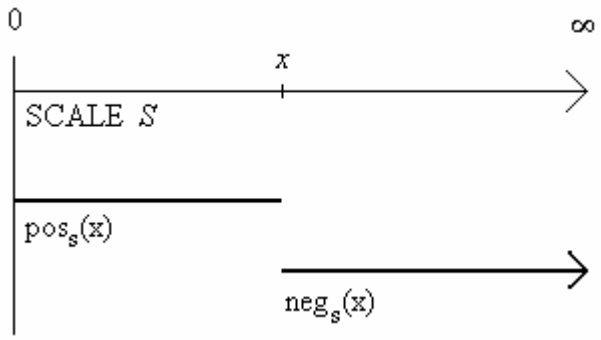
(23) states that for a degree *d* that is a proper subset of the scale *S*, there is a point p_1 that is contained within a degree consisting of every point p_2 that is itself contained with a scale such that if p_2 is less than or equal to p_1, then p_2 is contained within the degree *d*. In simpler language, degree *d* contains every point on a scale that is less than or equal to point p_1. So as long as p_2 is less than or equal to p_1, p_2 is a part of the positive degree.

Negative degrees are very similar, but whereas positive degrees go to the bottom of the scale, negative degrees go to the top. In formal terms,

(24) $\mathrm{NEG}(S) = \{d \subseteq S \mid \exists p_1 \in d \forall p_2 \in S[p_1 \leq p_2 \rightarrow p_2 \in d]\}$

The key thing to note is that for a negative degree, p_2 is contained only if it is greater than or equal to p_1.

(25)



Furthermore, for any given object *x* on a scale *S*, the maximal element of the positive degree is equal to the minimal element of the negative degree.

(26) $\max(\mathrm{pos}_S(x)) = \min(\mathrm{neg}_S(x))$

So with a sentence like (2), Mary's height is less than John's height, making Mary's height a proper subset of John's height. In formal terms with a positive adjective,

(27) tall(Mary) ⊂ tall(John)

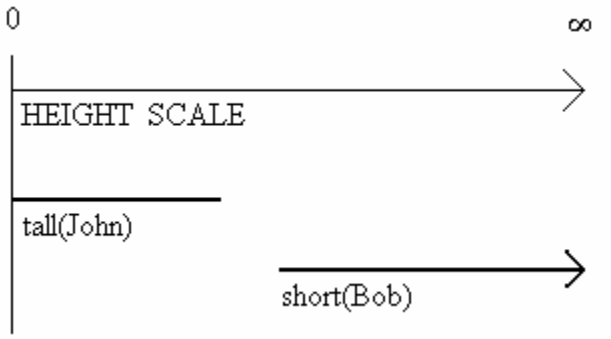
and with a negative adjective,

(28) short(John) ⊂ short(Mary).

Thinking of degrees as intervals now allows us to explain the unacceptability of (21). John's height is a positive degree, whereas Bob's height is a negative degree. Since neither is a proper subset of the other, the sentence becomes uninterpretable.

(29) short(Bob) ⊂ tall(John)

(30)



One additional point is to make explicit the *max* operator referenced in (26). Following von Stechow (1984) and Rullmann (1995), among others, I assume that there is a maximality operator which selects the maximal point of a degree interval, and strictly speaking it is this maximal point which comparatives select. In other words, if John is six feet tall, then he is also

five feet tall, four feet tall, three feet tall, etc., but the important part of John's height is the maximal point at six feet.

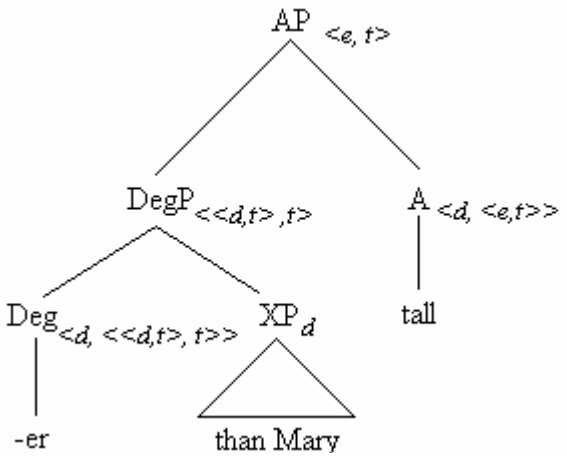
3.3 Syntactic Structures

The "classical view" (as Bhatt & Pancheva 2004 call it) of degree clause structures like comparatives comes from sources like Selkirk (1970), Bowers (1975), Bresnan (1973), Jackendoff (1977), Hellan (1981), Heim (2000), and others. In this syntax, the degree clause and the degree morpheme form a constituent. So in the case of (2),

(2) John is taller than Mary.

the degree clause *than Mary* combines with the morpheme *–er*, which then combines further up the tree with the gradable adjective. The fact that degree morphemes require specific complementary words in the degree clause (*than* in the case of comparatives, *as* in the case of equatives) is evidence for this constituency.

