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Investigating the form-meaning mapping in the acquisition of English and Japanese measure phrase comparatives

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Abstract We present a set of experiments investigating how English- and Japanese-speaking children interpret Measure Phrase comparatives (e.g., *X is 10 meters taller than Y / X-wa Y-yori 10-meters takai*). We show that despite overt cues to the comparative interpretation (i.e., the comparative *-er* morpheme in English, and explicit linguistic and visual reference to a contextual standard), children representing both languages diverge from their adult counterparts in that they access a non-adult-like 'absolute measurement' interpretation (i.e., *X is 10 meters tall*). We propose to account for their response pattern by appealing to proposals by Svenonius and Kennedy (in Frascarelli, ed., Phases of interpretation, Mouton de Gruyter, 2006) and Sawada and Grano (Nat Lang Semant 19:191−226, 2011) that *Meas* in the head of the DegP, which houses the differential, selects for an absolute minimal value: zero. We argue that young children appeal to this absolute zero minimum in lieu of the correct derived standard, and must learn to override this value by appealing to the context to set the standard of comparison when interpretation requires them to do so.

Keywords Language acquisition · Measure phrases · Differentials · Comparative constructions · English · Japanese

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1 Introduction

It is by now well established that English *gradable adjectives* (GA) such as *tall* have a comparative interpretation not only in the explicit comparative form with the *-er* morpheme, as in (1a) and (1b), but also in the plain (unmarked) positive form, as in (1c).

(1) a. This building is taller than that building.
b. This building is taller.
c. This building is tall.

The *-er* comparative morpheme in English expresses an *explicit* comparison between the maximal height of two individuals—either between the individual in the subject position and the one in the *standard phrase* introduced by *than*, as in (1a), or between the subject and a salient contextually retrievable standard, as in (1b) (e.g., another building or another salient object). However, the plain form of the adjective in (1c) also expresses a comparison—albeit an *implicit* one—between the height of the individual in the subject position and a contextual standard generated from a comparison class (e.g., buildings in the same district, architecture around the world, other objects in the immediate environment, etc.) (Bierwisch 1989; Cresswell 1976; Kamp 1975; Kamp and Partee 1995; Klein 1980; Sapir 1944; Siegal 1976; among others).

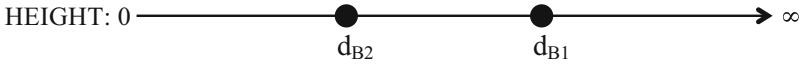
This pattern holds because *tall* and other GAs have a denotation that performs a mapping between individuals and totally ordered degrees on a scale, and requires that the truth value of the sentence in which the GA appears depends on the relation between these degrees, one of which serves as the standard of comparison.[1] These two types of comparisons can be schematized as in (2), where the degrees mapping to the two buildings (B1, the taller building, and B2, the standard of comparison), as well as to the contextual standard S_C, are captured on a scale whose dimension here, as determined by the adjective *tall*, is height (see especially Cresswell 1976; Heim 1985; Hellan 1981; Hoeksema 1983; Kennedy 1999, 2001; Pinkal 1989; among others).[2]

[1] We therefore assume, following others (e.g., Cresswell 1976; Heim 1985; Kennedy 1999; von Stechow 1984b), that GAs such as *tall* may have either of the following denotations, both of which relate individuals and degrees. In this paper, we will adopt (ii). We return to this denotation in Sect. 2.

i $[\![tall]\!]_{\langle d, et\rangle}$: $\lambda d.\lambda x.\text{tall}(x) \geq d$
ii $[\![tall]\!]_{\langle e, d\rangle}$: $\lambda x.\text{TALL}(x)$

[2] Schwarzschild (2008) has also described the sentences in (2a) as expressing that there is some threshold of height that the first building meets (and exceeds), but which the second building does not.

(2) a. This building is taller than that building.



b. This building is tall.

The same pattern of implicit and explicit comparison occurs in a language such as Japanese, as illustrated in (3), despite the fact that there is no overt comparative morphology in this language (Beck et al. 2004; Kennedy 2007a; Sawada 2009). In (3a), the explicit standard is provided by the *yori*-phrase, which is comparable to the English *than*-phrase. Although there is no comparative morpheme in (3b), the sentence indicates that the building is tall as compared to some stored or contextually retrievable standard.

(3) a. Kono biru-wa ano biru yori takai.
This building-TOP that building than tall
'This building is taller than that building.'
b. Kono biru-wa takai.
This building-TOP tall
'This building is tall.'

The English sentences in (1) allow for the introduction of a *Measure Phrase* (MP), as seen in the underlined phrases in (4). Here, however, two semantically distinct interpretations emerge, depending on the form of the adjective—whether it is explicitly comparative or in the plain, positive form.

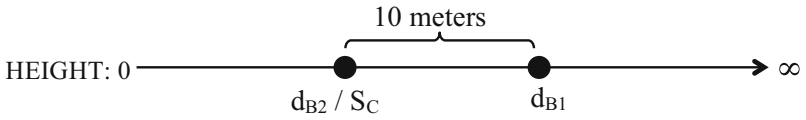
(4) a. This building is <u>10 meters</u> taller than that building. *differential comparative*
b. This building is <u>10 meters</u> taller. *differential comparative*
c. This building is <u>10 meters</u> tall. *absolute*

In (4a) and (4b), the GA *tall* carries the overt comparative morphology *-er*, and the MP indicates the extent to which the target degree (the degree of the first building's maximal height) exceeds the standard degree (the degree of the second building's height in (4a), or the contextual standard in (4b)). The comparative force of the original sentence is retained in both cases. In what follows, we will refer to this type of interpretation as a *differential comparative* interpretation.[3] (See Beck 2011, Schwarzschild 2005, and von Stechow 1984a for further discussion.)

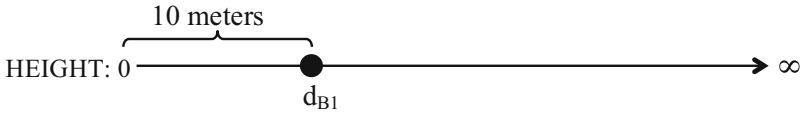
[3] The term '*differential comparative*' is generally used to refer to the relevant form in languages like English (i.e., MP+comparative GA) and to a particular semantic interpretation (e.g., von Stechow 1984a). In this paper, however, we will restrict the term's referent to the semantic *interpretation* alone, due to the morphosyntactic differences between the relevant constructions in English and Japanese. We use the phrase '*MP comparative*' to refer to the *surface form* in either language that yields the differential interpretation.

In contrast, (4c), where the GA is in its plain, positive form, obligatorily expresses the *absolute* height of the building, not how much it deviates from a shiftable contextual standard. In this case, the MP specifies the absolute degree to which the building extends along the dimension of height. The two semantically distinct contributions of the MP in English are illustrated in (5).

(5) a. This building is 10 meters taller (than that building).



b. This building is 10 meters tall.



The Japanese comparatives in (3) also allow for the introduction of an MP into the sentences, as illustrated in (6). In contrast to their English counterparts, those forms obligatorily yield comparative interpretations, regardless of whether there is an explicit standard phrase or not.

(6) a. Kono biru-wa ano tawaa yori 10 meetoru takai.
This building-TOP that tower than 10 meters tall
'This building is 10 meters taller than that tower.' *differential comparative*

b. Kono biru-wa 10 meetoru takai.
This building-TOP 10 meters tall
'This building is 10 meters taller.' *differential comparative*
#'This building is 10 meters tall.'[4] *#absolute*

Due to the absence of overt comparative morphology in Japanese, the sentence in (6b) appears at first glance to correspond to the English (4c): an MP composed with a GA in the plain, positive form. These sentences yield two distinct semantic interpretations, however. The Japanese version is obligatorily comparative, indicating that the building in question is 10 meters taller than some retrievable contextual standard (Hayashishita 2009; Kikuchi 2006; Kubota 2011; Nakanishi 2007; Snyder et al. 1995), but not that the building is 10 meters tall, as in the English example.[5] The absolute interpretation that is associated with the English

[4] Here, '#' is taken to mean that the intended meaning cannot be generated from the target string, although the string itself is licensed under another interpretation.

