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# WHAT *more* IS

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*Oh, you're a linguist? What word do you work on?*

## 1. Why *more*?

A wealth of research has targeted aspects of the grammar, meaning, use, and understanding of comparative sentences with *more* and cousins (*as much*, *less*, etc). In linguistics, their morphological properties have been studied extensively in English and in other languages, uncovering a surprising degree of overlap both in their depth of expression, and in the regularity of that expression cross-linguistically. At the interface between syntax and semantics, comparatives have been used to support some of the best arguments for the existence of 'degrees'. In semantics and philosophy of language, they have been used to probe the typology of measurement scales presupposed by natural language. And in cognitive psychology, they have been used to investigate the innate mechanisms undergirding reasoning about quantities.

This paper attempts to bridge these interdisciplinary discussions from the perspective of formal semantics. The appearance of *more* in English, and its correspondents in other languages, masks incredibly rich structure that, nonetheless, appears to be grasped by 3 year old children. As a semanticist, I may find myself content to accept these findings, and take up the task of specifying how the truth-conditional contributions of the parts of comparative sentences add up to the truth-conditions of the whole. And indeed, I do this in §2. But I may also want to understand the relationship between the truth-conditional theory and what the 3 year old has acquired. §3 begins that attempt. There, I integrate the

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semantic theory with data from cognitive psychology and cognitive development; this study raises, it seems to me, pressing questions about the scope and limits of semantics as a part of language science.

The first part of the discussion thus presents the results of a fairly standard compositional semantic analysis, before moving to ask how—and whether—the resultant theory can predict relevant facts about language understanding and acquisition. There, I point to observations about semantic competence that the theory is mute on, such as how we should expect *more gleeb* to be understood, for arbitrary noun *gleeb*. Viewing the silence as a scientific limitation, I discuss the parameters of a refocused theory in which formal semantics models the relationship between linguistic structure and nonlinguistic conceptualization. Ideally, such a refocusing would generate a proper superset of the predictions supported on the traditional picture. As it stands, though, I hope only to foreground the viability of semantics (as typically practiced in linguistics) as a major contributor to research in cognitive science.

My goals are thus, I take it, modest. But it is worth highlighting up front where the view that I inch towards could lead in the extreme. We're used to acting as if semantic theory produces statements that describe a relation between structured linguistic objects and entities (structured or otherwise) in a mind-independent world. Such a theory will characterize language acquisition as a process of internalizing a relation of the appropriate sort, and it will ground philosophical projects that use linguistic analyses in the service of drawing (real) metaphysical conclusions. I do wonder whether either of these are right. For now, though, I simply invite the reader to consider whether something in this case study might challenge her view of what a semantic theory is about. Later, we might return to the question of how best to view the study of semantics in relation to semantic competence (cf. Soames 1989, Pietroski 2018).

## 2. Grammar

I emphasize three features of the grammar of sentences with *more*. The first is structural, and the second and third are semantic. First, the expression pronounced *more* is decompositional (and univocal). Across its various occurrences, it realizes at least two underlying pieces of morphosyntax, e.g. those represented as input to a morphophonological rule like (1).[1]

(1) **Decomposition**
[ MUCH ER ] $\rightsquigarrow$ *more*

Second, comparatives with *more*, *as (much)*, *too (much)*, etc., impose a 'measurability' condition on the XP targeted for comparison. In (2), this is sketched as a definedness condition on the combination *more* XP, such that the extension of XP, ⟦XP⟧, has non-trivial order-theoretic properties.

(2) **Measurability**
⟦*more* $\alpha$⟧ is defined only if ⟦$\alpha$⟧ is non-trivially ordered.

Third, comparative sentences invoke dimensions for comparison that are strongly structure preserving with respect to the measured domain (i.e., with respect to ⟦$\alpha$⟧, given *more* $\alpha$). In (3), this is sketched as a condition on accessible measure functions, which have elements of scales as their outputs.

(3) **Measures**
The available measures for $\alpha$ strongly depend on the nature and structure of ⟦$\alpha$⟧.

As I discuss, (2) and (3) are due to the underlying piece MUCH in (1), and as such are predicted to hold wherever that morpheme occurs.

The relationship between (what we call) the *extension* of XP and the conditions (2) and (3) motivate the semantic theory presented in §2. §3 considers some of these facts from a wider perspective as well as facts from cognitive psychology that, squinting, appear to be related. There, I wonder whether, with eyes wide open, we shouldn't see these facts as inextricably linked.

## 2.1. Morphosyntax

***2.1.1.*** **more *isn't atomic*** Bresnan's (1973) seminal paper on the syntax of comparatives in English posits that the expression *more* conflates two morphemes, MUCH and -ER.[2] Formalized in terms of rules of pronunciation (here: morphophonological rules), this view may be summarized as in (4).

(4) a. MUCH ⇝ *much*
b. [ MUCH ER ] ⇝ *more*

I review some of the relevant data and arguments directly.

A first explanatory target for Bresnan is the distribution of the form *more* versus *-er* with adjectives and adverbs (i.e., APs). We can first observe that while the form *more* surfaces with *intelligent* but *-er* surfaces with *smart*, both surface with the (simplex) form *as*; see (5).

(5) a. more intelligent, as intelligent
b. smarter, as smart

Given that the two comparative forms are roughly synonymous, as are the two 'equative' forms, it doesn't appear that the difference between *-er* and *more* tracks any interesting semantic differences. Thus, Bresnan suggests an underlying identity, and attributes their variant shapes to morphophonological processes that are sensitive to some featural difference between two classes of adjectives:

for example, *more*, the default form, occurs with adjectives A and *-er*, the marked form, occurs with adjectives A*.

However, Bresnan supposes that the forms in (5) realize more than merely the combination of adjective plus morphemes like -ER and AS; rather, the comparative morphology masks interesting additional structure that can be revealed under other grammatical conditions. For example, the paradigm in (6) surfaces when a comparative form targets nouns or verbs (i.e. NPs, VPs), as in *as much coffee*, *too much coffee*, etc.

(6) a. more coffee
b. as much
c. too much
d. how much
e. that much

Intuitively, the forms in (6) invoke a general notion of 'quantity' whenever they occur: either indicating ordering relations between quantities (*as*, *too*, and *more*), inquiring about a specific quantity (*how*), or demonstrating a particular quantity (*that*). And of course, in all cases except that of *more*, the relevant comparative morpheme co-occurs with *much*.[3]

What is the theory of the morphophonology of English comparatives, then? Is there one kind of underlying structure—without *much*—for AP comparatives, but a different kind—with *much*—for NP and VP comparatives? Bresnan suggests not: rather, something like *much* always occurs, such that the underlying structure of forms like *as intelligent* and *as much coffee* both feature MUCH and AS, just as those for *smarter*/*more intelligent* and *more coffee*. Appearances to the contrary are derived, again, by the application of morphophonological rules.[4] Schematics of such rules are given in (7) and (8).

(7) a. [ [ MUCH ER ] INTELLIGENT$_A$ ] $\rightsquigarrow$ *more intelligent*
b. [ [ MUCH ER ] SMART$_{A*}$ ] $\rightsquigarrow$ *smarter*
(8) [ [ MUCH ER ] COFFEE$_N$ ] $\rightsquigarrow$ *more coffee*

The rest of this section provides evidence for the explanatory power of Bresnan's decomposition.

First, data from Corver (1990) use the distribution and interpretation of the anaphor *so* to suggest the kind of complexity to AP comparatives that a theory like Bresnan's expects. Outside of comparative contexts, *so* takes on the interpretation of some antecedent phrase: in (9), we understand *so* in the second sentence to be equivalent in meaning to *check the manuscript for errors*, and the complex *done so* to be equivalent to *checked the manuscript for errors*.

(9) Bill wants Ann to check the manuscript for errors.
In fact, she has already done so.

What happens when a comparative form like *too* occurs with *so*? (10a) positively attributes intelligence to Ann, and, of three logically possible contiuations, both of (10b-i) and (10b-iii) are possible, but (10b-ii) is not.

(10) a. Ann is intelligent.
b. i. In fact, she is too intelligent.
ii. *In fact, she is too much intelligent.
iii. In fact, she is too much so.