(31)[1]



An argument against this, as Bhatt & Pancheva (2004) point out, is that in general, the degree morpheme and the degree clause cannot appear together—a fact against constituency.

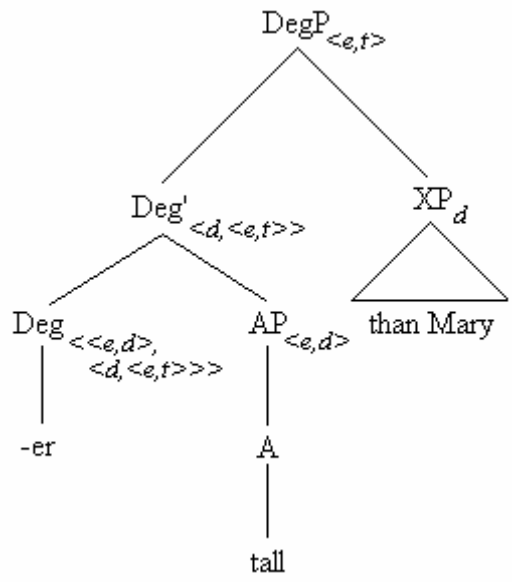
(32) *John is [more than Mary] tall.

There is also the matter of the type clash in (31). DegP is of type <<*d,t*>, *t*>, while A is of type <*d,* <*e,t*>>. In order to resolve this, DegP needs to Quantifier Raise (QR), leaving behind a trace of type *d* (this also assumes a type of semantic binding, like the version described in Heim & Kratzer 1998).

Kennedy (1997), following from others like Abney (1987), Larson (1988), Corver (1990), and Grimshaw (2005), offers an alternate interpretation. In his version, the AP and the degree morpheme form a constituent which then combines with the degree clause.

[1] These types derive from Heim (2000).

(33)



This structure also has the advantage that no type shifts need to occur in order for proper interpretation to happen. There is the worry, though, that in this structure, AP is now of type <*e,d*>, which is not a workable general type for any adjective not contained within a degree phrase. There is also the question of why sometimes the degree morpheme and the degree clause take scope together without the AP. Heim (2000) (by way of Bhatt & Pancheva 2004) gives the following example[2]:

(34) (This draft is 10 pages long.) The paper is required to be exactly five pages longer than that.

[2] The abbreviations, taken from Heim (2000): *p* = the paper; $long_w(p,d)$ = x is long to degree d in world w; *Acc(w)* = the set of worlds accessible from w. The world argument is suppressed when it is the utterance world.

a. *required* > *-er*: required [[exactly 5 pages –er than that]$_1$ [the paper be t_1-long]

$\forall w \in Acc: \max\{d: long_w(p,d)\} = 15$ pages

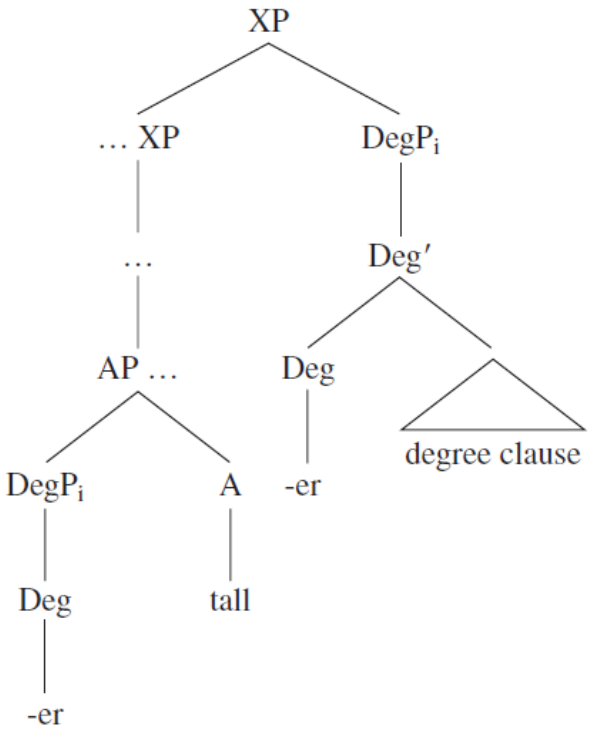
b. *-er* > *required*: [exactly 5 pages –er than that]$_1$ [required [the paper be t_1-long]]

$\max\{d: \forall w \in Acc: long_w(p,d)\} = 15$ pages

In (34)a, the paper is exactly fifteen pages long in every acceptable world. In (34)b, the paper is exactly fifteen pages long in those worlds where it is the shortest (that is, the paper must be at least fifteen pages long). More importantly, (34)b gives a reading where the degree morpheme and the degree clause take scope without the AP.

