a new semantics of degree

“degree constructions”:

comparatives with more-er-than,
equatives with as...as,
superlatives with most-est,
&c.

familiar idea: degree heads express
relations between degrees-qua-measures
on the standard picture, various measure
functions apply to \([\text{coffee(s)}]\):

Al drank hotter coffee than Bill did.
Al drank more coffee than Bill did.
Al drank more coffees than Bill did.

analogously, various measure functions
apply to \([\text{run...}]\):

Al ran more quickly than Bill did.
Al ran in the park more than Bill did.
Al ran to the park more than Bill did.

today:

challenge the theoretical intuition that these
sentences uniformly describe measures of
stuff like coffee and running
while sometimes our language describes measures of such things, sometimes it describes measures of things like *states* and *pluralities*.

### outline:

- the standard semantics
- reasons to doubt it
- a new semantics

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### adjectives

- Al drank hotter coffee than Bill did.
- Al drank more coffee than Bill did.
- Al drank more coffees than Bill did.

### first pass idea:

\[ [-\text{er/more}] \approx \text{greater-than relation between two degrees} \]

\[ [\text{hot}] \approx \text{mapping from } x \text{ to "how hot" } x \text{ is (i.e., a degree of temperature)} \]
“degrees” needn’t be Fahrenheit or Celsius

“It is not... the business of logic or linguistics (at least syntax) to explain how it is that we make the comparisons we do make or what the principles are by which we make them [but] to tell us how we put the comparisons we do make into the linguistic forms into which we put them.” (Cresswell 1976)

Al’s coffee is hotter than Bill’s is.

Al drank more coffee than Bill did.

coffee-A-drank

coffee-B-drank

}[Al’s coffee is hotter than Bill’s is.] =

HOT(A’s-coffee) > HOT(B’s-coffee)
coffee doesn’t denote a mapping between entities and degrees

it just denotes a property. contrast:

\[
\text{[coffee]} = \lambda x. \text{COFFEE}(x) \\
\text{[hot]} = \lambda d \lambda x. \text{HOT}(x) = d
\]


how do we get degrees to more in such cases?

morphosyntax

Al’s coffee is hotter than Bill’s is.
Al’s coffee is as hot as Bill’s is.

morphosyntax

Al’s coffee is hotter than Bill’s is.
Al’s coffee is as hot as Bill’s is.

Al drank more coffee than Bill did.
Al drank as much coffee as Bill did.

aha! much provides the mapping to degrees with nouns

Al drank more coffee than Bill did.
Al bought more coffee than Bill did.

(cop. Al drank/bought as much coffee...)
Al drank/bought more coffee than Bill did.  

⇒ *much* can describe measures by volume, or by weight  

are there any restrictions?  

Al drank/bought more coffee than Bill did.  

⇒ *much* can describe measures by volume, or by weight, *but not* by temperature

why not?  

\[ \lambda x. \text{COFFEE}(x) \]

part-wholes  

part-wholes

part-wholes  

part-wholes

part-wholes  

part-wholes

idea:

[[\textit{much}]] allows any dimension that respects the part-whole structure of nominal extensions


\[\mu(\text{coffee-A-drank}) > \mu(\text{coffee-B-drank})\]

plurals

Al drank more coffees than Bill did.

\[\mu(x) = d, \text{ where } \mu \text{ is any measure function that tracks part-whole relations holding amongst the xs}\]

morphosyntax

Al drank more coffees than Bill did.

Al drank as \textit{many} coffees as Bill did.
the idea:

\[ \text{[many]} \text{ is more like [hot] than [much], it incorporates a specific measurer} \]

\[ \text{[many]} \approx \lambda d \lambda x. \text{NUMBER}(x) = d \]

Al drank more coffees than Bill did.

\[ \text{Al drank more coffees than Bill did.} \]

\[ \text{Al drank hotter coffee than Bill did.} \]

\[ \text{Al drank more coffee than Bill did.} \]

\[ \text{Al drank more coffees than Bill did.} \]

the story so far

\[ \text{[Al drank more coffees than Bill did.]} \approx \]

\[ \text{[Al drank more coffees than Bill did.]} \approx \]

\[ \text{NUMBER(coffees-A-drunk) > NUMBER(coffees-B-drunk)} \]

\[ \text{adjectives like hot name specific measurers, e.g. HOT} \]

\[ \text{much allows constrained, variable measures} \mu \]

\[ \text{many incorporates NUMBER} \]

adverbs

Al ran more quickly than Bill did.