The pattern in (10b) receives a straightforward explanation on Bresnan's analysis: no *much* surfaces in (10b-i) because of the rule that deletes it with APs; (10b-ii) is ungrammatical because it represents a failure to apply that (obligatory) rule; and (10b-iii) is available because *so*, as a category-neutral element, fails to trigger the rule that deletes that morpheme before adjectives (cf. (9), where the anaphor resumes a VP).

***2.1.2. Neither is* many** Bresnan and others allowed the decompositional theory just described to coexist alongside a distinct decomposition in which *more* realizes the conflation MANY plus -ER. Wellwood (2018), though, argues that the surface form *many* itself realizes MUCH along with the nominal plural morpheme, PL (that realized as *-s* in, for example, *coffees*). Any sufficient morphophonological rule like (11) is posited to account for the surface variation.[5]

(11) [ MUCH PL ] ⇝ *many*

Earlier research tends to assume that *many* realizes a distinct lexical atom, and if so that would be important for whether *more* is ambiguous or not. It occurs in the same environments as the form *much*, but its distribution is limited to those combinations targeting plural nouns, e.g. (12).

(12) a. more books
b. as many
c. too many
d. so many
e. how many

And indeed, such a division of the data into those with underlying MUCH and those with underlying MANY could be leveraged to capture the fact that while the former occurrences are neutral with respect to a variety of different dimensions for comparison (cp. *as much coffee* and *too much heat*), occurrences of *many* always involve comparisons by number.

Yet consideration of a broader range of data suggest that the distribution of the form *many* is, as expected by a theory that accepts a rule like (11), syntactically- rather than semantically-conditioned. To see this, observe that

sentences with forms like (13b) and (13c) appear to be synonymous, but it is not possible to combine a noun such as *furniture* with *many* directly, (13a).[6]

(13) a. *many furniture
b. many pieces of furniture
c. much furniture

The same point can be made by inspection of verbal comparatives. (14b) and (14c) can both be used to describe a small number of intersections, while (14a) cannot.

(14) a. *The lines didn't intersect many.
b. The lines didn't intersect much.
c. The lines didn't intersect many times.

Minimally, the data in (13) suggest that it must at least be possible to restrict MUCH to the number dimension under some circumstances, and so there is no necessary semantic pressure to posit MANY as a distinct primitive.

Furthermore, there is little evidence for such a distinction across languages. For example, the only difference between the equivalents of *much/many* in Spanish is singular or plural agreement on the univocal form *mucha*, (15); *mucha* in (15a) says something about beer-drinking by volume, while *muchas* in (15b) about the number of units consumed.

(15) a. Silvia tomó **mucha** cerveza durante la cena
Silvia took much beer during the dinner
'Silvia drank a lot of beer at dinner.'
b. Silvia tomó **muchas** cervezas durante la cena
Silvia took much.PL beer.PL during the dinner
'Silvia drank many (bottles/cups of) beer at dinner.'

The point is bolstered by French data, where the univocal form *beaucoup* surfaces, and the difference in plurality (with concomitant semantic effects) can be detected in agreement morphology on the verb, (16a)-(16b).[7]

(16) a. **Beaucoup** de bière **a** été bue hier soir.
much DE beer have.SG been drunk last night
'Much beer was drunk last night.'
b. **Beaucoup** de bières **ont** été bues hier soir.
much DE beer.PL have.PL been drunk last night
'Many beers were drunk last night.'

An even broader look at the crosslinguistic picture confirms the viability of the general reduction: where English has *much/many*, other languages display a univocal form paired with (broadly) some marker of plurality; Wellwood (2018)

cites additional examples from Mandarin, Macedonian, Italian, and Bangla. Moreover, in all cases the interpretive pattern is the same as it is in English: the base form corresponding to *much* involves variable dimensions, while the form occurring in broadly plural contexts involves only number.

## 2.2. Distributional semantics

***2.2.1. Lexical determinants*** Descriptively, there are two major generalizations regarding the meaningfulness of comparative sentences that need to be accounted for. At the 'lexical' level,[8] the comparative form is natural and straightforwardly interpretable only with lexical items whose predicative domains have non-trivial structure. Those which have such properties are the 'measurable' predicates, and those which lack it are the 'non-measurable' predicates (Wellwood 2014, forthcoming). The measurability distinction divides mass from (singular) count nouns, atelic from (singular) telic verbs, gradable from non-gradable adjectives, and verbs like *want* from (singular uses of) *know*.

Distributionally, *coffee* is a mass noun and *notebook* is a count noun. Mass nouns are natural and straightforwardly interpretable in direct composition with the quantificational determiners *some*, *most*, and *all*, (17a), while count nouns are not, (17b); a division along the same line is observed with *more* in the comparative, compare (18a) and (18b).

(17) a. some coffee, most coffee, all coffee
b. ? some notebook, most notebook, all notebook
(18) a. I bought more coffee than you did.
b. ? I bought more notebook than you did.

Semantically, the predominant way of distinguishing such mass and count nouns is in the structure of their domains of predication.[9] For example, mass nouns like *coffee* show cumulative and divisive reference: any two portions of coffee, taken together, count as coffee (cumulativity), and arbitrary subdivisions thereof also count as coffee (divisiveness).[10] The same, mutatis mutandis, is not obviously true of a notebook. Typically, such observations are taken as evidence that the relevant mass noun domains are mereologically structured but count noun domains are not.

Distributionally, *talk* is an atelic verb—it fails to include, as part of its intuitive descriptive content, information about an 'end' or *telos*—and *finish* is, in contrast, a telic verb. Atelic verbs are perfect in composition with temporal adverbials specifying the duration of a certain episode, (19a), while (singularly-interpreted) telic verbs are not, (19b); and, the same asymmetry is detectable with *more*, compare (20a) and (20b).[11]

(19) a. talked for an hour, talked the most
b. ? finished one sentence for an hour, finished it the most

(20) a. You talked more than I did.
b. ? You finished one sentence more than I did.

The distinction between atelic and telic verbs, too, has been attributed to differences in domain: two episodes of talking, considered together, count as talking (cumulativity), and arbitrary subdivisions thereof do too (divisiveness). The same can't be said for an episode of finishing a sentence. Thus it is usually held that atelic predicates denote in domains with mereological structure, while telic predicates do not.

Gradable adjectives like *tall* are distinguished from non-gradable adjectives like *pregnant* in being perfectly acceptable with modifiers indicating different extents of a relevant property. That is, in its plain form, *tall* indicates the property of having greater-than-average height. When modified, greater heights may be indicated, (21a); however, *pregnant* resists such modification, (21b), and the same split is observed in (22a) and (22b).

(21) a. Andre the Giant tall, tall to a great extent
b. ? full term pregnant, pregnant to a great extent
(22) a. He was taller than I was.
b. ? She was more pregnant than I was.

Early semantic treatments of the distinction between gradable and non-gradable adjectives typically resolve it as a difference in vagueness. Contemporary degree-theoretic treatments resolve it type-theoretically: *tall* (whether wholly or in part), but not *pregnant*, expresses a 'measure function'—a mapping from individuals to degrees along a scale representing, e.g., increasing height. Wellwood (2012, forthcoming), instead, suggests that the difference is one of domain: gradable adjectives are true of states ordered in terms of how much, e.g., height they instantiate, while non-gradable adjectives are true of states which are either simply instantiated or not.

Wellwood (2014, forthcoming) provides a similar analysis to account for certain differences between attitude predicates like *want* and *know*. Whereas one can want a certain man's phone number to a greater or lesser extent, (23a) and (24a), it is odd to say that knowing a certain man's name works the same way, (23b) and (24b).

(23) a. hardly wanted that man's number, wanted that man's number to a great extent
b. ? hardly knew that man's name, knew that man's name to a great extent
(24) a. I wanted that man's number more than you did.
b. ? I knew that man's name more than you did.

Villalta (2008) accounts for the difference between predicates like *want* $\phi$ and *know* $\phi$ in terms of their types, on a par with standard accounts of the difference between gradable and non-gradable adjectives (cf. Lassiter 2011). Wellwood (2014, forthcoming) suggests, instead, that *want* $\phi$ expresses a property of states ordered by increasing desire, whereas *know* $\phi$ expresses a property of states that one simply instantiates or not.