Bhatt & Pancheva (2004) suggest that this contradictory evidence can be resolved by what they call "late merger of the degree clause." In this version, the degree morpheme begins as a sister to the gradable predicate before moving later in the derivation to become a sister of the degree clause, leaving a copy behind. It is this copy that is pronounced, while the degree clause merges countercyclically after the degree morpheme has moved covertly to its scope position. The degree clause then merges as an argument to the QR-ed degree morpheme. Thus the degree morpheme is interpreted in its scope position but pronounced in its base position.

(35)[3]



I will not delve into the implications of this theory any further, as it should not directly affect the goal of this thesis; it is merely presented for sake of completion.

3.4 Factor Phrases

The most extensive analysis of factor phrases (words like *twice* and *seven times*) comes from Bierwisch (1989), who observes a number of characteristics about them. He notes that for a sentence like (36),

(36) Hans ist doppelt so groß wie Eva.

Hans is twice as tall as Eva.

[3] This tree is taken from Bhatt & Pancheva (2004).

Hellan (1981)[4] and von Stechow (1984) assume the following representation:

(37) $\exists x_1 \exists x_2 \exists x_3 [[\text{HANS } [\text{TALL } x_1]] \wedge [\text{EVA } [\text{TALL } x_2]] \wedge [x_3 = 2] \wedge [x_1 = x_2 \times x_3]$

In other words, there are three degrees x_1, x_2, and x_3, such that the degree to which Hans is tall is equivalent to the degree of Eva's *tall*-ness multiplied by a factor of two. While this does not take into account an example like (4),

(4) You must be as tall as this line to ride the rollercoaster.

in that (37) assumes that Hans's height is exactly twice Eva's without the possibility of it being greater, this can be easily fixed.

(38) $\exists x_1 \exists x_2 \exists x_3 [[\text{HANS } [\text{TALL } x_1]] \wedge [\text{EVA } [\text{TALL } x_2]] \wedge [x_3 = 2] \wedge [x_1 \geq x_2 \times x_3]$

Although the formal representations have changed somewhat since Bierwisch (1989), the basic principle shown in (38) is still usable. Bierwisch further states that this seems to imply that

[4] Hellan (1981)'s work comes to me via von Stechow (1984) and Bierwisch (1989).

equative phrases are based on multiplication and differential comparatives on addition, as evidenced by (5) and (6), where (6) seems to rule out the possibility of addition or subtraction in equatives via measure phrases, while (5) is based on addition and subtraction.

(5) John is three feet taller than Mary.

(6) *John is three feet as tall as Mary.

(39) *Formal representation of (5) via Bierwisch (1989):*

$\exists x_1 \exists x_2 \exists x_3$ [[JOHN [TALL x_1]] $\wedge$ [MARY [TALL x_2]] $\wedge$ [x_3 = 3 ft] $\wedge$ [$x_1 = x_2 + x_3$]

This of course excludes the fact that comparatives can combine with factor phrases of the form *n times* without difficulty, as in (8).

(8) John is two times taller than Mary.

This may be a special case, however; I will go into further detail in section 4.

Bierwisch (1989) also points out that in general, equatives of negative adjectives cannot take factor phrases. This however only applies to dimensional adjectives like *tall* and *long*; evaluative adjectives like *good* and *pretty* are unaffected.

(40) Dieses Brett ist dreimal so long wie der Tisch.

This board is three times as long as the table.

(41) ?Dieses Brett ist dreimal so kurz wie der Tisch.

This board is three times as short as the table.

(42) Der Film ist dreimal so gut wie das Buch.

The film is three times as good as the book.

(43) Der Film is dreimal so schlecht wie das Buch.

The film is three times as bad as the book.

The acceptability of (43) versus the unacceptability of (41) may be due to the fact that multiplying degrees of quality is imprecise and thus does not require the precision that multiplying degrees of dimension does; thus negative adjectives are more likely to lead to an unacceptability judgment in those cases. This is presumably related to sentences (18) and the reason why it too is unacceptable.

