Equatives, measure phrases and NPIs*

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Abstract. Standard semantic accounts of the equative ascribe it an 'at least' meaning, deriving an 'exactly' reading when necessary via scalar implicature. I argue for a particular formulation of this scalar implicature account which considers that (i) equatives license NPIs in their internal arguments, and (ii) equatives whose internal arguments are measure phrases (MPs) are, in contrast to clausal equatives, ambiguous between 'at most' and 'exactly' interpretations. The analysis employs particular assumptions about MPs, scalar implicature and the notion of set complementation to enable 'at least' readings to be sensitive to the direction of a scale, thereby becoming 'at most' readings in certain constructions.

1 Introduction

I begin by discussing some data that present a challenge to standard accounts of the equative: MP equatives, whose internal arguments are measure phrases (MPs). Standard equatives are ambiguous between an 'at least' and 'exactly' interpretation; for many speakers of English, MP equatives are instead ambiguous between an 'at most' and 'exactly' interpretation. Section 2 briefly presents standard accounts of the semantics of the equative and then discusses the fact that NPIs are licensed in the internal argument of equatives. This observation plays a significant role in the analysis, which is presented at the end of Section 2. Section 3 expands the analysis to a treatment of equative modifiers and discusses extensions of the analysis to the semantics of the comparative.

1.1 Equatives and MPs

It's been observed that equatives are ambiguous. These two possible meanings are reflected in the two felicitous responses to (A) in (1). In (B), John's being taller than Sue is incompatible with (A) (on the 'exactly' reading); in (B′), John's being taller than Sue is compatible with (A) (on the 'at least' reading).

(1) (A) John is as tall as Sue is.
(B) No, he's taller than Sue is. (B′) Yes, in fact he's taller than Sue is.

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Equatives with measure phrases or numerals in their internal argument ('MP equatives') present a challenge to this account. (I follow Pancheva (2006) in using the term 'clausal' to describe comparatives and equatives which have a potential clausal source and 'phrasal' to describe those with no potential clausal source, like MP equatives and e.g. *John is as tall as himself *(is)*. Following Hankamer (1973), I will use the terms **target** and **correlate** to refer to the subordinate and matrix material in comparatives, respectively.)

(2) a. (I think) John biked as far as 500 miles yesterday.
b. The DOW dropped as much as 150 points yesterday.
c. Sometimes Mars is as far as 235 million miles from Earth.
d. The waves reached as high as 6ft before nightfall.
e. GM plans on laying off as many as 5,000 employees.

The first thing to note about MP equatives is that their distribution is restricted relative to clausal equatives. Roughly speaking, they are licensed when the value of the correlate is indeterminate.[1] This is manifested in different ways: the measure could be the imprecise either due to speaker ignorance (2a) or because the measure need not be precise in the context. Alternatively, the correlate could denote a range, either of times (2c), individuals (2d) or worlds (2e). This restriction on the distribution of MP equatives seems related to their being more marked than their (roughly synonymous) MP construction counterparts like *John biked 500 miles yesterday.*

Nouwen (2008, *to appear*), discussing what he calls 'Class B' comparative quantifiers (*at most 6ft*, *up to 6ft*), provides a different perspective on this indeterminacy requirement: he suggests that such constructions involve quantification over ranges (epistemic ranges in the case of examples like (2a) and (2b)).

When clausal equatives involve ranges, as in (3), their 'at least' interpretation is manifested as follows.

(3) $\underbrace{\text{The boys}}_{\textbf{correlate}}$ are as tall as $\underbrace{\text{Sue (is)}}_{\textbf{target}}$.

In a situation in which the boys' heights range from 4ft to 6ft, (3) is true if Sue is 4ft tall or shorter (and false if Sue is $4\frac{1}{2}$ft tall). This means that, for clausal equatives with range-denoting correlates, the heights of the boys denoted by the correlate must be at least as high as the value denoted by the target. Clausal equatives therefore receive an **at least** interpretation.

