

States in the semantics of degree achievements^{*}

Christopher Baron || MIT[†]

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1 Introduction

* Verbs like *widen* and *straighten*, so-called ‘degree achievement’ or ‘deadjectival’ verbs (DAs), have been of interest since Dowty (1979)

- (1) The gap widened.
- (2) Buffy straightened the bar.

* (1) describes an increase in the gap’s width; (2) indicates (minimally) that the bar got straighter as a result of Buffy’s Slayer strength

* These verbs can take different kinds of modifiers describing how much change has occurred, as in (3)

- (3) a. The gap widened (by) 6 inches.
- b. The gap widened from 3 inches to 9 inches.
- c. The gap widened (by) 6 inches from 3 inches to 9 inches.

* The differential measure phrase *6 inches* (optionally introduced with an overt *by*) specifies the increase in width the gap undergoes

* We can use source/goal PPs like *from 3 inches* and *to 9 inches* as well, as in (3b); when both are present, we can infer the value of the differential (i.e. that it is 6 inches)

– We can also overtly specify all three, as in (3c)

* The Big Question: why do the measure phrases in (3) *have* to be widths—that is, why can’t *from 3 inches* describe the gap’s depth at the beginning of its widening?

– It’s obvious that it doesn’t, but from what does that actually follow?

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[†]cjbaron@mit.edu.

- * The Big Problem: standard assumptions about adjectives (and DAs) and these kinds of source/goal adverbs make it extremely hard to adequately answer that question
- * I'll argue a handy solution can be found in the work of Wellwood (2014, et seq.) in which degrees are divorced from the lexical semantics of adjectives, and analyzed instead as Davidsonian state predicates
 - On such a theory, degrees will be introduced via additional functional structure; this will be incorporated into our semantics for DAs
 - This will allow us to explain why the inches named in (3) must be widths, rather than just explain why they *can* be widths

2 Standard views

2.1 Adjectives & DAs

- * A fairly standard view about adjectives treats them as having a degree-based semantics; that is, some part of their semantics involves a function mapping entities to degrees on an ordered scale
- * This is implemented in different ways; sometimes adjectives are taken to encode relations between degrees and individuals (e.g. Heim 2001)

$$(4) \quad \llbracket \text{wide} \rrbracket = \lambda d \lambda x. \text{WIDTH}(x) \succcurlyeq d \quad \langle d, et \rangle$$

- * Others take adjectives to directly lexicalize measure functions (e.g. Kennedy 1999)

$$(5) \quad \llbracket \text{wide} \rrbracket = \lambda x. \text{WIDTH}(x) \quad \langle e, d \rangle$$

- A note: while I will frame the argument in terms of entries like (4), nothing hinges on this decision

- * DAs typically describe an increase in a gradable property in time¹; this requires a time-sensitive entry for adjectives, such that they measure entities at a particular time

$$(6) \quad \llbracket \text{wide} \rrbracket = \lambda d \lambda x \lambda t. \text{WIDTH}(x)(t) \succcurlyeq d \quad \langle d, \langle e, it \rangle \rangle$$

- * Following Hay et al. (1999) we can treat DA morphology (e.g. *-en*) as a function taking an adjective and returning a function from individuals to sets of events

$$(7) \quad \llbracket \text{-en} \rrbracket = \lambda f_{\langle d, eit \rangle} \lambda x \lambda e. \text{MAX}(\lambda d. f(d)(x)(\text{END}(e))) \succ \text{MAX}(\lambda d'. f(d')(x)(\text{BEG}(e)))$$

- * Taking (6) and (7) together, we posit the structure in (8a) and derive the meaning in (8b) for (1) (ignoring aspect/tense and assuming existential closure)

¹See Deo et al. (2013) for a somewhat different take; there, they discuss non-temporal uses of DAs.