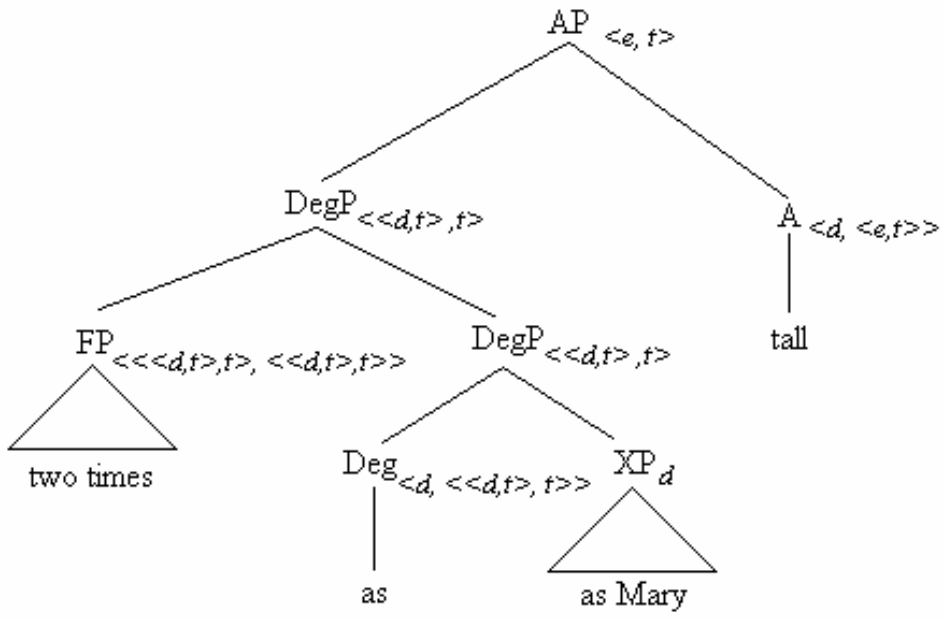
(18) *Bob is five feet short.

An alternate possibility is that evaluative adjectives are essentially closed scales; that is, while it is theoretically possible to imagine something of infinite length, there is a point at which, say, perfect beauty is reached (with the definition of perfection varying from individual to individual) and that thus there is no such thing as *infinite beauty*, hyperbolic sentences aside.

As far as the syntax of factor phrases, Bierwisch (1989) assumes the following structure[5]:

[5] I have adapted Bierwisch's original structure to more closely mirror the structure in (31), but all positions within the tree remain the same. The types, however, are mine.

(44)



The factor phrase (FP) is a modifier of the DegP, not an argument, and thus attaches as in (44).

One final point regarding Bierwisch (1989): two of the words he lists as factor phrases are *half* and *double*. *Double* does not behave like other factor phrases, requiring special language to be accommodated.

(45) *John is double as tall as Mary.

(46) *John is double taller than Mary.

(47) John is double the height of Mary.

Based on this patterning, we can tentatively place *double* in a separate category from other factor phrases, one that we will not deal with any further here. *Half*, however, behaves differently depending on the environment. In some cases it can pattern along the same lines as *twice*.

(48) John is half as tall as Mary.

(49) *John is half taller than Mary.

Kennedy & McNally (2005) note, however, that it can occur on its own in a manner similar to words like *mostly*.

(50) The glass is half full.

(51) Her eyes were half closed.

This may simply be a case of two different instances of the word *half*. Whether they are distinct or whether the version in (48) and (49) is related to the version in (50) and (51) is beyond the scope of this thesis.

Beyond Bierwisch (1989), factor phrases rarely come up in the literature. Kennedy (1997, 2001) does not mention them. Doetjes (1997, 2007) deals only with *n times* phrases in relation to adverbial times (e.g., *John went to the store three times today*), while Rett (2008) only refers them in a footnote (which I will return to in section 4).

3.5 Formal Semantics of Degree Phrases

Although there are a number of different approaches as to how to build up degree phrases compositionally, there are certain areas that are common to all of them. It is agreed, for instance, that comparatives introduce a greater-than relation between two objects, while equatives introduce a greater-than-or-equal-to relation. Taking Kennedy & McNally (2005)'s denotations as an example,

(52) $[[\text{er/more than } d_c]] = \lambda G_{<d,et>}\lambda x.\ \exists d[d > d_c \wedge G(d)(x)]$

(53) $[[\text{as as } d_c]] = \lambda G_{<d,et>}\lambda x.\ \exists d[d \geq d_c \wedge G(d)(x)]$

where *G(d)(x)* is the gradable adjective and d_c is the degree introduced by the degree clause, we see that, for instance, (52) simply introduces a degree which is greater than the degree d_c and states that, using *tall* as the gradable adjective, the property of *tall*-ness of an individual *x* is equal to *d* (i.e., *tall(x) = d*). One thing not included in (52) and (53) is the *max* operator from von Stechow (1984), but in order for their denotations to have any meaning, the *max* operator must be assumed for the degrees being compared. There are some variations in denotations (Meier 2003, for example, makes the maximality operator explicit, i.e., $max(d_1) > max(d_2)$), but this approach is basically the same as the others.