[5] See also Oda (2008) for a proposal about the inherent comparative nature of Japanese gradable adjectives, which is consistent with the obligatory differential comparative interpretation associated with (6b). We return to this proposal in the Discussion (Sect. 7) in light of the evidence we present from our acquisition studies.

counterpart is simply not available in this Japanese example. In order to express an absolute measurement, speakers of Japanese must resort to an explicitly non-comparative construction: a copular sentence with a nominalized GA (e.g., Watanabe 2013).

(7) a. Kono biru-wa takasa(-ga) 10 meetoru da.
This building-TOP height(-NOM) 10 meters COP
'The height of this building is 10 meters.'

The possible patterns of form-meaning mapping in English and Japanese are summarized in (8) and (9).

(8) English form-meaning mapping patterns:

Form	**Meaning**
plain GA (e.g., *tall*)	*comparative*
comparative GA (e.g., *taller*)	*comparative*
MP + plain GA (e.g., *10 meters tall*)	*absolute*
MP + comparative GA (e.g., *10 meters taller*)	*differential comparative*

(9) Japanese form-meaning mapping patterns:

Form	**Meaning**
plain GA (e.g., *takai*)	*comparative*
MP + plain GA (e.g., *10 meetoru takai*)	*differential comparative*

These observable variations in the interpretation of comparative and MP constructions in English and Japanese would appear to pose a challenge for the child acquiring language. Not only does she need to determine whether or not there is comparative morphology in the language she is acquiring and how comparative constructions are instantiated in general; she also needs to determine the range of possible interpretations associated with these various forms. We focus on English and Japanese here, because of the clear contrast between the interpretations available with the MP + plain GA combination. The picture becomes much more complicated for the language learner when one considers a wider range of interpretive and structural variability across languages. (See Beck et al. (2009) and Beck (2011) for overviews.) Our tactic is to zero in on one particular contrast between two languages in order to isolate one specific puzzle: the acquisition of differential comparatives and MP constructions. In doing so, we highlight further challenges that arise in the acquisition of comparative constructions in general.

At first glance, in English, the acquisition of comparatives might ostensibly seem simple: there *is* a comparative morpheme in this language, and when it is present, the sentence carries a comparative interpretation. However, there is a challenge with plain-form positive GA constructions. Even in the absence of the comparative morpheme, the GA yields a (implicit) comparative interpretation, as we observed in (1). But when an MP is introduced with this non-comparatively-marked GA, the comparative force completely disappears, and an absolute interpretation is the only

one available. Furthermore, when an MP is combined with a GA in the comparative form, the absolute interpretation is not available. That is, the range of possible interpretations for each MP construction is highly restricted, and determining what kind of interpretation is possible or impossible with a certain form is by no means a simple task.

Perhaps, then, Japanese is the more consistent and transparent language for the language learner: despite the lack of comparative morphology, a comparative interpretation is *always* present with a GA, even when an MP is introduced with the bare GA. (See Oda 2008.) It is therefore tempting to expect that Japanese children have it relatively easy, in that they can always stick with a comparative interpretation. Thus we might expect Japanese children to rapidly converge on the target comparative interpretation of the relevant constructions as soon as they acquire the correct comparative semantics associated with GAs. English-speaking children, in contrast, should initially show some confusion with respect to MP+GA constructions, at a point in development when they appear in many ways to have already mastered the semantics of the plain-form GA and non-MP comparative constructions.

What is striking, though, is that in our research we find the same non-adult-like pattern of behavior in children across both languages—a pattern that does not correspond to these expectations. To preview our results: we show that children acquiring English and Japanese strikingly resemble each other in that they are inclined to interpret MP comparative constructions as expressing *absolute* measurement, rather than assigning the differential comparative interpretation, which is the only possible option in their target language. They do so regardless of explicit comparative morphology (English) and regardless of the fact that their language does not generate this absolute interpretation in the grammar (Japanese). Furthermore, they appear to be oblivious to fact that the *than*/*yori* standard phrase obligatorily signals the presence of comparison relative to a contextually-retrievable standard. This pattern seems to persist well into 5–6 years of age, indicating that children arrive at these interpretations despite any input they have encountered that should have led them to different interpretations. We are therefore led to conclude that children from both languages have access to the same semantics of the MP construction, which leads them to adopt non-adult interpretations in both instances.

The rest of the paper is structured as follows. In Sect. 2, we review the theoretical background concerning MP comparative constructions and differential interpretations. In Sect. 3, we briefly review previous developmental findings relevant to children's interpretation of comparative constructions. In Sects. 4 through 6, we present a set of experiments on children's interpretation of differential comparatives with and without a standard phrase, along with results from adult control participants in both languages. Finally, in Sect. 7, we summarize our combined results and argue that the source of children's non-adult-like interpretations of the target constructions seems to lie in the semantics of the Measure Phrase itself. We consider the implications of this proposal for semantics and for language development.

2 Theoretical background

We begin by presenting our assumptions about the positive form GAs and comparative constructions, and move swiftly to cross-linguistic generalizations about MP constructions provided in the previous literature (e.g., Schwarzschild 2005; Sawada and Grano 2011). We assume, following others (e.g., Kennedy 1999; Kennedy and McNally 2005; Kennedy 2007b; von Stechow 1984b) that a plain, positive form relative GA such as *big* or *tall* composes with the *pos* morpheme, whose function is to relate the GA to a standard of comparison provided by a contextually relevant salient comparison class (Bartsch and Vennemann 1973; Cresswell 1976; Kennedy 1999; von Stechow 1984b). We assume the denotation of *pos* is as given in (10). (See Kennedy 2007b and Kennedy and Levin 2008.)

(10) $[\![pos]\!]$: $\lambda g_{\langle e,d\rangle}.\lambda x.g(x) > d_s$

When an explicit standard phrase is present, however, the sentence is true as long as the relationship between the degrees corresponding to the objects holds, as in (2a). We further assume, following e.g. Bhatt and Takahashi (2011), Hackl (2001), and Lechner (2001, 2004), that the *-er* morpheme is of type $\langle\langle e,d\rangle, \langle e,\langle e,d\rangle\rangle\rangle$ and takes two arguments —the one provided by the main clause and the one provided by the standard— and that the Degree Phrase headed by this morpheme undergoes Quantifier Raising for interpretation (Bhatt and Takahashi 2011; Heim and Kratzer 1998).

As we mentioned in the Introduction, an MP (e.g., *10 meters*) can combine with either a plain, positive form GA or a comparative-marked GA, but the available interpretations vary. In English, when an MP is combined with a GA in the positive form, it yields an absolute interpretation. When an MP combines with a comparative GA, it yields a differential comparative interpretation, as noted in (11).

(11) a. This building is 10 meters tall. (plain GA, absolute interpretation)
b. This building is 10 meters taller. (comparative GA, differential interpretation)

Interestingly, while the combination of MP + comparative GA (as in (11b)) should always be possible with any GA associated with a scale, only a restricted set of GAs in English can combine with an MP when in the positive form. For example, although *10 meters tall* is possible, the following combinations are ungrammatical in English:

(12) a. *2 tons heavy
b. *2 km far
c. *60 mph fast

As Schwarzschild (2005) has observed, the set of adjectives that can directly be combined with an MP when in the positive form differs from language to language, suggesting that the MP+GA combination is lexically conditioned. For example, as

he observed, the combinations in (12), which are ruled out in English, are possible in some other languages, as shown in (13).

