

## The degree functions of negative adjectives

Galit Weidman Sassoon

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**Abstract** This paper provides a new account of positive versus negative antonyms. The data includes well-known linguistic generalizations regarding negative adjectives, such as their incompatibility with measure phrases (cf. *two meters tall/ \*short*) and ratio phrases (*twice as tall/ #short*) as well as the impossibility of truly cross-polar comparisons (*\*Dan is taller than Sam is short*). These generalizations admit a variety of exceptions, e.g., positive adjectives that do not license measure phrases (cf. *#two degrees warm/cold*) and rarely also negative adjectives that do (cf. *two hours late/early*). Furthermore, new corpus data is presented regarding the use of *twice* with positive and negative adjectives. The analysis the paper presents supposes that grammar associates gradable adjectives with measure functions—mapping of entities to a set of degrees isomorphic to the real numbers (Kennedy, Projecting the

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G. W. Sassoon (✉)  
ILLC, University of Amsterdam, Science Park 904, Room C3-136K,  
1098 XH, Amsterdam, The Netherlands  
e-mail: galitadar@gmail.com; adar69@012.net.il

G. W. Sassoon  
Haverstede 19, 1112 HR, Diemen, The Netherlands

adjective: The syntax and semantics of gradability and comparison, 1999). On this analysis, negative adjectives map entities to values that are *linearly reversed* and *linearly transformed* in comparison with their values in the positive antonyms. As shown, the generalizations, as well as their exceptions, directly follow. Negative polarity is explained in terms of function reversal, and non-licensing of measure phrases is explained in terms of transformation by an unspecified value.

**Keywords** Negative adjective · Transformation · Degree · Measure · Comparison · Ratio modifiers

## 1 Introduction

Existing accounts of ‘positive’ and ‘negative’ antonyms often treat the concepts of antonymy and polarity as primitive (Lehrer and Lehrer 1982), or else they provide criteria to distinguish between positive and negative antonyms, but these criteria typically have exceptions. Despite it being notoriously difficult to define the set of negative as opposed to positive adjectives, it is clear that there is a phenomenon underlying this intuitive distinction, as illustrated shortly. Hence, Sects. 2–4 of this paper focus on paradigmatic antonym pairs, such as *long-short*, *tall-short*, *deep-shallow*, *wide-narrow*, and *old-young*. Discussion of additional data and analyses pertaining to non-paradigmatic pairs (such as *warm-cold*, *heavy-light*, *expensive-inexpensive*, *rich-poor*, *late-early*, and *fast-slow*) is delayed to Sect. 5.

Section 2 describes well-known (but, to my mind, still puzzling) linguistic contrasts between positive and negative adjectives in paradigmatic antonym pairs. As some contrasts pertain to the licensing of numerical degree phrases, this paper presupposes that grammar encompasses a set of degrees identical or isomorphic to the set of real numbers,  $\mathbb{R}$  (Kennedy 1999, 2001; Fox and Hackl 2006; Fox 2007; Nouwen 2008). Gradable adjectives map entities to such degrees. Yet, this paper rejects the standard assumption that the mapping is generally *additive* (in the sense defined in Sect. 3; cf. Klein 1991). A new analysis is presented according to which adjectives are ‘negative’ iff they are predominantly associated with *linearly reversed and transformed* mapping functions (cf. the definitions in (14) and (51) below). Section 4 shows in detail that the facts regarding paradigmatic antonym pairs follow directly from this analysis. Section 5 focuses on a broader set of antonym pairs, showing that many are characterized differently than the paradigmatic pairs discussed earlier. Still, the proposed analysis nicely captures the facts. In addition to grammaticality judgments, novel findings are presented, based on a corpus study of uses of the ratio modifier *twice* in equative constructions (i.e., constructions of the form ‘*as Adj. as*’) with positive and negative antonyms. The paper concludes with a brief comparison of the analysis with existing accounts.

When one looks at a broad set of antonym pairs, the data is far from ‘clean’. We need a theory that is flexible enough to accommodate this situation, while still producing clear-cut predictions regarding paradigmatic cases and regarding the connections between the different tests for the polarity of adjectives. I hope to show that my theory does precisely that.

## 2 Paradigmatic positive and negative antonyms

Gradable adjectives impose orderings on the entities under discussion. Intuitively, the entity orderings imposed by negative adjectives, like *short*, are *reversed* in comparison with those of their positive antonyms, e.g., *tall*, as statements like (1) demonstrate.

- (1) Dan is taller than Sam iff Sam is shorter than Dan.

Furthermore, the reversal triggered by the use of negative antonyms is *linear* in the sense that it preserves the differences between entities, as the intuitive judgments in (2) demonstrate.

- (2) a. Dan is two inches taller than Sam iff Sam is two inches shorter than Dan.  
 b. Dan is two inches shorter than Sam, who is two inches shorter than Bill iff Dan is four inches shorter than Bill.

The ontology underlying these intuitions can be described as follows. The adjectives in a paradigmatic antonym pair are associated with a common measure, e.g., a measure of heights. Let us call this measure the *base function*. While positive adjectives associate directly with their base functions, their negative antonyms are *linearly reversed* in comparison with them, e.g. *tall* assigns higher values to entities with bigger heights, whereas *short* assigns higher values to entities with smaller heights; *old* assigns higher values to entities with more age, whereas *young* assigns higher values to entities with less age, etc. Nonetheless, the differences between entities' values in positive and negative antonyms are identical (cf. (2a)).

One could argue that adjectives like *short* and *young* are neither special nor negative in any sense at all. Rather, they too (like *tall* and *old*) are interpreted as 'non-reversed' in comparison with measures of 'shortness' and 'youth', respectively. But 'shortness' and 'youth' are themselves 'reversed' height and age measures. Thus, the notion of linear reversal resists this objection. Furthermore, as illustrated below, a number of systematic linguistic differences exist between these adjectives and their antonyms. These would be unexpected if these adjectives weren't special ('negative').

Consider two birds, an ostrich and a chicken. The height of the former, sixty inches, is twice the height of the latter. First, we can felicitously say that the ostrich is *sixty inches tall*, but we cannot felicitously say that the chicken is *thirty inches short*. Generally speaking, while some positive adjectives license numerical degree modifiers ('measure phrases' like *sixty inches*), negative adjectives virtually never do. Then again, we could say both that the ostrich is *thirty inches taller than the chicken* and that the chicken is *thirty inches shorter than the ostrich*. Thus, in the comparative, both positive and negative adjectives license numerical degree modifiers (Horn 1972; Seuren 1978, 1984; von Stechow 1984b; Bierwisch 1989; Kennedy 2001).

Second, cross-polar comparisons like *The ostrich is taller than the chicken is short* are infelicitous (Kennedy 1999, 2001). The inverse cross-polar comparison,

i.e., *The chicken is shorter than the ostrich is tall*, is rather odd too, but it is marginally accepted when there is no emphatic stress on *tall* (Landman 2005). However, when *tall* is replaced by a different antonym, as in *The ladder is shorter than the house is high*, or *than the gap is wide*, the result is perfectly acceptable (Büring 2007). Generally, we prefer cross-polar comparisons with the negative adjective in the matrix clause to comparisons with it in the *than*-clause (as in *\*The gap is wider than the ladder is short*).

Third, though it is perfectly acceptable to say that the ostrich is *twice as tall as the chicken*, to say that the chicken is *twice as short* is awkward (Horn 1972; Seuren 1978, 1984; von Stechow 1984b; Bierwisch 1989; Kennedy 2001). In general, the use of ratio statements with negative adjectives is not completely ruled out. Yet, these statements are significantly less felicitous than ratio statements with the corresponding positive antonyms, as the following felicity contrasts demonstrate.

- (3) a. The table is twice as tall/long/big/wide as the sofa.  
 b. #The table is twice as short/small/narrow as the sofa.
- (4) a. This swimming pool is twice as deep as that one.  
 b. #This swimming pool is twice as shallow as that one.

Furthermore, ratio statements with negative adjectives are significantly less common, and their use seems to be restricted to non-default interpretations of negative adjectives (cf. Sect. 5.4).

Finally, classification by cultural conventions is irrelevant, e.g., whether being *old* is regarded as more positive than being *young* or not is orthogonal to the distinction we are after. Linguistically, *old* is positive and *young* is negative; thus it is *old* that combines with numerical degree modifiers, such as *two years*, also in its positive (non-comparative) form (Kennedy 1999; Svenonius and Kennedy 2006). The next part of this paper presents a semantic analysis that accounts for the linguistic contrasts between positive and negative antonyms, not for cultural facts.

### 3 A new proposal: linear function reversal and transformation

#### 3.1 Basic assumptions

To set the stage, Sect. 3.1 presents some background assumptions regarding partial information and gradability.

Following Stalnaker (1978), let us call the linguistic and world knowledge of a given community of speakers *an actual context*. The interpretation of linguistic expressions in contexts *c* is typically modeled via a set of indices  $T_c$ —the worlds (Stalnaker 1978) or completions (van Fraassen 1969; Kamp 1975; Fine 1975; Veltman 1984; Landman 1991) consistent with the information in *c* (completions being ‘classical’ contexts, wherein every statement is either true or false). The truth of a statement  $\phi$  in *c* is defined based on these indices:

- (5) a.  $\llbracket \varphi \rrbracket_c = 1$  iff  $\forall t \in T_c, \llbracket \varphi \rrbracket_t = 1$   
 b.  $\llbracket \varphi \rrbracket_c = 0$  iff  $\forall t \in T_c, \llbracket \varphi \rrbracket_t = 0$   
 c. Otherwise,  $\llbracket \varphi \rrbracket_c$  is *undetermined*.

For example, the truth of a statement like *It rains* is considered common knowledge in a given context  $c$  iff it holds true in every completion  $t$  in  $T_c$ ; the falsity of a statement is considered common knowledge in  $c$  iff it is false (it does not rain) in every completion  $t$  in  $T_c$ . The truth value is *undetermined* in  $c$  iff  $T_c$  includes both a completion in which it is true (it rains) and a completion in which it is false (it does not rain).

Semanticists often characterize gradable adjectives as mapping entities  $x$  (elements of the domain of discourse  $D_x$ ) to *degrees*. For example, the adjective *tall* maps entities to degrees representing their heights. There is much controversy as to the nature of these degrees (for a review see Klein 1991). According to one view, degrees are elements of a linearly ordered set isomorphic to the real numbers,  $\mathfrak{R}$ .<sup>1</sup> It may well turn out that, for example, rather than actual numbers, different extents of brain activation and suppression underlie the notion of degrees. However, treating degrees as actual numbers is most useful in demonstrating notions such as additivity and its lack thereof, degree differences, degree ratios, etc. What is more, the identification of degrees with numbers does not imply that speakers consciously possess the concept ‘real number’ any more than they possess concepts like ‘lambda’ (assuming the latter are part of grammar). Thus, this paper represents degrees straightforwardly numerically. The number ‘5’, for example, can represent a quantity of apples. In the same way, ‘5’ can also represent a given amount of water, happiness, or height, these seen as entities in the domain  $D_x$  (even if abstract ones).

This paper assumes a  $\lambda$ -categorical language in the style of Heim and Kratzer (1998), with basic types  $x$  for individuals,  $t$  for truth values, and  $r$  for numerical degrees, and basic semantic domains  $D_x$ ,  $D_t$ , and  $D_r = \mathfrak{R}$  (sets of individuals, truth values, and numerical degrees, respectively). Gradable adjectives are interpreted as follows:

- (6) For any context  $c$ , for any  $t \in T_c$  and any gradable adjective  $P$ :
- Let  $f_{P,t} \in \mathfrak{R}^{D_x}$  be the *degree function of  $P$  in  $t$*  (a function from entities  $x$  in the domain  $D_x$  to real numbers  $r$  in  $\mathfrak{R}$ )
  - $P$  holds true of an object  $x \in D_x$  in  $t$  iff  $x$ 's value exceeds  $P$ 's cutoff point:  $f_{P,t}(x) > \text{cutoff}(P,t)$  (Kennedy 1999).

Furthermore, semantic theories often postulate that adjectives' degree functions are additive with respect to their dimension (the ‘stuff’, so to speak, they measure). For instance, the degree function of *tall* is *additive with respect to height* in that its values represent differences and ratios between entities' heights (Klein 1991). Thus equally tall entities  $x_1$  and  $x_2$  are mapped to the same number (e.g., 5), and their

<sup>1</sup> Cf. Bartsch and Venneman (1971), Kennedy (1999, 2001), Kennedy and McNally (2005), Winter (2005), and Landman (2005); for recent work independently motivating dense scales see Fox and Hackl (2006); Fox (2007), and Nouwen (2008).

concatenation (placing end to end)  $x_1 \oplus_{\text{height}} x_2$  is mapped to twice that number (e.g., 10). Formally:

- (7) A degree function  $f$  is additive with respect to a dimension  $Q$  iff  $\forall x_1, x_2 \in D: f(x_1 \oplus_Q x_2) = f(x_1) + f(x_2)$  (Klein 1991).

However, many functions are additive with respect to height. We have seen that the mapping of two equally tall entities,  $x_1$  and  $x_2$ , and their concatenation,  $x_1 \oplus_{\text{height}} x_2$ , to the values 5, 5 and 10, respectively conforms to the additivity constraint. But so does their mapping to 2, 2, and 4, respectively, and their mapping to 100, 100, and 200, respectively, etc. Each mapping corresponds to the outcome of measuring heights with some possible ruler (inch, meter, etc.) The absence of a *unique* additive mapping convention is represented by associating *tall* with different functions in different indices (completions  $t$  of a context  $c$ ).

Finally, we have intuitions about *specific entity values* only in the zero case: conventional additive height measures (meter rulers, inch rulers, etc.) always assign the value '0' to surfaces (Krantz et al. 1971). But they differ in the values they assign to entities possessing height. However, being additive, they all share the same degree ratios. For example, since the height of  $x_1 \oplus_{\text{height}} x_2$  is twice the height of  $x_1$ , the ratio between their degrees is the number 2 in all the examples just given ( $2 \times 5 = 10$ ;  $2 \times 2 = 4$  and  $2 \times 100 = 200$ ).<sup>2,3</sup>

- (8)  $\forall x_1, x_2 \in D_x, \exists r \in \mathfrak{R}: \forall t \in T_c, f_{\text{tall},t}(x_1)/f_{\text{tall},t}(x_2) = r$

To summarize, this section sets up the following background:

- (i) A context-set representation of partial information
- (ii) A 'numerical' approach to gradability
- (iii) Additivity, at least for paradigmatic positive adjectives like, e.g., *tall*:
  1. Entities with no height are mapped to '0' in every index (completion);
  2. other entities are mapped to an undetermined (index-dependent) number; but
  3. the ratio between two entities' height-values is a given index-invariant number.

What about the degree functions of negative adjectives like *short*? Semanticists often assume that the values they assign to entities depend on the quantities of height possessed by the entities (Rullmann 1995; Landman 2005) or not possessed

<sup>2</sup> Additive height functions must map all and only entities with no height to zero, for otherwise they would fail to represent height ratios. Example (11) below demonstrates this.

<sup>3</sup> In particular, for any entity  $x$ , an index-invariant number represents the ratio between  $f_{\text{tall},t}$  of  $x$  and  $f_{\text{tall},t}$  of a meter unit-object in every  $t$ . So the mapping of entities to numbers *per a unit* like *meter* is 'conventional' in that it systematically and unambiguously determines a value for any entity in any context  $c$  (cf. the analysis of unit names in Sect. 4).

by the entities (Seuren 1978, 1984; von Stechow 1984a; Kennedy 1999, 2001; Schwarzschild 2005). But is the mapping of entities to degrees in negative adjectives like *short* additive with respect to these quantities? The next section argues that it is not, based on the kinds of intuitions we do or do not have about the degrees assigned by negative adjectives.