[1] There are a few instances of MP equatives being used in the absence of indeterminacy, however. An article on Vitamin D states "A study from the University of California, San Diego recommended doses as high as 2,000 international units a day – far more than the 200 to 600 governments recommend." (http://www.theglobeandmail.com/news/national/d-is-the-new-c-sunshine-vitamin-is-suddenly-hot/article1423352) In this case, the MP equative does not seem to be indeterminate, and is used in a context in which the recommendation was exactly 2,000 units. These MP equatives therefore seem to be more like DP equatives, which I discuss briefly in Section 3.

When MP equatives have range-denoting correlates, they are interpreted differently. One article reports "The European Union will impose import duties as high as 20 percent on some leather shoes from China and Vietnam" and goes on to explain that "it will impose rising tariffs over six months, to a maximum of almost 20 percent of their value".[2] This example demonstrates that, in MP equatives, when the correlate expresses a range the maximum value of the correlate range must be at most as high as the value denoted by the target. MP equatives therefore can receive an **at most** interpretation.

This seems to be the case for MP equatives generally, like those in (2). (2e), for instance, is reported by speakers of the relevant dialect to be true if GM plans on laying off 4,500 employees, but not if GM plans on laying off 5,500 employees. (In other words: (2e) is true if, given all of the possible worlds consistent with GM's plans, the world in which GM lays off the highest number of employees (i.e. the maximum in the range of ordered worlds) is a world in which they hire 5,000 employees or fewer than 5,000 employees.)

In this paper, I argue that there is a natural account for the apparent fact that MP equatives receive an interpretation opposite that of clausal equatives. It draws on the observations that MPs are themselves scalar, that the target of equatives is downward-entailing, and that scalar implicatures are interpreted differently in downward-entailing contexts. Before presenting the analysis in Section 2, I'll discuss some background assumptions.

1.2 Background assumptions

I follow many others in assuming that gradable adjectives denote relations between individuals and degrees.

(4) $[\![\text{tall}]\!] = \lambda x \lambda d.\mathsf{tall}(x, d)$

I additionally assume that positive and negative antonyms (like *tall* and *short*) differ in their ordering, which is observable in their behavior in comparatives (Seuren, 1984; von Stechow, 1984, a.o.). Positive antonym scales are downward-montontonic, with open lower bounds of zero and closed upper bounds (5a). Negative antonym scales like *short* are upward-monotonic, with closed lower bounds and closed upper bounds of infinity (5b).

(5) Context: John is 5ft tall.

a. $\lambda d.\mathsf{tall}(\mathsf{john}, d) = (0,5]$ b. $\lambda d.\mathsf{short}(\mathsf{john}, d) = [5,\infty]$

Following Bresnan (1973), I assume that comparatives and equatives with overt tense morphology are clauses that have undergone elision along the lines of (6).

(6) John is taller than [$_{\text{CP}}$ Op$_d$ Sue is ~~d tall~~]

[2] Sentences from "EU to impose 20% duties on shoes from China", http://www.chinadaily.com.cn/english/doc/2006-02/21/content_522184.htm.

I adopt the 'A-not-A' account of the comparative in (7) (McConnell-Ginet, 1973; Kamp, 1975; Hoeksema, 1983; Seuren, 1984; Schwarzschild, 2008, a.o.). An important consideration of this theory is the observation that NPIs are licensed in the targets of (clausal) comparatives (8).

(7) $\lambda D' \lambda D \exists d[D(d) \wedge \neg D'(d)]$

(8) a. He would rather lose his honor than so much as a dime.
 b. She is happier now than ever before.

This is predicted by the A-not-A analysis given the assumption that the downward-entailingness of degree quantifiers is calculated in terms of sets of degrees, rather than sets of individuals (cf. Seuren, 1984; von Stechow, 1984; Hoeksema, 1983, 1984; Heim, 2003).