(13) a. pesante [quasi due tonnellate] (Italian)
heavy almost 2 tons
b. Het dorp is twee kilometer ver (Dutch)
the village is 2 km far
c. 60 Stundenkilometer schnell (German)
60 kilometer-per-hour fast

And in French, whereas *haut* 'high' can appear in the MP+GA construction, *grand* 'tall' cannot.

(14) a. haut de 1.27 m (French)
'1.27 m high'
b. *grand de 1.27 m
'1.27 m tall'

Still other languages place a general ban on the MP+GA combination, while allowing MPs to combine with a comparative GA. Thus, the Spanish, Korean, and Russian examples in (15) are ungrammatical:

(15) a. *Pedro es un metro alto (Spanish)
Pedro is one meter tall
b. *i kenmwul-un sip mite khu-ta. (Korean)
this building-TOP ten meter tall
c. *On dva metra vysokij (Russian)
he two meter tall

(Sawada and Grano 2011, pp. 77–79)

Japanese adds yet another dimension to this paradigm. In Japanese, the MP+GA combination is a possible surface string, but as we observed in the Introduction, it can only be interpreted as a differential comparative. Thus, the interpretation generated by the grammar differs from that of the English example discussed earlier.

(16) Kono biru-wa 10 meetoru takai.
This building-TOP 10 meters tall
'This building is 10 meters taller.' *differential comparative*
#'This building is 10 meters tall.' *#absolute*

In sum, we observe that languages differ with respect to the availability of the absolute interpretation with the MP+GA structure. English and certain other languages such as French allow an idiosyncratic set of GAs to be combined with an MP, giving rise to the absolute interpretation. Spanish, Korean, and Russian

generally do not allow the MP+GA combination. Japanese does allow the MP+GA combination, but this combination does not license the absolute interpretation, only a differential one. A tentative generalization that we might draw from these observations is that while a differential interpretation can be expressed by the MP +GA combination in any language, an absolute measurement is only possible in a limited set of languages, namely those in which the possibility of the MP+GA combination is lexically conditioned, lacking systematic generalizations across languages (Schwarzschild 2005).

This generalization is not entirely correct, however. Sawada and Grano (2011) (henceforce, S&G) have pointed out that with certain GAs, the MP+GA construction does license an absolute interpretation in Japanese, as illustrated in (17).

(17) a. Kono sao-wa 5-do magat-teiru.
This rod-TOP 5-dgree bend-TEIRU
'This rod is 5 degrees bent.'
Not: 'This rod is 5 degrees *more* bent.'

b. Kono fusuma-wa 3-senti ai-teiru.
This sliding door-TOP 3-centimeter open-TEIRU
'This door is 3 centimeters open.'
Not: 'This door is 3 centimeters *more* open.'

c. Pisa-no syatoo-wa 3.97-do katamui-teiru.
Pisa-GEN leaning tower-TOP 3.97-degree incline-TEIRU
'The Leaning Tower of Pisa is 3.97 degrees inclined.'
Not: 'The Leaning Tower of Pisa is 3.97 degrees *more* inclined.'

d. Kono tokei-wa 2-fun hayai.
This clock-TOP 2 minutes fast.
'This clock is 2 minutes fast.'
Not: 'This clock is 2 minutes fast*er*.'

(Sawada and Grano 2011, p. 194)

S&G present a semantic generalization that unifies the observations about the Japanese data in (6) and (17). They argue that the GAs that give rise to absolute interpretation are those that are associated with a *lower closed scale* (i.e., are absolute minimum standard GAs, in the typology presented in Kennedy and McNally (2005)). Relative GAs such as *tall* or *long*, which map onto an open scale that lacks such a minimal element, do not license an absolute interpretation in the MP+GA combination.

The semantic distinction between these two types of GAs has several empirical consequences. For example, whereas the negation of a predicate that has a lower closed scale entails its antonym, the same pattern of entailment is not licensed with an open scale adjective.[6]

[6] For further details on scalar structure, we refer the reader to Kennedy (2007b), Kennedy and McNally (2005), and Rotstein and Winter (2004).

(18) a. *Lower closed scale*
Kono sao-wa magat-tei-nai. ⊨ Kono sao-wa masugu-da.
this rod-TOP bend-TEIRU-NEG this rod-TOP straight-PRED
'This rod is not bent.' 'This rod is straight.'

b. *Open scale*
Taro-wa se-ga takaku-nai. ⊭ Taro-wa se-ga hikui.
Taro-TOP height-NOM tall-NEG Taro-TOP height-NOM short
'Taro is not tall.' 'Taro is short.'
(Sawada and Grano 2011, p. 194)

In addition, patterns of adverbial modification also help to sort GAs into those that map onto a scale with a minimum standard and those that do not (e.g., *partially bent* vs. **partially tall*).

S&G have further demonstrated that even in languages that put a general ban on MP+GA combinations, a lower closed scale GA in its plain, positive form can be modified by an MP and give rise to an absolute interpretation. Compare the examples in (19) with those in (15), where the MP+GA combination led to ungrammaticality:

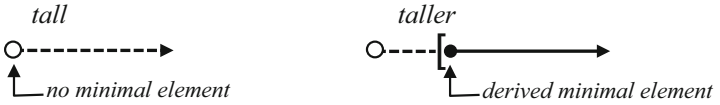
(19) a. Esta varilla está doblada noventa grados. (Spanish)
this rod is bent ninety degrees
'This rod is ninety degrees bent.'
b. i hwoychori-nun i-to (cengto) hwies-ta. (Korean)
this rod-TOP two-degree about bent-DECL
'This rod is (about) two degrees bent.'
c. Etot prut pognut na p'at' gradusov. (Russian)
this rod bent by five degrees
'This rod is five degrees bent.'
(Sawada and Grano, 2011, p. 196)

In order to capture these empirical facts, S&G propose a theoretical account that involves two crucial assumptions. First, they adopt the theory of comparative semantics developed by Kennedy and McNally (2005) and Kennedy and Levin (2008), and assume that the function of comparative morphology, as presented in (20), is to turn a basic measure function into a difference function that has a scale with a minimal element, as illustrated in (21). The derived minimal element corresponds to the degree introduced by the comparative standard.[7]

(20) $[\![\textit{-er}]\!]$: $\lambda g_{\langle e,d\rangle}.\ \lambda y_{\langle e\rangle}.\ \lambda x_{\langle e\rangle}.g(x) - g(y)$

[7] Kennedy and Levin (2008) call this newly-formed minimal element 'derived zero'. We choose not to employ this terminology to avoid confusion, because in our account we use the word *zero* to refer only to the 'natural', or 'absolute', zero. See Sect. 7 for details.

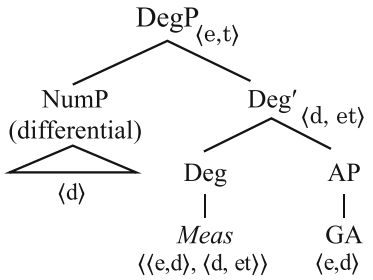
(21)



Under this approach, comparative GAs and lower closed scale GAs form a semantic natural class, because they both are associated with a scale that includes a minimal element. With comparative GAs, the standard of comparison provides a derived minimal element; with lower closed scale GAs, the minimal element is built into the lexically specified scale.