### 3.2 Negative adjectives and transformation values

Recall that we have a very strong intuition that the degree function of *short* is *linearly reversed* in comparison with that of *tall* (cf. Sect. 2). Differences between values of entity pairs are identical in a positive adjective and its negative antonym (e.g., for any  $x, y$  in  $D_x$ ,  $x$  is taller than  $y$  by exactly as much as  $y$  is shorter than  $x$ ). However, what is less for the positive adjective is more for its negative antonym (where  $f_{tall,t}$  assigns smaller values,  $f_{short,t}$  assigns bigger values). What kind of functions are linearly reversed in that sense, in comparison with, e.g.,  $f_{tall,t}$ ?

Let the function  $f_{0-tall}$  be such that for any  $x$  in  $D_x$  it assigns the value  $f_{tall,t}$  assigns to  $x$  multiplied by  $-1$  (i.e.,  $f_{0-tall} := \lambda x \in D_x. 0 - f_{tall,t}(x)$ ). Consider again the two equally tall entities  $x_1$  and  $x_2$  whose value in  $f_{tall,t}$  is 5.

- (9) a.  $f_{0-tall}(x_1) = 0 - f_{tall,t}(x_1) = -5$
- b.  $f_{0-tall}(x_2) = 0 - f_{tall,t}(x_2) = -5$
- c.  $f_{0-tall}(x_1 \oplus_{height} x_2) = 0 - f_{tall,t}(x_1 \oplus_{height} x_2) = -(5+5) = -10$

We see that, by its definition,  $f_{0-tall}$  is *reversed* in comparison with  $f_{tall,t}$  (while the latter assigns  $x_1 \oplus_{height} x_2$  a bigger degree than the one it assigns to  $x_1$ ,  $10 > 5$ , the former assigns  $x_1 \oplus_{height} x_2$  a smaller degree,  $-10 < -5$ ). Furthermore,  $f_{0-tall}$  is *linearly* reversed in comparison with  $f_{tall,t}$  as the difference between these two degrees is preserved (the absolute difference between  $-10$  and  $-5$  is still 5). Finally,  $f_{0-tall}$  is additive. It maps all (and only) entities with no height to zero, it maps other equally tall entities to the same number (e.g., both  $x_1$  and  $x_2$  are mapped to  $-5$ ), and it maps their concatenation to twice that number ( $x_1 \oplus_{height} x_2$  is mapped to  $-10$  which is precisely twice  $-5$ ).

However, there are many—in fact, infinitely many—other functions that are linearly reversed in comparison with  $f_{tall,t}$ . For any real number  $Tran \in \mathfrak{R}$ , a function  $f_{Tran-tall}$  that assigns any  $x$  the degree  $(Tran - f_{tall,t}(x))$  linearly reverses the degrees assigned by  $f_{tall,t}$ . Moreover, only when the constant  $Tran$  is 0 (namely in  $f_{0-tall}$ ) is the function additive. Functions (whether reversed or not) that are transformed by a constant  $Tran \neq 0$ , like those in (10), do not adequately represent ratios between entities' heights.

- (10) a.  $f_{1-tall} := \lambda x \in D_x. 1 - f_{tall,t}(x)$
- b.  $f_{3.75-tall} := \lambda x \in D_x. 3.75 - f_{tall,t}(x)$
- c.  $f_{-4-tall} := \lambda x \in D_x. -4 - f_{tall,t}(x)$
- ...
- d.  $\forall Tran \in \mathfrak{R}, f_{Tran-tall} (:= \lambda x \in D_x. Tran - f_{tall,t}(x))$  linearly reverses  $f_{tall,t}$ .

The function in (10a),  $f_{1-tall}$ , maps any  $x$  in  $D_x$  to the constant  $1 - f_{tall,t}(x)$ , i.e., the zero point is transformed (or displaced) by 1. For example:

$$\begin{aligned}
 (11) \quad & a. \quad f_{1-tall}(x_1) = 1 - f_{tall,t}(x_1) = 1 - 5 = -4 \\
 & b. \quad f_{1-tall}(x_2) = 1 - f_{tall,t}(x_2) = 1 - 5 = -4 \\
 & c. \quad f_{1-tall}(x_1 \oplus_{height} x_2) = 1 - f_{tall,t}(x_1 \oplus_{height} x_2) = 1 - 10 = -9
 \end{aligned}$$

This function is linearly reversed in comparison with  $f_{tall,t}$  (e.g., the absolute difference between  $-9$  and  $-4$  is still 5). However, the transformation value, 1, functions as the ‘local zero’ (or the reference value), so entities with no height are mapped to ‘1’, not ‘0’. Thus, this function fails to be additive. The ratios between entities’ degrees do not adequately represent the ratios between their heights; e.g., the ratio between the degrees of  $x_1 \oplus x_2$  and  $x_1$  is 9/4 and the ratio between their heights is 8/4.

Significantly, our intuitions do not tell us anything about negative adjectives, besides their being linearly reversed in comparison with their positive antonyms. In other words, we do not know *which* linearly reversed function they denote. In particular, we do not have intuitions that unequivocally tell us that the transformation value of *short*,  $Tran_{short,t}$ , is 0, in every context  $t$  in  $T_c$  of any actual context  $c$ . The transformation value is unspecified (index-dependent); i.e. for any actual context  $c$  the following holds:

$$(12) \quad \text{Linear reversal: } \forall t \in T_c, \exists Tran \in \mathfrak{R}, f_{short,t} = \lambda x \in D_x. Tran - f_{tall,t}(x)$$

$$(13) \quad \text{An undetermined transformation value: } \neg \exists Tran \in \mathfrak{R}, \forall t \in T_c, f_{short,t} = \lambda x \in D_x. Tran - f_{tall,t}(x)$$

The basic motivation for this claim comes from intuitions corresponding to entities with, e.g., no height (surfaces and points). Our intuitions concerning their values (or lack thereof) directly reflect the unspecified transformation value of *short*.

Recall that in every completion  $t$  of every context  $c$ ,  $f_{tall,t}$  is additive (it maps entities with no height to 0; cf. Sect. 3.1). Hence, *short* is not transformed in a context  $c$  ( $Tran_{short,t} = 0$  in every  $t$  of  $T_c$ ) iff the degree of entities with no height  $x_0$  in *short* is known to be 0 in  $c$  (because in every  $t \in T_c$  it is  $Tran_{short,t} - f_{tall,t}(x_0) = 0 - 0 = 0$ ). But is this so? Can we positively say that *short* maps entities with no height, such as the surface of the floor, to zero? (Or, in other words, that the surface of the floor is short to degree zero?) Not really. When I ask speakers to examine their intuitions regarding this issue, they are puzzled. They have absolutely no idea which entities are ‘zero short’, so to speak. This is the natural sign of an unspecified transformation value. The degree function of *short* transforms height quantities by a non-zero constant,  $Tran_{short}$ . We know nothing about this constant (it may be any number). It varies across contexts in  $T_c$ , rendering the zero point undetermined.<sup>4</sup>

<sup>4</sup> Some semantic theories (von Stechow 1984b; Kennedy 1999) endorse the view that entities with (almost) no height are mapped to (a degree that approximates) infinity (formally, the largest interval  $(0, \infty)$ , not the zero interval  $(0, 0)$ ). Hence, in these theories as well, *short* transforms height values by a non-zero constant.



Some readers may object to the assumption that  $f_{\text{tall}}$  is defined for entities with no height, given that sentences such as *This idea is zero centimeters tall* or *This surface is zero inches tall* are unacceptable (cf. Kennedy 2007). But note that the infelicity of the former can be explained by the inapplicability of the measurement method (a ruler) to ideas, and the infelicity of the latter can be explained by a triviality filter (it is never informative enough; cf. Fox and Hackl 2006). While the issue whether, e.g., ideas are part of the domain of *tall* or not is outside the scope of this paper, for my argument to go through it is sufficient that rulers *do* have a value ‘0’, that this measurement method *is applicable* for surfaces, and that when appropriately applied to surfaces it yields just this value, ‘0’ (regardless of the reasons why the above statements may be inappropriate). The situation is rather different for *short*, where no such convention or intuition about the zero exist. In fact, statements like *This surface is zero inches short* are not only inappropriate, but also senseless. Intuitively, the location of the zero point in adjectives like *short* is uncertain. To represent this fact, the degree functions of negative adjectives should be transformed by an *unspecified* constant.<sup>5</sup>

Thus, the least tall entities are the shortest, but their degrees in *tall* and *short* are not the same, because reversed functions are also transformed. But why are they transformed? Positive numbers are easier to work with. We usually use negative adjectives like *short* to discuss heights of people, furniture, or buildings, but not, say, planets or universes. Hence, a viable possibility is that the reversed functions associated with *short* are transformed in order to turn positive the values of at least those entities that are usually under discussion—those that we might rank as *short* or *not short* (see more on this role of transformation values in Sects. 5.3–5.4).

Let  $M_C$  be a model for a set of contexts  $C$ , with a set of completions  $T \subseteq C$  (cf. (5)–(7) above). The function of transformation values can be made explicit by adding to the definition of a model a function ‘ $f$ ’ ( $ADJ \times T \rightarrow \mathbb{R}^{D_x}$ ), from adjectives  $A \in ADJ$  and completions  $t \in T$  into base functions,  $f(A,t) \in \mathbb{R}^{D_x}$ , and a function ‘Tran’ ( $ADJ \times T \rightarrow \mathbb{R}$ ), from adjectives  $A \in ADJ$  and completions  $t \in T$  into transformation values,  $Tran(A,t) \in \mathbb{R}$  (called ‘ $Tran_{A,t}$ ’), such that for any  $t \in T$ :

(14) Antonymy and polarity:

- a. If A and B are *antonyms*, their base functions are identical:  
 $f(B,t) = f(A,t)$ .
- b. If A is *positive*,  $f_{A,t} = \lambda x \in D_x. f(A,t)(x) - Tran_{A,t}$
- c. If B is *negative*,  $f_{B,t} = \lambda x \in D_x. Tran_{B,t} - f(B,t)(x)$
- d. If A,B form a *paradigmatic* antonym pair and A is positive:  
 $f(A,t)$  is **additive** and  $Tran_{A,t} = \mathbf{0}$

<sup>5</sup> Domains of measure functions may be restricted (Kennedy 2007). However, we do have clearer intuitions about zero points in adjectives like *tall* than in adjectives like *short* or *warm*, a fact that cannot be captured if all exclude the zero point from their scale in the first place. Perhaps, then, while the domain of  $f_{\text{tall}}$  is unrestricted (it maps all abstract entities to zero), the interpretation of *tall* is not  $f_{\text{tall},t}$  itself, but rather,  $\lambda x, s.t. f_{\text{tall},t}(x) \neq 0. f_{\text{tall},t}(x)$ .

Thus, in every  $t$ ,  $f$  associates *tall* and *short* with one and the same base function  $f(\text{tall},t) = f(\text{short},t)$  (cf. (14a)), namely, one of the functions that adequately represent height. However, unlike  $f_{\text{tall},t}$ ,  $f_{\text{short},t}$  is reversed in comparison to their base function (cf. (14b,c)). Furthermore, the transformation value of paradigmatic positive adjectives like *tall* is zero (cf. (14d)), meaning that in degree constructions *tall* ultimately denotes its contextually given additive base function,  $[\text{tall}]_t = \mathbf{f}_{\text{tall},t} = f(\text{tall},t)$ . Conversely, the transformation value of negative adjectives is unspecified (completion-variant), meaning that in degree constructions adjectives like *short* ultimately denote a degree function that is virtually always transformed in comparison with the base function,  $[\text{short}]_t = \mathbf{f}_{\text{short},t} = \lambda x \in \mathbf{D}_x. \text{Trans}_{\text{short},t} - f(\text{tall},t)(x)$ .<sup>6</sup>

Note: To avoid confusion, whenever I say, e.g., “the degree function of *short*”, I refer to the final, reversed, and transformed function,  $f_{\text{short},t}$ , not to the additive base function,  $f(\text{short},t)$ . Furthermore, since the latter equals  $f_{\text{tall},t}$ , I never refer to it by writing ‘ $f(\text{short},t)$ ’, only ‘ $f_{\text{tall},t}$ ’ (same with  $f(\text{tall},t)$ ).

Now that we have motivated transformation values (by our uncertainty concerning which entities are mapped to zero), Sect. 4 explores their predictive fruitfulness.

#### 4 Direct results

Let us examine the workings of a simplified context  $c$ , represented by three possible completions ( $T_c = \{t_1, t_2, t_3\}$ ).<sup>7</sup> Let the domain of discourse consist of three entities ( $\mathbf{D}_x = \{x_1, x_2, x_3\}$ ), where  $x_1$  is an inch unit-object, and  $x_2$  and  $x_3$  constitute the ostrich and the chicken from Sect. 2, respectively. Tables 1 and 2 present the mapping functions of *tall* and *short* in  $c$ , respectively.

On the one hand, the functions associated with the positive adjective *tall* in  $c$  are all additive. Their transformation value equals zero (none has a ‘transformed local zero’, so to speak). Hence, they all adequately represent the ratios and differences between entities’ heights. For instance, the fact that in  $c$  the height of the ostrich,  $x_2$ , is twice the height of the chicken,  $x_3$ , and sixty times the height of the inch,  $x_1$ , is represented by the fact that in every  $t$  of  $T_c$ ,  $f_{\text{tall},t}(x_2)$  (the value *tall* assigns to the ostrich) is twice  $f_{\text{tall},t}(x_3)$  (the value *tall* assigns to the chicken), and sixty times  $f_{\text{tall},t}(x_1)$  (the value *tall* assigns to the inch); e.g., in  $t_1$ ,  $f_{\text{tall},t_1}(x_2) = 60 = 2f_{\text{tall},t_1}(x_3) = 2 \times 30 = 60f_{\text{tall},t_1}(x_1) = 60 \times 1$ .

<sup>6</sup> Unless contexts  $c$  bias towards a non-transformed interpretation (cf. Sect. 5.4), the chances that  $\text{Trans}_{\text{short},t} = 0$  in a completion  $t$  are  $1/\#\mathcal{R}$ , i.e., very close to zero.

<sup>7</sup> An actual context is consistent with infinitely many completions, but three suffice to demonstrate our main points.

**Table 1** Functions associated with *tall* in c based on additive measures (possible rulers)

$f_{tall,t}$	Transformation value of <i>tall</i> in t $Tran_{tall,t}$	Inch unit-object $x_1$	Ostrich from Sect. 2 $x_2$	Chicken from Sect. 2 $x_3$
$t_1$	<b>0</b>	1	60	30
$t_2$	<b>0</b>	2	120	60
$t_3$	<b>0</b>	3	180	90

**Table 2** Functions associated with *short* in c based on function reversal:  $\forall t \in T_c, \forall x \in D_x, f_{short,t}(x) = Tran_{short,t} - f_{tall,t}(x)$

$f_{short,t}$	Transformation value of <i>short</i> in t, $Tran_{short,t}$	Inch unit-object $x_1$	Ostrich $x_2$	Chicken $x_3$
$t_1$	<b>10</b>	$10-1 = 9$	$10-60 = -50$	$10-30 = -20$
$t_2$	<b>0</b>	$0-2 = -2$	$0-120 = -120$	$0-60 = -60$
$t_3$	<b>-10</b>	$-10-3 = -13$	$-10-180 = -190$	$-10-90 = -100$

On the other hand, the functions associated with the negative adjective *short* in c are not straightforwardly based on possible additive measuring conventions. Rather, they are based on linear function reversal. Most of the linearly reversed functions are also transformed. In completions  $t_1$  and  $t_3$ , then, the reversed values *short* assigns are transformed by a non-zero constant. Consequently, they fail to represent height ratios. For example, the transformation value of *short* in  $t_1$ ,  $Tran_{short,t_1}$ , is 10; consequently, in  $t_1$  *short* assigns the ostrich  $x_2$  the degree  $10 - f_{tall,t_1}(x_2) = 10 - 60 = -50$ , which is not twice the degree it assigns to the chicken,  $10 - f_{tall,t_1}(x_3) = 10 - 30 = -20$ .