(9) Context: Mary is 6ft tall, John is 5ft tall, Sue is 4ft tall.
 a. Mary is taller than John. $\rightarrow$ Mary is taller than Sue.
 b. Mary is taller than Sue. $\nrightarrow$ Mary is taller than John.

I have had to omit the discussion of this calculation and its consequences due to space restrictions, but I hope to return to address the topic in future papers.

To sum up: NPIs appear to be licensed in the targets of comparatives, and entailment patterns between supersets and subsets of degrees (9) confirm that the targets of comparatives are downward-entailing. This fact is captured by the 'A-not-A' analysis in (7) because it characterizes the target of comparatives as downward-entailing. Finally, I would like to point out Hoeksema's (1983) observation that the definition in (8b) is equivalent to the one in (10) that invokes set complements (written as $\overline{D}$).

(10) $[\![\text{-er}]\!] = \lambda D' \lambda D \lambda d. d \in D \wedge d \in \overline{D'}$

(10) additionally differs from (8) in not existentially binding the differential degree d. This allows for further modification by e.g. *much* and *3 inches* in *John is much/3 inches taller than Sue*. I assume that, in the absence of a differential modifier, the differential argument d is bound via existential closure.

2 Equatives

Previous analyses of the equative have exploited the fact that to be exactly as tall as Sue is to be at least as tall as Sue, and therefore that the 'exactly' reading entails the 'at least' reading (but not vice-versa). The equative has for this reason been considered to be another type of scalar-implicature phenomenon (on a Horn scale with the comparative), assigning the weak 'at least' reading to the semantics of the equative and deriving the former from the latter via scalar implicature where context allows (Horn, 1972; Klein, 1980; Chierchia, 2004). This suggests an analysis in which the maximum degree denoted by the correlate (John's height in (1)) must be greater than or equal to the maximum degree denoted by the target (Sue's height in (1)).

(11) $[\![\text{as}]\!] = \lambda D' \lambda D.\textsc{Max}(D) \geq \textsc{Max}(D')$

This definition will erroneously predict that MP equatives, too, have an 'at least' interpretation, not an 'at most' interpretation. (This is true regardless of whether we interpret the MP as denoting a single degree n or an upward-monotonic scale with a lower bound of n, which I argue for in the next section.)

I present an alternative analysis below, in Section 2.2. Before doing so, I introduce some independent observations and assumptions which motivate it.

2.1 MPs and scalar implicatures

The analysis below relies on the observation that MPs (and numerals) are themselves scalar, thus accounting for their different interpretation in equatives. The traditional SI account of sentences like *John has 3 children* assigns the numeral an 'at least' semantics (≥ 3), deriving the 'exactly' interpretation via scalar implicature, where appropriate (contra Geurts, 2006). This means that the denotation of an MP target (in a positive-antonym equative, like those in (2)) is an upward-monotonic set of degrees, with a lower bound of d (for a d-denoting numeral) and an upper bound of ∞.

In a context in which Sue is 5ft tall, the target of the equative *John is as tall as Sue (is)* denotes the degrees to which Sue is tall (12a), which is downward-monotonic. The target of the equative *John could be as tall as 5ft*, on the other hand, denotes the degrees greater than or equal to 5ft (12b) (an upward-monotonic scale).

(12) a. $[\![\text{Op}_d \text{ Sue is } \cancel{d\text{ tall}}]\!] = \lambda d.\mathsf{tall}(\mathsf{sue},d) = (0{,}5]$
b. $[\![\text{5ft}]\!] = \lambda d.d \geq \text{5ft} = [5{,}\infty]$

This particular characterization of MPs is significant in light of independent observations tying it to SIs in downward-entailing contexts. Chierchia (2004) argues that SIs (a) can be calculated sub-sententially, and (b) are calculated differently in downward-entailing contexts. I'll illustrate this point as Chierchia does, independently of equatives and MPs. *Or* is typically characterized as scalar, ambiguous between a weak reading (A or B or both) and a strong reading (A or B but not both). The strong reading then comes about, where pragmatically possible, as the result of scalar implicature (13a). In downward-entailing environments, though, this SI is affectively cancelled; (15b) cannot be used to negate the claim that Sue didn't meet both Hugo and Theo (and is therefore incompatible with Sue having met both). Chierchia's explanation is that SIs are calculated in terms of informativity, and what counts as the most informative in upward-entailing contexts is actually the least informative in downward-entailing contexts (and vice-versa).