- (8) a. $[\exists e [\text{The gap } [\text{wide } -\text{en}]]]$
 b. $\llbracket (8a) \rrbracket = 1$ iff
 $\exists e [\text{MAX}(\lambda d. \text{WIDTH}(\text{gap})(\text{END}(e)) \succcurlyeq d) \succ \text{MAX}(\lambda d'. \text{WIDTH}(\text{gap})(\text{BEG}(e)) \succcurlyeq d')]$

- * While Hay et al. (1999) aren't the only analysis of DAs on the market (e.g. Abusch 1986, Winter 2006, Kearns 2007, Kennedy & Levin 2008, a.o.), competing analyses typically invoke the same ingredients and have this general shape
 - i.e. a degree semantics for adjectives, and a meaning for DA morphology that yields an eventive predicate encoding a comparison of an entity at two different times

2.2 Sources & goals

- * Source and goal PPs are fairly standardly treated as VP modifiers, functions relating events to their SOURCE and GOAL (e.g. $\langle e, vt \rangle$ functions, Parsons 1990, a.o.)
- * Sources and goals are often locations, as in (9), but they can also be degree expressions, as in (10).

(9) Daphne walked from the market to her apartment.

(10) The gap widened from 3 inches to 9 inches.

- * (9) is true iff Daphne's walking started at the market, and ended at her apartment; the market is the source of this event, and her apartment the goal
- * On this sort of a view, *from* and *to* can have the following meanings; with them, we can derive the meaning for (9) in (12)

(11) a. $\llbracket \text{from} \rrbracket = \lambda x \lambda e. \text{SOURCE}(x)(e)$ $\langle e, vt \rangle$

b. $\llbracket \text{to} \rrbracket = \lambda x \lambda e. \text{GOAL}(x)(e)$ $\langle e, vt \rangle$

(12) $\llbracket (9) \rrbracket = 1$ iff $\exists e [\text{WALK}(\text{Daphne})(e) \ \& \ \text{SOURCE}(\text{market})(e) \ \& \ \text{GOAL}(\text{apartment})(e)]$

- * (12) says (9) is true iff there is an event of Daphne walking, and that event has as its starting point the market and the end point Daphne's apartment
- * Intuitively, the relationship between the PPs and the verb in (10) is similar—it's true iff the gap's width increases over time, with its starting width 3 inches, and ending width 9 inches
- * Expressions like *3 inches* are typically taken to be type *d*, so we can't appeal to $\langle e, vt \rangle$ operators; we posit (13) and (14)

(13) $\llbracket \text{from}_d \rrbracket = \lambda d \lambda e. \text{SOURCE}(d)(e)$ $\langle d, vt \rangle$

(14) $\llbracket \text{to}_d \rrbracket = \lambda d \lambda e. \text{GOAL}(d)(e)$ $\langle d, vt \rangle$

- * We can put these entries together with the meaning we derived in (8b) to derive the following meaning for (10); the adverbs will compose via PM

- (15) $\llbracket (10) \rrbracket = 1$ iff
 $\exists e[\text{MAX}(\lambda d.\text{WIDTH}(\text{gap})(\text{END}(e)) \succcurlyeq d) \succ \text{MAX}(\lambda d'.\text{WIDTH}(\text{gap})(\text{BEG}(e)) \succcurlyeq d')$
 $\& \text{SOURCE}(3 \text{ inches})(e) \& \text{GOAL}(9 \text{ ins})(e)]$

3 Problems

3.1 The basic issue

- * The meaning in (15) says the source of the gap's widening event was 3 inches, and its goal 9 inches
 - What does that actually mean, though? We intuitively *want* it to mean that the gap's starting *width* is 3 inches
 - How do we guarantee *3 inches* and *9 inches* in (15) are widths of the gaps?
 - Widths, lengths, and depths all can be described in inches!
- * *From* and *to* don't have access to the scale associated with *wide*
- * Even if degrees carry information about what scale they're on—e.g. *WIDTH*—that's not enough to ensure that these particular degrees name can only widths²
- * With the (very standard) tools described so far, we can't prevent *3 inches* from specifying the gap's depth, so long as the gap happened to be 3 inches deep at the beginning of its widening event
- * Another way to see this is through the following

(16) *CONTEXT*: We have a metal bar, and that the bar is very pliable; in addition to being straightenable (it is currently quite bent), it's also lengthenable. As Buffy straightens the bar, she also stretches that bar out a bit—originally, it was 3 inches long, and now, it's 9 inches, in addition to being straight(er).