Al ran more quickly than Bill did.

Al ran more quickly than Bill did.

more joyfully

straighter

more buoyantly
the idea: adverbs are just like adjectives

\[ \text{quickly} \approx \text{mapping from } e \text{ to "how quick" } e \text{ is} \]

\[ \text{quickly} = \lambda d \lambda e. \text{QUICKLY}(e) = d \]

Al ran more quickly than Bill did.

\[ [\text{Al ran more quickly than Bill did.}] \approx \text{QUICKLY}(\text{Al's-run}) > \text{QUICKLY}(\text{Bill's-run}) \]

verbs

Al ran more than Bill did.

\[ \text{RUN} \]

degrees of speed

degrees of joyfulness (whatever those are)

degrees of straightness?

degrees of bouyancy (?)
verbs are just like nouns, they denote properties. contrast:

\[
[\text{run}] \approx \lambda e. \text{RUN}(e)
\]

\[
[\text{quickly}] \approx \lambda d \lambda e. \text{QUICKLY}(e) = d
\]

Al ran more than Bill did.
Al ran as much as Bill did.

Morphosyntax

Al ran as much as Bill did.

\[
\Rightarrow \text{much can describe measures by distance, or by duration}
\]

Part-wholes

Al ran as much as Bill did.

\[
\Rightarrow \text{much can describe measures by distance, or by duration, but not by speed}
\]

part-wholes

the distance/duration of the running in this circle is greater than the distance/duration of the running in this circle.

Al ran more than Bill did.

[Al ran more than Bill did.] = \[ \mu(Al's\-run) > \mu(Bill's\-run) \]

idea:

\[ [\text{much}] \text{ allows any dimension that respects the part-whole structure of nominal and verbal extensions} \]

\[ [\text{much}] = \lambda d \lambda \alpha. \mu(\alpha) = d \]

plurals

Al ran to the store more than Bill did.
<table>
<thead>
<tr>
<th>A's runs to the store</th>
<th>B's runs to the store</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="A's scenario" /></td>
<td><img src="image2" alt="B's scenario" /></td>
</tr>
</tbody>
</table>

Al ran to the store more than Bill did.
Al ran to the store as much as Bill did.

OOPS!

Outline:
- The standard semantics
- Reasons to doubt it
  - A new semantics

The story so far
- Adjectives like *hot* and adverbs like *quickly*
- *Much* allows constrained variable measurers $\mu$
- *Many* names $\text{NUMBER}$

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A's runs to the store</td>
<td>3</td>
</tr>
<tr>
<td>B's runs to the store</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drank hot coffee than Bill did.</td>
<td>HOT</td>
</tr>
<tr>
<td>Drank more coffee than Bill did.</td>
<td>$\mu$</td>
</tr>
<tr>
<td>Drank more coffees than Bill did.</td>
<td>$\text{NUMBER}$</td>
</tr>
<tr>
<td>Ran more quickly than Bill did.</td>
<td>QUICKLY</td>
</tr>
<tr>
<td>Ran in the park more than Bill did.</td>
<td>$\mu$</td>
</tr>
<tr>
<td>Ran to the store more than Bill did.</td>
<td>$\text{NUMBER}$</td>
</tr>
</tbody>
</table>

There are a number of cases that are not obviously explicable on the standard picture.
a counter-prediction

(here are some of them)

If much disallows dimensions like speed because they don’t track part-wholes...

Al accelerated more than Bill did.

a home for modifiers

Al accelerated more than Bill did.

Al accelerated as much as Bill did.

=> why does it allow for a measure by speed here?

If adjectives just name mappings between individuals and degrees...

Al was hotter in the park after running than Bill was.

Al was hotter in the park after running than Bill was <hot in the park after running>.

normally, in the park is thought to denote a (complex) property of events

Al ran in the park yesterday.

... RUN(e) & IN-THE-PARK(e) & YESTERDAY(e) ...
Al was hotter in the park after running than Bill was.

⇒ what is in the park modifying here?

ggradable adjectives denote properties of states (Landman 2000, Fults 2006):

... HOT(\(s\)) & IN-THE-PARK(\(s\)) & AFTER-RUNNING(\(s\)) ...

a strange equivalence

Al was hotter in the park after running than Bill was.