(13) a. Sue met Hugo or Theo. b. Sue didn't meet Hugo or Theo.

Importantly, it looks as though the targets of equatives are downward-entailing environments as well; they license NPIs.

(14) a. He would just as much lose his honor as he would a dime.
b. She is as happy now as ever before.

Extending Chierchia's observation to equatives therefore has the consequence that targets of MP equatives are always interpreted weakly. The consequence of this is that, while the targets of (positive-antonym) clausal equatives denote downward-monotonic degree sets, the targets of (positive-antonym) MP equatives denote upward-monotonic degree sets.

2.2 A more sensitive semantics

The crux of the analysis that follows is a reformulation of the equative morpheme which takes into account that equative targets are downward-entailing and that the difference between the targets of clausal equatives and the targets of MP equatives is one of monotonicity.

The definition of the equative morpheme below draws on the set-complement reformulation of the comparative in (10).[3]

(15) $[\![\text{as}]\!] = \lambda D' \lambda D[\textsc{Max}(D) \in \widehat{\overline{D'}}]$, where
$\widehat{\overline{D}} =_{def}$ the smallest D' such that $\overline{D} \subseteq D'$ and D' is a closed set.

This definition invokes the notion of a 'closure of the complement', the smallest superset of the complement with closed bounds.[4] It is downward-entailing in its target (D'), correctly predicting the licensing of NPIs.

(16) Context: Mary is 6ft tall, John is 5ft tall, Sue is 4ft tall.
Mary is as tall as John. → Mary is as tall as Sue. *is true iff*
$\textsc{Max}(\ (0{,}6]\ ) \in \widehat{\overline{(0,5]}} \quad \rightarrow \textsc{Max}(\ (0{,}6]\ ) \in \widehat{\overline{(0,4]}}$ *is true iff*
$6 \in [5, \infty] \rightarrow 6 \in [4, \infty]$ ✓

Positive-antonym MP equatives differ from positive-antonym clausal equatives in that their target is upward-monotonic. The definition in (15) allows the 'greater than' relation we associate with the 'at least' reading of the equative to be sensitive to the ordering on the target scale; it affectively employs a different relation ('at least', 'at most') based on the direction of the target scale.

(17) John is as tall as Sue. (John's height = 5ft; Sue's height = 5ft; **true**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{\overline{(0,5]}} \quad \rightsquigarrow 5 \in [5, \infty]$ ✓

(18) John is as tall as Sue. (John's height = 6ft; Sue's height = 5ft; **true**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{\overline{(0,5]}} \quad \rightsquigarrow 6 \in [5,\infty]$ ✓

[3] The definition in (15) is a simplified version of $= \lambda D' \lambda D \lambda d[d = \textsc{Max}(D) \wedge d \in \widehat{\overline{D'}}]$, which is required for an account of modified equatives (see §4).

[4] Direct application of (15) will result in some scales having a closed lower bound of zero. This is formally unattractive but actually harmless, assuming that it is infelicitous to predicate a gradable property of an individual if that individual doesn't exhibit that property at all (cf. #*That couch is intelligent*). We could alternatively reformulate the definition of a closure of a complement to omit this possibility.