***2.2.2. Grammatical determinants*** The second major descriptive generalization concerns grammatical elaborations that bring along a shift in measurability. For example, while singular count noun occurrences like *beverage* in *a beverage* are non-measurable (cf. ?*I bought more beverage than you did*), their plural variants are (cf. *I bought more beverages than you did*). This distinction thus divides the singular and plural count NPs, singular versus plural telic VPs, non-gradable from stage-level APs, and singular from plural uses of *know* $\phi$.

A predicate once non-measurable is not always so. While bare count nouns like *notebook* are awkward in the 'non-singular' contexts in (25a) and (26a), their plural variants are perfectly acceptable and interpretable here, see (25b) and (26b).

(25) a. ? some notebook, most notebook, all notebook
b. some notebooks, most notebooks, all notebooks
(26) a. ? I bought more notebook than you did.
b. I bought more notebooks than you did.

Usually, mereological approaches hold that a bare form like *notebook* applies truthfully only to whole, individual notebooks, but not to arbitrary subparts of any given notebook nor to arbitrary groupings of notebooks. In contrast, *notebooks* applies to pluralities of notebooks, the minimal parts of which are individual notebooks. In other words, the domain of the plural predicate has a structure equivalent to the powerset of its singular correspondent.[12]

Similarly, or so I'll suggest, telic predicates used to describe singular episodes are awkward with quantificational language, (27a) and (28a),[13] but they are fine when used to describe a plurality of episodes, (27b) and (28b).

(27) a. ? finished that sentence for an hour, finished that sentence the most
b. finished your sentences for an hour, finished your sentences the most
(28) a. ? You finished that sentence more than I did.
b. You finished your sentences more than I did.

Mereological approaches extended to the verbal domain account for these data just like they do (25) and (26): a telic predicate can be singular or plural (cf.

Ferreira); when singular, it denotes a 'flat' set, in this case containing events; when pluralized, the predicate denotes an ordered set of pluralities thereof.[14]

Non-gradable adjectives like *pregnant* are not always bad with quantificational modifiers, nor in the comparative form. While modifiers that attempt to describe the extent of a given pregnancy are odd, (29a), those that quantify over occasions of being pregnant are fine, (29b); this is also the most natural sense invited when *more* appears following the adjective, compare (30b) to (30a).

(29) a. ? full term pregnant, pregnant to a great extent
b. pregnant every calendar year, pregnant again and again
(30) a. ? She was more pregnant than I was.
b. She was pregnant more than I was.

In Wellwood (2018, forthcoming), I argued that comparatives like (30b) are (syntactically and semantically) more like the verbal comparative in (28b) than like the adjectival comparative in (22a): they involve quantification over pluralities of events. Here, though, the relevant pluralities are derived from a lexically stative property: abstract syntax contributes functional structure that is interpreted as a map from a property of states onto a property of occasions on which such states hold, which is subsequently pluralized.

Wellwood (forthcoming) analyzes contrasts like (31) in a parallel fashion.

(31) a. ? Regarding that question, I knew the answer more than you did.
b. Regarding those questions, I knew the answer more than you did.

Instances of *know* $\phi$ are only non-measurable if used to describe singular states or occasions of knowing. In such cases, the sentence involves a singular property of states or events, on a par with a singular telic predicate like *finish one sentence*. In a context permitting multiple such episodes, (31b), the sentence can involve a property of pluralities of occasions consisting in knowing the (relevant) answer. This property, again, has the structure of a set of pluralities ordered by inclusion.

### 2.3. Compositional semantics

I describe the theory of comparatives in which the semantic contribution of *more* is fixed, in part, by the structure or lack thereof on the domain of its target XP.[15] The measurable predicates have extensions that are intrinsically ordered, as determined by the kinds of distributional evidence just discussed. I first present the compositional semantics of both the measurable and non-measurable predicates, emphasizing the interplay of lexical and grammatical factors in shifting the stuff or things targeted for measurement. Then I present the details for each of MUCH and ER.

***2.3.1. Measuranda*** I assume that mass nouns like *coffee* and atelic verbs like *talk* apply to anything matching their descriptive content, which includes, for example, any portion of coffee or episode of talking, and arbitrary subparts or superparts of the same. More formally, *coffee* expresses the function in (32a) and *talk* that in (32b), with $e$ is the type of ordinary entities (e.g., stuff and things) and $v$ the type of 'eventualities' (e.g., states, processes, and events; cf. Bach 1986).[16]

(32) a. $[\![ \text{coffee} ]\!] = \lambda x_e \,.\, \textbf{coffee}(x)$
b. $[\![ \text{talk} ]\!] = \lambda e_v \,.\, \textbf{talk}(e)$

These extensions have the structure of a partial order with a maximal element—the sum of all portions of coffee or episodes of talking—i.e., that of a join semi-lattice (Cartwright, Link, Bach).

The lattice-theoretic structure of the mass and atelic predicates secures their status as measurable predicates; in contrast, the domains of count and telic predicates lack such structure. The restrictions on the functions in (33a) and (33b) are included to capture the intuition that expressions like *notebook* and *finish* $\epsilon$, $\epsilon$ standing for whatever might have been finished, apply only to entities with no relevant subparts or superparts of the same type.[17,18]

(33) a. $[\![ \text{notebook} ]\!] = \lambda x_e : \text{Atom}(x) \,.\, \textbf{notebook}(x)$
b. $[\![ \text{finish } \epsilon ]\!] = \lambda e_v : \text{Atom}(e) \,.\, \textbf{finish}(e, [\![\epsilon]\!])$

Such extensions, then, lack interesting order-theoretic properties: each corresponds to a 'flat' set of entities.

Of course, a count noun like *notebook* is licit in the comparative form when it occurs with the plural morpheme; the semantic consequence of this derivation is a property of elements in the algebraic closure of the bare noun's extension (cf. Bale & Barner 2009). A parallel derivation is possible for the telic VP (se Wellwood, Hacquard, and Pancheva 2012), although the plural morpheme is silent in such contexts. I will use double variable names like $vv$ to range over pluralities, and the Greek letter $\nu$ to mark neutrality with respect to the basic types $e$ or $v$.[19] The interpretation of the plural morpheme, PL, in (34) takes a property of atoms to a property of pluralities that have those atoms as parts.[20]

(34) $[\![ \text{PL} ]\!] = \lambda P_{\nu t} : \text{Atomic}(P) \,.\, \lambda v v_\nu \,.\, \forall v_\nu [\, v \precsim vv \rightarrow P(v) \,]$

In canonical cases, the morpheme in (34) combines with lexically atomic predicates to deliver properties of pluralities; e.g. *notebooks* realizes the combination of *notebook* and PL, interpreted as in (35a), and the possibility of a 'zero derivation' of *finish* and PL is interpreted as in (35b).

(35) a. $[\![ \text{notebook PL} ]\!] =$
$\lambda x x_e \,.\, \forall x_e : \text{Atom}(x) [\, x \precsim xx \rightarrow \textbf{notebook}(x) \,]$

b. ⟦ [ finish $\epsilon$ ] PL ] ⟧ =
$\lambda e e_v$ . $\forall e_v$ : Atom($e$)[ $e \precsim ee \rightarrow$ **finish**($e$, ⟦$\epsilon$⟧) ]

The extensions have the structure of a partial order with a maximal element—that plurality which has all of the relevant atomic entities as its minimal parts.[21]

It is possible to capture the parallelisms in distribution and interpretation of gradable/non-gradable adjectives and attitude verbs by adding just one more piece. The major difference, if it is major, is just that such expressions are satisfied in part by states. The additional piece is the function in (36): it takes a property $P$ to a property of atomic entities $v$. It contributes nothing more to restrict entities $v$ except to say that they are constituted by some $P$-entity $v'$ (i.e., $v \rhd v'$).[22]

(36) ⟦ AT ⟧ = $\lambda P_{vt}$ . $\lambda v_v$ : Atom($v$) . $\exists v'_v$[ $P(v') \wedge v \rhd v'$ ]

Given these assumptions, gradable adjectives and attitude verbs are assigned lexical interpretations as in (37a) and (37b), paralleling the unrestricted interpretation of mass nouns and atelic verbs.