 - a. # Buffy straightened the bar from 3 inches to 9 inches.
- * While (16a) is intuitively odd, even in this context, our theory so far is hard pressed to explain why—we don't as of yet have anything in the semantics that prevents the source and goal of straightening events from being lengths
- * We might wonder then whether it's an issue of the pragmatics—perhaps there is a salience constraint on SGPPs that renders (16a) odd
- * We can informally describe this as follows
 - Descriptions of straightening events make certain properties (of the affected arguments) salient (i.e. degrees of bend) but not others (lengths or widths)

²Cresswell (1976), a.o., being relevant here.

- SGPPs are restricted to describing those properties (of affected arguments) made salient by the event description that they modify
- So in (10) we guarantee the inches are widths because descriptions of widenings make salient widths as properties of the affected argument, and we guarantee (16a) is odd because descriptions of straightenings do not make salient lengths
- * As a solution to the problem of the tight connections between SGPPs and verbal predicates they modify, it's not obvious this is right, though
- * Descriptions of baking events, too, make salient certain properties of the affected argument—temperature of the baking and baked objects, lengths of time it takes to bake things, etc.; we might want to describe them with SGPPs

- (17) a. # Angel baked the cake from 70°F to 425°F.
 b. Angel baked the cake, and it went from 70°F to 425°F.

- * If the constraints on SGPPs that guarantee (16a) is odd concern salience, it seems like we'd expect (17a) to be felicitous (like its counterpart (17b)) since they characterize a property of an affected argument made salient in baking descriptions that holds of the cake, i.e. its temperature
 - It's not clear, then, that this kind of a solution will work for us
- * The Slightly Broader Point: we don't have anything yet in either our semantics or pragmatics that enforces a tight enough connection between SGPPs and the verbal predicates, including DAs, that they modify

3.2 A red herring

- * One might think the whole issue is about ellipsis—there are elided adjectives in (10) and (16a) such that they're really like (18a) and (18b), respectively

(18) a. The gap widened from 3 inches wide to 9 inches wide.
 b. # Buffy straightened the bar from 3 inches straight to 9 inches straight.
- * (18a) is perfectly grammatical (if somewhat redundant) and what ho! we have an adjective specifying that the inches in question are in fact widths
- * Inches don't name degrees of straightness, though, so perhaps that's precisely why (18b) is unacceptable, and by extension (16a)
 - The idea here would be that ellipsis is at the root of the problem—earlier, in arguing that we didn't have enough information to guarantee that the inches in (10) were widths, I was simply mistaken
 - We do have that information, it's simply covert (and that's all that was missing)

- * Unfortunately, this actually doesn't really work; let's walk through this
- * *from 3 inches wide* would have a structure like the following

$$(6) \quad \llbracket \text{wide} \rrbracket = \lambda d \lambda x \lambda t. \text{WIDTH}(x)(t) \succcurlyeq d \quad \langle d, \langle e, \text{it} \rangle \rangle$$

$$(19) \quad \llbracket \text{from } [3 \text{ins wide}] \rrbracket$$

- * *3 inches* saturates the degree argument of *wide*, yielding $[\lambda x \lambda t. \text{WIDTH}(x)(t) \succcurlyeq 3 \text{ inches}]$
- * Setting aside the time argument, what we have here is a set of entities with widths of at least 3 inches; does this work with either entry for *from* we've posited?

$$(13) \quad \llbracket \text{from}_d \rrbracket = \lambda d \lambda e. \text{SOURCE}(d)(e) \quad \langle d, \text{vt} \rangle$$

$$(11a) \quad \llbracket \text{from} \rrbracket = \lambda x \lambda e. \text{SOURCE}(x)(e) \quad \langle e, \text{vt} \rangle$$

- We can't extract a degree from this set, so (13) won't work as our entry for *from* in this situation, but maybe we can extract an entity from it, say via a choice function, so that the net result is suitable input to (11a)!