I will now demonstrate how the following generalizations are accounted for:

- (i) the infelicity of ratio-modifiers with default interpretations of negative adjectives (Sect. 4.1);
- (ii) the incompatibility of numerical degree modifiers with negative adjectives (Sect. 4.2);
- (iii) the compatibility of numerical degree modifiers with derived comparatives of negative adjectives (Sect. 4.3); and
- (iv) the infelicity of cross-polar comparisons (Sect. 4.4).

#### 4.1 Ratio modifiers

This subsection shows that lack of additivity due to unspecified transformation values yields ratio modifiers infelicitous.

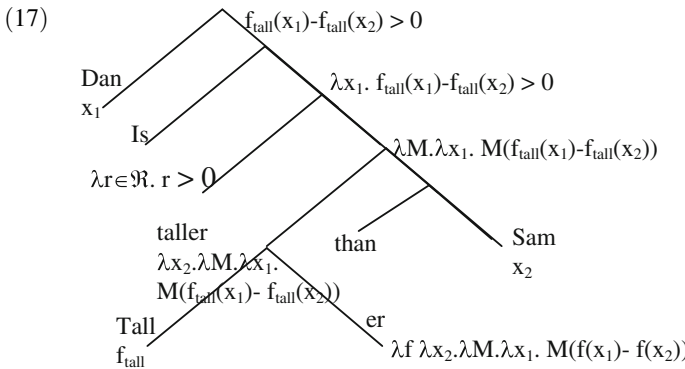
I adopt the widely employed view that comparison statements involve the application of a difference operation (von Stechow 1984b; Schwarzschild and Wilkinson 2002; Kennedy and McNally 2005; Schwarzschild 2005; Kennedy and

Levin 2008, p. 17). I take comparison statements like *Dan is taller than Sam (by 2 inches)* to hold true in a completion  $t$  iff the difference between Dan and Sam's degrees in  $t$  is a positive real number (twice the degree of an inch unit object in  $t$ ; cf. (15)). Similarly, I take ratio statements to involve the application of a ratio operation (von Stechow 1984b), namely, *Dan is twice as tall as Sam* holds true in  $t$  iff Dan's degree equals twice Sam's in  $t$ .

$$(15) \quad \llbracket \text{Dan is 2 inches taller than Sam} \rrbracket_t = 1 \text{ iff } f_{\text{tall},t}(\llbracket \text{Dan} \rrbracket_t) - f_{\text{tall},t}(\llbracket \text{Sam} \rrbracket_t) = 2r_{\text{inch},t} \text{ (where } r_{\text{inch},t} \text{ is the degree of height of an inch unit-object in } t)$$

$$(16) \quad \llbracket \text{Dan is twice as tall as Sam} \rrbracket_t = 1 \text{ iff } f_{\text{tall},t}(\llbracket \text{Dan} \rrbracket_t) = 2 \times f_{\text{tall},t}(\llbracket \text{Sam} \rrbracket_t)$$

The basic interpretation of phrasal *er* as a difference operation is  $\lambda r_2 \in \mathfrak{R}.\lambda M_{(r,t)}.\lambda r_1 \in \mathfrak{R}.M(r_1 - r_2)$  (where the variable  $M$  has to be saturated by a degree predicate like *two inches*; cf. Schwarzschild and Wilkinson 2002; Landman 2005), and the interpretation of *as* is  $\lambda r_2 \in \mathfrak{R}.\lambda r_1 \in \mathfrak{R}.\llbracket er \rrbracket(r_2, \lambda r.r \geq 0, r_1)$ , which reduces to:  $\lambda r_2.\lambda r_1.r_1 - r_2 \geq 0$ . Given the latter, I assume that normally, the use of the comparative rather than the equative excludes the possibility that  $M$  is  $\lambda r.r \geq 0$ ; i.e., in the absence of an overt numerical degree modification,  $M$  is saturated by the predicate  $\lambda r \in \mathfrak{R}.r > 0$  (implying that  $r_1 - r_2 > 0$ ), as illustrated below. Finally, when *er* combines with an adjective as in *taller*, interpretation type shifts to an individual level:  $\lambda f \in \mathfrak{R}^{D_x}.\lambda x_2 \in D_x.\lambda M.\lambda x_1 \in D_x.\llbracket er \rrbracket(f(x_2))(M)(f(x_1))$ , which reduces to  $\lambda f \in \mathfrak{R}^{D_x}.\lambda x_2 \in D_x.\lambda M.\lambda x_1 \in D_x.M(f(x_1) - f(x_2))$ .<sup>8</sup>



Ratio morphemes like *twice* are modifiers of difference morphemes (usually in English, the equative *as*).<sup>9</sup> The interpretation of *twice* in each  $t$  is  $\lambda C_{(r,t)}.\lambda f \in \mathfrak{R}^{D_x}.\lambda x_2 \in D_x.\lambda x_1 \in D_x.C(2f(x_2))(f(x_1))$ , where the variable  $C$  has to be saturated by basic interpretations of difference morphemes (e.g., *as*). The interpretation of *twice as tall*,  $\llbracket \text{twice} \rrbracket_t(\llbracket \text{as} \rrbracket_t)(\llbracket \text{tall} \rrbracket_t)$ , then, reduces to  $\lambda x_2 \in D_x.\lambda x_1 \in D_x.f_{\text{tall},t}(x_1) - 2 \times f_{\text{tall},t}(x_2) \geq 0$ , as illustrated in (18).

<sup>8</sup> For an analysis of clausal comparisons see Sect. 4.4.

<sup>9</sup> In English, unlike Russian or Hebrew, the equative is often preferred to the comparative, but both forms exist.



$$\begin{aligned}
 \text{b. } & f_{\text{short},t2}(x_2) = \text{Tran}_{\text{short},t2} - f_{\text{tall},t2}(x_2) = 0 - 120 = \mathbf{-120} \\
 & f_{\text{short},t2}(x_3) = \text{Tran}_{\text{short},t2} - f_{\text{tall},t2}(x_3) = 0 - 60 = \mathbf{-60} \Rightarrow \\
 & \qquad \qquad \qquad f_{\text{tall},t2}(x_2) = 2 \times f_{\text{tall},t2}(x_3) \\
 \text{c. } & f_{\text{short},t3}(x_2) = \text{Tran}_{\text{short},t3} - f_{\text{tall},t3}(x_2) = -10 - 180 = \mathbf{-190} \\
 & f_{\text{short},t3}(x_3) = \text{Tran}_{\text{short},t3} - f_{\text{tall},t3}(x_3) = -10 - 90 = \mathbf{-100} \Rightarrow \\
 & \qquad \qquad \qquad f_{\text{tall},t3}(x_2) \neq 2 \times f_{\text{tall},t3}(x_3)
 \end{aligned}$$

- (22)  $\llbracket \text{The ostrich is twice as short as the chicken} \rrbracket_c = 1$  iff  
 $\forall t \in T_c, \llbracket \text{The ostrich is twice as short as the chicken} \rrbracket_t = 1$  iff  
 $\forall t \in T_c, f_{\text{short},t}(\llbracket \text{The ostrich} \rrbracket_t) = 2 \times f_{\text{short},t}(\llbracket \text{The chicken} \rrbracket_t)$  iff  
 $\forall t \in T_c, \text{Tran}_{\text{short},t} - f_{\text{tall},t}(\llbracket \text{The ostrich} \rrbracket_t) =$   
 $2 \times (\text{Tran}_{\text{short},t} - f_{\text{tall},t}(\llbracket \text{The chicken} \rrbracket_t))$  iff  
 $\forall t \in T_c, \text{Tran}_{\text{short},t} - f_{\text{tall},t}(x_2) = 2 \times \text{Tran}_{\text{short},t} - 2 \times f_{\text{tall},t}(x_3)$  iff  
 $\forall t \in T_c, 2 \times f_{\text{tall},t}(x_3) - f_{\text{tall},t}(x_2) = \text{Tran}_{\text{short},t}$
- (23)  $\llbracket \text{The ostrich is twice as short as the chicken} \rrbracket_c = 0$  iff  
 $\forall t \in T_c, \llbracket \text{The ostrich is twice as short as the chicken} \rrbracket_t = 0$  iff  
 $\forall t \in T_c, f_{\text{short},t}(\llbracket \text{The ostrich} \rrbracket_t) \neq 2 \times f_{\text{short},t}(\llbracket \text{The chicken} \rrbracket_t)$  iff  
 $\forall t \in T_c, 2 \times f_{\text{tall},t}(x_3) - f_{\text{tall},t}(x_2) \neq \text{Tran}_{\text{short},t}$

We see that ratio statements with negative adjectives can be neither verified nor falsified in c. In fact, in both their truth conditions and their falsity conditions ((22)–(23)), a meta-language variable occurs,  $\text{Tran}_{\text{short}}$ . Its value is unspecified in c (it varies across  $T_c$ ), rendering the truth value of such statements inherently undetermined. As this is the case in every actual context c where negative adjectives like *short* receive their default (reversed and transformed) interpretation, ratio statements are (by default) uninterpretable with negative adjectives.

### 4.2 Numerical degree modifiers

The present proposal directly predicts the indeterminacy of the degrees negative adjectives assign and, consequently, their incompatibility with numerical degree modifiers.

Let unit nouns like *meters* belong to a nominal category UNIT, and their semantics be based on measurement theory (Krantz et al. 1971; Klein 1991), as follows.<sup>10</sup>

First, unit nouns are lexically related to a set of dimensions A, e.g., gradable adjectives like *tall*, *wide*, *long*, etc. (cf. Murphy 2006). Per a dimension A, unit nouns are directly linked to a set of entities, which, by virtue of a convention, are regarded as *unit objects relative to A*. For example, the set of unit objects of the noun *meter* relative to the dimension *tall*,  $D_{m,tall}$ , consists of the entities

<sup>10</sup> For a lengthy justification of this analysis see Sassoon (2007, 2010).

whose height we call ‘one meter’ (e.g., the meter bar in Paris). This set is convention based (and therefore completion invariant) in actual contexts.<sup>11</sup>

Second, in any completion  $t$ , let  $r_{m,t} \in \mathfrak{R}$  stand for the non-zero degree the dimensions of *meter* assign to their unit objects in  $t$ .<sup>12</sup> Generally, for any *unit*  $\in$  UNIT:

(24) *Set of unit objects*

Let  $D_{u,A} \subseteq D_x$  be the set of unit objects of *unit* relative to dimension  $A$ .

(25) *Unit objects’ degree*

$\forall t \in T, \exists r_{u,t} > 0, r_{u,t} = \sigma(\{[A]_t(x_u): A \text{ is a dimension of } unit$   
 $\& x_u \in D_{u,A}\})$

(‘ $\sigma$ ’ being a function from singletons to their unique members)

Finally, like numerals and difference morphemes, unit nouns are ambiguous between a number-level interpretation, *meters<sub>num</sub>*, and an individual-level interpretation, *meters<sub>ind</sub>* (Landman 2005).<sup>13</sup> The basic, number-level interpretation of a unit name like *meters<sub>num</sub>* in a completion  $t$  is  $\lambda r \in \mathfrak{R}. \lambda r_1 \in \mathfrak{R}. r_1 = r \times r_{m,t}$  (i.e.,  $r_1$  equals  $r$  times the value of a meter unit-object,  $r_{m,t}$ ). Accordingly, the individual-level interpretation of *meters* in any context  $t$  is  $\lambda r \in \mathfrak{R}. \lambda f \in \mathfrak{R}^{D_x}. \lambda x \in D_x. [meter_{num}]_t(r, f(x))$ , which reduces to  $\lambda r \in \mathfrak{R}. \lambda f \in \mathfrak{R}^{D_x}. \lambda x \in D_x. f(x) = r \times r_{m,t}$ . The variable ‘ $f$ ’ can only be saturated by a dimension of *meter* in  $t$  (e.g.,  $f_{tall,t}, f_{wide,t}, f_{long,t}$ );  $f$  assigns  $x$  a value that equals  $r$  times the value of a meter unit-object,  $r_{m,t}$ . Generally:

(26) *Numerical degree predicates*

$\forall t \in T$ , for any *unit*  $\in$  UNIT, adjectival dimension  $P$  of *unit*, and numeral  $r$ :

$$\begin{aligned} [r \text{ unit}_{ind} P]_t &= [unit_{ind}]_t([r]_t)([P]_t) \\ &= \lambda x \in D_x. [P]_t(x) = [r]_t \times r_{u,t} \\ &= \lambda x \in D_x. f_{P,t}(x) = r \times r_{u,t} \end{aligned}$$

In any  $t$ , a numerical degree predicate  $r \text{ unit } P$  denotes a predicate true of entities whose degree in  $P$  is  $r$  times the degree of a unit-object in  $t$ .

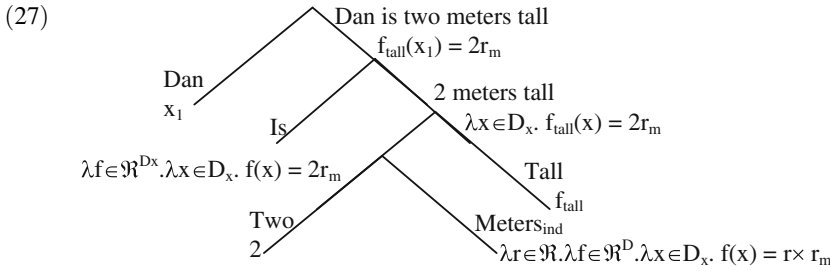
For example, the derivation of the interpretation of *Dan is two meters tall* is given in (27) below.<sup>14</sup>

<sup>11</sup> See Schwarzschild (2005), Brasoveanu (2009), and Bale (2008) for the view that unit nouns in classifier constructions (such as *pounds of cheese*) can directly refer to the set of unit objects.

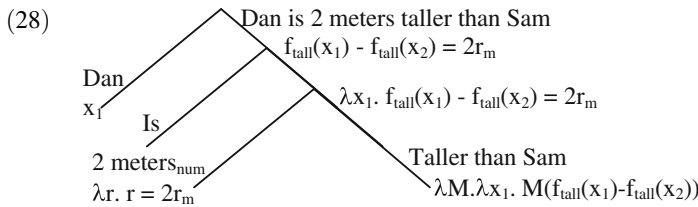
<sup>12</sup> As argued in Sassoon (2010), the comparability of the dimensions of a unit noun (e.g., *tall, wide, long*, etc.) follows, e.g. *Dan is 2 inches taller than this bed is long* is true iff  $f_{tall,t}([Dan]_t) - f_{long,t}([the\ bed]_t) = 2 \times r_{i,t}$ , i.e., the difference between Dan’s degree of height and the bed’s degree of length equals twice the degree of an inch unit object (the value  $f_{tall,t}$  assigns to its unit objects, which equals the value  $f_{long,t}$  assigns to its unit objects).

<sup>13</sup> Schwarzschild (2005), Brasoveanu (2009), and Bale (2008) independently support this ambiguity view.

<sup>14</sup> I assume that unit names like *meters* have an adjectival argument in English (a nominal one in Russian and Hebrew), as the latter specifies the dimension of measurement, e.g., height, width, length, etc. However, unit names with but one measurement dimension need not select for such an argument. For example, the unit *grams* is uniquely associated with measures of weight; *two grams* can only be interpreted as twice the *weight* of a gram unit-object (see also Murphy 2006).



In comparatives, as in, e.g., *two meters taller*, the adjective *tall* is an argument of *er*, not of the unit noun *meters*, which, therefore, receives its basic, numerical interpretation, as shown in (28).