Second, S&G propose that the functional head *Meas* imposes a semantic selectional restriction requiring its internal argument to have both a salient measurement system and a minimal element. The Deg head *Meas*, originally proposed by Svenonius and Kennedy (2006), has the syntax and semantics defined in (22) and (23).[8]

(22)



(23) $[\![Meas]\!] = \lambda g_{\langle e,d\rangle}$: g is a function from objects to measurable degrees and g has a minimum element $\lambda d.\lambda x.g(x) \geq d$

Under this approach, the presence of an MP is associated with *Meas*, a functional head that relates a gradable predicate to a differential. *Meas*, then, imposes a semantic restriction on its complement, allowing only those predicates that come with a scale featuring a minimum element. Lower closed scale adjectives can be directly combined with *Meas*, because they have a built-in minimum element, and the combination yields an absolute interpretation (see (17) and (19)). Comparative GAs also satisfy this selectional requirement, but in this case the minimum element is not provided by the lexical semantics of the GA but corresponds to the contextually determined standard of comparison, as illustrated in (21), which results in a differential interpretation. Thus, the empirical generalization about the data presented above is successfully accounted for.

[8] Svenonius and Kennedy argue that GAs are of type ⟨e,d⟩, and S&G follow them in treating GAs as entities of this semantic type. Another possibility, which we noted in footnote 1, is that they are instead of type ⟨d, ⟨e,t⟩⟩ (Cresswell 1976; von Stechow 1984a; Alrenga et al. 2012; Kennedy and McNally 2005; among others). The type proposed for GAs has various theoretical implications, of course; however, for simplicity's sake we follow S&G's treatment of GAs here, without any theoretical commitment one way or the other.

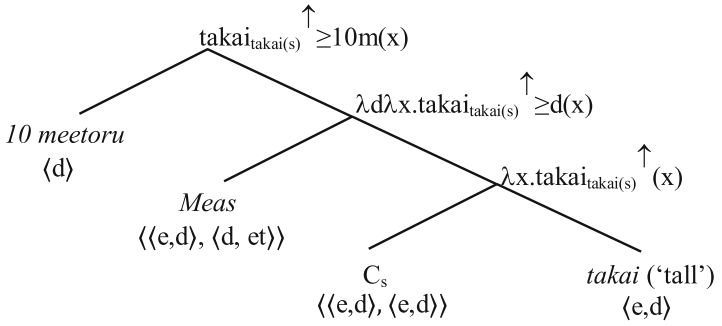
S&G assume that the selectional restriction of *Meas* is universal. In other words, (23) applies to all languages, regulating the range of possible MP+GA combinations. In addition, following Schwarzschild (2005), S&G argue that English (and certain other languages such as French) allows a lexically idiosyncratic set of open scale adjectives to *override* the selectional restriction of *Meas*, making it possible for these adjectives to be combined with an MP to yield expressions such as *10 meters tall*. Languages like Japanese, Spanish, Korean and Russian, in contrast, do not have such a set of exceptional lexical items. Among those languages, however, Japanese is assumed to have a covert mechanism of 'scale shift', which coerces the scale associated with an open scale GA such as *tall* into a scale that now includes a minimal element (much as with comparative GAs in English). Thus when an open scale adjective such as *takai* 'tall' appears with an MP, the covert coercion operator, as defined in (24), is inserted to resolve the clash between *Meas* and the open scale relative GA and coerce the meaning of the GA into having a contextually determined implicit standard as its minimal element.

(24) $[\![C_s]\!]([\![ADJ]\!]) = \lambda g.\lambda x.g_{g(s)}{}^{\uparrow}(x)$
(s: a contextually determined object)

(Sawada and Grano 2011, p. 216)

The derivation of *10 meetoru takai* '10 meters tall' therefore proceeds as in (25) (a variation of S&G's (73)).

(25)



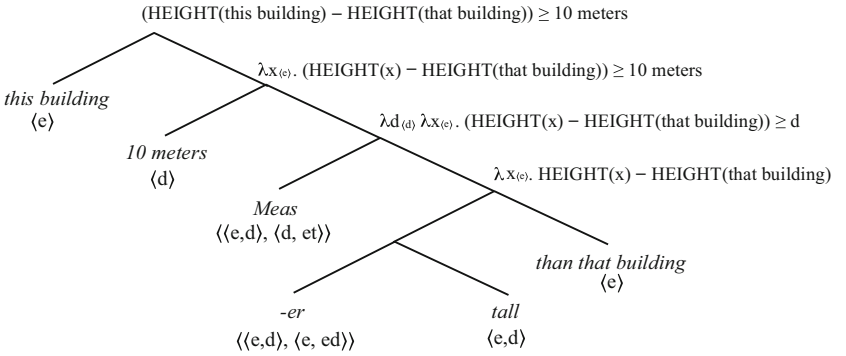
This account quite nicely derives the fact that the combination of an MP and an open scale GA in Japanese can *only* be interpreted as a differential comparative. In order for such a GA to co-occur with an MP, scale shift via coercion is necessary, because this step essentially converts the semantics of the GA to that of a comparative GA and gives rise to a derived minimal element that satisfies the requirements of *Meas*.[9] In contrast to Japanese, languages such as Spanish lack the

[9] A possible alternative to the coercion approach is to posit a null comparative morpheme MORE whose semantics is essentially the same as that of C_s, along the lines of Beck et al. (2004). S&G discuss this possibility, but then reject it on the grounds that the coercion approach handles some facts better (see Sawada and Grano 2011, Sect. 6). In this paper we adopt the coercion approach, but without making any serious theoretical commitment, as the choice between these two options does not seem to make any significant difference with respect to our acquisition data.

covert coercion operation. Thus, in those languages open scale GAs in their plain, positive form cannot ever be combined with an MP, because such a combination necessarily violates the selectional restriction of *Meas*.

Let us now apply S&G's theory to English MP comparatives. Given the relevant lexical entries previously adopted for *Meas* and GAs and a lexical entry for the comparative morpheme as defined above in (20), the logical form of the sentence *This building is 10 meters taller than that building* is as presented in (26).

(26)



Returning to the contrast between English and Japanese that lies at the center of this research, we assume that the differences between these two languages are reduced to those in (27).[10]

(27) a. English has an idiosyncratic set of *open scale (relative)* GAs that can combine directly in their positive form with *Meas* and yield an absolute interpretation. Japanese does not. However, Japanese *does* permit such a combination with absolute *minimum* standard GAs, which have a lower closed scale.

b. In English, the overt comparative morphology introduces a derived minimal element to the scale associated with an open scale GA, satisfying the requirements of *Meas*. In Japanese, the covert coercion operator C_s serves the same function.

These assumptions become crucial as we review the set of combined experimental results from both languages.

[10] S&G assume that *yori* 'than' in Japanese is of type ⟨e, ⟨ed, ed⟩⟩, taking an entity x and a GA g as arguments and returning a function that maps entities to a derived scale, with the minimal point of this scale determined by the comparative standard x. In other words, S&G's proposal is that in Japanese, the semantics of comparison rests in the standard marker *yori*. An alternative position would be to follow Beck et al. (2004) and postulate a null comparative morpheme, whose syntax and semantics are similar to those of English *–er* (see footnote 9).

3 Developmental background

In this section, we first provide a baseline for how children of the same age as those in our experiments (5–6 years) fare with comparative expressions without MPs, and with MPs in the absence of comparatives. We then turn to their comprehension of MP expressions. To begin, by 3 to 4 years of age, children recognize that relative GAs such as *big* and *tall* rely on a contextually given standard of comparison in the positive form, and that this standard not only depends on a contextually salient comparison class but also shifts from context to context (Barner and Snedeker 2008; Ebeling and Gelman 1994; Gelman and Ebeling 1989; Syrett et al. 2006; Syrett et al. 2010). Thus, they are aware that the truth conditions of a sentence that involve a GA vary according to the context in which the sentence is uttered, because the denotation of the GA relies on the context, which in turn suggests that they have knowledge of *pos*.