(37) a. ⟦ tall ⟧ = $\lambda s_v$ . **tall**($s$)
b. ⟦ want $\phi$⟧ = $\lambda s_v$ . **want**($s$, ⟦$\phi$⟧)

I assume that here, too, the states satisfying either of these properties are ordered with respect to the magnitude or intensity of the relevant sort. In contrast, non-gradable adjectives and attitude verbs express the properties in (38a) and (38b), which are restricted to atomic states.

(38) a. ⟦ pregnant ⟧ = $\lambda s_v$ : Atom($s$) . **pregnant**($s$)
b. ⟦ know $\phi$ ⟧ = $\lambda s_v$ : Atom($s$) . **know**($s$, ⟦$\phi$⟧)

While the gradable adjectives and attitude verbs lexically satisfy the measurability condition, like mass nouns and atelic verbs they can appear in syntactic structures that support different interpretations, as when they are combined with AT and PL. Under just these conditions, too, the non-gradable adjectives and attitude verbs are licit in the comparative form, as well; the relevant derived properties for the latter cases are given in (39a) and (39b).

(39) a. ⟦ [ pregnant AT ] PL ⟧ =
$\lambda e e_v$ . $\forall e_v$ : Atom($e$)
[ $e \precsim ee \rightarrow \exists s_v$ : Atom($s$)[ **pregnant**($s$) $\wedge$ $e \rhd s$ ] ]
b. ⟦ [[ know $\phi$]AT]PL ⟧ =
$\lambda e e_v$ . $\forall e_v$ : Atom($e$)
[ $e \precsim ee \rightarrow \exists s_v$ : Atom($s$)[ **know**($s$, ⟦$\phi$⟧) $\wedge$ $e \rhd s$ ] ]

***2.3.2. The selection of measures*** In general, two factors determine which dimension for comparison *more* $\alpha$ involves: (i) the nature of the satisfiers of $\alpha$, and (ii) how they're ordered. With respect to (i), it appears generally unavailable to measure stuff for its temporal duration, or to measure events for their weight. In other words, *more coffee* can't be used to describe how long the coffee lasted, and *run more* can't be used to indicate how heavy the runner was.

More importantly, with respect to (ii), while it is true that some coffee instantiates some amount of temperature, tastiness, volume, and weight, only volume and weight may be invoked by (40a), and only distance and duration may be invoked by (40b), despite any running also instantiating some amount of speed and effort expended (Schwarzschild 2002, 2006, Nakanishi 2007, Wellwood et al. 2012).

(40) a. I bought more coffee.
b. I ran more.

Similarly, while a screen that fades in and out of different colors can display some variation in pinkness, attractiveness, or hue, (41a) seems only to describe relative hue, and only the intensity of desire is permitted for (41b), despite any episode of wanting varying in how appropriate the desire is, or how suddenly it comes on.

(41) a. This screen is redder.
b. I wanted $\phi$ more.

It is standard in degree-theoretic treatments of comparatives to interpret the piece -ER as a strict exceeding relation between degrees; in (42), $\delta$ standing in for the *than*-clause (when present in the sentence[23]).

(42) $[\![\text{-ER } \delta]\!] = \lambda g_{vd} \,.\, \lambda v_v \,.\, g(v) > [\![\delta]\!]$

The argument $g$ to (42) is filled by MUCH, with its interpretation defined as in (43): it is a variable over measure functions **m**, fixed in a context by the assignment function $\sigma$ which maps entities of type $e$ or $v$ to a degree $d$.[24]

(43) $[\![\text{MUCH}_\mu]\!]^\sigma = \lambda v_v \,: \exists \precsim [v \in \text{Domain}(\precsim)].\ \sigma(\mu)(v)$

Definedness conditions on the interpretation of MUCH conspire to ensure that the relevant $v$s are drawn from a measurable domain $D_v$ (this requirement is represented in (43)), and that the selection of any given measure **m** preserves the structure inherent to $D_v$.

To capture the basic facts like that discussed for (40) and (41), the first condition placed on the selection of $\sigma(\mu)$ comes from Schwarzschild (2002, 2006), and is therefore called S(chwarzschild)-monotonicity in (44).[25]

(44) **S-monotonicity**
**m** is S-monotonic if, $\forall v, v' \in \text{Domain}(\precsim)$, $v \prec v' \rightarrow \mathbf{m}(v) < \mathbf{m}(v')$.

To see the effect of (44), consider that only volume or weight are possible measures given *more coffee*. $[\![coffee]\!]^{\sigma}$, we have said, consists of portions of coffee $c$, and its arbitrary subparts, $c' \precsim c$, or superparts, $c \precsim c''$. Clearly, for any two portions of coffee such that $c \prec c'$, it is true that **volume**$(c) <$ **volume**$(c')$ and **weight**$(c) <$ **weight**$(c')$, but it doesn't follow that, for example, **temperature**$(c) <$ **temperature**$(c')$.

The second piece comes from consideration of plural contexts, wherein the only available dimension is number. For instance, the sentences in (45) and (46) are only naturally interpreted as comparisons by number, whether of units of coffee, episodes of running to the store, etc., despite the dimensions otherwise available to their minimal variants (40) and (41).

(45) a. I bought more coffees.
b. I ran to the store more.
(46) a. That screen was red more.
b. I knew the answers more.

A theory of measure selection constrained only by (44) fails to predict the restriction to number in such cases (see Wellwood 2018, forthcoming). For example, a plurality consisting of three cups of coffee weighs more than a plurality consisting of two cups of coffee, but **weight** isn't permissible for (45a), etc.

The restriction to number for relevantly plural domains is effected by a second condition, A(utomorphism)-invariance. An automorphism $h$ is any bijective, endomorphic, and order-preserving function, i.e. an invertible map from a set into and onto itself such that $x \precsim y$ iff $h(x) \precsim h(y)$.[26] I thus relativize the selection of measures **m** to just those that map every element $v$ of the measured domain to the same degree as $h(v)$, for any automorphism $h$ on that same domain; see (47).

(47) **A-invariance**
**m** is A-invariant if, $\forall v \in \text{Domain}(\precsim_v)$, $\mathbf{m}(v) = \mathbf{m}(h(v))$.

Non–number-based measures for plural domains fail one or another of the requirements summarized by (47). Resuming the example of **weight**, while it may be true for arbitrary pluralities $ab$ and $b$ that $b \precsim ab$ and **weight**$(b) <$ **weight**$(ab)$, there is no guarantee that **weight**$(a) =$ **weight**$(h(a))$—for example, it may be that $h(a) = b$ but **weight**$(a) <$ **weight**$(b)$.

## 3. Theory

So far, the semantic analysis I have sketched will capture the basic data presented in §2: it assigns MUCH and ER an interpretation that allows them to combine with each other and relevant other morphemes to deliver accurate predictions about when native speakers will judge a comparative sentence true or false. Those judgments accord with the ordering relations on degrees permitted by S-monotonicity and A-invariance for the domain of predication introduced by XP given *more* XP. Readers satisfied by the presentation of an extensionally-adequate characterization of the compositional interpretation of such sentences need read no further.

Now I shift to consider what it is that people understand when they understand comparative sentences, and what it is that children have acquired when we want to say that they've acquired the meaning of *more*. This is thus an explicit look at semantic competence, rather than semantics simpliciter; however, I hope to show that a great deal of what is very interesting about comparatives happens here, and, correspondingly, is where we find much of the action for semantics as science. My study will aim to target how the formal analysis just sketched relates to broad issues at the interface between language and non-linguistic cognition.

Pursuing such a study through the lens of comparatives in particular is appropriate, now, as quite a lot is known on both sides of that interface. And indeed, without a lot of squinting, there are observations and generalizations that look like they should be tightly related. At the same time, a brief look at the cross-linguistic picture suggests that the relevant facts are remarkably uniform across languages. In fact, without any revision to our assumptions about what a semantic theory does, we'll find a host of 'suspicious coincidences'. I thus raise the question of whether we should not view these correspondences are revealing the interplay of deeper principles.

This section thus proceeds in two parts, the first focusing on issues surrounding decomposition, and the second on measures.

### 3.1. Why decomposition?

***3.1.1. No containment*** I have argued that *more* decomposes into two pieces. The evidence certainly seems to support such a conclusion. But why should the data look that way? Consider in light of this question the paradigm in (48), which shows elaborations of this decomposition that have been proposed in the literature.