⇒ but if that’s so, what provides degrees in adjectival comparatives?

if both much and high have the semantics of measure functions...

The rabbit can jump as high as 6 feet.

The rabbit can jump as much as 6 feet high.

⇒ why do these mean the same thing?

what is much measuring here?

part of the solution:

\[ \text{much} \Rightarrow \emptyset / \_AP \]
the solution will be: *much always* measures

**Outline:**

what have we been doing?

1) measuring the same stuff/events
2) with multiple “measurers”

---

where have we gone wrong?

1) we are measuring the wrong stuff
2) there are too many measurers

---

proposal:

1) what we’re measuring varies
2) *much always* measures

---

importantly, there are two ways we can understand “measurement”

**Practically:**

measure coffee, *temperature-wise*
conceptually:

measure heat, *as instantiated by coffee*

conceptual definition:

measurement is a structure-preserving map from an “empirical relational structure” to a numerical one


distinguish:

measured object, e.g. *coffee*

object of measurement, e.g. *heat*

“It is evident, even without a more detailed analysis of these complex problems, that that which we measure, and that on which or by means of which we measure, are not to be identified…” (Berka 1983)

{\text{[much]} = \lambda P \lambda \alpha. P(\alpha) \& \mu(\alpha) = d, \text{ s.t.:}}

i) \exists \geq_{P}; \text{ and,}

ii) \mu \text{ is a homomorphism from } <D_{P}, \geq_{P}> \text{ to } <D_{d}, \geq_{d}>.

[much] \approx \lambda \mu \lambda \alpha. P(\alpha) \& \mu(\alpha) = d, \text{ s.t.:}

i) what is measured is ordered;

ii) \mu \text{ preserves ordering relations on the measured domain in the mapping to degrees}

Wellwood 2012, Wellwood under review

sometimes this is a part-whole ordering:
so the interpretations of *more coffee, run* 
*more* remain the same

Al drank more coffee than Bill did.

\[ \mu(\text{coffee-Al-drank}) > \mu(\text{coffee-Bill-drank}) \]

Al ran in the park more than Bill did.

\[ \mu(\text{Al's-park-run}) > \mu(\text{B's-park-run}) \]

for *hot* and *quick*, it is more difficult to draw 
the picture, but the claim is...

[coffee] : \( \exists \) a part-whole ordering on stuff
[run] : \( \exists \) a part-whole ordering on processes
[hot] : \( \exists \) an ordering of “heat” states
[quickly] : \( \exists \) an ordering of “quick” states

so the interpretation of sentences with *hotter* 
and *more quickly* look different
Al drank hotter coffee than Bill did.
\[ \mu(\text{hotness-of-Al's coffee}) > \mu(\text{hotness-of-Bill's coffee}) \]
\[ \text{cp. HOT(Al's-coffee) > HOT(Bill's-coffee)} \]

Al ran more quickly than Bill did.
\[ \mu(\text{quickness-of-Al's-run}) > \mu(\text{quickness-of-Bill's-run}) \]
\[ \text{cp. SPEED(Al's-run) > SPEED(Bill's-run)} \]

now we can see how this avoids the problems:

an expected equivalence

The rabbit can jump as high as 6 feet.
The rabbit can jump as much as 6 feet high.

\[ \mu(\text{height-of-R's-jump}) \geq 6\text{-feet} \]

an expected equivalence

The rabbit can jump as **much** high as 6 feet.
The rabbit can jump as **much as** 6 feet **high**.

what about readings by number?

idea: *many* is the suppletive form of *much* in the environment of nominal PLURAL

evidence: in some languages, the meaning of *many* is expressed by plural *much*

\[ \text{much 'MUCH' ~ many 'MUCH + PL_{num}'} \]
\[ \text{cp. go 'GO' ~ went 'GO + PAST'} \]
Al tomó mucha agua. Al drank much water
Al tomó muchas aguas. Al drank many waters

in others, no distinction is made at all

Izjadoh poveče supa ot-kolkoto Ana.
ate-I more soup from-how.much Ana
Posetih poveče mesta ot-kolkoto Ana.
visited-I more places from-how.many Ana

Roumi Pancheva, p.c.

in general, if pluralities are just sets*...