Moreover, English-speaking children frequently produce comparatives in the absence of an explicit *than* standard phrase well into 4 years of age (Hohaus et al. 2014) and are exposed to the occurrence of comparative GAs without an explicit standard phrase in the input. To illustrate the latter point, we conducted a search of child-directed speech from six major corpora in the CHILDES database (MacWhinney 2000), including Adam and Sarah (Brown 1973), Naomi (Sachs 1983), Nina (Suppes 1974), Peter (Bloom et al. 1974, 1975), and Shem (Clark 1979). Using the CLAN program, we targeted a list of frequent GAs in the comparative *-er* form, selecting GAs that are known to occur early in children's production: *big, close, easy, early, fast, happy, high, nice, old, tall, wide*. This search yielded 499 occurrences. Of these, 45.5% featured the comparative adjective in utterance-final position (thus with no standard phrase following), and only 22.0% of the total occurrences included an overt *than*-standard. The input pattern in English clearly indicates to the child that a standard phrase is optional. In other words, children do not receive evidence that a standard phrase is required in order to link the interpretation of the comparative GA to a contextually relevant standard. This point is relevant to the design of our Experiment 1.

Third, although the form of comparative constructions produced by children sometimes deviates from that of adults', most notably in terms of the standard marker and the choice of comparative morpheme (cf. Donaldson and Wales 1970; Hohaus et al. 2014; Layton and Stick 1978; Moore 1999), children have been shown in both judgment tasks and act-out tasks to correctly interpret comparative constructions, such as those as in (28) (Gor and Syrett 2015; Syrett and Lidz 2011).

(28) a. Sheriff Woody fed more bear cubs than Jessie.
b. The monkey pushed the rock further than the elephant did.

This kind of production-comprehension asymmetry is often attested in the literature on language acquisition and development. Relative clauses (e.g., *the dog that caught the ball*) provide a prime example: while they may not be productive in children's utterances until later in development, and while children may appear to misinterpret relative clauses in act-out tasks (Sheldon 1974; Tavakolian 1981), children

demonstrate an early ability to correctly interpret relative clauses when certain contextual features of the experiment are controlled for (Hamburger and Crain 1982) or when morphosyntactic cues help to disambiguate interpretation (Guasti et al. 2008).

Finally, by at least 4 years of age, children begin to demonstrate an understanding of MPs in the absence of comparatives, varying their interpretation with the syntactic environment in which the MP appears. For example, 4-year-olds appear to understand that *three-pound strawberries* is not interpreted in the same way as *three pounds of strawberries*, thereby distinguishing between an MP in an attributive phrase and an MP in the pseudopartitive construction (Syrett 2013). Furthermore, they recognize that there are differences in the consequences of operations (such as subtraction) performed on a set described by one or the other expression, indicating an awareness that the two measurement expressions differ with respect to monotonicity (Syrett 2013).

Taken together, this background suggests that (at least English-speaking) children may possess a command of the components of the MP comparative construction by 5 years of age, the approximate mean age of children in the studies presented here. However, a command of the subparts does not ensure proper compositionality for the whole. Nor does it ensure that children acquiring different languages, such as English or Japanese, will be aware of the language-specific constraints regarding which interpretations are licensed or not. Thus, the following questions remain: (a) Do English-speaking children understand that the interpretation of a sentence such as (11b) with a comparative GA is obligatorily differential (with or without an explicit standard phrase), and therefore that the MP signals the extent to which the individual in subject position deviates from the contextual standard? (b) Do Japanese-speaking children understand the same obligatory differential comparative interpretation with (16), even though there is no comparative morpheme present in the sentence? The answers to these questions will provide a window into children's developing semantic representation of degree constructions, and their reliance (or not) on evidence from the input for acquiring the language-specific constraints on interpretation—which will in turn provide a window into the representation of these expressions as a whole. We turn now to a set of three experiments investigating the interpretation children assign to such MP constructions.

4 Experiment 1

4.1 Participants

All child participants in all experiments reported here were native speakers of their language, and no other language was spoken in the home environment more than 20% of the time. The Japanese-speaking children and adults were recruited and tested in Tokyo and Kanagawa, Japan. The English-speaking children and adults were recruited and tested in New Jersey in the United States. Children were tested in their local preschools, and were of comparable socioeconomic status. All adults were undergraduate college students.

Participants in Experiment 1 included 16 Japanese-speaking children (4;2–6;2; mean: 5;3), 16 Japanese adults, 16 American English-speaking children (4;1–5;4; mean: 4;9), and 27 American English-speaking adults. Three additional Japanese children were excluded due to a response bias. Four additional English adults and one additional English child were excluded due to non-native speaker status.

4.2 Stimuli and procedure

The experiment was designed so that participants were engaged in a series of trials asking them to compare amounts or extents. The experimental session was divided into two tasks, the order of presentation being counterbalanced across participants. In one task, participants were asked to compare the height or length of individuals according to a novel unit of measurement (a 'kirari' in Japanese, and a 'chipani' in English).[11] This unit was portrayed by yellow stars, which were either aligned vertically on a tree for height, or aligned horizontally along a log for length. (See the left and center picture in Fig. 1.) This novel unit was used because it did not require children to rely on their prior lexical knowledge of units of measurement (e.g., meters, feet, etc.).

The task began with a brief training session to acclimate participants to using the novel unit to measure objects and making comparative judgments based on it. Children had no difficulty with this training. In the second task, participants were asked to compare amounts of known objects or substances (e.g., piles of sand, oranges, etc.). Stimuli were presented via a series of PowerPoint slides with child-friendly images, as shown in Fig. 1.

The experiment was designed as a version of the Truth-Value Judgment Task (Crain and McKee 1985; Crain and Thornton 1998) using a prediction mode (Boster and Crain 1993; Chierchia et al. 1998). For example in Task 1, the participant and puppet (for children; adults heard a prerecorded background narration) were first shown an animal (e.g., a tiger) against the tree marked with *kiraris/chipanis*, and this animal's height was indicated. They were then shown a second animal (e.g., a lion) on a separate screen, and the puppet made a prediction about the difference in height/length/quantity between the two animals (e.g., "I think the lion is 2 chipanis taller!"). The experimenter then said, "Let's place the lion against the tree and the tiger to see if you're right!" This phrasing was used so that explicit reference was made to the contextual standard for comparison. Then the next slide was shown, with the two animals side by side next to the tree. The puppet reminded the child of his prediction (e.g., "Remember, I said that the lion is 2 chipanis taller!") and asked the child whether he was right or wrong. The child provided a 'yes'/'no'-answer, and was often encouraged to provide a justification for his/her response. Task 2 proceeded in the same way, with the quantities being compared shown side by side in the final scene of the trial.

[11] The difference in phonological form was based on the phonotactics of the two languages, and on what seemed more natural in each.

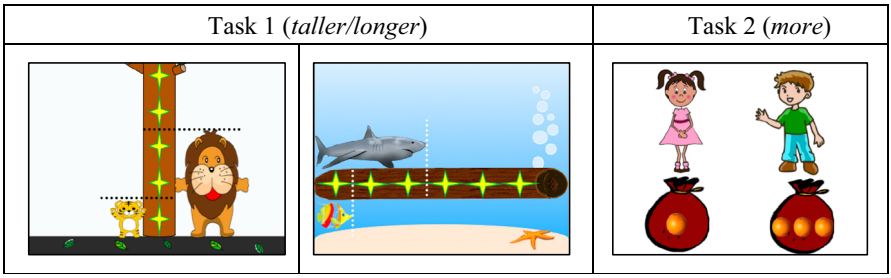


Fig. 1 Examples of representative images appearing in Tasks 1 and 2 of Experiment 1

A template for the measurement expressions used in Experiment 1, in the English and Japanese versions, respectively, is presented in (29)–(30). (The '#' here stands for a numeral, such as '2'.) Note two aspects of these stimuli in particular. First, in neither language is there an explicit standard *than/yori*-phase in the target utterance. Second, the GA in English carried the *-er* morpheme, indicating a comparative interpretation. As we noted earlier, Japanese of course lacks such a morpheme, but the sentence has an obligatory differential comparative interpretation for adults. Thus, in both languages, the stimulus sentences should have the semantic force of differential comparatives.