This analysis of unit names presupposes that their semantics involves the application of a ratio operation; e.g. the interpretation of *Dan is r inches tall* boils down to ‘Dan is *r times* taller than an inch unit-object’. It follows that the distribution of unit names should be restricted to adjectives whose degree functions adequately represent ratios between quantities of the ‘stuff’ they measure (additive functions). This means that unit names do not combine with transformed adjectives, rendering combinations like *inch short* uninterpretable. Unit names do combine with adjectives whose degree functions are additive, like *tall*, rendering combinations like *inch tall* perfectly interpretable.

Let us first focus on *tall*. Recall that the height of the ostrich is sixty times the height of the inch in *c*. The degree function of *tall* adequately represents this fact given that in every context *t* in  $T_c$ , *tall* maps the inch to some number *n*, and the ostrich to sixty times that number,  $60n$  (cf. (29)). Consequently, *The ostrich is sixty inches tall* is true in *c* (cf. (30)).

- (29) a.  $f_{tall,t}(x_2) = \mathbf{60}$      $f_{tall,t}(x_1) = \mathbf{1}$      $\Rightarrow$      $f_{tall,t}(x_2) = 60 \times f_{tall,t}(x_1)$
- b.  $f_{tall,t2}(x_2) = \mathbf{120}$      $f_{tall,t2}(x_1) = \mathbf{2}$      $\Rightarrow$      $f_{tall,t2}(x_2) = 60 \times f_{tall,t2}(x_1)$
- c.  $f_{tall,t3}(x_2) = \mathbf{180}$      $f_{tall,t3}(x_1) = \mathbf{3}$      $\Rightarrow$      $f_{tall,t3}(x_2) = 60 \times f_{tall,t3}(x_1)$

- (30)  $\llbracket \textit{The ostrich is sixty inches tall} \rrbracket_c = 1$     iff
- $\forall t \in T_c, \llbracket \textit{The ostrich is is sixty inches tall} \rrbracket_t = 1$     iff
- $\forall t \in T_c, f_{tall,t}(\llbracket \textit{The ostrich} \rrbracket_t) = 60 \times r_{i,t}$
- (s.t.  $r_{i,t}$  is the real number  $f_{tall,t}$  assigns to the inch unit-objects)    iff
- $\forall t \in T_c, f_{tall,t}(x_2) = 60 \times f_{tall,t}(x_1)$



The situation is different with *short*. As its degree function is reversed and transformed by an unspecified value in *c*, we cannot assume that *short* is a dimension of meter. In every *t* in  $T_c$  in which *tall* maps the inch unit-object to *r* and the ostrich to  $60r$ , *short* maps the inch unit-object to  $\text{Tran}_{\text{short},t} - r$  and the ostrich to  $\text{Tran}_{\text{short},t} - 60r$ . But none of these two degrees,  $\text{Tran}_{\text{short},t} - r$  and  $\text{Tran}_{\text{short},t} - 60r$ , is sixty times the other, unless  $\text{Tran}_{\text{short},t} = 0$  (cf. (31)). Since it is not the case that in every context *t* the ostrich’s degree in *short* equals sixty times the inch unit-object’s degree in *short* (e.g., in  $t_1$  and  $t_3$  it doesn’t), the statement *The ostrich is sixty inches short* is not true in *c* (cf. (32)). And since it is not the case that in every context *t* the ostrich’s degree in *short* does not equal sixty times the inch unit-object’s degree in *short* (e.g., in  $t_2$  it does), *The ostrich is sixty inches short* is not false in *c* (cf. (33)).

$$\begin{aligned}
 (31) \quad & \text{a. } f_{\text{short},t_1}(x_2) = \text{Tran}_{\text{short},t_1} - f_{\text{tall},t_1}(x_2) = 10 - 60 = \mathbf{-50} \\
 & \quad f_{\text{short},t_1}(x_1) = \text{Tran}_{\text{short},t_1} - f_{\text{tall},t_1}(x_1) = 10 - 1 = \mathbf{9} \quad \Rightarrow \\
 & \quad \quad \quad f_{\text{short},t_1}(x_2) \neq 60 \times f_{\text{short},t_1}(x_1) \\
 & \quad \text{b. } f_{\text{short},t_2}(x_2) = \text{Tran}_{\text{short},t_2} - f_{\text{tall},t_2}(x_2) = 0 - 120 = \mathbf{-120} \\
 & \quad \quad f_{\text{short},t_2}(x_1) = \text{Tran}_{\text{short},t_2} - f_{\text{tall},t_2}(x_1) = 0 - 2 = \mathbf{-2} \quad \Rightarrow \\
 & \quad \quad \quad f_{\text{short},t_2}(x_2) = 60 \times f_{\text{short},t_2}(x_1) \\
 & \quad \text{c. } f_{\text{short},t_3}(x_2) = \text{Tran}_{\text{short},t_3} - f_{\text{tall},t_3}(x_2) = -10 - 180 = \mathbf{-190} \\
 & \quad \quad f_{\text{short},t_3}(x_1) = \text{Tran}_{\text{short},t_3} - f_{\text{tall},t_3}(x_1) = -10 - 3 = \mathbf{-13} \quad \Rightarrow \\
 & \quad \quad \quad f_{\text{short},t_3}(x_2) \neq 60 \times f_{\text{short},t_3}(x_1)
 \end{aligned}$$

$$\begin{aligned}
 (32) \quad & \llbracket \textit{The ostrich is sixty inches short} \rrbracket_c = 1 && \text{iff} \\
 & \forall t \in T_c, \llbracket \textit{The ostrich is sixty inches short} \rrbracket_t = 1 && \text{iff} \\
 & \forall t \in T_c, f_{\text{short},t}(\llbracket \textit{The ostrich} \rrbracket_t) = 60 \times r_{i,t} \\
 & \text{(s.t. } r_{i,t} \text{ is the real number } f_{\text{short},t} \text{ assigns to the inch unit-objects)} && \text{iff} \\
 & \forall t \in T_c, \text{Tran}_{\text{short},t} - f_{\text{tall},t}(x_2) = 60 \times (\text{Tran}_{\text{short},t} - f_{\text{tall},t}(x_1)) && \text{iff} \\
 & \forall t \in T_c, 60 \times f_{\text{tall},t}(x_1) - f_{\text{tall},t}(x_2) = 59 \times \text{Tran}_{\text{short},t}
 \end{aligned}$$

$$\begin{aligned}
 (33) \quad & \llbracket \textit{The ostrich is sixty inches short} \rrbracket_c = 0 && \text{iff} \\
 & \forall t \in T_c, \llbracket \textit{The ostrich is sixty inches short} \rrbracket_t = 0 && \text{iff} \\
 & \forall t \in T_c, 60 \times f_{\text{tall},t}(x_1) - f_{\text{tall},t}(x_2) \neq 59 \times \text{Tran}_{\text{short},t}
 \end{aligned}$$

Nor can *tall* be the dimension of *meters*, with *meters<sub>ind</sub>* nonetheless selecting *short* as an argument. In every *t* in  $T_c$  in which *tall* maps the inch unit-object to *r* and the ostrich to  $60r$ , *short* maps the ostrich to  $\text{Tran}_{\text{short},t} - 60r$ . But neither of the two degrees, *r* and  $\text{Tran}_{\text{short},t} - 60r$ , is sixty times the other (cf. (34)). Again, it is not the case that in every context *t* the ostrich’s degree in *short* equals sixty times the inch unit-object’s degree in *tall* (e.g., in  $t_1$ ,  $t_2$ , and  $t_3$  it doesn’t), so the statement *The ostrich is sixty inches short* is not true in *c* (cf. (35)). The falsity condition in (36) is actually satisfied in *c*, but that happens solely because we use a simplified example, with but three indices (three possible transformation values). The falsity condition is violated once a context  $t_4$  is added which is, say, identical to  $t_1$  except that the transformation value equals 120 (cf. (37)). In other words, it is generally not the case that in every context *t* the ostrich’s degree in *short* does not equal sixty times the inch unit-object’s degree in *short* (e.g., in  $t_4$  it does). So *The ostrich is sixty inches short* is not false in contexts *c*.

$$\begin{aligned}
 (34) \quad & \text{a. } f_{\text{short},t1}(x_2) = \text{Tran}_{\text{short},t1} - f_{\text{tall},t1}(x_2) = 10 - 60 = \mathbf{-50} \\
 & \quad f_{\text{tall},t1}(x_1) = \mathbf{1} \quad \Rightarrow \quad f_{\text{short},t1}(x_2) \neq 60 \times f_{\text{tall},t1}(x_1) \\
 & \quad \text{b. } f_{\text{short},t2}(x_2) = \text{Tran}_{\text{short},t2} - f_{\text{tall},t2}(x_2) = 0 - 120 = \mathbf{-120} \\
 & \quad \quad f_{\text{tall},t2}(x_1) = \mathbf{2} \quad \Rightarrow \quad f_{\text{short},t2}(x_2) \neq 60 \times f_{\text{tall},t2}(x_1) \\
 & \quad \text{d. } f_{\text{short},t3}(x_2) = \text{Tran}_{\text{short},t3} - f_{\text{tall},t3}(x_2) = -10 - 180 = \mathbf{-190} \\
 & \quad \quad f_{\text{tall},t3}(x_1) = \mathbf{3} \quad \Rightarrow \quad f_{\text{short},t3}(x_2) \neq 60 \times f_{\text{tall},t3}(x_1)
 \end{aligned}$$

$$\begin{aligned}
 (35) \quad & \llbracket \textit{The ostrich is sixty inches short} \rrbracket_c = 1 && \text{iff} \\
 & \forall t \in T_c, \llbracket \textit{The ostrich is sixty inches short} \rrbracket_t = 1 && \text{iff} \\
 & \forall t \in T_c, f_{\text{short},t}(\llbracket \textit{The ostrich} \rrbracket_t) = 60 \times r_{i,t} \\
 & \text{(s.t. } r_{i,t} \text{ is the real number } f_{\text{tall},t} \text{ assigns to the inch unit-objects)} && \text{iff} \\
 & \forall t \in T_c, \text{Tran}_{\text{short},t} - f_{\text{tall},t}(x_2) = 60 \times f_{\text{tall},t}(x_1) && \text{iff} \\
 & \forall t \in T_c, 60 \times f_{\text{tall},t}(x_1) + f_{\text{tall},t}(x_2) = \text{Tran}_{\text{short},t}
 \end{aligned}$$

$$\begin{aligned}
 (36) \quad & \llbracket \textit{The ostrich is sixty inches short} \rrbracket_c = 0 && \text{iff} \\
 & \forall t \in T_c, \llbracket \textit{The ostrich is sixty inches short} \rrbracket_t = 0 && \text{iff} \\
 & \forall t \in T_c, \text{Tran}_{\text{short},t} - f_{\text{tall},t}(x_2) \neq 60 \times f_{\text{tall},t}(x_1) && \text{iff} \\
 & \forall t \in T_c, 60 \times f_{\text{tall},t}(x_1) + f_{\text{tall},t}(x_2) \neq \text{Tran}_{\text{short},t}
 \end{aligned}$$

$$\begin{aligned}
 (37) \quad & f_{\text{short},t1}(x_2) = \text{Tran}_{\text{short},t1} - f_{\text{tall},t1}(x_2) = 120 - 60 = \mathbf{60} \\
 & f_{\text{tall},t1}(x_1) = \mathbf{1} \Rightarrow f_{\text{short},t1}(x_2) = 60 \times f_{\text{tall},t1}(x_1)
 \end{aligned}$$

Again, in both the truth conditions and the falsity conditions ((32)–(33), respectively, and (35)–(36), respectively) a meta-language variable occurs,  $\text{Tran}_{\text{short}}$ , whose value is unspecified in  $c$  (varies across  $T_c$ ), rendering the truth value of such statements inherently undetermined. As this is the situation in every actual context  $c$  in which negative adjectives like *short* receive their default (reversed and transformed) interpretation, combinations of numerical degree modifiers with negative adjectives are ungrammatical.

To summarize, lacking knowledge about  $\text{Tran}_{\text{short}}$ , for no number  $r$  can we say which entities are  $r$  inches short in  $c$  ( $\neg \exists x \in D_x: \forall t \in T_c, f_{\text{short},t}(x) = r$ ). So numerical-degree phrases like *two inches* cannot be used with *short*. Therefore, unit names are always interpreted as taking an additive (non-transformed) adjective as an argument, e.g., utterances such as ‘two inches’ are understood as meaning *two inches tall*, *two inches wide*, or *two inches long*, but never *two inches short* or *two inches narrow*. But in statements like, e.g., *The ostrich is sixty inches short*, the adjectival argument of *inches* is specified as *short*. Therefore, we cannot possibly interpret *inches* as equivalent to *inches tall* or *inches wide*. Consequently, the statement is uninterpretable (ungrammatical).

Importantly, while, e.g., *two meters short* is totally ungrammatical, *twice as short* is not as bad (as discussed in Sect. 5). The explanation is rather simple. Unlike ratio modifiers, unit names *must be conventionally (lexically) linked to a set of adjectives* (cf. (24)), all of which must be ones whose degree functions are additive (appropriately encode degree ratios), as illustrated in this section. Thus, speakers won’t link unit names to adjectives like *short* which are predominantly not interpreted as

additive, despite the existence of ad hoc contexts in which they are so interpreted. However, nothing prevents a *twice* modification in the ad hoc non-default additive contexts. As a result, while measure phrases are utterly bad with negative adjectives, our grammaticality judgments may almost fail to distinguish between ratio statements with positive and negative adjectives. Still, since ratio modifiers can only combine with negative adjectives in contexts that select for a secondary interpretation, *twice* is used less often with negative than with positive adjectives, as predicted, and as the distributional patterns discussed in Sects. 5.2–5.3 reveal.

### 4.3 Numerical degree modifiers in comparison statements

The situation is different in the comparative. A numerical degree phrase like *two inches<sub>num</sub>* is perfectly interpretable when combined with comparative adjectives either as a modifier, as in *two inches shorter* (cf. Sect. 4.3.1), or as an argument, as in *shorter than two inches* (cf. Sect. 4.3.2).

#### 4.3.1 Modification of difference comparisons

Recall our assumption that comparative adjectives express degree differences (cf. Sect. 4.1). For example, comparison statements like *The ostrich is taller than the chicken (is)* hold true in a given context *t* iff the difference between the degrees of height in *t* of the chicken and of the ostrich is a positive real number.

$$(38) \quad \begin{aligned} \llbracket \textit{The ostrich is taller than the chicken} \rrbracket_t &= 1 && \text{iff} \\ f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t) - f_{\text{tall},t}(\llbracket \textit{The chicken} \rrbracket_t) &> 0 && \text{iff} \\ f_{\text{tall},t}(x_2) - f_{\text{tall},t}(x_3) &> 0 \end{aligned}$$

The present analysis of negative adjectives correctly predicts that derived comparatives of negative adjectives will license numerical degree modifiers (as in *The chicken is thirty inches shorter than the ostrich*) by virtue of the fact that when degree differences are computed, the transformation values of the two degrees *cancel one another*.