- * Let's grant that would be enough to work for (11a): the source of the widening event is an entity with a 3 inch width, and the goal is an entity with a 9 inch width
- * If ellipsis has been the problem, and pronouncing an adjective within the source and goal PPs (or recognizing its presence) is the solution, why is (20) unacceptable in the pliable context spelled out earlier?

$$(20) \quad \# \text{ Buffy straightened the bar from 3 inches long to 9 inches long.}$$

- * We'd expect that the source of the straightening event is a 3-inch long individual; why can't this be the bar?
- * Even granting that both ellipsis and the presence of an adjective in SGPPs might play a role, we still fail to guarantee a tight enough connection between SGPPs and DAs they modify

4 A solution

4.1 Setting it up

- * We want (10), repeated below, to have a meaning like (21)—one in which the measurements of the gap's widths at the start and the end of the widening event have particular measurements

$$(10) \quad \text{The gap widened from 3 inches to 9 inches.}$$

$$(21) \quad \llbracket (10) \rrbracket = 1 \text{ iff} \\ \exists e [\text{MAX}(\lambda d. \text{WIDTH}(\text{gap})(\text{END}(e)) \succcurlyeq d) \succcurlyeq \text{MAX}(\lambda d'. \text{WIDTH}(\text{gap})(\text{BEG}(e)) \succcurlyeq d') \\ \& \text{WIDTH}(\text{gap})(\text{BEG}(e)) \succcurlyeq 3 \text{ inches} \& \text{WIDTH}(\text{gap})(\text{END}(e)) \succcurlyeq 9 \text{ inches}]$$

- * While there are perhaps a few different routes one could take to solve this problem, and derive a meaning like (21), let us note that we want a theory that is hospitable to connecting the semantics of degree with the semantics of eventuality predicates, in this case DAs and the events they describe
- * Such a theory can be found in the work of Wellwood (2014, 2015, et seq.)
- * Building on work by Fulst (2006), a.o., she argues that rather than lexically encoding measure functions, adjectives denote davidsonian predicates of states³—one piece of evidence in favor concerns the kinds of modifiers they can take

(22) a. Jenna is sad in the morning.
 b. Jenna ran in the morning.

(23) a. Jenna is happy in the park.
 b. Jenna ran in the park.

(24) a. Jenna is sad in the park in the morning.
 b. Jenna ran in the park in the morning.

- * We see that the same modifiers can target adjectives and eventive predicates, and since the latter are quite commonly taken to have eventuality arguments, we can take this as suggesting that adjectives do too
- * More specifically, we can take adjectives to denote davidsonian state predicates (i.e. $\langle e, st \rangle$ functions, where D_s is the set of all states)

(25) $\llbracket \text{wide} \rrbracket = \lambda x \lambda s. \text{WIDE}(x)(s)$

- * The result, then, is that *in the morning* and *in the park* are modifiers of eventualities, describing when and where Jenna’s sad state holds in the examples above, just as they describe when and where her running occurred
- * This semantics, though, leaves out degrees—if they are not introduced in the lexical semantics of adjectives, where do they come from?
- * On Wellwood’s theory, they come from functional morphology, i.e. MUCH_μ , a central building block to English *more* ($> [\text{MUCH} + \text{-er}]$)⁴
- * MUCH_μ encodes a context-sensitive measure function (Wellwood 2014, et seq.) that is employed to uniformly measure states, events, and entities (signified by type η) and introduce degree arguments

³See, e.g., Parsons (1990), Higginbotham (2000), Kawamura (2007), Landman (2000), Moltmann (2009), Wellwood (2014, 2015), Glass (2019) and references therein. See Maienborn (2005, 2007) and Katz (2003, 2008) for arguments against this kind of view.

⁴Following Bresnan (1973), Wellwood posits a rule of MUCH -deletion that eliminates surface realizations of the morpheme immediately preceding adjectives. *-er*, without an appropriate host, cliticizes to adjectives in comparatives.

$$(26) \quad \llbracket \text{MUCH}_\mu \rrbracket^g = \lambda d \lambda \alpha_\eta. g(\mu)(\alpha) \succ d \quad \langle d, \eta t \rangle$$

- * It's not a free-for-all, though; MUCH_μ can't deliver just any old measure function

$$(27) \quad \text{Mary ran more than John did.} \quad \text{DISTANCE, TIME, *SPEED}$$