4 Twice versus Two Times in Phrases of Comparison

4.1 Basic Assumptions

Let's look at the data again.

(8) John is two times taller than Mary.

(9) John is two times as tall as Mary.

(10) John is twice as tall as Mary.

(11) *John is twice taller than Mary.

There is an asymmetry here that needs to be explained. Why should *two times* be acceptable with either comparatives or adjectives while *twice* only works with equatives?

The first thing to observe is that (8) and (9) actually mean the same thing. After all, if John is six feet tall and Mary is three feet tall, (8) is still true. This bears a closer look. In the case of (1) and (2),

(1) John is as tall as Mary.

(2) John is taller than Mary.

they do not mean the same thing. Extrapolating from this, one would expect (8) to be true only if John's height were greater than six feet. This is, on the face of it, odd. And it is not just English that exhibits this quirk: in Macedonian, for example, the meaning of (8) and (9) can only be expressed with the comparative form (Monica Markovski, p.c.).

(54) Jon je po visok od Mari.

John is taller than Mary.

(55) Jon je visok kolku Mari.

John is as tall as Mary.

(56) Jon je dva puti po visok od Mari.

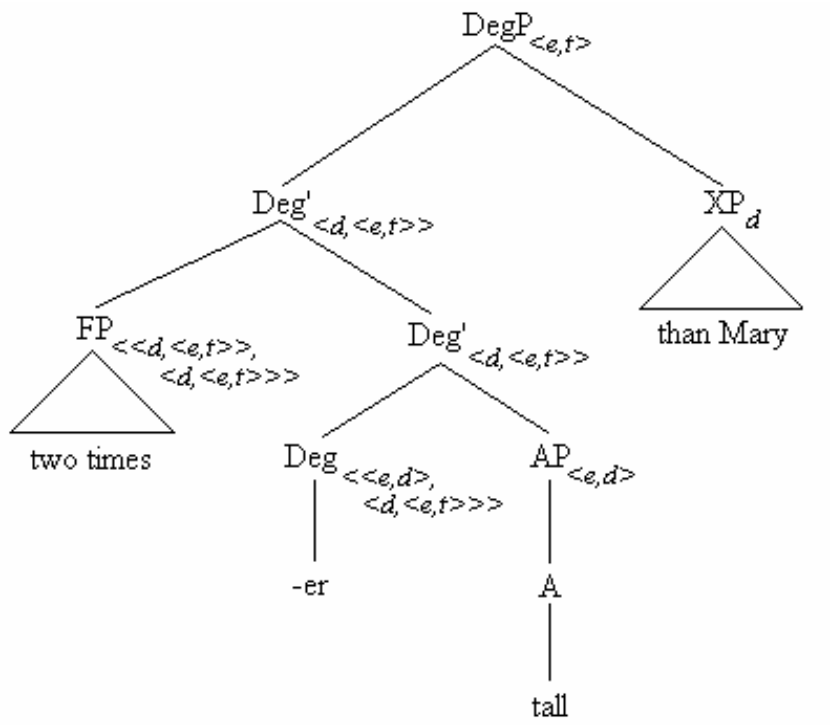
John is two times taller than/as tall as Mary.

(57) *Jon je dva puti visok kolku Mari.

John is two times as tall as Mary.

So the question remains: why do (8) and (9) mean the same thing? Given that (1) and (2) do not, the answer must lie within the factor phrase. First, I shall specify where the factor phrase attaches to the tree. Adapting Bierwisch (1989)'s syntactic structure with my types to the Kennedy syntax gives us a tree like (58):

(58)



The factor phrase attaches at Deg' in order to gain access to the degree within; this also has the advantage of corroborating Rett (2008)'s independent assumption that factor phrases attach at Deg', in order to account for their ability to affect the semantics in terms of its evaluative markedness. A sentence is evaluative if it refers to a degree that exceeds a contextually specified standard. So (59) is marked for evaluativity, while (60) is not:

(59) Paul is tall.

(60) Paul is as tall as Chris.

(61) Paul is as short as Chris.