Again, let us first focus on *tall*. The difference between the height of the ostrich and the height of the chicken equals exactly thirty times the height of an inch unit object. The degree function of *tall* adequately represents this fact, given that in every context *t* in  $T_c$ , the difference between the two degrees *tall* assigns to the ostrich and the chicken equals exactly thirty times the value *tall* assigns to an inch unit-object (cf. (39)). Consequently, the statement *The ostrich is thirty inches taller than the chicken* is true in *c* (cf. (40)).

$$(39) \quad \begin{array}{ll} \text{a. } f_{\text{tall},t_1}(x_2) - f_{\text{tall},t_1}(x_3) = 60 - 30 = \mathbf{30} & f_{\text{tall},t_1}(x_1) = \mathbf{1} \\ \text{b. } f_{\text{tall},t_2}(x_2) - f_{\text{tall},t_2}(x_3) = 120 - 60 = \mathbf{60} & f_{\text{tall},t_2}(x_1) = \mathbf{2} \\ \text{c. } f_{\text{tall},t_3}(x_2) - f_{\text{tall},t_3}(x_3) = 180 - 90 = \mathbf{90} & f_{\text{tall},t_3}(x_1) = \mathbf{3} \\ \text{d. } \Rightarrow \forall t \in T_c: f_{\text{tall},t}(x_2) - f_{\text{tall},t}(x_3) = 30 \times f_{\text{tall},t}(x_1) \end{array}$$

$$(40) \quad \begin{aligned} \llbracket \textit{The ostrich is thirty inches taller than the chicken} \rrbracket_t &= 1 && \text{iff} \\ f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t) - f_{\text{tall},t}(\llbracket \textit{The chicken} \rrbracket_t) &= 30 \times r_{i,t} && \text{iff} \\ f_{\text{tall},t}(x_2) - f_{\text{tall},t}(x_3) &= 30 \times f_{\text{tall},t}(x_1) \end{aligned}$$

Interestingly, the degree function of *short* also adequately represents the given height difference. This happens by virtue of the fact that when degree differences are computed, the transformation values of the two degrees cancel one another, leaving an untransformed value which, as we have just demonstrated, is equal to exactly thirty times the value *tall* assigns to an inch unit-object (cf. (41)). In any  $t$  the difference between the two degrees *short* assigns to the chicken and the ostrich equals exactly thirty times the value *tall* assigns to an inch unit-object, so *The chicken is thirty inches shorter than the ostrich (is)* is true in  $c$  (cf. (42)).<sup>15</sup>

$$\begin{aligned}
 (41) \quad & \text{a. } f_{\text{short},t1}(x_3) - f_{\text{short},t1}(x_2) = (\cancel{\text{Tran}}_{\text{short},t1} f_{\text{tall},t1}(x_3)) - (\cancel{\text{Tran}}_{\text{short},t1} f_{\text{tall},t1}(x_2)) \\
 & \quad = f_{\text{tall},t1}(x_2) - f_{\text{tall},t1}(x_3) = 60 - 30 = \mathbf{30} \qquad \qquad \qquad f_{\text{tall},t1}(x_1) = \mathbf{1} \\
 & \quad \text{b. } f_{\text{short},t2}(x_3) - f_{\text{short},t2}(x_2) = (\cancel{\text{Tran}}_{\text{short},t2} f_{\text{tall},t2}(x_3)) - (\cancel{\text{Tran}}_{\text{short},t2} f_{\text{tall},t2}(x_2)) \\
 & \quad \quad = f_{\text{tall},t2}(x_2) - f_{\text{tall},t2}(x_3) = 120 - 60 = \mathbf{60} \qquad \qquad \qquad f_{\text{tall},t2}(x_1) = \mathbf{2} \\
 & \quad \text{c. } f_{\text{short},t3}(x_3) - f_{\text{short},t3}(x_2) = (\cancel{\text{Tran}}_{\text{short},t3} f_{\text{tall},t3}(x_3)) - (\cancel{\text{Tran}}_{\text{short},t3} f_{\text{tall},t3}(x_2)) \\
 & \quad \quad = f_{\text{tall},t3}(x_2) - f_{\text{tall},t3}(x_3) = 180 - 90 = \mathbf{90} \qquad \qquad \qquad f_{\text{tall},t3}(x_1) = \mathbf{3}
 \end{aligned}$$

$$\begin{aligned}
 (42) \quad & \llbracket \textit{The chicken is thirty inches shorter than the ostrich} \rrbracket_t = 1 \qquad \text{iff} \\
 & f_{\text{short},t}(\llbracket \textit{The chicken} \rrbracket_t) - f_{\text{short},t}(\llbracket \textit{The ostrich} \rrbracket_t) = 30 \times r_{i,t} \\
 & \text{(s.t. } r_{i,t} \text{ is the real number } f_{\text{tall},t} \text{ assigns to the inch unit-objects)} \qquad \text{iff} \\
 & (\cancel{\text{Tran}}_{\text{short},t} - f_{\text{tall},t})(\llbracket \textit{The chicken} \rrbracket_t) - (\cancel{\text{Tran}}_{\text{short},t} - f_{\text{tall},t})(\llbracket \textit{The ostrich} \rrbracket_t) = 30r_{i,t} \text{ iff} \\
 & f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t) - f_{\text{tall},t}(\llbracket \textit{The chicken} \rrbracket_t) = 30 \times r_{i,t} \qquad \text{iff} \\
 & f_{\text{tall},t}(x_2) - f_{\text{tall},t}(x_3) = 30 \times f_{\text{tall},t}(x_1)
 \end{aligned}$$

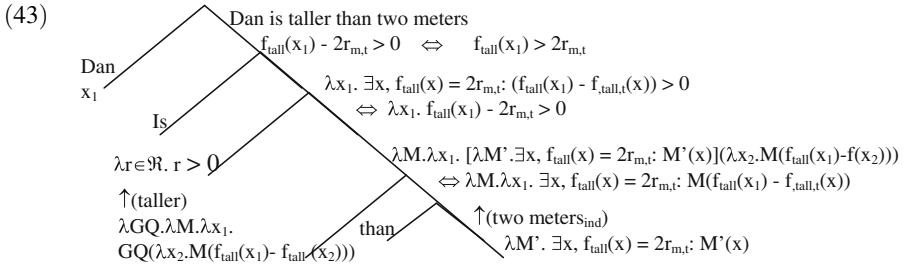
So the present analysis correctly predicts that numerical degree predicates are felicitous as modifiers of both positive and negative comparative adjectives.<sup>16</sup>

### 4.3.2 Numerical degree modifiers in object position

What about numerical degree modifiers in object position, as in *Dan is taller than two meters*? I analyze phrases like *two meters* as predicates, not degree terms. Thus, in object position, we have a mismatch that can be resolved by type-lifting the interpretation of *two meters*<sub>ind</sub> (i.e.,  $\lambda x \in D_x. f_{\text{tall}}(x) = 2r_{m,t}$ ) to a generalized quantifier meaning (the type of *two doctors* in *Dan kissed two doctors*), i.e. to  $\lambda M. \exists x, \llbracket \textit{two meters tall} \rrbracket_t(x): M(x)$  (which reduces to  $\lambda M. \exists x, f_{\text{tall}}(x) = 2r_{m,t}: M(x)$ ), and type-lifting the interpretation of *taller* ( $\lambda x_2. \lambda M. \lambda x_1. M(f_{\text{tall}}(x_1) - f_{\text{tall}}(x_2))$ ) accordingly, to  $\lambda GQ. \lambda M. \lambda x_1. GQ(\lambda x_2. M(f_{\text{tall}}(x_1) - f_{\text{tall}}(x_2)))$ . The derivation of *Dan is taller than two meters* is illustrated in (43) below.

<sup>15</sup> Recall that in *thirty inches shorter*, the predicate *short* does not function as the argument of *inches* (but as the argument of *er*), so *thirty inches* is interpretable.

<sup>16</sup> The root of the idea that in comparison predicates a transformation value is set up to zero, so to speak, is already present in Kennedy and McNally (2005), Svenonius and Kennedy (2006), and Winter (2005).



On this standard solution to this type mismatch, a sentence such as *Dan is shorter than two meters* is analyzed as ‘Dan is shorter than [something that is] two meters’; i.e., the difference between the degree to which Dan is short and the degree to which something—anything whose height is twice the height of a meter—is short is a positive real number (I leave it to the reader to verify this with a derivation). So the sentence is predicted to be interpretable (unlike, e.g., *Dan is two meters short*), and the interpretation is intuitively the right one.<sup>17</sup>

#### 4.4 Cross-polar anomalies

For the analysis of cross-polar comparisons, consider the following simplified analysis of clausal *er*, whereby it resembles phrasal *er* except that its internal argument is a generalized quantifier (type  $\langle\langle r,t \rangle, t \rangle$ ) rather than a number type *r* (this is to capture the so-called wide-scope readings of conjunctive quantifiers in *than*-clauses; cf. Schwarzschild and Wilkinson 2002; Heim 2006a).

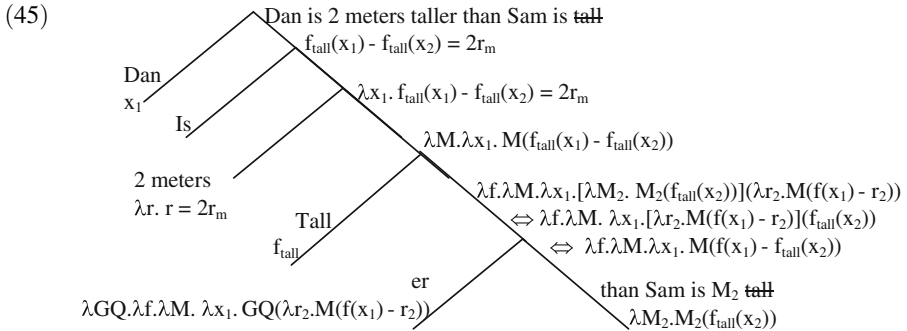
$$(44) \quad \llbracket er \text{ than} \rrbracket_t = \lambda GQ. \lambda M. \lambda f \lambda x_1. GQ(\lambda r_2. M(f(x_1) - r_2))$$

In accordance with (44), I represent *than*-clauses as generalized quantifiers—that is, I do not interpret *than Sam is tall* as  $f_{tall,t}(\llbracket Sam \rrbracket_t)$ , but rather as  $\lambda M_{\langle r,t \rangle}. M(f_{tall,t}(\llbracket Sam \rrbracket_t))$ , namely, a function from degree predicates *M* into truth value 1 iff *Sam*’s height is *M*. This is precisely the interpretation type of *than every boy is*:  $\lambda M. \llbracket boy \rrbracket_t \subseteq \lambda x \in D_x. M(f_{tall,t}(x))$ , namely, a function from degree predicates *M* into truth value 1 iff every boy’s height is *M*.<sup>18</sup> Also, I follow Bresnan (1973) in assuming that if the content of the *than*-clause predicate is recoverable (via identity

<sup>17</sup> Note that the negative polarity of *short* should not be blamed for the infelicity of, for example, *#Dan is as short as two meters*, as the corresponding equative with *tall* is just as bad (*#Dan is as tall as two meters*). Measure phrases are odd also in object position of clausal comparatives (e.g., *#Dan is taller/shorter than two meters is/are*), presumably because clausal comparatives often reinforce distributive ‘wide-scope’ readings (e.g., *Dan is taller than every boy* is considered true iff every boy is such that Dan is taller than him; similarly, *Dan is taller than two meters are* is interpreted as true iff Dan is taller than each one of some two meters).

<sup>18</sup> This is compatible with standard analyses of *than*-clauses (Bresnan 1973; Creswell 1976; Heim 2000, 2001), whereby a silent WH operator moves, leaving a trace *M* at the AP specifier (called DegP) to be bound by a lambda operator at the embedded CP level (Heim and Kratzer 1998). However, *M* is usually taken to be of the type of degree terms, and so *er* is analyzed as a determiner over degree predicates (the matrix clause is analyzed as a degree predicate, based on the assumption that the whole *er*-phrase moves at LF, leaving a trace at the specifier of the main clause’s AP, to be bound by a lambda operator; Heim 2000, 2001).

with the matrix clause predicate), it is obligatorily deleted. The derivation of *Dan is two meters taller than Sam is tall* is illustrated in (45).



Why are cross-polar comparisons like *\*The chicken is taller than the ostrich is short* infelicitous? For the statement to hold true the difference between the degree which *tall* assigns to the chicken and the degree which *short* assigns to the ostrich should be a positive real number:

$$\begin{aligned}
 (46) \quad & \llbracket \textit{The chicken is taller than the ostrich is short} \rrbracket_t = 1 \quad \text{iff} \\
 & f_{\text{tall},t}(\llbracket \textit{The chicken} \rrbracket_t) - (\text{Tran}_{\text{short},t} - f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t)) > 0 \quad \text{iff} \\
 & f_{\text{tall},t}(\llbracket \textit{The chicken} \rrbracket_t) + f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t) - \text{Tran}_{\text{short},t} > 0
 \end{aligned}$$

Since only the degree assigned by *short* ( $\text{Tran}_{\text{short},t} - f_{\text{tall},t}(\llbracket \textit{The ostrich} \rrbracket_t)$ ) introduces a transformation-value variable, this variable is not canceled out. As its value is unspecified in c, we cannot tell whether the degree difference is a positive number or not; for example, in  $t_1$  it is positive, but in  $t_4$  (a completion in all respects identical to  $t_1$ , except that the transformation value equals 120 rather than 10) it is not positive.

$$(47) \quad f_{\text{tall},t1}(x_3) - f_{\text{short},t1}(x_2) = 30 - (\text{Tran}_{\text{short},t1} - 60) = \mathbf{90} - \text{Tran}_{\text{short},t1}$$

Consequently, cross-polar comparisons (such as *\*The ostrich is taller than the chicken is short*) can never be verified or falsified and are, therefore, considered anomalies.

Finally, cross-polar comparisons are perfectly fine when a negative adjective is in the matrix clause and the positive counterpart in the *than*-clause is not its direct antonym, as in, e.g., *The ladder is shorter than the gap is wide* (Landman 2005; Büring 2007). For reasons of space, I cannot pursue a proper analysis of cross-polar anomalies. However, it is important to notice that in such examples we actually compare two negative degrees; for instance, according to Büring (2007) and Heim (2008), in the above example, we compare the degree of shortness of the ladder with the degree of narrowness of the gap. Thus, these comparisons are not truly cross-polar. Consequently, rather than forming counterexamples to my proposal, they lend additional support to it, at least in that the impossibility of interpreting a difference

comparison with one reversed and one non-reversed degree forces us into an interpretation with two reversed degrees (and two transformation values), *despite the presence of two antonyms*, a negative and a positive one.<sup>19</sup>

To conclude Sect. 4, the main linguistic contrasts characterizing paradigmatic antonym pairs follow directly from the present analysis. Having established that, we can now move on to explore non-paradigmatic antonym pairs, as well as additional features of negative and positive antonyms in general.

## 5 Non-paradigmatic antonym pairs

### 5.1 A taxonomy of adjective types

The present proposal clearly distinguishes between function reversal (namely, the use of functions that are linearly reversed in comparison with the base function) and linear transformation (namely, the displacement of the zero compared to the base function, as explained in Sect. 3.2). The use of this distinction can be stated as follows:

- (48) +/-Reversal determines the polarity of an adjective:
- a. The degree functions of positive adjectives are based on conventional or perceptual measures. They are not reversed with respect to these measures.
  - b. The degree functions of negative adjectives are reversed in comparison with the degree functions of their positive antonyms. In the absence of a completely specified rule of reversal and in an attempt to avoid negative values, by default these functions are transformed by an unspecified value.
- (49) +/-Transformation determines the licensing of numerical degree modifiers:
- a. Adjectives whose degree functions are directly based on some additive measuring system license numerical degree modifiers.
  - b. Adjectives whose degree functions are transformed in comparison with an additive measuring system do not license numerical degree modifiers.

This proposal distinguishes between the four groups of functions in (50) below. As established so far, the interpretations of positive and negative antonyms in paradigmatic pairs pattern with the function types (50a) and (50b) below, respectively. In addition, nothing in the proposals summarized above prevents positive adjectives from being transformed. To the contrary, Sect. 5.3 supports the hypothesis that many positive adjectives ('non-paradigmatic' ones) are indeed interpreted as transformed, i.e., pattern with (50c). Linear transformation regularly affects adjectival interpretations, as suggested by the definitions in (14) above.

<sup>19</sup> Future research should explicate the mechanism responsible for the reversal of the interpretation of *wide* and the specification of a transformation value identical to that of *short*.