(29) Template of English stimuli for Tasks 1 and 2:
  a. X is # chipanis taller/longer.
  b. X has # more [nouns].

(30) Template of Japanese stimuli for Tasks 1 and 2:
  a. X-wa #-kirari takai/nagai
     X-TOP #-kirari tall/long
     'X is # kiraristaller/longer.'
  b. X-no [noun]-wa #-ko ooi.
     X-GEN [noun]-TOP #-CL many
     'X has # more [nouns].'

There were three types of trials within each task: Differential, Absolute, and Neutral (control), as summarized in Fig. 2. Each participant saw all three types of trials within a session. In the Differential trials, the MP+GA combination was true under a differential comparative interpretation of the measurement expression (i.e., '2 chipanis taller' / '2 more [nouns]'), but false under an absolute interpretation (i.e., '2 chipanis tall' / '2 [nouns]'). In the Absolute trials, the MP+GA combination was false under a differential comparative interpretation of the measurement expression, but true under an absolute interpretation. In the Neutral trials, the MP+GA combination was false under both a differential comparative interpretation and an absolute interpretation. The Neutral trials provided us with a control that allowed us to identify participants who had a response bias to accept the puppet's statement, even when it

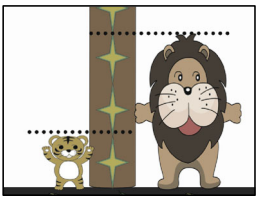
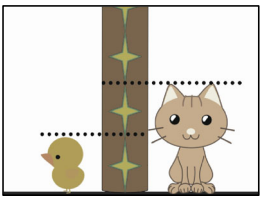
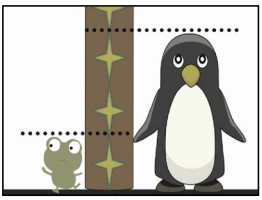
Differential	Absolute	Neutral (control)
		
The lion is 2 chipanis taller.	*The cat is 2 chipanis taller.*	*The penguin is 1 chipani taller.*
Differential True, Absolute False	Differential False, Absolute True	Differential False, Absolute False

Fig. 2 Three types of test trials, based on interpretation of the MP+GA combination

was not true under any circumstance. Each task had either 12 or 13 trials, including one to three filler items with no MP accompanying the GA, and an equal number of test trial types.

If participants assign an adult-like interpretation to the target measurement expressions, then they should accept the target utterances in the Differential trials and reject them in the Absolute and Neutral trials. If, in Task 1 (i.e., *taller/longer*), English children are unaware of the presence or interpretive force of the comparative *-er* morpheme (and consequently think that the MP measures absolute height), then they should reject the target utterances in the Differential and Neutral trials (albeit for different reasons) and accept them in the Absolute trials. Similarly, if Japanese children are at a disadvantage in that their language lacks a comparative morpheme to signal comparison (leaving aside the issue of what interpretive possibilities are provided to them in the input), then they should also reject the target utterances in the Differential trials and accept them in the Absolute trials.

The same general logic should apply to Task 2 (*more*). However, in this task, there is no novel unit of measurement, and we deliberately introduced measurements of quantities whose comparison is signaled by the periphrastic comparative in both languages (i.e., '2 more'/ '2-ko ooi'). While one could argue that the *-er* morpheme in English, being both unstressed and utterance-final, is not in a prosodically privileged position (relative to other parts of the utterance), the same cannot be said about *more*. Certainly no parent would object to our claim that this word is produced early in development, and young children are well aware of its interpretation. (This anecdotal conjecture is supported by a search of the Cross-Linguistic Lexical Norms database (http://www.cdi-clex.org), which indicates that by 18 months of age, over 80% of children understand *more* and over 50% are producing it (Dale and Fenson 1996).)

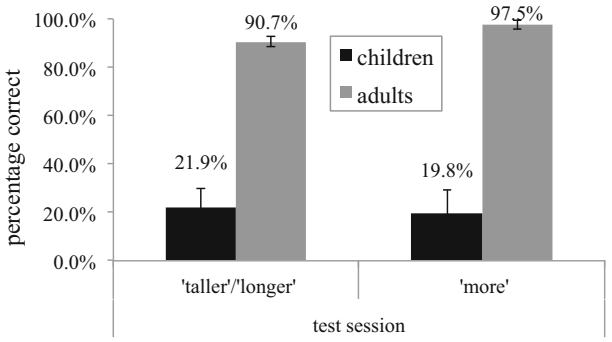


Fig. 3 Overall percentage correct for English participants in Experiment 1

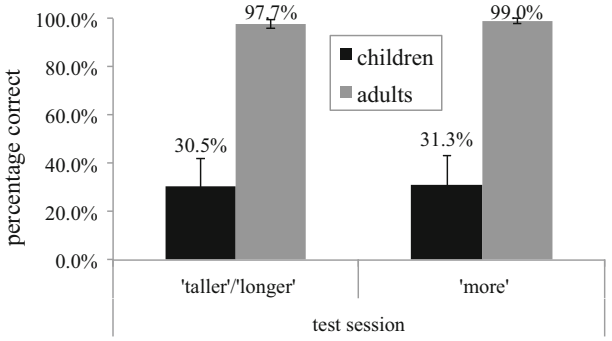


Fig. 4 Overall percentage correct for Japanese participants in Experiment 1

4.3 Results

The results in terms of overall percentage correct for the Differential and Absolute trials for the English participants are presented in Fig. 3, and results for the Japanese participants are presented in Fig. 4. Error bars represent standard error. We exclude the Neutral trials as controls here, since both groups of children demonstrated perfect or near-perfect performance on this trial type (Japanese children: 100% correct; English children: 90% correct), indicating that they had no difficulty with the task itself and were not providing the same affirmative response across the board.

As the figures indicate, both Japanese and English adults demonstrated near-ceiling performance, correctly interpreting the measurement expression throughout the trials and in both tasks. Both groups of children, however, performed significantly worse. Their overall low percentage of correct responses indicates that they *incorrectly rejected* the utterances in the Differential trials, and *incorrectly accepted* the utterances in the Absolute trials. The difference between adults and children was significant for both languages (Japanese: $t(62) = 8.14$, $p < 0.0001$; English: $t(83) = 14.72$, $p < 0.0001$). Among the English children, only three

performed at an adult-like level in the Differential trials, and among the Japanese children, five did so. The rest in both groups consistently rejected the sentences in the Differential trials and accepted them in the Absolute trials. Within each language, there was no difference between the two tasks for either the adults or the children (Japanese: adults $t(30) = 0.65$, $p = 0.52$, children $t(30) = 0.05$, $p = 0.96$; English: adults $t(51) = 1.16$, $p = 0.25$, children $t(30) = 0.17$, $p = 0.87$). There was also no difference between the age groups across languages (adults: $t(62) = 0.98$, $p = 0.33$; children: $t(83) = 1.20$, $p = 0.24$).

4.4 Discussion

In Experiment 1, both English and Japanese children appear to have assigned a non-adult interpretation to the target utterances, leading them to incorrectly reject the sentences in the Differential trials and incorrectly accept them in the Absolute trials. This pattern of responses appears to indicate that children from *both* languages consistently interpreted the MP comparative expression 'absolutely' (e.g., 'The lion is 2 chipanis tall', not '…taller [than a standard]'). Children's responses to the training items for Task 1 and to the filler items, which involved no numerical expression preceding the GA, indicated that they were easily able to make accurate comparisons with the comparative GA. In both languages, it was the presence of the numerical phrase that hindered their performance.