(48) Some decompositions

a. MUCH ER $\rightsquigarrow$ *more* (Bresnan 1973)

b. MUCH ER EST $\rightsquigarrow$ *most* (Bobaljik 2012)

c. TALL MUCH ER EST $\rightsquigarrow$ *tallest* (Dunbar & Wellwood 2016)

Bobaljik (2012) motivates the decomposition in (48b) through the study of morphological patterning in over 300 languages, and supposes that the patterns he observed reflects a universal constraint on 'how much meaning' a single (functional) morpheme can have.

Dunbar & Wellwood (2016) explore and develop Bobaljik's (2012) hypothesis, offering a more formal characterization of the relevant ban as in (49), where the notion of containment is defined relative to a set of possible meanings, and a set of rules of meaning composition (e.g. that defined in Heim & Kratzer 1998; cf. Pietroski 2005).[27]

(49) **No Containment**
No functional morpheme's meaning can contain another's.

(49) is proposed as a constraint on grammars, such that if an expression in the language can be decomposed, it must be decomposed. Applying this sort of reasoning to forms like *tallest*, we expect MUCH to be present here, too. (All else equal, this approach predicts that we should be able to find languages with morphophonological evidence for such a derivation on the surface.)

In conjunction with a general expectation—though I know of little work that spells this idea out in its details—that the set of possible functional morphemes is universal,[28] we can use this analysis to make predictions about the kinds of form-meaning pairings we should observe across languages. In particular, we should expect to see evidence for decomposition everywhere, with the parts making up a given morphological whole aligning (i.e., carving up the same semantic work in the same ways) across languages. And there are readily-available, simple enough cases that are highly suggestive in this regard.

In the case of comparatives, a couple of expectations come immediately to mind. If the univocal form *more* in English with a meaning like that I've specified—i.e. one that is neutral with respect to a host of the 'basic' domain entities like individuals, events, states, etc.—is emblematic of a general pattern, then we should expect to find other languages using a corresponding univocal form to express the same meaning. A quick survey suggests that this is so, e.g. the forms in (50) show up in the noted languages regardless of whether APs, NPs, or VPs are targeted.

(50) Cross-categorial 'more' correspondents

| | |
|---|---|
| French | *plus* |
| Spanish | *más* |
| Italian | *piú* |
| Romanian | *mai* |

Perhaps more compellingly, we find languages that show the morphological decomposition into MUCH and ER on the surface. (51), for example, are suggestive (Bobaljik 2012).[29]

(51) Some apparent decompositional correspondents

| | MUCH | MUCH ER | MUCH ER EST |
|---|---|---|---|
| Romanian | *mult* | *mai mult* | |
| Lithuanian | *daug* | *daug-iau* | *daug-iau-siau* |
| Turkish | *çok* | *daha çok* | |
| Guaraní | *heta* | *heta-ve* | |

Convergent evidence for this general approach would come from observation of the kinds of errors that children make, and plausible analyses of those errors as ones of morphological patterning rather than of the appropriate semantics.

***3.1.2. Acquisition*** If analyses like (48c) are right, they must be so in virtue of something fundamental about how language packages meaning, which may show reflexes in the process of language acquisition. For example, we might see children's error patterns in language acquisition reflecting the challenges of figuring out how those (universally available) pieces align with the morphological wholes they encounter in their early linguistic input. This expectation would suppose that children have the set of functional primitives at their disposal, and their task is to figure out how those primitives align with the (sometimes conflated) morphophonological structures they're exposed to.

Some of the most suggestive evidence for children's sensitivity to the kinds of representations (and rules) proposed in this paper come from studies of children's production (for references, see Syrett 2016). For example, children have been observed to produce forms like *more dirtier* where an adult would simply produce *dirtier*. Such an observation can be viewed an over-application of the morphophonological rules that produce *more* from MUCH-ER and which affix *-er* to *dirty* (cf. Bresnan 1973). Similarly, children have been observed to produce forms like *prettiest than the girls* instead of *prettiest of the girls*; this, in turn, can be viewed as an instance where an agreement process mis-targets the underlying -ER form rather than -EST (cf. Bobaljik 2012).

Moreover, I have suggested here and elsewhere (Wellwood 2014, 2018, forthcoming) that we should not consider the surface form *many* to express its own lexical simple, but rather as the composite of MUCH and PL. If this is right, and given no semantic issue with combining MUCH and a plural noun, then we may expect children to go through a stage where they over-extend the surface form *much* with plural nouns. Crucially, however, we would not expect children to over-extend the form *many* to mass nouns. This is exactly what Gathercole (1985) observed: in her longitudinal study, children produced forms like *much books* as late as age 7 years 6 months, but they never produced forms like *many soup*.

With respect to the semantics, we might expect, all else equal, that children show competency with *more* across its syntactic occurrences as soon as they show competency with *more* in any one of those occurrences. So far, the evidence is

suggestive that acquisition proceeds in this 'all or nothing' fashion, though more work needs to be done. For example, children appear to comprehend adjectival comparatives at least by age 3 (see Carey 1978 for early references), and nominal comparatives by the same age (Odic 2017). Wellwood, He, & Farkas (in prep) finds strong evidence that children understand adverbial comparatives like *longer than* and *farther than*, and they show adult-like performance for comparatives with *walk more*.

Yet, while the evidence for 'all-or-nothing' acquisition is so far suggestive, it is not conclusive. So far, Wellwood & Farkas (under revision) did not find 4 year olds to differentiate *jump more* from *walk more* with respect to dimensionality, the way that adults would. A plausible explanation for this non-adult-like pattern, though, would appeal to the possibility that children have not yet figured out that the abstract syntax of the *jump* comparative must contain an instance of the PL morpheme, which is required for comparatives with telic VPs (see Wellwood et al. 2012).

### 3.2. Why those measures?

So far, the semantic theory supposes that if we have an independent theory of the domain of predication for a given noun N, verb V, or adjective A, then we will be able to predict the dimensionality for *more* plus N, V, or A in line with the S-monotonicity and A-invariance conditions. But how might we predict, for a novel noun *gleeb* or a novel verb *sprow*, whether sentences containing *more gleeb* or *sprow more* are true? Of course, the nature and structure of the extension of *gleeb* or *sprow* should determine the measure. But, how do we know what the extensions of *gleeb* or *sprow* are?

To put the matter in stark relief, consider (52).

(52) *Ann, presenting a funny-shaped glass object containing a bright blue liquid*:
   a. I bought this gleeb$_N$ today.
   b. I have more of it than Sue does.

Upon utterance of (52b) the question of what *gleeb* means isn't determined, since it could minimally apply to the funny-shaped object, or to the liquid it contains. Upon utterance of (52b), however, intuition suggests that *gleeb* applies to the liquid. Along with that, we know that Ann speaks truly with (52b), then the comparative is true by a comparison of volume.

The question is, do we predict patterns of intuition like this? On the face of it, no. And the reason for this, I'll suggest, is that the theory makes no necessary connection between morphosyntactic objects and how we conceptualize in situations like (52).

***3.2.1. Not making the prediction*** Nothing in the semantic theory, of course, says that we can't have a lexical item pronounced *gleeb* which applies to a certain sort of glass object. Neither does the theory say that that meaning becomes impossible when *gleeb* is used with *more*. Why couldn't *gleeb* apply to glass objects of the relevant sort, and to arbitrary subparts of those objects? In such a case, the requirement for an ordering would be satisfied, and the conditions on measurement could be calculated against that ordering.

It won't do to say that we can rule out that meaning by saying that it fails to accord with our lifetime of language experience, which tells us that nouns targeted by *more* don't apply to objects. First, because we do have such nouns: *furniture* and *weaponry* intuitively apply to objects, and occur perfect well with *more*. And second, children at an age where they're language experience is still quite limited, and who are still actively in the business of learning their language, don't seem to entertain such meaning hypotheses either (cf. Barner & Snedeker 2005).