- (50) *Adjectival taxonomy by function type*
- Non-reversed and non-transformed, e.g.,  $\lambda x \in D_x \cdot f_{\text{tall,t}}(x) - 0$
  - Reversed and transformed, e.g.,  $\lambda x \in D_x \cdot 1 - f_{\text{tall,t}}(x)$
  - Non-reversed and transformed, e.g.,  $\lambda x \in D_x \cdot f_{\text{tall,t}}(x) - 1$
  - Reversed and non-transformed. e.g.,  $\lambda x \in D_x \cdot 0 - f_{\text{tall,t}}(x)$

In a sharp contrast, if the present theory of negative antonymy is comprehensive, negative adjectives should not pattern with (50d). Like their paradigmatic counterparts, negative adjectives in non-paradigmatic pairs should also denote reversed and transformed functions. Other interpretations (non-reversed or non-transformed) must remain secondary (rare in  $T_c$ ).

- (51) *Comprehensive rule of negative antonymy*  
 An adjective B is 'negative' in c iff in  $T_c$  it is predominantly interpreted as reversed, and as a result transformed, such that in nearly all the completions t in  $T_c$ ,  $f_{B,t} = \lambda x \in D_x \cdot \text{Tran}_{B,t} - f(B,t)(x)$ .

Let us call the converse rule, whereby non-paradigmatic negative antonyms may be predominantly reversed but not transformed, the *narrow* rule of negative antonymy. According to the narrow rule, adjectives may be predominantly associated with functions of all the four types of the taxonomy in (50), including (50d). The following sections show that reversal and transformation are wide-ranging, supporting the comprehensive rule.

## 5.2 Distributional differences between positive and negative adjectives

The tests presented in Sect. 2 to distinguish positive and negative adjectives are insufficient. Sometimes it is hard to determine which adjective is the positive antonym in a pair. This is likely to happen in the following circumstances.

- The adjectives are associated with no conventional measure phrases, or both the negative and the positive antonym fail to license measure phrases, except in the comparative. For example, it is somewhat awkward to say that *Yesterday was thirty degrees warm*, though it is perfectly acceptable to say that *Yesterday was thirty degrees warmer than today* (Kennedy 2001). So in terms of the licensing of numerical degree modifiers, *warm* resembles its negative antonym *cold* and not other positive adjectives.
- Felicity contrasts between ratio statements with the two given antonyms are hardly felt (as in, e.g., *twice as bald* versus *twice as hairy*).<sup>20</sup>
- In the absence of an indirect antonym, the cross-polar (a)nomaly test fails. For example, *dirty* and *clean* are direct antonyms, and it is hardly possible to find a related but more indirect antonym comparable with either.<sup>21</sup>

<sup>20</sup> Recall that the tests in Sect. 2 only state that "negative adjectives cannot combine with measure phrases/ ratio modifiers, while positive adjectives *sometimes* do."

<sup>21</sup> Recall that this test (Büring 2007) states that cross-polar comparisons are possible with a negative adjective in the matrix clause and a positive indirect antonym in the *than*-clause (e.g., *The ladder is shorter than the gap is wide* is fine, although *#The gap is wider than the ladder is short* is not).



Thus, sometimes positive adjectives resemble negative ones in crucial respects. This section attempts to provide an additional test for the polarity of adjectives, and to give a firmer basis to the claim that ratio modifiers are generally more compatible with positive adjectives than with negative ones. To this end, I present a corpus study of distributional differences between positive and negative adjectives. The main findings are that, generally, the ratio modifier *twice* is used significantly more often with positive adjectives than with their *negative* antonyms. The converse pattern occurs virtually only when *twice* is relatively rare with both antonyms (cf. Sect. 5.3). The rare exceptions (two *negative* adjectives that license *twice* relatively frequently) are discussed in Sect. 5.4.

Ratio modifiers are not used *frequently* enough for us to be able to assess significant data from linguistic corpuses. For instance, for *twice as good as*, I have found only 8 results in the British National Corpus (BNC; 100 million words, 1980–1993, collected by Mark Davies, Brigham Young University), and only 15 results in the corpus of Contemporary American English (360 million words, 1990–2007, also collected by Mark Davies). When searching with Google the results are substantial (e.g., an estimated 196,000 results for *twice as good as*), but there is a problem of reliability (usage of non-native speakers, duplicates and quotations, possible effects of Google’s specific searching criteria, removed entries, etc.) However, even with these caveats, it appears that the tendency observed in our intuitive judgments concerning ratio statements (e.g., (3)–(4) above) finds expression in the estimated Google results for a large number of adjectives.<sup>22</sup>

I Google-searched for 50 antonym pairs (100 adjectives). Some pairs are incompatible with ratio modifiers in both the negative and the positive form (examples include the adjectives *typical*, *atypical*, *official*, *unofficial*, *honest*, and *dishonest*). For 23 of these pairs I found estimates of fewer than 1,000 results which, considering the size of the corpus, is a very small number; considering the range of artifacts, the differences between positive and negative adjectives in these pairs are not informative. The other 27 pairs yielded the results in Table 3.

Blocks 1 and 2 of Table 3 present the number of ratio comparisons (entries of the form *twice as ADJ as*) and equative comparisons (entries of the form *as ADJ as*), with positive and negative antonyms in the 27 remaining pairs, as well as the ratio between these numbers.<sup>23</sup>

The number of equative comparisons is generally greater in positive adjectives than in their negative antonyms (cf. rows B and D in Table 3). Given studies of children’s performance (Gobbo and Agnoli 1985), and brain responses (Molfese 1985), we can presume that this is due to an additional load in the processing of negative adjectives (see also Horn 1989, as well as Giora 2006 and other papers in the same volume). For this reason, instead of directly comparing the number of ratio comparisons in positive adjectives and their negative antonyms (rows A and C in Table 3), I first calculated the proportion of ratio comparisons out of the total

<sup>22</sup> Also, Lapata and Keller (2005) demonstrate that Google-based counts correlate with frequencies obtained from a carefully edited, balanced corpus such as the BNC, and they reliably predict speakers’ judgments.

<sup>23</sup> All searched items were put in quotation marks (as in: “twice as tall as”). The searches were all conducted on the same day, within the same two-hour frame.

number of equative comparisons for each adjective (rows A/B and C/D in Table 3), thereby *factoring out the processing effect on the frequency of use*.

**Table 3** The use of *twice* with adjectives and their antonyms (estimated Google results for each phrase)

**I. More uses with the positive adjective, in comparison with the negative antonym (A/B > C/D)**

		A	B	C	D	A/B	C/D	(A/B) (A/B+C/D) (%)
		twice as pos as	as pos as	twice as neg as	as neg as	twice as <u>pos as</u> as pos as (%)	twice as <u>neg as</u> as neg as (%)	
likely	unlikely	566,000	1,590,000	214	196,000	35.5975	0.1092	100
smart	foolish	15,500	1,320,000	6	133,000	1.1742	0.0045	100
frequent	rare	25,500	327,000	273	616,000	7.7982	0.0443	99
tall	short	90,500	1,880,000	934	3,240,000	4.8138	0.0288	99
intelligent	foolish	1,860	309,000	6	133,000	0.6019	0.0045	99
wide	narrow	209,000	2,570,000	420	593,000	8.1323	0.0708	99
strong	weak	143,000	6,140,000	141	412,000	2.3290	0.0342	99
long	short	323,000	23,300,000	934	3,240,000	1.3863	0.0288	98
old	young	75,200	4,990,000	1,750	3,810,000	1.5070	0.0459	97
old	new	75,200	4,990,000	184	381,000	1.5070	0.0483	97
deep	shallow	44,300	2,130,000	206	275,000	2.0798	0.0749	97
dirty	clean	1,680	212,000	639	1,200,000	0.7925	0.0533	94
big	small	191,000	7,230,000	20,700	6,670,000	2.6418	0.3103	90
happy	sad	2,880	1,860,000	154	471,000	0.1548	0.0327	83
rich	poor	13,600	547,000	1,100	169,000	2.4863	0.6509	79
smart	stupid	15,500	1,320,000	3,370	1,080,000	1.1742	0.3120	79
intelligent	stupid	1,860	309,000	3,370	1,080,000	0.6019	0.3120	66
fast	slow	1,440,000	19,000,000	31,700	787,000	7.5789	4.0280	65
hot	cold	22,200	1,790,000	7,910	1,050,000	1.2402	0.7533	62
happy	unhappy	2,880	1,860,000	65	52,600	0.1548	0.1236	56
warm	cold	5,160	565,000	7,910	1,050,000	0.9133	0.7533	55
Average		155,515	4,011,381	3,904	1,268,505	4.03	0.37	86

**II. Fewer uses with the positive adjective, in comparison with the negative antonym (A/B < C/D)**

		A	B	C	D	A/B	C/D	(A/B) (A/B+C/D) (%)
		twice as pos as	as pos as	twice as neg as	as neg as	twice as <u>pos as</u> as pos as (%)	twice as <u>neg as</u> as neg as (%)	
good	bad	196,000	6,400,000	103,000	1,630,000	3.0625	6.3190	67
wise	stupid	235	197,000	3,370	1,080,000	0.1193	0.3120	72
healthy	sick	193	764,000	1,420	283,000	0.0253	0.5018	95
late	early	56	4,120,000	5,880	4,280,000	0.0014	0.1374	99

Table 3 continued

		A	B	C	D	A/B	C/D	(A/B) (A/B+C/D) (%)
		twice as pos as	as pos as	twice as neg as	as neg as	twice as <u>pos as</u> as pos as (%)	twice as <u>neg as</u> as neg as (%)	
right	wrong	<b>6</b>	<b>171,000</b>	<b>2,510</b>	<b>289,000</b>	0.0035	0.8685	<b>100</b>
quick	slow	<b>798</b>	<b>19,100,000</b>	<b>31,700</b>	<b>787,000</b>	0.0042	4.0280	<b>100</b>
Average		<b>32,881</b>	<b>5,125,333</b>	<b>24,647</b>	<b>1,391,500</b>	<b>0.54</b>	<b>2.03</b>	<b>89</b>

**III. Less than 1000 uses with both the positive and the negative adjective**

		twice as pos as	twice as neg as			twice as pos as	twice as neg as
similar	different	738	13	opaque	transparent	108	253
similar	dissimilar	738	1	full	empty	38	2
relaxed	nervous	679	30	open	closed	37	1
safe	dangerous	679	542	honest	dishonest	8	4
safe	unsafe	679	63	normal	abnormal	7	3
beautiful	ugly	552	556	possible	impossible	6	1
probable	improbable	510	3	certain	uncertain	6	64
wet	dry	480	357	calm	angry	3	347
hairy	bald	273	2	glad	sad	2	155
easy	difficult	270	673	necessary	unnecessary	0	2
true	false	248	1	typical	atypical	0	0
wise	foolish	237	7	official	unofficial	0	0
wonderful	awful	163	18	<b>Average</b>		<b>258</b>	<b>124</b>

If, as I suspect, the use of ratio modifiers with negative adjectives is indeed problematic, then the proportion of ratio comparisons out of the total number of equative comparisons (i.e., the likelihood of modification by *twice* given the use of an equative) should be greater among positive adjectives than among their negative antonyms ( $A/B > C/D$ ).<sup>24</sup>

All in all, the licensing and frequency of use of ratio modifiers seems to be affected by a combination of several factors, one of which is the polarity of the adjective. The results confirm my expectation for about 75% of the adjectives.

<sup>24</sup> In order to test reliability, I searched for ratio comparisons with these 27 antonym pairs on a different day. The results were highly similar. There is a correlation of 0.99 between the two searches with regard to the proportion of ratio comparisons with a positive adjective out of the total number of ratio comparisons with that adjective and its negative antonym ( $A/(A + C)$ ). The high correlation persisted when I controlled for the adjectives' frequency by dividing the counts of ratio comparisons in the second search by counts of entries of the form *ADJ* for each adjective. I found a correlation of 0.95 between the rightmost row  $(A/B)/(A/B + C/D)$  in Table 3 and the corresponding row of the second search, where B and D represent the frequency of the adjective *ADJ*.

As presented in Block I of the table, in 78% (21) of the antonym pairs, the proportion of ratio comparisons (out of the total number of equative comparisons) among the positive adjectives (A/B) is larger than the proportion of ratio comparisons (out of the total number of equative comparisons) among their negative antonyms (C/D). In three of these pairs, the difference is rather marginal (*happy/unhappy*,<sup>25</sup> *warm/cold*, and *hot/cold*), but given the large number of entries (and the significant effect on the other 18 pairs), this study supports the hypothesis that *twice* combines more often with positive than with negative adjectives.

Yet, as presented in Block II of the table, in 22% (6) of the antonym pairs, the pattern is reversed. The following sections explore these unexpected data. Section 5.3 addresses positive adjectives that resemble negative ones with respect to the (non-)licensing of measure phrases (e.g., *warm*) and/or ratio statements (e.g., the positive adjectives in Block II of Table 3). Section 5.4 addresses exceptional uses of negative adjectives with ratio modifiers and sometimes also measure phrases.

### 5.3 Positive adjectives that resemble negative ones

The present analysis directly captures properties of exceptional positive adjectives, like *warm*. The latter resemble their negative antonyms in that they only license numerical degree modifiers in the comparative (cf. *#twenty degrees warm* versus *twenty degrees warmer*). The degrees of positive adjectives are not reversed, but they may well be transformed. This explains the infelicity of *two degrees warm* (as opposed to the felicity of *two degrees warmer*). It also captures our unclear intuitions concerning the zero point of *warm*, when interpreted as mapping objects to their temperature (as measured by a thermometer).

Why is it that the zero of this interpretation of *warm* is transformed? Entities that scientists claim possess no heat are mapped to zero on the Kelvin scale. However, they are not mapped to zero Celsius! The Celsius scale is transformed relative to the Kelvin scale.<sup>26</sup> The existence of a transformed unit name like *Celsius* supports the view that temperature predicates may be associated with transformed temperature measures. In particular, entities with no heat are mapped to  $-273^{\circ}\text{C}$ . We do not often encounter or discuss such entities, and we normally perceive entities to be without heat long before they reach  $-273^{\circ}$ . I submit that positive adjectives, when linked to external measures whose corresponding perceptual measures have a different zero point, are likely to be associated with a non-zero transformation value, i.e. with non-additive degree functions. Thus, we expect them (i) not to license ratio modifiers (or to do so relatively rarely, by allowing for secondary, context-depen-

<sup>25</sup> Speakers often assert, for instance, that they are *twice as happy*, but merely as a manner of speech—a figurative way of stating that they are much happier. However, this obviously does not show that *twice as happy* is ungrammatical; in fact, it is completely grammatical! Note that even if quantities of happiness, sadness, love, etc. are mapped to numbers, the creation of a convention regarding unit objects is hardly possible because these quantities are inner states which are never accessible to the whole community. Thus, no numerical degree modifiers exist for these measures (Sassoon 2010; see also the discussion in Sect. 5.3 below).

<sup>26</sup> Entities with the heat of  $r$  Kelvin units are mapped to  $r - 273^{\circ}\text{C}$  (for further discussion of related linguistic facts and their account see Sassoon, 2007, 2010).

dent, additive interpretations), although (ii) since they derive from some additive measuring system by transformation, these measures are likely to have unit names and to license numerical degree modifiers in the comparative.

The zero in non-additive conventional scales like the Celsius scale is assigned to some salient, highly relevant point (e.g., the freezing point of water). But this is an arbitrary choice. The zero could have been assigned to many other points, equally easy to recognize and at least as relevant to discourses about, in this case, temperature. In parallel, this paper claims that, generally, the functions of negative adjectives are transformed so as to locate the zero among entities that might be under discussion in their contexts of use.