- * Building on work by Schwarzschild (2005, 2006) and Nakanishi (2004, 2007), Wellwood restricts the possible measure functions that MUCH_μ can deliver to those that preserve the ordering relations that hold of entities in the measured domain
- * That is, it's constrained to monotonic measures

$$(28) \quad \text{s-MONOTONICITY: A measure function } \mu : D_\eta \mapsto D_\delta \text{ is s-MONOTONIC if, for all } \alpha, \beta \in D_\eta, \text{ if } \alpha \prec_\eta \beta \text{ then } \mu(\alpha) <_\delta \mu(\beta)$$

- * As a constraint on possible measure functions, (28) allows comparisons of distance and time in (27) because any subpart of Mary and John's runnings will necessarily occupy less space and duration

- It rules out comparisons of speed because it's not necessarily the case that a subpart of a running event is any slower than the whole—many will know the feeling of starting strong and fading fast in a race!

- * If we are to apply this to adjectives, we wonder how are states described by adjectives ordered such that MUCH_μ can measure them monotonically

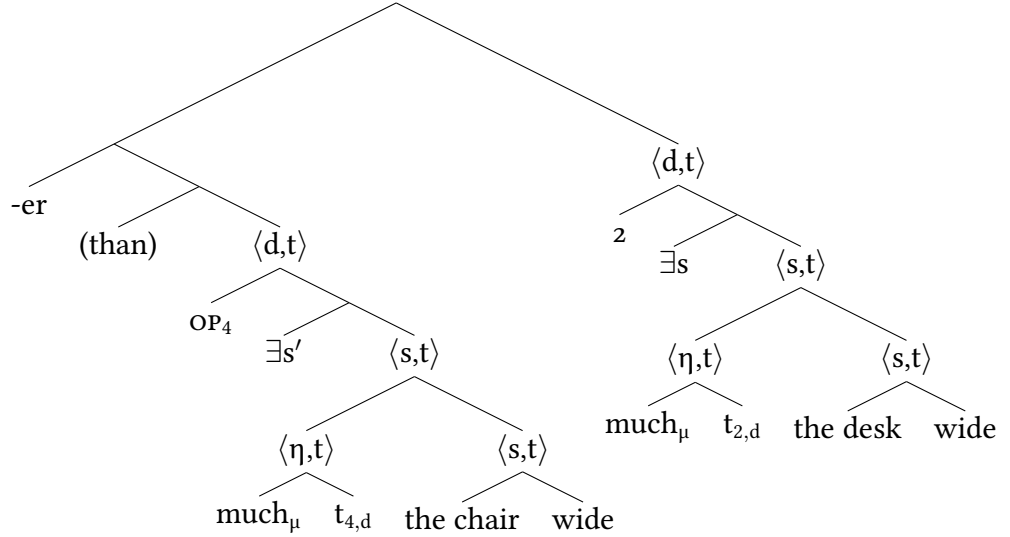
- We could go a mereological route, as in Moltmann (2009), Baglini (2015), and, Francez & Koontz-Garboden (2015), and assume that wide states have part-whole structures—smaller amounts of heat, say, are part of larger amounts of heat
- Wide states, then, are ordered by how much *width* they instantiate, but not lengths or depths
- Straight states are ordered by how much *bend* they instantiate, not lengths

- * To see how these ingredients come together in comparatives, let's look at the following (assuming a syntax for comparatives like Heim 2001)

$$(29) \quad \llbracket \text{-er} \rrbracket = \lambda D \lambda D'. \text{MAX}(D') \succ \text{MAX}(D) \quad \langle dt, dtt \rangle$$

$$(30) \quad \text{The desk is wider than the chair is.}$$

a.



b. $\llbracket (30a) \rrbracket^g = 1$ iff

$$\text{MAX}(\lambda d. \exists s[\text{WIDE}(\text{desk})(s) \ \& \ g(\mu)(s) \succcurlyeq d]) \succ \\ \text{MAX}(\lambda d'. \exists s'[\text{WIDE}(\text{chair})(s') \ \& \ g(\mu)(s') \succcurlyeq d'])$$

- * What these truth conditions demand is that we measure the wide states of the chair and the desk, and if the measure of the desk's wide state is greater than the chair's, they will yield truth