What could be the source of children's difficulty? One possibility is that the children were not attuned to the fact that they were supposed to make a comparison between the individuals or quantities in the scene. On the one hand, they may be so accustomed to numerals denoting the cardinality of a set that they thought the experimenter and puppet were concerned with evaluating absolute size or quantity. On the other hand, the linguistic cue to comparison (in the case of English) may have been so subtle that they may have overlooked it and focused on the numerical MP preceding the GA. If children were indeed oblivious to the fact that they needed to make a comparison between two individuals/degrees, then we would predict that introducing an explicit standard phrase into the stimulus sentences (e.g., *than the tiger*) might improve their performance. We tested this hypothesis in Experiment 2.

5 Experiment 2

5.1 Participants

Sixteen Japanese-speaking children (4;4–6;3, mean: 5;4) and 18 American English-speaking children (3;9–6;3, mean: 4;8) participated. Ten additional Japanese children and six additional English children were excluded due to a 'yes' response bias across all trials.[12]

[12] This number collapses over both the 'taller' and 'more' experiment sessions. Children who exhibited a 'yes' bias for one session were not tested on the subsequent session, and were therefore excluded from the data analysis. Also excluded were children who were tested on both sessions, but whose overall responses, particularly to the Neutral trials, indicated a response bias.

5.2 Design

The only difference between Experiments 1 and 2 was in the verbal stimuli. In Experiment 2 we introduced an explicit standard phrase, as shown in the underlined parts of examples (31)–(32), in an attempt to signal deviation from a linguistically explicit and contextually salient standard and unambiguously indicate that the construction should be interpreted as a differential comparative.

(31) Template of English stimuli for Tasks 1 and 2:
  a. X is # chipanis taller/longer than Y.
  b. X has # more [nouns] than Y.

(32) Template of Japanese stimuli for Tasks 1 and 2:
  a. X-wa Y-yori #-kirari takai/nagai.
     X-TOP Y-than #-kirari tall/long
     'X is # kiraris taller/longer than Y.'
  b. X-no [noun]-wa Y-no-yori #-ko ooi.
     X-GEN [noun]-TOP X-GEN-than #-CL many
     'X has # more [nouns] than Y.'

5.3 Results

Once again, children consistently rejected the Neutral items (Japanese: average 90% correct; English: average 79% correct). As before, we analyze the results from the Differential and Absolute test trials. The results of Experiment 2 are presented below, paired with those from Experiment 1 for comparison. The results from the English children are presented in Fig. 5, and the results from the Japanese children are presented in Fig. 6.

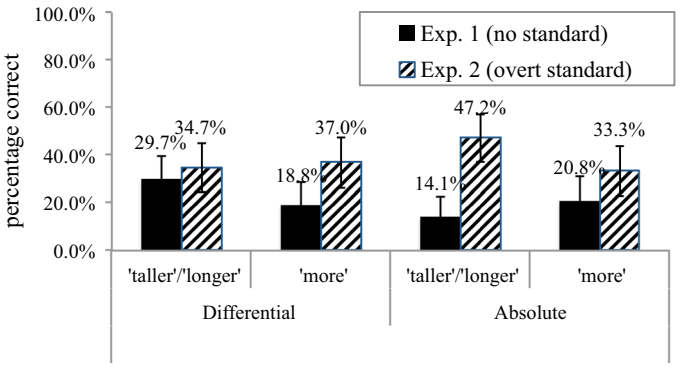


Fig. 5 Overall percentage correct for the English children in Experiments 1 and 2

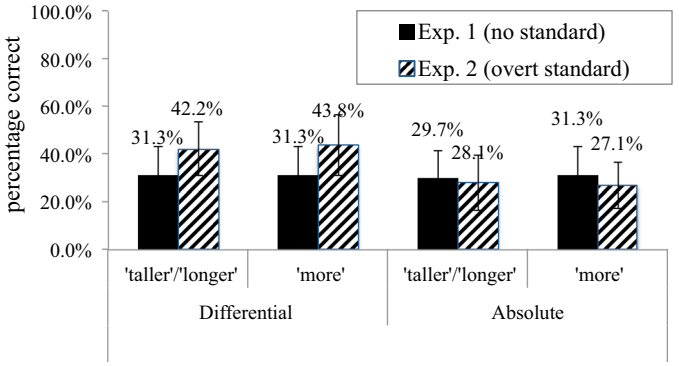


Fig. 6 Overall percentage correct for the Japanese children in Experiments 1 and 2

As can be seen, adding the standard phrase to the test sentences produced little to no change in either group. For the Japanese participants, there was no difference in the children's performance between Experiments 1 and 2 ($t(62) = 0.50$, $p = 0.62$). For the English children, the difference between Experiments 1 and 2 was marginally significant ($t(66) = 1.96$, $p = 0.05$). This marginal effect was driven by the fact that for the *taller/longer* Absolute trials, children were slightly more successful when they were provided with a standard phrase, although their performance was still not anywhere near that of the adults in Experiment 1. As before, there was no difference between the *taller/longer* items or the *more* items for either group (Japanese: *taller/longer* $t(30) = 0.50$, $p = 0.62$, *more* $t(30) = 0.20$, $p = 0.85$; English: *taller/longer* $t(32) = 1.53$, $p = 0.13$, *more* $t(32) = 1.20$, $p = 0.24$).

5.4 Discussion

English- and Japanese-speaking children in Experiment 2, who were this time given an explicit *than/yori* standard phrase that should have signaled comparison to a contextually retrievable standard, still patterned with the children in Experiment 1. The combined results of Experiments 1 and 2 reveal that while adults (perhaps unsurprisingly) correctly interpret MP comparatives in their respective languages as differential, children acquiring these languages consistently interpret the relevant forms absolutely. This conclusion is based on the low percentage correct in both the Differential and Absolute trials: children *incorrectly rejected* the Differential trials, and *incorrectly accepted* the Absolute trials. Children from both languages behaved more or less the same, even though there are several significant differences in linguistic forms between English and Japanese (presence/absence of a comparative morpheme, word order, etc.). This would suggest that English and Japanese-speaking children share their source of difficulty.

One might be led to hypothesize (for good reason) that the source of children's difficulty was in their incremental processing of these sentences, and in their failure

to revise an incorrect syntactic structure once it had been built. What might such an account entail? Let's take as a starting point the English comparative used in Experiments 1 and 2, repeated here as (33).

(33) X is # chipanis taller/longer (than Y).

Upon hearing the beginning of the utterance, *X is # chipanis tall/long*, children may posit that the utterance expresses an absolute measurement of the individual in question. (The same would apply to *X has #* in the 'more' task.) They would therefore start to build the syntactic structure corresponding to this interpretation, which would yield an absolute interpretation (licensed by the grammar in their language). However, upon encountering the *-er* morpheme afterwards (and the *than*-phrase in Experiment 2), they would be confronted with linguistic evidence that the assembled structure is not correct. But given cognitive overload and/or limited working memory capacity, they would then be unable to revise this incorrect representation, or would be unable to inhibit the response based on the initial structure, and would therefore appear to be forced into the absolute interpretation. The process of being stuck in the initial parse has been well documented in children's misinterpretation of locally structurally ambiguous sentences (Choi and Trueswell 2010, Trueswell et al. 1999; see Omaki and Lidz (2015) for a review of literature on children's incremental processing of syntactic material).

Something similar might also be argued to apply to the Japanese examples from Experiment 1. The template for task 1 is repeated here. Upon encountering the numeral, a child of age 4, who is by now accustomed to a numeral frequently denoting exact cardinality of a set, might think that the numeral picks out an absolute amount associated with the individual in subject position.