⟦coffee⟧ = {a, a\#b, a\#b\#c, ...}

⟦coffee⟧ = {a, a\#b, a\#b\#c, ...}

=> μ applies to elements of this set, things like a\#b\#c

traditional idea (contra Link 1983, Boolos; Gillon 1992, Schwarzschild 2006, a.o.)

⟦coffees⟧ = { {a}, {a,b,c}, {a,b,c}, ...}

⟦coffees⟧ = { {a}, {a,b,c}, {a,b,c}, ...}

=> μ applies to elements of this set, things like {a,b,c}

what measures are defined for sets?
measures defined for sets:
=> cardinality

measures defined for sets:
=> cardinality
=> others?

Al drank more coffees than Bill did.

μ(Al’s-plurality-of-coffees) > μ(Bill’s-plurality-of-coffees)

idea: readings requiring cardinal measures arise whenever much measures a plurality

there are also verbal plurals (“pluractional” morphemes)

Ivan izkačvasē vrâh Musala poveče ot Ana.
Ivan izkači vrâh Musala poveče ot Ana.
Ivan izkačv vrâh Musala poveče ot Ana.
Ivan izkačv vrâh Musala poveče ot Ana.

“Ivan reached the top of Mt. Musala more than Ana did”

telic VPs like reach the top, run to the park, jump must be plural in the comparative

Al ran to the park more than Bill did.

μ(Al’s-plurality-of-runnings-to-the-park) > μ(Bill’s-plurality-of-runnings-to-the-park)

see crosslinguistic discussion in Wellwood, Hacquard, Pancheva 2012
μ(μ(patience-of-Al) > μ(patience-of-Bill)) => word order excludes certain possibilities/ includes other ones
μ(μ(event-of-Al's-being-patient) > μ(event-of-Bill's-being-patient))
μ(μ(Al's-plurality-of-events-of-being-patient) > μ(Bill's-plurality-of-events-of-being-patient))

an interesting case

Al is more patient than Bill is.
Al is patient more than Bill is.
Al is patient more than Bill is.

⟦coffee⟧: Ǝ a part-whole ordering on stuff
⟦run⟧: Ǝ a part-whole ordering on processes
⟦hot⟧: Ǝ an ordering of “heat” states
⟦quickly⟧: Ǝ an ordering of “quick” states
⟦coffees⟧: Ǝ an ordering of pluralities
⟦run-PL⟧: Ǝ an ordering of pluralities

this view predicts grammatical effects on measurement to be the norm

Al is more patient than Bill is.
Al is patient more than Bill is.

μ(μ(patience-of-Al) > μ(patience-of-Bill)) => word order excludes certain possibilities/ includes other ones
μ(μ(event-of-Al's-being-patient) > μ(event-of-Bill's-being-patient))
μ(μ(Al's-plurality-of-events-of-being-patient) > μ(Bill's-plurality-of-events-of-being-patient))
a not-so-counter prediction

Al accelerated as much as Bill did.

3 measurements possible, of:
- the accelerating itself
- an event of accelerating
- a plurality of such events

a not-so-counter prediction

Al accelerated as much as Bill did.

\[ \mu(\text{acceleration-of-Al}) \geq \mu(\text{acceleration-of-Bill}) \]

\[ \mu(\text{event-of-Al's-acceleration}) \geq \mu(\text{event-of-Bill's-acceleration}) \]

\[ \mu(\text{Al's-plurality-of-events-of-acceleration}) \geq \mu(\text{Bill's-plurality-of-events-of-acceleration}) \]

conclusions

the standard semantics for degree constructions has much to recommend it

conclusions

its general framework can be maintained in the face of problems only if...

measurement is uniformly encoded by much (i.e., gradable adjectives/adverbs do not have a degree semantics), and

our language records measurement of more kinds of things than we thought

Al drank hotter coffee than Bill did.  \( \mu \)

Al drank more coffee than Bill did.  \( \mu \)

Al drank more coffees than Bill did.  \( \mu \)

Al ran more quickly than Bill did.  \( \mu \)

Al ran in the park more than Bill did.  \( \mu \)

Al ran-pl to the park more than Bill did.  \( \mu \)
thanks!