Indeed, situations like (52) are presumably encountered all the time in first language acquisition. But if we can't predict with any confidence what a novel XP must mean, we cannot predict how *more* XP should be interpreted. This is a problem, among other things, if explaining language acquisition is the central goal of linguistic theory (Chomsky 1965). So far, we're only able to fit the behavior into the descriptive theory after we've observed the behavior. In other words, lacking an independent theory of what there is in the learner's environment, the theory will be little more than a post hoc accounting of the data.[30]

We can do better. Consider now some plain, intuitive generalizations which, considered in the present light might help to illuminate the solution. (53) condenses 4 distinct comparative sentences, each targeting a noun that, intuitively, applies to a kind of substance; all, expanded and considered, show the same pattern of dimensional interpretation.

(53) Ann bought more coffee/mud/gold/water than Sue did.
SUBSTANCE $\rightsquigarrow$ **volume**, **weight**

Here is how thinking about this can help with (52): if we knew that learners deploy only certain *classes* of concepts under such-and-so conditions, then a decent theory of conceptualization can tell us about their properties. For example, it may turn out that OBJECT concepts apply to entities but never arbitrary subparts of those entities.

This suggests a general approach where it is primarily the conceptual class of a given noun that matters for our purposes, not the grammatical class. The string in (54) expands to four different comparatives, two of which target mass nouns (*furniture*, *weaponry*), but all intuitively apply to objects, and the dimension is uniformly number.[31]

(54) Ann found more furniture/weaponry/chairs/Pokémons than Sue did.
OBJECTS $\rightsquigarrow$ **number**

Given an appropriate theory linking morphosyntax with conceptualization, we would expect that a minimal variant of the situation in (52) which presents pluralities of funny-shaped glass items would not necessarily rule out the object-based meaning for *gleeb*.

From another angle, the context in (52) doesn't seem to make a container-specific meaning BRIGHT BLUE LIQUID CONTAINED IN A FUNNY SHAPED GLASS OBJECT available for *gleeb*. It's tricky to come up with an appropriate context against which plausible intuitions might be checked. But here is an attempt: Ann's funny-shaped glass object is huge but contains little bright blue liquid, and she also has a barrel full of the bright blue liquid. Sue, meanwhile, has the same sort of glass object filled with more of the same liquid as Ann's, and Sue possesses no other amounts of that liquid. Under these conditions, could we hear *Ann has more gleeb* as false?

Parallel challenges for the acquisition of a novel verb like *sprow* can easily be constructed. For instance, one might consider a certain waggling circumnavigation of a certain sort of landmark, leading to intuitions about the meaning of *sprow* that leads to *more sprow* quantifying over the waggling sort of activity rather than over a complete circuit of the landmark. Here again, we want to know why such circuits—'events'—are not labeled by measurable verbs, but certain sorts of waggling—a 'process' (Vendler 1957)—are.

What appears to be missing is an independent theory of the conceptual categories that a semantic theory can interface with in a systematic fashion.

***3.2.2. Conceptualizing*** Meanwhile, research in vision science and cognitive development has revealed categories of perception and conception that are largely thought to be hard-wired. Humans, like other species, deploy these categories in order to parse and reason about the world around them. Importantly, these systems are often domain-specific, and encapsulated: depending on which categories are deployed, the mind can do different things. I'll emphasize some of what is known about the (psychologist's) distinction, then, between objects and substances, and between events and processes. And I'll show some directions in which a systematic alignment between these categories and portions of linguistic competence has been pursued.

For example, adults are able to consistently track up to 4 moving entities in an array (Pylyshyn & Storm 1988). This ability depends, however, on one's ability to parse the scene *in terms of* objects: if the moving entities appear to pour from one location to another, like a substance might, tracking ability is substantially impaired (vanMarle & Scholl 2003). Some evidence from infants suggests that they make a similar distinction. 8 month olds detected two rigid, cohesive objects made of sand being replaced with one such rigid, cohesive object, but failed to detect the change in quantity when the sand was poured (Huntley-Fenner et al. 2002). They did notice, however, when the poured pile of sand quadrupled in size (Hespos et al. 2012).[32]

What makes the difference in whether we are likely to see a scene as consisting of objects or substance? Various proposals exist, and echo the kinds of language used to describe semantic atoms: objects have some 'integrity' (Moltmann 1998), 'non-arbitrary structure' (Prasada et al. 2002), or, they meet a principle of 'unity and organization' (Rips & Hespos 2015) that substance entities lack. Indeed, they appear to be just the things that meet appropriate conditions for 'isolation' and 'non-arbitrary division', such that it makes sense to count them (see Frege's criteria; Koslicki 1997): while it is sensible to count how many cups are on the table, it is not sensible to count how many milks are in the cups.

Prasada et al. (2002) studied this by investigating adult's preferences to label one and the same portion of (novel) stuff in object as opposed to non-object terms. Presented with some regularly-shaped as opposed to irregularly-shaped stuff (think of clay molded into the shape of a cube as opposed to a splatter), participants preferred to label the former using a noun in count syntax but the latter with the same novel noun in mass syntax (e.g., *a blick* vs *some blick*). Presenting the irregularly-shaped piece alongside others of the same shape, this preference flipped; and this shift wasn't merely due to the presence of a multiplicity—presented with discrete pieces of the stuff in different shapes, participants' preferences flipped back.

Less is known about the representation of events and processes, though research that suggests a primitive basis for event vs process representation is accruing. First, we know that adults represent events at different temporal grain-sizes as hierarchically nested (e.g. Zacks & Swallow 2007). They have also been observed to perceive that the time taken for a continuous flow of activity differs depending on how that activity is structured: an object moving continuously along a spatially contiguous path was perceived to take less time than an object moving for the same duration along discontinuous parts of the same path (Liverence & Scholl 2012). According to those authors, this reflects a difference in the number of events represented. Infants, meanwhile, can detect numerical differences between sets of jumping events (Wynn 1996), even controlling for differences in continuous extent (Wood & Spelke 2005).

Recently, Wellwood et al. (2018a,b) investigated the distinction between events and processes directly, leveraging the semantic analogy between the referential properties of NPs and VPs to advance this discussion (see Taylor 1977, Bach 1986). At issue was whether there was a common psychological construct corresponding to the presence of the predicate Atom in smantic representations like (55) and (56).

(55) . . . $\mathbf{fem}_N$ **(-s)** . . .

a. $[\![ \text{fem} ]\!] = \lambda x_e \,.\, \mathbf{fem}(x)$

b. $[\![ \text{fem PL} ]\!] = \lambda x x_e \,.\, \forall x_e : \underline{\text{Atom}}(x)[\, x \precsim xx \rightarrow \mathbf{fem}(x)\,]$

(56) . . . $\mathbf{sprow}_V$ (PL) . . .

a. $[\![ \text{sprow} ]\!] = \lambda e_v \,.\, \mathbf{sprow}(e)$

b. $[\![ \text{sprow PL} ]\!] = \lambda e e_v \,.\, \forall e_v : \underline{\text{Atom}}(e)[\, e \precsim ee \rightarrow \mathbf{sprow}(e)\,]$

Building on important antecedent work (e.g. Soja et al. 1991, Prasada et al. 2002, Maguire et al. 2011), we manipulated whether a flower-like line drawing with *n* 'petals' was broken up into *n* arbitrary vs non-arbitrary pieces (images condition), and whether an object traversed an invisible path corresponding to those drawings, with temporal pauses replacing the spatial gaps (animations condition). In our first experiment, we asked how people would prefer to describe the image or animation, given a choice between *there is/are some gleeb(s)* (images) or *the star did some gleebs/gleebing* (cf. Barner et al. 2008). We found that non-arbitrariness of shape, whether spatial or temporal, strongly predicted the resulting judgments: adults strongly preferred count syntax to describes scenes with non-arbitrarily divided stuff/process.

To show the systematic correspondence between these categories of conceptualization, and the choice of dimension with *more* requires some more work. There are two kinds of study wanting: (i) the same world is presented but described using known language that implies a difference of category, and the grammatical categorization predicts dimensionality (validating the semantic theory); and (ii) two 'unambiguous' worlds (as determined independently by research in cognitive psychology) are presented, and the conceptual category directly predicts dimensionality.