(59) is evaluative because it implies a standard of tallness that Paul exceeds it. (60) is non-evaluative. It merely states that Paul's height is greater than Chris's; it makes no mention of where either is in relation to a standard of tallness. (61), meanwhile, is evaluative because the negative adjective implies that Paul is short, which therefore means he exceeds the standard for shortness. Evaluativity can be tested by determining whether the sentence entails the corresponding positive construction; that is, (59) entails that Paul is tall, while (60) does not: it makes no reference to a contextually supplied standard. (61), however, does, as the use of the negative adjective *short* refers to a standard of shortness and entails that Paul is short. This evaluative property (EVAL) is located within Deg': this allows it to affect the evaluativity of an expression within a DegP, rather than a whole CP. For instance, the evaluativity of (61) is not affected by the addition of a modifier such as *at least*:

(62) Paul is at least as short as Chris.

Even though the semantics of the complete expression should be non-evaluative (i.e., (62) does not mutually entail that Paul is as tall as Chris), (62) is still evaluative because it still refers to the contextually-supplied standard of shortness, so while (62) does not entail that Paul is as tall as

Chris, it does entail that Paul is short. This illustrates why EVAL is located within Deg'. However, with a sentence like (63),

(63) Paul is twice as short as Chris, but neither one is short.

the factor modifier *does* affect the evaluativity. The factor phrase in (63) does not preserve the evaluativity that would otherwise be present. This leads Rett to believe that the factor phrase is affecting the semantics and thus must be base-generated in Deg'.

Placing FP as an adjunct to Deg' means that it is of type $\langle\langle d, \langle e,t\rangle\rangle, \langle d, \langle e,t\rangle\rangle\rangle$. This gives it access to the merged gradable adjective and degree morpheme, allowing it to modify the degree relation; any further up the tree and the factor phrase would have to become needlessly complicated to enact the required modification, as I will show in section 4.2.

4.2 The Compositions of Twice *and* Two Times

Let's assume for now that Bierwisch (1989)'s intuition regarding factor phrases is correct, and that they generally only combine with equatives, in the way of words like *twice* and *half*.[6] A way to include equatives and exclude comparatives is thus necessary. The key difference between comparatives and equatives, remember, is the presence of $>$ versus $\geq$. Thus a denotation for the equative degree morpheme *as*, which is of type $\langle\langle e,d\rangle, \langle d, \langle e,t\rangle\rangle\rangle$, would look like (64).[7]

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[6] It should be noted that I do not believe this assumption to be correct, as evidenced by sentences like (8); however, it serves as a useful starting point.

[7] I will use Kennedy's version of the degree construction, as with the fewest moving parts it will be easier to see what is occurring with the factor phrase.

(64) $[[as]] = \lambda G_{<e,d>} \lambda d \lambda x\ [G(x) \geq d]$

This denotation simply takes the gradable adjective *G(x)* (which is of type <*e,d*>, meaning that it takes an individual and returns a degree, not a truth value) and states that the degree the adjective returns is greater than or equal to another degree (which, using (10) as the sentence being interpreted, will later be supplied by the degree clause *as Mary*). Combining *as* with the adjective *tall* (which I assume simply is denoted as *λx[tall(x)]*, i.e., "the height of *x* is some certain degree") gives us (65).

(65) $[[as\ tall]] = [[as]]\ ([[tall]])$

$= \lambda d \lambda x\ [tall(x) \geq d]$

Now we need a denotation for *twice*, one that loosely means something like "*x* is tall to a degree greater than or equal to another degree *d* multiplied by a factor of 2". The key thing, once again, is to ensure that equatives are allowed and comparatives disallowed. With that in mind, I suggest a denotation for *twice* like (66):

(66) $[[twice]] = \lambda F_{<d,<e,t>>} \lambda d \lambda x\ [\max\{d_x: F(d_x)(x)\} \geq 2d]$

This denotation takes in Deg', which is of type <*d, <e,t>*>, and introduces another degree d_x, the maximum of which is greater than or equal to the degree *d* times 2. This additional degree allows us to compare our two degrees *tall(x)* and *d*.

(67) [[twice as tall]] = [[twice]] ([[as tall]])

$= \lambda d \lambda x\ [\max\{d_x\text{: tall}(x) \geq d_x\} \geq 2d]$

Functionally, d_x is equal to *tall(x)*, as the maximal value of d_x must be equal to the smallest value of *tall(x)* that we're interested in. So for all intents and purposes, *tall(x)* ≥ *2d*, which is the desired outcome. The rest of the denotation continues as normal.[8]

(68) [[John is twice as tall as Mary]] = [[twice as tall]] ([[than Mary]])([[John]])

$= \lambda x\ [\max\{d_x\text{: tall}(x) \geq d_x\} \geq 2(d_m)([[\text{John}]])$

$= 1$ iff $\max\{d_x\text{: tall(John)} \geq d_x\} \geq 2(d_m)$

$= 1$ iff $\text{tall(John)} \geq 2(d_m)$

Since $max(d_x)$ is equal to *tall(John)*, the redundant information is removed, leaving simply *tall(John)*.