(ADJ) \( [\exists X \text{[Al is [2; tall much -er]]}] \)

1. \( \lambda X. \text{TALL}(s) \land \lambda X. \text{PL}(x) \land \mu(s)=d \)
   \( = \lambda X. \text{TALL}(s) \land \mu(s)=d \)
2. \( (1)^{\lambda X. \text{PL}(x)} \exists d[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{TALL}(s) \land \exists d[\mu(s)=d \land d > d] \)
3. \( (2)^{\lambda X. \text{AL}} \)
   \( = \lambda X. \text{TALL}(s) \land \text{TALL}(s) \land \exists d[\mu(s)=d \land d > d] \)
4. \( \text{[(ADJ)]] is T iff:} \)
   \( \exists s[\text{TALL}(s) \land \text{TALL}(s) \land \exists d[\mu(s)=d \land d > d]] \)

(ADJ) \( [\exists X \text{[Al ate [2; cookie-s much -er]]}] \)

1. \( \lambda X. \text{COOKIES}(x) \land \lambda X. \text{PL}(x) \land \exists y[\text{Tall}(x,y) \land P(y)] \)
   \( = \lambda X. \text{PL}(x) \land \exists y[\text{Tall}(x,y) \land \text{COOKIES}(y)] \)
2. \( (1)^{\lambda X. \text{PL}(x)} \exists d[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists y[\text{Tall}(x,y) \land \text{COOKIES}(y)] \land d > d \)
3. \( (2)^{\lambda X. \text{AL}} \exists d[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists y[\text{Tall}(x,y) \land \text{COOKIES}(y)] \land d > d \)
4. \( \text{[(ADJ)]] is T iff:} \)
   \( \exists x[\text{PL}(x) \land \exists y[\text{Tall}(x,y) \land \text{COOKIES}(y)] \land d > d]] \)

(ADJ) \( [\exists X \text{[Al ran [2; quick much -er]-ly]]} \)

1. \( \lambda X. \text{QUICK}(s) \land \lambda X. \text{PL}(x) \land \mu(s)=d \)
   \( = \lambda X. \text{QUICK}(s) \land \mu(s)=d \)
2. \( (1)^{\lambda X. \text{PL}(x)} \exists d[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{QUICK}(s) \land \exists d[\mu(s)=d \land d > d] \)
3. \( (2)^{\lambda X. \text{AL}} \exists d[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{QUICK}(s) \land \exists d[\mu(s)=d \land d > d] \)
4. \( \text{[(ADV)]] is T iff:} \)
   \( \exists x[\text{QUICK}(s) \land \exists d[\mu(s)=d \land d > d] \land \theta(e,s)] \)

(VERB) \( [\exists X \text{[Al [2; ran much -er]]}] \)

1. \( \lambda X. \text{RUN}(e) \land \lambda X. \text{PL}(x) \land \exists \mu[\text{Tall}(x,y) \land P(\beta)] \)
   \( = \lambda X. \text{PL}(x) \land \exists \mu[\text{Tall}(x,y) \land \text{RUN}(e)] \)
2. \( (1)^{\lambda X. \text{PL}(x)} \exists \rho[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists \rho[\text{Tall}(x,y) \land \text{RUN}(e)] \)
3. \( (2)^{\lambda X. \text{AL}} \exists \rho[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists \rho[\text{Tall}(x,y) \land \text{RUN}(e)] \land d > d \)
4. \( \text{[(VERB)]] is T iff:} \)
   \( \exists e[\text{Tall}(x,y) \land \text{RUN}(e) \land \mu(\rho)=d \land d > d] \)

(V-PL) \( [\exists X \text{[Al [2; ran-pl] much -er]}] \)

1. \( \lambda X. \text{RUN}(e) \land \lambda X. \text{PL}(x) \land \exists \mu[\text{Tall}(x,y) \land P(\beta)] \)
   \( = \lambda X. \text{PL}(x) \land \exists \mu[\text{Tall}(x,y) \land \text{RUN}(e)] \)
2. \( (1)^{\lambda X. \text{PL}(x)} \exists \rho[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists \rho[\text{Tall}(x,y) \land \text{RUN}(e)] \)
3. \( (2)^{\lambda X. \text{AL}} \exists \rho[G(a)(d) \land d > d] \)
   \( = \lambda X. \text{PL}(x) \land \exists \rho[\text{Tall}(x,y) \land \text{RUN}(e)] \land d > d \)
4. \( \text{[(V-PL)]] is T iff:} \)
   \( \exists e[\text{Tall}(x,y) \land \text{RUN}(e) \land \mu(\rho)=d \land d > d] \)

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