4.2 Moving to DAs

- * These moves necessitate changes to the compositional semantics of DAs we posited earlier—the introduction of states means that *-en* can no longer be as in (7), repeated below

$$(7) \quad \llbracket -en_{OG} \rrbracket = \lambda f_{\langle d, eit \rangle} \lambda x \lambda e. \text{MAX}(\lambda d. f(d)(x)(\text{END}(e))) \succ \text{MAX}(\lambda d'. f(d')(x)(\text{BEG}(e)))$$

- * Now, we want *-en* to introduce comparison of two states of the kind described by the root adjective; obviously, they can't be any two old states—we must establish some relation between them
- * Intuitively the relevant states are starting and end points for the event, so why not posit that they are source and goal states of the event *e*?

$$(31) \quad \llbracket -en_{2.0} \rrbracket = \lambda f_{\langle e, st \rangle} \lambda h_{\langle d, \eta t \rangle} \lambda x \lambda e. \\ \exists s \exists s' [f(x)(s) \ \& \ f(x)(s') \ \& \ \text{MAX}(\lambda d'. h(d')(s')) \succ \text{MAX}(\lambda d. h(d)(s)) \ \& \ \text{SOURCE}(e)(s) \ \& \ \text{GOAL}(e)(s')]$$

- * This entry demands an adjective, MUCH_μ (to actually measure those states⁵), an individual, and yields a predicate of events
- * Now, *widen* has the following meaning

⁵We could also just build this into the meaning of *-en*.

$$(32) \quad \llbracket \text{widen} \rrbracket^g = \lambda x \lambda e. \exists s \exists s' [\text{WIDE}(x)(s) \ \& \ \text{WIDE}(x)(s') \ \& \ \text{SOURCE}(e)(s) \ \& \ \text{GOAL}(e)(s') \ \& \\ \text{MAX}(\lambda d'. g(\mu)(s') \succcurlyeq d') \succ \text{MAX}(\lambda d. g(\mu)(s) \succcurlyeq d)]$$

- * We can smoothly integrate source and goal PPs now: we write entries for *from* and *to*, type-neutral like MUCH_μ , and give SGPPs additional structure

$$(33) \quad \llbracket \text{from} \rrbracket = \lambda \alpha_\eta \lambda e. \text{SOURCE}(\alpha)(e)$$

$$(34) \quad [\text{from} [\varepsilon [\text{MUCH}_\mu \ 3 \ \text{inches}]]]$$

$$(35) \quad \llbracket (34) \rrbracket^g = \lambda e. \text{SOURCE}(\varepsilon \eta [g(\mu)(\alpha_\eta) \succcurlyeq 3 \ \text{inches}])(e)$$

- * $\llbracket \text{MUCH}_\mu \ 3 \ \text{inches} \rrbracket$ yields the set of objects α of type η such that their contextually-available measure is at least 3 inches; we need to pick out a particular object from that set that is input to *from*
- * I take ε to be a choice function (von Heusinger 2004), picking out an object α_η from the set of three inch objects; *from* relates this object to events
 - One might want to stipulate that ε picks out a state, but it's actually unnecessary to do so
 - (31) ensures that the source of *widen* events are wide states
 - Adopting the common requirement that the objects bearing thematic roles like SOURCE are unique (Dowty 1988, a.o.), ultimately guarantees the source α_η in (34) is a wide state when (34) modifies *widen*
- * Since wide states are ordered by how much width they instantiate, but not length or depth or anything else, MUCH_η cannot yield lengths or depths in (10)
- * By the same logic, straightening events have straight states as their sources, and since LENGTH isn't an appropriate measure we predict (16a) to be unacceptable

5 Summing up

- * In the beginning, a question was asked: why do measure phrases in SGPPs like (10), repeated below, *have* to be interpreted as widths?

(10) The gap widened from 3 inches to 9 inches.

- * The overall problem is that standard assumptions about the ingredients of (10) do not allow us to ensure a tight enough connection between SGPPs and the predicates they modify such that we can answer that question
 - We discussed some plausible analyses and found them wanting, though we didn't discuss other viable alternatives, e.g. a vector-based semantics à la Zwarts & Winter (2000) or the directed scale segment analysis of Schwarzschild (2013, 2014)

- These alternatives do merit closer investigation
- * However, it was argued that switching to a state-based semantics for adjectives, and making concomitant changes to our semantics of degree achievements, lets us enforce such a tight connection, and answer the question above as well

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