However, when a comparative attempts to combine with *twice*, it breaks down.

(69) [[twice taller]] = [[twice]] ([[taller]])

8 d_m represents the degree of Mary's height and is the end result of [[as Mary]].

$= \lambda d \lambda x\ [\max\{d_x\text{: tall}(x) > d_x\} \geq 2d]$

The reason (69) breaks down is that *twice* requires the maximum degree that is smaller than *tall(x)*, and there is no such number—after all, is d_x equal to *tall(x)* – 1? *tall(x)* – 0.1? *tall(x)* – 0.00000000000000000000000000000000000001? There is no way of determining a value for d_x. To put it in mathematical terms, d_x approaches *tall(x)* from below but never reaches it. This then explains why (10) is acceptable and (11) is not. Furthermore, this also corroborates Bierwisch (1989)'s observation that factor phrases only appear with equatives, not comparatives. The denotation for *half* is simply a matter of changing the factor.

(70) $[[\text{half}]] = \lambda F_{<d,<e,t>>} \lambda d \lambda x\ [\max\{d_x\text{: } F(d_x)(x)\} \geq 1/2\ d]$

This still leaves the matter of *n times* phrases unresolved. However, using *twice* as a guide, we can modify (66) slightly to allow compatibility with both equatives and comparatives.

(71) $[[n \text{ times}]]$[9] $= \lambda F_{<d,<e,t>>} \lambda d \lambda x.\ \exists d_x\ [F(d_x)(x) \wedge d_x \geq nd]$

(71) takes the Deg' and states that it is larger than some degree d_x, and that d_x is greater than or equal to a degree *d* multiplied by some factor *n*. So, interpreting (9) gives us the following:

[9] I am not concerned in this thesis how *n times* is built up compositionally. Suffice to say that the number that the factor in the phrase ends up being replaces *n* in (71).

(72) [[two times as tall]] = [[two times]] ([[as tall]])

$= \lambda d \lambda x.\ \exists d_x\ [tall(x) \geq d_x \wedge d_x \geq 2d]$

[[John is two times as tall as Mary]] = [[two times as tall]]

([[as Mary]])([[John]])

$= 1$ iff $\exists d_x\ [tall(John) \geq d_x \wedge d_x \geq 2d_m]$

$= 1$ iff $tall(John) \geq 2d_m$

Like (68), *tall(John)* is equal to d_x, and thus the redundant information is removed, leaving the final line of (72). This is precisely the desired result for (9).

Combining *two times* with the comparative, however, gives a subtly different result.

(73) [[two times taller]] = [[two times]] ([[taller]])

$= \lambda d \lambda x.\ \exists d_x\ [tall(x) > d_x \wedge d_x \geq 2d]$

According to (73), the sentences in (8) and (9) do not technically mean the same thing. It is in fact the case that *tall(John)* cannot be exactly equal to twice Mary's height. *tall(John)* must be slightly larger than $2d_m$. However, it is also true that (73) does not specify the size of the interval between *tall(x)* and d_x. Thus *tall(x)* only needs to be an atom taller than d_x for this to hold true. This means that *tall(x)* can round down to the value of d_x—pragmatically, their values are identical. It seems to be virtually impossible to construct an example where (73) fails

pragmatically. Even when dealing with incredibly small objects like atoms, it is still possible for *tall(x)* and *d(x)* to be pragmatically equivalent. For example, if there is an atom of hydrogen with an atomic weight of 1.00794 atomic mass units (u) and a molecule of hydrogen gas (which consists of two atoms of hydrogen) with an atomic weight of 2.01588 u, we can still say (74),

(74) This molecule of H_2 is two times heavier than that atom of hydrogen.

because even at this level of smallness, there is no way of knowing if the molecule actually weighs 2.01588…1 and we have simply rounded down. Thus pragmatically, a sentence like (8) will look like (75).

(75) [[John is two times taller than Mary]] = [[two times taller]]

([[than Mary]])([[John]])

$= 1$ iff $\exists d_x$ [tall(John) $> d_x \wedge d_x \geq 2d_m$]

$= 1$ iff tall(John) $\geq 2d_m$

Two times and *twice* will also work with closed-scale adjectives like *dry*.[10]

(76) Dara is twice as dry as Michael.