Both types of tests have been conducted for object and substance. Regarding (i), adults evaluated *more of the blob* by area and *more of the blobs* by number, given identical displays of blobby dots (Odic et al. 2018). Regarding (ii), adults evaluated *more fem* by area when presented with what was plausibly parsed as scattered substance, and by number when presented with scattered objects (Barner & Snedeker 2004). Preliminary results from the dynamic domain suggest similar patterning (Wellwood et al. in prep): (i) presented with scenes in which two entities, A and B, move up and down on the screen a different number of times and to different distances, adults evaluted *jump more* by number but were more flexible with *move more*; (ii) minimally different animations lead to measurable differences in adults that can be used to detect visual effects on quantification.

## 4. A speculative proposal

Somehow, speakers come to acquire a language which links words with basic categories of (mental) concepts and categories that they otherwise deploy, quite unselfconsciously, in order to represent and reason about the world. Given an appropriate linking hypothesis, it should be possible to explore these connections using the formal semanticist's toolkit, as some of the work just reviewed has done.

One hypothesis worth exploring is that lexical items act as 'pointers' into conceptual domains, outside of language (Glanzberg 2014). This is so for *coffee* and *run*, for example. Items like *more*, then, might be understood as generalizations over operations that are defined at the class-level. There are good reasons to think such an account could be fruitful. Many cognitive psychologists and

developmental psychologists have described the properties of 'core' cognitive systems, systems for representing and reasoning about different content domains, and which operate in a more or less modular, encapsulated fashion (e.g. Spelke 1998, 2003; Carey 2009).

But what about the fine-grained functional vocabulary, of which MUCH and ER are members? One (strong) way of thinking about the relationship between these morphosyntactic pieces and extralinguistic units is that it is one to one. Then it would simply be a matter of discovery which pieces of morphosyntax are related to which dedicated representations or operations in nonlinguistic cognition. Such an approach can certainly be methodologically useful (see, e.g., recent discussion and references in Tucker et al. 2018). However, discovering whether this strong hypothesis has evidence in its favor will depend on very many factors, both properly linguistic and nonlinguistic. I offer some speculations here.

The meaning of MUCH, in particular, may be thought of as some kind of pointer, too, but to a domain general concept (this is the term used in Odic 2017). This perspective is made possible on my account of the semantics of *more*, but not on previous accounts. For Kennedy (1999), like Cresswell (1976) before and many since, gradable adjectives lexically encode measure functions—usually, mappings from individuals to elements of scales—in with little to no expectation for structure-preserving relationships between input and output. Similarly, many semanticists have supposed that the *more* that appears with mass nouns is different from that which appears with count nouns, the latter hard-wiring a function from pluralities to their cardinalities. A uniform analysis in which MUCH introduces the measure, in tandem with certain results from psycholinguistics and cognitive psychology, are thus suggestive.

Children's earliest demonstration of competency with *more*'s cousin, *most*, has been shown to be independent of the children's developing knowledge of precise cardinality. Just like adults under speeded conditions, children instead use representations from their approximate number system (ANS) to evaluate comparatives with plural nouns (Halberda et al. 2008). The ANS is an evolutionarily-ancient system that generates percepts of 'numerosity', demonstrably in place in human children within the earliest time window in which it is possible to test (see especially Dehaene 1997, Feigenson et al. 2004). In contrast, demonstrating facility with natural number requires an exceedingly lengthy, explicit learning process, which is striking in light of how quickly it appears that almost any other category of expression is acquired.[33]

On my formal theory, both **approximate number** and **exact number** are grammatically-licensed measures with plural XPs, just in case both meet the structure-preservation conditions imposed on that valuation. And indeed, despite the fact that natural number is modeled as a set of ordered points and ANS representations as ordered Gaussian distributions, these two 'scales' are isomorphic (e.g., Gallistel & Gelman 1992; cf. Odic et al. 2015); if one of them satisfies S-monotonicity and A-invariance, so will the other. As Gallistel & Gelman (1992) discuss in detail, a child's protracted learning path to natural number

understanding could be due to difficulty in establishing the relevant isomorphism betweentheir count list and their antecedently-available ANS.

Such considerations raise the possibility of deep connections between the grammar of comparatives and the cognition deployed for magnitude estimation and comparison, suggested in quite another context by Fox & Hackl (2006). They argue that it is possible to resolve a grab bag of grammatical puzzles related to exhaustivity inferences, scalar implicature, question semantics, and definite descriptions, only if the scales invoked by natural language are dense. They note the odd consequence of this that, "when we say that John has 3 kids or that he has more kids than Mary, the presupposed scale [. . . ] is not the ordered set of natural numbers or anything like it. Instead, it is the same domain of measurements that is needed to capture our intuitions of space and time, something closer to the rational or real numbers" (538)—in other words, just the sorts of structures posited for magnitude estimation systems like the ANS.

Are these just coincidences? If so, the more relevant data accrues, the more suspicious they look. It seems to me that these observations are telling us that we should pursue something like the strong linking hypothesis sketched above, however treacherous it seems on its face. Stating the matter again: We appear to find evidence for the same set of morphosyntactic pieces, even if bundled differently on the surface, being 'wired' into cognition in quite the same ways (within and across individuals, across development, and across languages; see e.g. Halberda et al. 2008, Hackl 2009, Pietroski et al. 2009, Lidz et al. 2011, Tomaszewicz 2011 on the study of *most*).

I think that the data, and the current gap in our ability to predict much of it, warrants reconsideration of the dichotomy between the study of semantics proper, and of semantic competence. The view of semantic theory on which it obviously maps expressions to things in the *mind independent* world (Lewis 1970) is complicated by the apparently pervasive intrusion of categories of mind that are not, themselves, usefully characterized in terms of the way the world is, so much as the way we think the world is (cf. Scholl 2007). Yet the usual fall-back position—that semantics relates linguistic expressions to what we "talk *as if*" there is—isn't particularly useful, either, if at the same time we deny that such talk reflects our human cognition (e.g. Bach 1986, Pelletier 2011, Moltmann 2017).

One promising approach is to think about our semantic theory in terms of charactrizing functions-in-extension versus functions-in-intension in Church's (1941) sense. In the former sense, we characterize a set of input-output pairs, using whatever theoretical vocabulary we have available to us; in this sense, $\ulcorner \lambda x_e \, . \, \textbf{coffee}(x) \urcorner$ is just a fancy name for a set, one of many equivalent formulations. In Church's sense of 'intensional', though, different extensionally-equivalent ways of specifying the function correspond to different *ways of computing* the function. In the context of an explicitly cognitive theory, we can produce formal statements that specify *different psychological hypotheses* about

the information and operations involved in understanding the meaning of a given expression (i.e., as specifying 'Level 1.5' information, see Peacocke 1986; Lidz et al. 2011; cf. Marr 1982).

In this way, semantics as typically practiced—a practice that regularly provides for, among other things, the existence of whatever sorts of entities with whatever structural relations between them is required to get good compositional explanations off the ground—should "in effect" be considered "an extension of syntax," specifying "the construction of another level of mental representation beyond LF ['Logical Form']", a level which may itself enter into ""real semantic interpretation"' (Chomsky 1981, p324)—i.e. what Lewis has in mind. If so, there can be real and present movement on testing specific linguistic and semantic hypotheses by leveraging an independent theory—that provided by cognitive psychology—which has so far been wanting.

## 5. Conclusion

I've given an analysis of *more* in which it invokes something very much like the concept of measurement. Figuring out whether a sentence with *more* is true often involves checking in with cognitive systems that represent and compute magnitudes. I suggested that a theory of the meaning of *more* will tie together our formal and explicitly cognitive studies, delivering new avenues for profitable inquiry into the nature of language and mind. The cognitive science of the future, in my view, will draw on formal semantic description as a means of developing novel and sophisticated hypotheses about mental representation. The linguistics of the future will say how the functional and contentful vocabularies of language interact with mental representation in the ways that they distinctively do. Hopefully, it will also say *why* they interact in those ways.

The semantic theory I've defended for *more* assigns little heavy-lifting to any element of the open-class vocabulary, and very little to any particular element of the closed-class. Instead, morphemes like MUCH and -ER, appropriately generalized, each have a job to do, and they do their job wherever they occur. Meanings get fancier as the number of functional morphemes increase, and combine in just the way that they do. This sort of theory raises to the fore questions about the set of possible (functional) morphemes, and restrictions on that set such that we should expect to see decomposition like this all over the place. I've barely scratched the surface of these questions here, instead focusing my attention on connections between the semantic theory and the relevant neighboring sciences.