Importantly, I do not (and cannot) claim that the average language-acquiring child has access to scientific knowledge regarding, e.g., Kelvin and Celsius thermometers. If anything it is the other way around, insofar as scientific concepts are often rooted in primary perception. Speakers tend to agree that locating the exact point where something ceases to contain heat is not an easy matter. That suffices for me to say that the zero point in the predominant interpretation of temperature predicates is undetermined. Also, scientists invent and use transformed thermometers *because*, like all of us, they too find the point at which entities cease to have any heat/temperature hardly ever relevant to them in daily-life conversations about temperatures. Then again, the semantic component of grammar constantly evolves and scientific concepts penetrate into it. Evidence for that is the fact that sometimes we do interpret temperature predicates as non-transformed (surely, scientists do). That must be the case when we accept non-figurative *twice* statements, i.e. when we accept “A is twice as hot as B” as meaning that ‘the quantity of heat in A is two times the quantity of heat in B’. Still, in non-scientific contexts, the transformed interpretation seems to be the more salient.

Other examples include adjectives like *heavy* or *rich*. Richness is often measured by the amount of money one’s possessions are worth. Still, zero richness is not conventionally or intuitively identified with entities having absolutely no possession. Similarly, a lack of a feeling of ‘heaviness’ can occur in things with more than zero weight. The air or feathers are not heavy at all, though they do have some weight. Languages may vary as to whether the degree functions of adjectives like, e.g., *rich*, *heavy*, or *warm* (as measuring amounts of possession, weight, or external temperature, respectively) are transformed (are affected by, e.g., our *perception* of such stimuli) or not. Thus, languages may differ as to the licensing of ratio modifiers, as well as of numerical degree modifiers in non-comparative forms.<sup>27</sup>

Certain readers may still ask why this is so. If adjectival semantics is governed by our world knowledge and intuitions concerning the measures that adjectives are associated with, one would expect a strong correlation between an adjective’s meaning and the presence or absence of transformation. One would expect that

<sup>27</sup> Further examples in point may be the two Hebrew nominalizations *miskal* ‘weight’ and *koved* ‘heaviness’. Only the former licenses measure phrases (*mishkall* #*koved shney kilos*; ‘weight/ #heaviness of two kilos’) and ratio phrases (*mishkall* ?*koved kaful*; ‘double weight/ ?heaviness’). The existence of several nominalizations with different properties independently supports the view that the corresponding adjective carries both transformed and non-transformed interpretations.

with my theory we will be able to formally predict when a predicate is to be interpreted as transformed. At this point I should remind readers that this is never the case with grammaticized semantic distinctions. When intuitive semantic distinctions are incorporated into grammar, they turn into formal features that can be associated with words quite arbitrarily. An example in point is the female–male gender distinction, as well as the mass–count distinction. Though e.g. the word for water is likely to classify as a mass noun in every language, for many other words we cannot predict whether they will be classified as mass or count in a given language. Words like *furniture* are count in Italian, mass in English, and both in Hebrew. For relevant discussion see Chierchia (1998), who describes words like *furniture* as ‘fake mass nouns’, i.e., grammatically mass (they do not combine with numerals, \**three furnitures*) but cognitively count (experimental evidence shows that *furniture* patterns with count nouns when it comes to counting and individuating tasks). In the same way, adjectives related to measures regarding whose zero point we have no conventions, intuitions, or important experiences are likely to be classified as transformed. The classification of other adjectives is not predictable. This shouldn’t be surprising or troubling: since the standard type of gradable adjectives varies across and within languages, why wouldn’t the transformation value do so as well?

Moreover, for any additive adjectival interpretation, we can in principle construct an adjectival interpretation that is exactly similar except transformed. Thus, we can expect languages to contain near-synonyms that differ with respect to transformation. For example, according to Schwarzschild (2005), *tall* in French (‘grande’) cannot license measure phrases. I’d say that it has a transformed interpretation. Children, of course, can learn this semantic distinction based not on semantic features alone, but also on the way such adjectives are used, e.g., with/without measure phrases, in just the same way as they can learn about mass/ count words based on whether they are used with numerals or not. In fact, by Google-searching for potential examples of near-synonyms, I have found that *happy* seems to have additive uses, while *glad* does not (based on their estimated counts of *twice*-comparisons, which were 2,880 and 2, respectively; for conversion into fractions of total occurrences, see Table 3); *smart* has additive uses (15,500 counts), while *wise* does not (235 counts); and *fast* has additive uses (1,444,000 counts), while *quick* does not (798 counts). In fact, the reversed pattern found for *quick-slow* (798 vs. 31,700 counts, respectively) may also result from *slow* being the reverse of *fast*, not of *quick*, in most of these uses (but see also the discussion of deviation-from-a-midpoint interpretations below).<sup>28</sup>

Most importantly, the distributional findings in Table 3 provide supporting evidence for the analysis of many positive adjectives as transformed, despite not being reversed.

<sup>28</sup> It may well be that aside from differences in connotation (rendering e.g. smartness relatively more measurable than wisdom), speech register plays a role in differentiating among near-synonyms here (C. Bartels, p.c.). Figurative *twice*-comparisons are colloquial, informal constructions, and thus more likely to employ the more common, colloquial choice of adjective: *smart* rather than *wise*, *fast* rather than *quick*, *happy* rather than *glad*.

First, the fact that both the positive and the negative members of 23 of the 50 antonym pairs for which I Google-searched have less than 1,000 counts of ratio comparisons with *twice* (Block III of Table 3) is consistent with the idea that the positive counterparts of transformed negative adjectives may also be transformed.

Second, Block II of Table 3 presents a small group of adjective pairs that appear to pattern differently than expected. The negative adjectives here occur *more often* with ratio modifiers than their positive antonyms. Are they reversed and non-transformed? There is good reason to think that this is not the case. Rather, in these pairs the positive adjectives as well are transformed.

Had the negative adjectives in Block II been non-transformed, we would have expected *twice* to modify their equatives as often as it modifies the equatives of the non-transformed positive adjectives in Block I. However, *twice* is significantly rarer with the negative adjectives of Block II than with the positive adjectives of Block I (2.03 vs. 4.03%, on average). Moreover, *twice* is even rarer in the positive adjectives in Block II (0.54%, on average). This would have been unexpected if these were interpreted as non-transformed.

To illustrate this point, let us divide the adjectives into those that tend to combine with *twice* more than once per 100 equatives, versus those that do not (i.e., do so less than once per 100 equatives). Importantly, only two negative adjectives tend to combine with *twice* more than once per 100 equatives (*slow* and *bad*), while all the rest (90% of the 27 negative adjectives in Blocks I and II), as well as many positive adjectives, do not.

Figure 1 illustrates this in a graph. Significantly, the values of the negative adjectives are clearly located between the levels 0 and 1% (i.e., less than 1 use of *twice* per 100 equatives), with but two exceptions, *bad* and *slow* (the latter is represented twice; once in comparison with *fast* and once in comparison with *quick*). Thus, the difference between Block I and II of Table 3 concerns mainly the values of positive adjectives. In Block II, but not in Block I, these values approximate 0%.

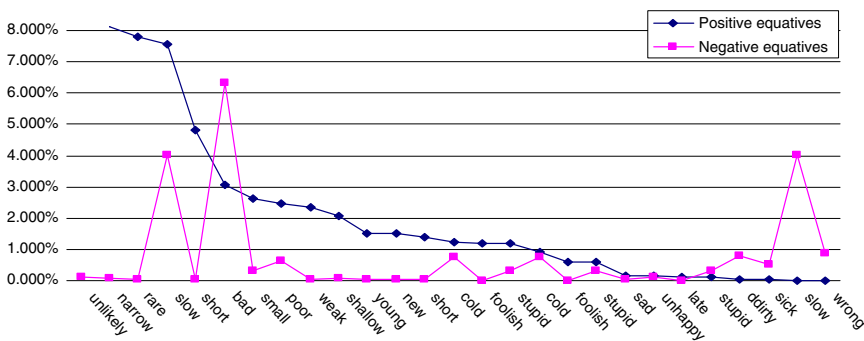


Fig. 1 Distribution of *twice* in equatives with positive versus negative antonyms

The unexpected distribution of *twice* among the antonyms in Block II is, therefore, due to the non-use of *twice* with certain positive adjectives, which is consistent with them being predominantly transformed, like their negative ant-



onyms. The next section makes sense of the remaining two exceptions, *bad* and *slow* (which appear to pattern with (50d), i.e. to be interpreted as predominantly reversed but not transformed).

At any rate, we must also keep in mind that additional factors may play a role in explaining the non-use of *twice*. In particular, a viable possibility is that some positive adjectives tend to associate with *base functions* which are not additive. Consider, for instance, the adjective *felicitous*. We often have intuitions about felicity contrasts between sentences, but never about absolute levels of felicity. Thus, *felicitous* resembles, e.g., *heavy*, whose degree function transforms the values of an additive base function. It is difference-preserving, but not ratio-preserving. Its association with a transformation value has no effect, given that it maps to zero an arbitrarily chosen, context-variant amount of felicity in the first place (Featherston, to appear; Sassoon 2010). Likewise, the data this paper addresses follows just as much from the assumption that the base functions of weight and temperature adjectives or of psychological adjectives like *happy* are difference-preserving but not additive (except in scientific contexts).

Last but not least, the present proposal may have consequences with regard to evaluativity. Rett (2007) argues that negative adjectives tend more towards evaluative implications (e.g., the question *How tall is the ostrich?* and the equative *The ostrich is as tall as the chicken* do not imply that the ostrich is tall, while the question *How short is the ostrich?* and the equative *The ostrich is as short as the chicken* do imply that the ostrich is short). However, as Krasikova (2008) observes, gradable predicates in Russian that are not morphologically marked for comparison trigger evaluative implications regardless of their polarity. Interestingly, they also do not combine with measure phrases! While Krasikova (2008) proposes that different constraints govern the distribution of measure phrases and evaluative interpretations in English and Russian, the present analysis suggests that an account for the two languages in terms of one principle may be possible (by connecting evaluativity and transformation).<sup>29</sup>

In conclusion, the proposal that a transformation procedure systematically affects adjectival interpretations explains also why some positive adjectives license numerical degree modifiers only in the comparative, and it correctly predicts that this would be the case when our intuition is that the zero point is uncertain and/or irrelevant. Future research should inquire whether evaluativity, which seems to

<sup>29</sup> The relevant generalization is that adjectives that do not license measure phrases in the non-comparative form are evaluative. (I am indebted to Micha Breakstone for drawing my attention to this generalization; for related discussion see Bierwisch 1989; Breakstone 2009.) This generalization seems to apply to all the negative adjectives in English and Russian, and to all the positive ones in Russian, but, crucially, also to those positive adjectives in English that fail to license measure phrases. Examples in point are *heavy*, *fat*, *rich*, and *warm* (cf. the infelicity of *#twenty degrees warm*, *#two million euros rich*, and *#thirty kilograms heavy/fat* and the evaluativity and hence odd nature of, for instance, *?This feather is as heavy as that one* and *?This ice cream is as warm as that one*). Rett's (2007) theory, according to which evaluativity pertains to 'marked' (i.e., negative) adjectives, fails to capture these facts. However, they directly follow if evaluativity is seen as characterizing adjectives whose predominant interpretation is transformed by an unspecified value. Note that to accommodate the facts, Rett's (2007) analysis has to be heavily modified, as it derives evaluativity from a comparison with an alternative unmarked (positive) antonym, whereas in the case of positive evaluative adjectives the antonym (being negative and evaluative) is not unmarked.



characterize adjectives with transformed interpretations, can be derived from the existence of a transformation value.

#### 5.4 Negative adjectives that resemble positive ones

The comprehensive theory of negative antonymy ties together function reversal and transformation. By default, negative adjectives are transformed by an unspecified value. This proposal correctly predicts the fact that statements with, e.g., *twice as short as* are less acceptable and less often used than statements with *twice as tall as*. But what happens when we do use them?

It is well known that the interpretation of adjectives is remarkably amenable to contextual modification (adaptation to ad-hoc contextual purposes; cf. Kennedy and McNally 2005). Context may affect all the default features of adjectival degree functions. For example, Kennedy and McNally (2005) have observed that adjectives like *dry* have a default absolute-standard interpretation; thus we understand statements like *The floor is dry* to convey that the floor is completely dry—there is no humidity at all on the surface of the floor. But in certain uses, *dry* is interpreted as a relative-standard adjective; for example, we understand statements like *My skin is dry* to convey that the humidity of my skin is below some standard.

The status of the transformation value (whether it is necessarily thought to equal zero or not) may change in a similar fashion. For example, consider a situation in which the length of different short stories is measured based on the number of words in each story. In this situation, some speakers may utter and accept as felicitous ratio statements like *This story is twice as short as that one*. In the given situation, *short*'s degree function is indeed locally based on an ad hoc 'scientific' measuring convention (number of words); that is, the degree function of *short* in this ad hoc use is reversed but not transformed. Indeed, the association of adjectives with ad hoc additive measures is most typical of contexts of scientific or technological inquiry. For example, many search results for *twice as slow as* regard measurements of speed of software, discs, processors, etc.; the same is true of positive adjectives, e.g. uses of *twice as heavy* often regard stars or chemical particles.

The negative adjective *short* has several other types of secondary interpretations. In statements like *I am short of money*, the degree function of *short* can be described as measuring the lack of some 'stuff' other than height. The same holds true when *short* is used to describe temporal length, length of musical notes, etc. Here, *short* does not function as the negative antonym of *tall*. We need a separate examination to determine whether the degree functions of *short* in these uses are transformed or not. At any rate, it is definitely the case that 'additive', convention-based interpretations (such as the word-count measure for short stories) do not form the dominant or default interpretation of *short*, as indicated by the fact that the likelihood of modification by *twice* is drastically smaller for the negative equative *as short as* than for each of its positive counterparts.

Significantly (and also surprisingly), some of the exceptional uses of negative adjectives can actually be explained by their association with a transformation value. Let me explain this important point in some detail.

As observed by Kennedy (1999, 2001), negative adjectives (as well as positive ones) typically have a secondary interpretation whereby they measure deviations from a midpoint. Speakers who accept cross-polar comparisons (such as *Dan is taller than Mary is short* or *Your clock is faster than mine is slow*) typically interpret the adjectives in this way (e.g., the distance from some standard height or some required time point is measured by both the positive and the negative antonyms).

First, note that the general availability of a deviation-from-a-midpoint interpretation for positive and negative adjectives provides additional motivation for the definitions in (14). In these interpretations, the transformation value is contextually restricted to be the value of some agreed-upon entity. Consider, for example, a deviation-from-the-required-time interpretation for *early* and *late* in a context  $c$  in which the required time is the time of some event  $x_c$  (say, a certain meeting). Intuitively, *early* and *late* share an additive base function in each  $t$  in  $T_c$ , representing the time of different events in  $t$  (arrivals to the meeting; cf. (52a)). The transformation value is the meeting time in  $t$  (52b). According to the definitions of antonymy and polarity in (14a–c), then, in every  $t$  in  $T_c$ , these adjectives measure deviations of arrival times from the meeting time, as illustrated in (52c,d):

- (52) a.  $f(\text{early},t) = f(\text{late},t) = \lambda x \in D_x. \text{Time}_t(x)$ .  
 b.  $\text{Tran}(\text{early},t) = \text{Tran}(\text{late},t) = \text{Time}_t(x_c)$ .  
 c.  $f_{\text{late},t} = \lambda y \in D_x. f(\text{late},t)(y) - \text{Tran}(\text{late},t)$   
 $= \lambda y \in D_x. \text{Time}_t(y) - \text{Time}_t(x_c)$   
 d.  $f_{\text{early},t} = \lambda y \in D_x. \text{Tran}(\text{early},t) - f(\text{early},t)(y)$   
 $= \lambda y \in D_x. \text{Time}_t(x_c) - \text{Time}_t(y)$ .