(19) John is as tall as Sue. (John's height = 5ft; Sue's height = 6ft; **false**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{(0,6]} \quad \rightsquigarrow 5 \in [6,\infty]$ ✗

(20) The waves reached as high as 6ft. (waves' height = 6ft; **true**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 6 \in [0,6]$ ✓

(21) The waves reached as high as 6ft. (waves' height = 5ft; **true**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 5 \in [0,6]$ ✓

(22) The waves reached as high as 6ft. (waves' height = 7ft; **false**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 7 \in [0,6]$ ✗

(15) works just as well for negative-antonym equatives, whose clausal arguments are upward-monotonic (see (5b)). I assume a definition of the maximality operator in which it is sensitive to the direction of the scale (see Rett, 2008).

(23) John is as short as Sue. (John's height = 5ft, Sue's height = 5ft; **true**)
$\textsc{Max}(\ [5,\infty]\ ) \in \widehat{[5,\infty]} \quad \rightsquigarrow 5 \in [0,5]$ ✓

(24) John is as short as Sue. (John's height = 4ft, Sue's height = 5ft; **true**)
$\textsc{Max}(\ [4,\infty]\ ) \in \widehat{[5,\infty]} \quad \rightsquigarrow 4 \in [0,5]$ ✓

(25) John is as short as Sue. (John's height = 5ft, Sue's height = 4ft; **false**)
$\textsc{Max}(\ [5,\infty]\ ) \in \widehat{[4,\infty]} \quad \rightsquigarrow 5 \in [0,4]$ ✗

To extend the analysis to negative-antonym MP equatives (like *The temperature dropped as low as 2° Kelvin*), we must recall that the target also involves a negative antonym (e.g. 2° low, rather than 2° high). This is consistent with Bresnan's (and Kennedy's (1999)) assumptions about the syntax of comparatives and equatives ((26), cf. (6)).

(26) John has fewer children than Sue.
-er ([Op'_d Sue has d'-few children]) ([Op_d John has d-few children])

MP targets of negative-antonym equatives are thus in fact downward-monotonic, which results in the correct truth conditions.

(27) The temperature dropped as low as 2°Kelvin. (highest temp = 2^o; **true**)
$\textsc{Max}(\ [2,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 2 \in [2,\infty]$ ✓

(28) The temperature dropped as low as 2°Kelvin. (highest temp = 3^o; **true**)
$\textsc{Max}(\ [3,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 3 \in [2,\infty]$ ✓

(29) The temperature dropped as low as 2°Kelvin. (highest temp = 1^o; **false**)
$\textsc{Max}(\ [1,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 1 \in [2,\infty]$ ✗

3 Expansions and extensions

More about MP equatives. It should be obvious that there is more empirical ground to cover before this analysis can be complete. Footnote 1 discusses MP equatives that don't appear to involve ranges; these equatives seem to unambiguously have an 'exactly' interpretation, and be evaluative (in the sense of Rett, 2008). Furthermore, there seems to be a fair amount of speaker variation with respect to grammaticality judgments and interpretation of MP equatives; it'd be nice to know more about the source of this variation. Finally, few languages allow MP equatives; it'd be nice to have a better understanding of the relevant cross-linguistic variation. I am in the process of conducting a cross-linguistic survey on the interpretations of equatives in an attempt to address these issues.

Equative modifiers. Importantly, this analysis calls for a semantics of superlative modifiers like *at least* and *at most* that are not sensitive to the direction of the scale: *at least* can modify MP equatives, forcing them to have an 'at least' interpretation (30a), and *at most* can modify clausal equatives, forcing them to have an 'at most' interpretation (30b).[5]

(30) a. John biked at least as far as 500 miles yesterday.
     b. John is at most as tall as Sue (is).

I argue that such an analysis requires the assumption that pragmatic strengthening is applied to equatives before the equatives are modified. The modifiers therefore take strengthened, 'exactly' equative meanings as their arguments, and add a restricting clause based on an objective scale direction ($\leq$ or $\geq$).

MP comparatives. The assumptions made above about the denotation of MPs in DE contexts doesn't extend straightforwardly to comparatives given the definition in (10). In particular, feeding an upward-monotonic denotation of MPs into (10) erroneously predicts that all MP comparatives are true.