Such an exploration opens up new questions that have and will mutually benefit research in formal semantics, cognitive science, and the philosophies of language and mind of mind. Far from remaining neutral on the question of what sorts of stuff our expressions relate to, semantic theory can be seen as, in fact, busily offering testable hypotheses about the representations and operations that linguistic representations call for out of the maze of nonlinguistic cognition.

And that's good. At least, if it's true, semanticists will be well-placed to shine in the relevant interdisciplinary engagements: there are so many things that we theorize to exist or happen, which other cognitive scientists haven't even heard of. More than just supposing that we model "talk *as if*", our probes could prove instrumental to a deeper understanding our common linguistic and cognitive inheritance.

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## Notes

1. I use small caps to indicate morphemes, the smallest meaningful grammatical units, and italics for mentions of expressions. The way I use these conventions, expressions like *more* may be internally complex, but morphemes like MUCH, by hypothesis, are not.
2. She supposes this is so apart from nominal plural contexts, where she allows *more* to decompose into ER plus a distinct primitive, MANY. See the next section.
3. Cresswell 1976 suggests initial evidence for treating *much* as semantically significant at the end of his paper, noting the non-synonymy of *Drink this water* and *Drink this much water* (cp. the *much*-support approach of Corver 1990; cf. Rett 2008, 2015, Solt 2015).
4. The rules have been '*much* deletion' and 'comparative formation'. See Dunbar & Wellwood 2016 for recent discussion.
5. Of course, an appropriate morphophonological theory will also need to say how the impact of PL fails to impact the rule of comparative formation sketched in the previous section.
6. Here and below, I use '*' to mark the hypothesis that a string is ungrammatical, and I use '?' to simply indicate that there is something semantically odd about an otherwise-grammatical sentence.
7. See Doetjes 1997 for a broader cross-linguistic look at morphological patterning like this.
8. Characterizing the data as indicating distinctions at the 'lexical' level is more than a little contentious. Some morphological and semantic theories, for example, treat the mass/count distinction as decided grammatically, not in the lexicon. I set these complications aside here.

9. For early discussion, see Quine 1960, Cheng 1973, Cartwright 1975, Massey 1976, Burge 1977, Bunt 1979, 1985, Link 1983, Krifka 1989.
10. 'Arbitrary', to a certain limit; see discussion especially in Bunt 1979, 1985, and Champollion 2010.
11. (20b) has an alternative reading that implies your number of completed sentences exceeded mine by 1. This reading corresponds to a parse of (20b) that is orthogonal for present purposes.
12. This is so whether those pluralities are conceived of as a sets (Winter 2001; ordering: subset relation) or sums (Link 1983; ordering: individual part). A little more will need to be said if plural domains are modeled as aggregates (Gillon 1992) or replaced by the use of plural variables (Boolos 1984), recently: Yi 2005, McKay 2006).
13. van Geenhoven 2004 has a nice discussion of 'coercions' in this domain, in her discussion of 'pluractional' morphology in West Greenlandic. She ultimately analyzes pluractionality in terms of times, rather than events. See Cusic 1981 for a look at pluractional morphology across languages, and Henderson 2012 for an event-semantic treatment of such morphology in Kaqchikel, a Mayan language.
14. As above, this glosses over some details and debates in the semantics of plurals.
15. With respect to the background mereological theory, I essentially follow Champollion & Krifka 2016. The relevant notion of parthood, indicated by $\preceq$, is understood to be 'unstructured' as opposed to 'structured'. For example, a hand is a structured part of an arm, but an unstructured part of a plurality of hands, etc. See *ibid.*, pp. 513-515.
16. (32a) is the characteristic function of the set $\{x \in D_e \mid x \text{ is coffee}\}$, and (32b) that of $\{e \in D_v \mid e \text{ is talk}\}$, etc.
17. The usages in (33b) suggest that atoms are atoms simpliciter, not relative to a description. They imply a very fine-grained ontology indeed.
18. A recent crop of work suggests that Atoms are determined in a context-sensitive fashion; see e.g., Rothstein 2010, Sutton & Filip 2016. If so, the predicate Atom can be rewritten here and below as $\text{Atom}_c$.
19. I use the double letter variable notation from plural logic, with the intention only of making it visually clear when pluralities are at issue (i.e., those predicates for which a relation $\preceq$ is defined, but which bottoms out in atoms). I think it possible for my semantics to remain neutral, for the most part, with respect to the best representation of pluralities. The way I've set up the system here, though, pluralities are of the same type as singular individuals—whether type $e$ or $v$—as in Link 1983 and others.
20. Where I use $\preceq$ to relate pluralities to their parts, Liebesman (2016) uses the more neutral formulation $A(v, vv)$, which could be read as '$v$ is among/one of/part of/a subset of $vv$', depending on how one resolves the nature of pluralities. Crucially, though, I assume that relations like $\preceq$ are defined only between things of the same type, as noted previously (see Champollion & Krifka 2016).
21. I thus assume the 'inclusive' theory of plurality; see Gillon 1992, Zweig 2008, 2009, among others.
22. The symbol '$\triangleright$' is used by Link 1983 to indicate a relation of material constitution, cf. the $C$ relation in Parsons 1979. I use it to indicate material constitution when formalizing the semantic relationships between, for example, *coffee* and

*coffees*; Wellwood 2018, forthcoming suggest that it is the covert counterpart of the 'singulative' morphology that surfaces in other languages. In the same way as $\preceq$ is 'overloaded' to stand in for 'the appropriate ordering relation' given the input arguments, $\triangleright$ can indicate material *or* temporal constitution. I assume nothing more about the latter relation than that it holds between two eventualities, e.g. event $e$ and state $s$, just in case the occurrence of $e$ is wholly temporally dependent on and coincident with the instantiation of $s$.

23. 'Intransitive' uses of the comparative like (40) and (41) suggest analyzing -ER as bringing along an implicit argument that is valued by $\sigma$ when there is no *than*-clause. In that case, a more perspicacious notation would look like $[\![\text{-ER}_{\delta}]\!]^{\sigma}$, with $\sigma(\delta)$ on the right hand side of $>$. See Alrenga et al. 2012 and Larson & Wellwood 2015.
24. Alternatively, -ER may be interpreted in terms of an inclusion relation between sets of degrees, or *intervals*; see e.g. Schwarzschild & Wilkinson 2002, and discussion and references in Fleisher 2016.
25. Schwarzschild's analysis restricts $\preceq$ just to part-whole relations, but (44) generalizes that definition to whatever ordering obtains between $v$ and $v'$. This assumes a very fine-grained picture of the domain, as indicated also by my use of 'inherent' in referring to the ordering on the relevant $v$s and $v'$s.
26. In other words, an automorphism is a strongly structure-preserving permutation.
27. In (49), I use 'morpheme' where Dunbar & Wellwood use 'head', the more technically-accurate usage.
28. That is, universally available, even if not universally expressed. For detailed discussion of the kinds of crosslinguistic differences that have been observed in the expression of comparative morphology, see e.g. Beck et al. 2010; Beck 2011, and Bochnak 2013, 2015. See Mitrović & Sauerland 2014 for an explicit statement of this assumption, applied to the crosslinguistic expression of coordination and disjunction.
29. Bobaljik 2012 doesn't investigate the matter of cross-categorial occurrences, so I do not know how these forms are preserved/changed across AP, NP, and VP contexts. See Doetjes 1997 and Neeleman et al. 2004 for detailed morphosyntactic discussion of these sorts of morphological paradigms.
30. The form of the problem is quite general, and may be reproduced across syntactic categories. And the issue, as Chomsky (1959) put it (in quite a different context), is that "we don't know what the current stimuli are until [the subject] responds".
31. I follow Gillon 1992 and subsequent works in supposing that mass syntax *per se* makes no commitments with respect to atomicity; see Gillon 2012 for an accessible overview of the relevant issues.
32. For an overview of the substance/object distinction in cognitive psychology, see the reviews in Hespos & vanMarle 2012 and Rips & Hespos 2015.
33. If words for natural number develop at all; cf. Pica et al. 2004.

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