For example, if the meeting time is  $10r_{h,t}$  in  $t$ , arrival at the required time is neither *late* nor *early*. It has a zero deviation from itself ( $f_{\text{late},t}(x_c) = 10r_{h,t} - 10r_{h,t} = 0$ ). But if the time Sam arrived is  $11r_h$  ( $r_{h,t}$  being the time value of an hour in  $t$ ), Sam is *one hour late* ( $f_{\text{late},t}(\llbracket \text{Sam} \rrbracket_t) = 11r_{h,t} - 10r_{h,t} = 1r_{h,t}$ ). Similarly, if the time of Dan's arrival is  $8r_{h,t}$ , then Dan is *two hours early* ( $f_{\text{early},t}(\llbracket \text{Dan} \rrbracket_t) = 10r_{h,t} - 8r_{h,t} = 2r_{h,t}$ ). We can describe this situation as one in which *Dan arrived earlier than Sam arrived late*. Thus, functions of precisely the forms given by definitions (14a–c) (with the transformation value in every  $t$  in  $T_c$  specified to be the value  $f(\text{late},t)$  assigns to an agreed-upon entity  $x_c$ ) give us the results we want.

Importantly, interpretations like those in (52c,d) are *inherently comparative*—they are always based on a calculation of the *difference* between the degrees of two agreed-upon entities. This means that the transformation values of the base function, if there are any, cancel out. The resulting functions are therefore additive with respect to ‘deviation from the required time’. In this interpretation, then, *slow* and *early* are positive (‘non-reversed’) with respect to measures of deviations. Bigger deviations have bigger values, and zero is assigned precisely to arrival events not deviating at all from the required time. Hence, unsurprisingly, in these interpretations the antonyms easily compare, and they even license measure phrases, e.g., Dan may be *two minutes late/early*, and his clock may be *2 minutes*

*slow/fast* (meaning that the difference between the time according to Dan’s clock and the ‘actual’ time, say, 10:30 Greenwich time, is 2 min).<sup>30</sup> The fact that *slow* and *early* license measure phrases is consistent with the fact that this interpretation has the basic default (‘dominant’) form of a reversed and transformed function. Perhaps it is even more dominant than the one whereby the transformation value is unrestricted (as in *Dan woke up late; he always arrives late*, etc.)

Consider the sentence *2 o’clock is twice as late as 1*. We can *only* make sense of it by interpreting *late* as measuring deviations from some event planned to occur at 12 o’clock. Likewise with *twice as early as*. So *twice* combines with *late* and *early* only when the transformation value is specified (corresponds to the time of an agreed-upon entity), i.e. in a difference (deviation-from-a-midpoint) interpretation. Presumably, examples of deviation measures can also be construed for *good* and *bad* in their different senses, e.g., as measures of students’ grades in mathematics, of amounts and weights of good and evil deeds, etc.

Finally, arriving an hour early, Dan is “minus one hour late”, so to speak, but in an attempt to avoid negative degrees for entities under discussion—the basic motivation of transformation values in the first place (cf. Sect. 3.2)—we tend to grade with *late* only arrivals that are late (in comparison with the transformation value), and to grade with *early* only arrivals that are early. The ban on negative degrees for entities under discussion, then, justifies the very fact that we use negative adjectives in degree constructions at all (i.e., that we bother ranking entities with reversed and transformed measures).<sup>31</sup>

To wrap up: if we restrict the transformation value in the way just described, the functions denoted by negative adjectives turn from being ‘transformed by an unspecified value’ into being difference measures, like those their derived comparatives denote. With this observation we can now consider (as a last point) different, yet similar cases.

*Unhappy* and *sad* can be interpreted either as negative antonyms of adjectives like *happy* and *glad* or as (linguistically) positive adjectives, in the sense of being directly linked to a measure of (amounts, so to speak, of) sorrow or unhappiness. Nonetheless, crucially, perceptual measures of happiness and unhappiness (or joy and sorrow) are usually felt to be linearly reversed relative to each other (e.g., Dan is happier than Sam in some respect to some extent iff Sam is unhappier than Dan in that respect to that extent). For this reason, *happy* and *unhappy* and *glad* and *sad*

<sup>30</sup> Here is another example, for interested readers, with a deviation-from-a-midpoint interpretation for *slow* and *fast*. Intuitively, the base function they share represents the time shown by different clocks  $x$ ,  $f(\text{fast},t) = f(\text{slow},t) = \lambda x \in D_x.\text{Time}_t(x)$ . The transformation value in each  $t$  is the actual time (say, the time a precise clock  $x_p$  shows in  $t$ ),  $\text{Tran}(\text{fast},t) = \text{Tran}(\text{slow},t) = \text{Time}_t(x_p)$ , meaning that these adjectives measure deviations of clocks from the actual time in every  $t$  in  $T_C$ :  $f_{\text{fast},t} = \lambda y \in D_x.\text{Time}_t(y) - \text{Time}_t(x_p)$  and  $f_{\text{slow},t} = \lambda y \in D_x.\text{Time}_t(x_p) - \text{Time}_t(y)$ . Thus, if the time value of  $x_p$  is  $10r_{h,t}$  in  $t$ , the precise clock is neither *slow* nor *fast* (it has a zero deviation from itself:  $f_{\text{slow},t}(x_p) = 10r_{h,t} - 10r_{h,t} = 0$ ). However, if the time my clock shows is  $9r_{h,t}$  ( $r_{h,t}$  being the value of 1h in  $t$ ), then my clock is *one hour slow* ( $f_{\text{slow},t}(\llbracket\text{my clock}\rrbracket_t) = 10r_{h,t} - 9r_{h,t} = 1r_{h,t}$ ), and if the time your clock shows is  $11r_{h,t}$ , your clock is *one hour fast* ( $f_{\text{fast},t}(\llbracket\text{your clock}\rrbracket_t) = 11r_{h,t} - 10r_{h,t} = 1r_{h,t}$ ).

<sup>31</sup> Notice that it disappears in the comparative. Thus we can report that Dan arrived earlier than Sam when both are late. In such uni-polar comparisons, specifying transformation values makes no sense: they cancel out anyways.

satisfy the criterion for antonymy. They can be construed as sharing a base function, compared to which *unhappy/sad* are linearly reversed, and are therefore considered antonyms according to the definitions in (14a–c).

Importantly, when both antonyms of a given pair can easily be described as transformed (both tend to license neither *twice* nor measure phrases), it makes it harder to determine which one is the negative. The good news is that the proposal to define negative antonyms as reversed and transformed, and positive ones as non-reversed and either transformed or not, has the advantage that it *entails* that in some cases (i.e., when the positive is transformed) there will be symmetry between the two antonyms, which will make it difficult to say which one is the negative (which one is based on reversal of the function of the other).

Examples in point are found in Block II of Table 3, such as, for instance, the antonym pair *healthy–sick*, where ~0.02% of equatives with *healthy* are *twice as*-equatives, and ~0.5% of equatives with *sick* are *twice as*-equatives—all in all very few ratio statements altogether (1,420 results for *twice as sick as* versus 193 for *twice as healthy as*). Note that *sick* has secondary interpretations, which the antonym *healthy* does not seem to share (as, for example, in *I am sick of not getting a job*). In addition, as is the case with *short*, ad hoc measures may be associated with *sick* and form secondary interpretations that trigger uses of *twice as sick* which are not even reversed. Consider, for example, the statement *Dan is three aspirins sick* versus the infelicitous statement *#Dan is three aspirins healthy* (I thank Louise McNally for drawing my attention to this example). Here, *sick* is associated with a non-transformed, and in fact non-reversed, additive measure function (the more aspirins you need, the sicker you are). This measure phrase is, nonetheless, novel, and its use is still amusingly anecdotal, showing that this interpretation has hardly (as yet) become a default one for *sick* (no unit name exists whose dimension set, as specified in the mental lexicon, includes *sick*). For this reason, together with the fact that *sick* does not often associate with *twice*, *sick* should not normally be regarded as the positive element in this antonym pair. Finally, note that for doctors, adjectives like *healthy/sick with respect to blood pressure* measure deviations from some ideal blood pressure value(s). In this interpretation *sick* is positive—the larger the deviation, the larger the value it assigns (for a discussion of such distance adjectives see Sassoon 2007).

Another example is the antonym pair *clean–dirty*. I classify *dirty* as the positive member of this antonym pair, because the (default) interpretation of these two adjectives seems to be related to measures of quantities of dirt. Thus, it is unsurprising that *dirty* patterns with positive adjectives and *clean* with negative (reversed and transformed) ones. The negative flavor of *dirty* may result from a culturally biased negative attitude towards dirt (same with *old* and our culturally biased attitudes to age). This classification is supported by the fact that it is hard to identify a zero point for *clean*, perhaps because *dirty* has no maximal point (there is no ‘*dirtiest*’ point). This is the general tendency in antonym pairs (seen in Block I of Table 3). Positive adjectives tend not to have a maximal point (e.g., there is no *tallest* point), a fact which renders the zero point of their negative antonym undefined. Moreover, newly invented measure phrases such as *two stains* or *twenty grains of dust* seem to be more compatible with *dirty* than with *clean* (though they

are quite odd with both; e.g., compare *\*two stains clean* to *?twenty stains dirty*). Similar doubts arise also concerning adjectives like *bad* and *wrong*.<sup>32,33</sup>

To summarize, the present analysis distinguishes between function reversal and linear transformation (zero displacement), while explaining why there is, nonetheless, a tight correlation between the two. The analysis of negative adjectives as reversed, and therefore, by default, transformed, is interesting and non-trivial because it encapsulates the characteristics of most of the uses of negative adjectives. Reversal fails to trigger the displacement of the zero only in a small minority of cases, and these are barely ever default interpretations of negative adjectives. In some cases, zero displacement creates difference measures, which are additive with respect to differences. These are the deviation-from-a-midpoint interpretations. They can become very dominant (as they bear the default interpretation of negative adjectives), to the point of allowing the licensing of measure phrases.

### 5.5 A short comparison with previous theories

As mentioned in footnote 4 above, the present proposal bears resemblance to interval ('extent') theories of antonymy (e.g., von Stechow 1984a, b; Kennedy 1999, 2001). Yet it improves upon them in terms of empirical coverage.

First, *warm* is a positive adjective, but does not allow for numerical degree modification except in the comparative. The 'extent' analysis of antonymy fails to capture this fact. In this analysis, degrees of positive adjectives, including *warm*, are initial intervals and degrees of negative adjectives are final intervals, so it is incorrectly predicted that only the latter do not combine with numerical degree modifiers. The present proposal does capture these facts by allowing transformation without reversal. While negative adjectives are reversed and transformed, positive adjectives are not reversed, but may well be transformed and hence may not license measure phrases.

Second, these theories analyze *Dan is two meters short* as equivalent to *Dan is as short as two meters*. However, while the former is utterly ungrammatical and polarity dependent, the latter is less unacceptable and its odd nature is not due to polarity, given that *#Dan is as tall as two meters* is equally odd. Furthermore, the corresponding comparative, *Dan is shorter than two meters*, is perfectly acceptable and natural, a fact that is not straightforwardly captured (Landman 2005). By

<sup>32</sup> Adjectives like *dirty* may turn out to be predominantly negative, based on diagnostic tests beyond those I consider in this paper. Rullmann (1995) and Heim (2006b, 2008) discuss and address scopal differences between positive and negative adjectives. Validation of these scope facts across antonym pairs and languages, as well as a complete account, await further research. This issue falls outside the limits of this paper, as does the question of whether there are discrepancies between the results of Rullmann's and Heim's tests and of the tests reviewed above.

<sup>33</sup> Israel (2004) notes that while some positive adjectives combine with the negative prefix *un-*, negative adjectives never do (cf. *unhappy* versus *#unsad*; *unsafe* versus *#undangerous*; *unwise* versus *#unfoolish*, etc.). Notice, however, that none of the positive adjectives in the paradigmatic antonym pairs mentioned in Sect. 1 combines with *un-* (*#untall*, *#unwide*, *#undeep*, *#unold*, etc.) Thus the measure-phrase test and the negative-prefix test seem to apply to non-overlapping sets of antonym pairs; the actual restrictions on the licensing of *un-* fall beyond the scope of this paper.

contrast, the analysis I propose in this paper does capture this data in a rather natural (or at least standard) way (cf. Sect. 4.3.2).

The present proposal also deviates slightly from alternative theories of measure phrase licensing.

First, there are the accounts of Schwarzschild (2005) and Landman (2005). Both of these have to inherently rely on type ambiguity in adjectives that license measure phrases. They do so by virtue of an additional special interpretation (the ‘interval’ interpretation in Schwarzschild 2005 and the ‘dimensional’ interpretation in Landman 2005). On the present proposal, by contrast, the facts follow directly from the basic interpretation of adjectives (a predominantly non-transformed interpretation).

Second, Winter (2005) attempts to explain facts concerning measure phrase licensing in positive adjectives based, roughly, on the adjective’s scale being unbound from above; for example, maximum tallness does not exist, but maximum shortness (= zero tallness), in principle, does. I find Winter’s (2005) proposal problematic for the following reasons. The scale of *open* and *close* is bound when applied to standard doors, but measure phrases are licensed, as in *60 degrees open* and *60% open*.<sup>34</sup> Conversely, *warm*, *hot*, and *cold* are unbound, yet do not license measure phrases. To explain the latter, Winter (2005) argues that measure phrases do not combine with adjectives that do not exhaust their scale, like *warm*, which cannot refer to entities with zero temperature. But for this to work for, e.g., *heavy*, entities perceived as having zero weight must exist. This is more dubious. (Perhaps the air?) Besides, *tall* and *wide* do license measure phrases, although they do not exhaust their scale. Languages do treat surfaces and points as (abstract) entities; if so, entities with, e.g., zero height exist.

## 6 Conclusions

- The basic motivation for transformation values is that they correctly capture our uncertainty concerning the zero points of negative adjectives.
- Moreover, they provide a straightforward account of significant contrasts between positive and negative adjectives in paradigmatic antonym pairs.
- In addition, they provide a straightforward account of similarities between non-paradigmatic positive adjectives and their negative antonyms.

<sup>34</sup> Winter’s proposal correctly predicts that *empty* and *full* do not license measure phrases (for Winter that is because they are both bound). However, notice that, as Winter himself mentions, these adjectives are somewhat odd with measure phrases even in the comparative (as illustrated by the oddness of *??This bucket is two liters fuller/emptier than that one*), which suggests that some additional independent factor is at play here (see relevant discussion of the interpretation of *full* in Sassoon 2007, Chaps. 5 and 7). Furthermore, intuitively, a glass can count as *full* while not being *completely full* (the interpretations of *full* and *completely full* are not quite identical). There is some context dependency regarding the standard (or maximum point) of *full*, then, which produces vagueness with regard to the zero point of *empty*. This, together with the fact that these adjectives are almost never used with *twice* (Google searching, I have found less than an estimated 1,000 uses for both antonyms together), supports the view that they are represented as transformed.



- Are there any negative adjectives that are “reversed but not transformed”? The answer given in this paper is ‘No’. Adjectives that appear exceptional have been explained as having positive counterparts that have been transformed, leaving doubts concerning only very few cases, if any (e.g., *bad* and *slow*). However, future research should study the data more thoroughly within and across languages. Such research might show that many negative adjectives do tend to regularly license ratio modifiers and measure phrases. If so, that would be better captured by the *narrow rule of antonymy*, namely by assuming that negative adjectives are linearly reversed, and that adjectives associated with additive measures (like *tall*, *short*, *heavy*, *light*, etc.) license measure phrases iff they are not transformed.
- Finally, future research should establish how well the present proposal combines with accounts of cross-polar nomalies and sub-deletion comparisons in general (cf. Sect. 4.4), and whether transformation values can explain evaluative implications (as these characterize adjectives that fail to license measure phrases, cf. Sect. 5.3). Moreover, positive and negative adjectives seem to differ also with regard to scope interactions and the licensing of negative polarity items (Kennedy 1999; Heim 2006b, 2008), topics not addressed here at all.

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