(31) John is taller than 5ft. (John's height = 4ft; **false**)
$\exists d[d \in (0{,}4] \wedge d \in \overline{[5, \infty]}] \quad \rightsquigarrow \quad \exists d[d \in (0{,}4] \wedge d \in (0, 5)\ ]$ ✓

It seems that the incorrect truth conditions in (31) underscore the argument in Pancheva (2006) that comparative subordinators are meaningful and can differ semantically. Some languages employ different comparative subordinators for MP targets than they do for clausal targets (cf. Spanish *de lo que* DP versus *de* MP). One possible way of adopting Pancheva's analysis while holding fixed this particular characterization MPs as denoting their weak meaning in DE contexts is to argue that the comparative morpheme *-er* is a simple quantifier over degrees, while clausal *than* is a function from a set to its complement (thus resulting in the NPI data above), and MP *than* is an identity function over degree sets.

(32) a. $[\![\text{-er}]\!] = \lambda D' \lambda D \lambda d.d \in D \wedge d \in D'$
     b. $[\![\text{than}_{clausal}]\!] = \lambda D \lambda d.d \notin D$ b. $[\![\text{than}_{MP}]\!] = \lambda D \lambda d.D(d)$

[5] 'At least' and 'at most' interpretations also differ in whether they compare the maximum degree of the minimal individual in the correlate range or the maximum degree of the maximal individual in the correlate range. I'm assuming for the present paper that this is a pragmatic effect, but there might be more to the difference.

Slavic languages provide independent evidence that MP targets of comparatives are treated differently from clausal targets of comparatives. ((33) is Pancheva's example from Russian, in which clausal comparatives are formed with the *wh*-phrase *čem*, and phrasal comparatives are formed with a covert subordinator.)

(33) a. ??Ivan rostom bol′še čem dva metra.
Ivan in-height more what two meters
b. Ivan rostom bol′še dvux metrov.
Ivan in-height more [two meters]$_{\text{GEN}}$
'Ivan measures in height more than two meters.'

This discussion of MPs in comparative and equative targets helps provide an explanation for why languages employ two different subordinators for clausal comparatives and MP comparatives: the two types of targets denote different types of scales (in relation to the scale denoted by the correlate). It's also compatible with the possibility that some languages disallow MP equatives entirely.

DP equatives. Some phrasal equatives have DP rather than MP targets.

(34) a. John can reach as high as the ceiling (*is).
b. This rubber band can stretch as wide as a house (*is).

It appears as though these equatives, too, must be indeterminate, or a range of some sort (35a), but this requirement comes in the absence of any obvious unmarked counterparts ((35b), cf. MP contructions).

(35) a. ??John reached as high as the ceiling.
b. ??John can reach the ceiling's height.

It's not clear to me which of the three readings ('at least', 'at most', 'exactly') DP equatives have. (34a), for instance, seems both compatible with John being capable of reaching lower than the ceiling's height and with John being capable of reaching higher than the ceiling. I suspect that the meaning of these DPs rely heavily on the contextual salience of the DP, not just the measure denoted by the DP. This point is made especially clear by DP equatives like *This train will take you as far as Berkeley*, which is intuitively false if the train will take you somewhere equidistant to Berkeley (but not to Berkeley itself).

Conclusion. Clausal equatives have a weak 'at least' interpretation while MP equatives have a weak 'at most' interpretation. I argue that these phenomena can be assimilated in a neo-Gricean SI framework if we characterize the weak meaning of the equative in a way that is sensitive to the scalar ordering of its internal argument. The account relies on independent observations that numerals (and therefore MPs) are themselves scalar, and that scalar implicature is calculated sub-sententially and differently in downward-entailing contexts (Chierchia, 2004). It has potential implications for studies of the comparative, as well as modifiers derived from degree quantifiers with MP targets which have independently been observed to display similar characteristics (Nouwen *to appear*).

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