(77) Dara is two times as dry as Michael.

(78) [[twice as dry]] = $\lambda d \lambda x$ [max$\{d_x$: dry(x) $\geq d_x\} \geq 2d$]

[10] I am assuming that *dry*, similarly to *tall*, is an adjective that maps individuals to degrees of dryness. In (78) and (79), d_m represents the degree of Michael's dryness.

[[Dara is twice as dry as Michael]] = [[twice as dry]]

([[as Michael]])([[Dara]])

= λx [max{d_x: dry(x) $\geq d_x$} $\geq$ 2(d_m)([[Dara]])

= 1 iff dry(Dara) $\geq$ 2(d_m)

(79) [[Dara is two times as dry as Michael]] = [[two times as dry]]

([[as Michael]])([[Dara]])

= 1 iff $\exists d_x$ [dry(Dara) $\geq d_x \wedge d_x \geq 2d_m$]

= 1 iff dry(Dara) $\geq 2d_m$

This, once again, is exactly the desired result.

With closed-scale adjectives, *twice* and *two times*, just like ordinary measure phrases, work in both directions. (78) and (79) show the composition of sentences involving *dry*, and (82) and (83) show the composition with *wet*.

(80) Michael is twice as wet as Dara.

(81) Michael is two times as wet as Dara.

(82) [[Michael is twice as wet as Dara]] = [[twice as wet]]

([[as Dara]])([[Michael]])

= λx [max{d_x: wet(x) $\geq d_x$} $\geq$ 2(d_d)([[Michael]])

= 1 iff wet(Michael) $\geq$ 2(d_d)

(83) [[Michael is two times as wet as Dara]] = [[two times as wet]]

([[as Dara]])([[Michael]])

= 1 iff $\exists d_x$ [wet(Michael) $\geq d_x \wedge d_x \geq 2d_d$]

= 1 iff wet(Michael) $\geq 2d_d$

Moreover, with open scale adjectives like *tall*, their negative counterparts also work as desired.

(84) Mary is twice as short as John.

(85) [[twice as short]] = [[twice]] ([[as short]])

= $\lambda d \lambda x$ [max$\{d_x$: short(x) $\geq d_x\} \geq 2d$]

In (85), we note that the degrees on the scale of shortness are exactly what we want—for instance, if we assume that Mary is three feet tall and John is six feet tall, then plugging the numbers into (85) means that *max{d_x: 3 $\geq d_x \geq$ 12}*. Since the scale of shortness is reversed relative to the scale of tallness, this is correct, since three would be larger on the shortness scale (i.e., further from the "starting point" of infinity) than twelve.

There is however a concern related to fractional factors. Although *half* has been demonstrated in (70) to be fine, there is a puzzle with phrases like *a third*. While (86), the equative form, follows the pattern, (87) and (88) do not.

(86) Andrew is a third as tall as Mitch.

(87) Andrew is a third taller than Mitch.

(88) Andrew is a third [less tall/shorter] than Mitch.

The meaning of (87) and (88) loosely translate to (89) and (90), respectively.

(89) tall(Andrew) = tall(Mitch) + 1/3(tall(Mitch))

(90) tall(Andrew) = tall(Mitch) – 1/3(tall(Mitch))

(87) and (88) behave more like comparatives with measure phrases, looking more like (91) than what we would expect from factor phrases.

(91) Andrew is 12 inches taller than Mitch.

tall(Andrew) = tall(Mitch) + 12 in.

This puzzle has yet to be satisfactorily explained.

5 Conclusion

In this thesis I have argued that factor phrases like *twice* and *two times* do not in fact mean the same thing but have subtly different denotations. I have also stated that factor phrases attach to degree constructions as an adjunct to Deg' in Kennedy (1997) and others' framework. This leads to further support of this analysis of degree constructions. Moreover, although Bierwisch (1989) has done some work on factor phrases, I have taken many of his assumptions further, supported them where appropriate, and altered them where necessary to fit

the data. Given the data regarding both adjectives like *tall* and *dry* and the observations made by Bierwisch (1989) and Rett (2008), my denotations of *twice* and *two times* appear to be correct.

Further work in this area may also include continuing this line of research with other factor phrases such as *double*, which does not follow the pattern established by *twice*, *two times*, etc., and potentially investigating the relations between these factor phrases and adverbial versions found in eventive and temporal sentences. There is also the curious behavior of fractional factor phrases, which do not follow the pattern of phrases like *twice*. However, my analysis can hopefully be extended to account for these as well.

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