(34) a. X-wa #-kirari takai/nagai.
X-TOP #-kirari tall/long
'X is # kiraris taller/longer.'

This explanation falls short, however, as soon as one turns to the Japanese test sentence from Experiment 2, repeated here as (35).

(35) X-wa Y-yori #-kirari takai/nagai.
X-TOP Y-than #-kirari tall/long
'X is # kiraris taller/longer than Y.'

In contrast to the word order of the English example (where the standard appears at the end of the sentence), in Japanese the *yori* standard phrase *precedes* the MP. Thus, children in this experiment should encounter a signal early in the utterance that a comparison is being made between the subject and another salient individual, and therefore should not be led down the garden path. It is striking, then, that the Japanese children in this experiment patterned just like the English children, and fared no better in their interpretation of differential comparatives.

Let us now return to the Neutral control trials to see if they might shed light on this unexpected response pattern. Recall that the Neutral trials differed from the Differential and Absolute trials in that the sentence was false under either interpretation. For example, in a display in which a frog is one chipani tall and a penguin is three chipanis tall (as in Fig. 2), the statement *The penguin is 1 chipani taller (than the frog)* is false under both a differential (1 chipani taller) and an absolute (1 chipani tall) interpretation. Children robustly responded to the puppet's statements correctly by rejecting these descriptions of the scene. It is possible, though, that they were doing this for the wrong reason, and were positing an incorrect representation for the comparative construction. How might such an explanation play out?

One possibility comes to us from the literature on children's interpretation of nominal modifiers, such as attributive adjectives and relative clauses. Previous research has documented that when faced with nominal modifiers that are presented in an infelicitous context or that make demands on processing, children appear to mistakenly interpret the target statement as if it were a simple conjunction. For example, when asked to point to "the second green ball" in a series of green and red balls, children might point to the ball that is in the second ordinal position and is green, rather than the intended target (the second of the green balls) (Hamburger and Crain 1982; Matthei 1982; Roeper 1972). Likewise, when asked to act out the sentence *The cow bumps into the dog that jumps over the pig*, children have been shown to manipulate the toys so that the cow first bumps into the dog and then jumps over the pig (Sheldon 1974; Tavakolian 1981). These findings have often been interpreted as children positing syntactic representations that are wildly different from those of adults, yet consistent with representations allowed by the child grammar (e.g. Tavakolian 1981).[13]

Let us consider the possibility, then, that although children performed successfully with the Neutral trials, they did so based on an incorrect representation of the target statement, namely *conjunction*. In this case, they might interpret (36a) as (36b) (and similarly for Japanese, taking into account differences in word order). The statement in (36b) is false in the situation in Fig. 2, since although the penguin *is* taller than the frog, it is not one chipani tall. As the conjunction of a true and a false proposition yields a truth value of 'false', children would reject this sentence in the Neutral trials, albeit for the wrong reasons.

(36) a. The penguin is 1 chipani taller (than the frog).
b. The penguin is 1 chipani (tall) AND taller (than the frog).

To be clear, if children did access the conjunctive interpretation, this could have masqueraded as them assigning an absolute interpretation to the entire sentence, since the first proposition in the proposed conjunction representation is in essence an absolute interpretation. Since the second proposition is always true, the truth value of the entire sentence rides on whether or not the first proposition—which has an absolute interpretation—is true or false.

[13] But see Crain and Thornton (1998, Chap. 18) for arguments against this interpretation.

Could this strategy explain children's responses to the Differential and Absolute trials? Consider the scenes depicted in Fig. 2 once more. In the Differential trial, the lion is three chipanis tall and the tiger is one chipani tall. The target statement is *The lion is 2 chipanis taller (than the tiger)*. Because this statement is false under an absolute interpretation, it is also false under a conjunctive interpretation (since the first conjunct expresses absolute interpretation). The lion is not two chipanis tall, and the conjunction of a false proposition with the true one (that he is taller than the tiger) results in a truth value of 'false'. In the Absolute trial example, the cat is two chipanis tall and the chick is one chipani tall. Thus, the absolute interpretation of the target *The cat is 2 chipanis taller (than the chick)* is true, as is the conjunctive interpretation, since the cat is both two chipanis tall *and* taller than the chick.

Thus, the response pattern observed in children could be explained by their erroneously interpreting the puppet's statements as conjunction. Experiment 3 was designed to test whether this conjunction interpretation underlies children's absolute responses. To this purpose, we incorporated key manipulations into the design in order to target the truth conditions of conjunction.

6 Experiment 3

6.1 Participants

Thirty-three Japanese-speaking children (4;1–6;2, mean: 5;5), 16 Japanese adults, 23 American English-speaking children (4;0–5;8, mean: 4;9), and 16 American English-speaking adults participated.[14] Four additional Japanese children and 10 additional English children were excluded due to response bias (Japanese: three 'yes' and one 'no'; English: nine 'yes' and one 'no'). One additional English adult was excluded due to non-native speaker status.

6.2 Stimuli and procedure

This experiment made use of the same experimental methodology as Experiments 1 and 2. As in Experiment 2, the test sentences appearing in Experiment 3 included an overt standard of comparison in the form of a *than/yori*-phrase, so that we could supply children with enough lexical material for them to posit two distinct propositions, according to a possible conjunction interpretation. However, in addition to the three kinds of trials incorporated into Experiments 1 and 2 (as shown in Fig. 2 earlier), we introduced a new trial type, as shown in Fig. 7.

The 'Absolute-taller' trials are the same as the Absolute trials in Experiments 1 and 2: each test sentence is true under both the Absolute interpretation and the Conjunction interpretation (e.g., 'The cat is 2 chipanis and is taller'). Like the Absolute-taller and Neutral trials, the new 'Absolute-shorter' trial type differs from

[14] The difference in sample size for the child groups arose from the variability we observed in the response pattern of the Japanese children, which we discuss in Sect. 6.3 below. We increased the sample size of that population during data collection to allow for more noticeable trends to surface within that group.

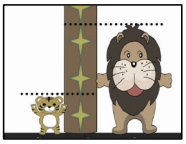
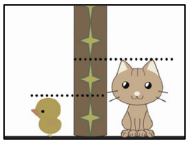
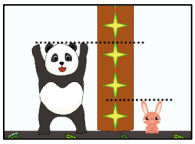
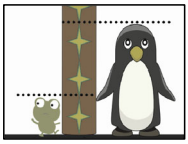
Differential	Absolute-taller (Previous version)	Absolute-shorter (New version)	Neutral (control)
			
The lion is 2 chipanis taller…	*The cat is 2 chipanis taller…*	*The rabbit is 1 chipani taller…*	*The penguin is 1 chipani taller…*
Differential True, Absolute False, Conjunction False	Differential False, Absolute True, Conjunction True	Differential False, Absolute True, Conjunction False	Differential False, Absolute False Conjunction False

Fig. 7 Four types of test trials employed in Experiment 3

the Differential trials in that the differential interpretation of the target statement is false. It shares with the Absolute-taller trials the fact that the absolute interpretation of the test sentence is true. This allows us to determine whether children are indeed just disregarding the standard phrase (and allows this trial type to differ from the Neutral trials). However, it differs from the previous Absolute-taller trials in that the conjunction interpretation is false in these new trials. We accomplished this difference by having the (degree of the) height of the animal in subject position be *less* than that of the animal in the standard phrase. The Neutral trials remain as a control in this experiment, since the statement is false under all of the target interpretations. There were three instances of each trial type, for a total of 12 trials in the experimental session. This time, we only presented children with Task 1 (*taller/longer*), to zero in on the differences between these four trials in one task.

6.3 Results

As in Experiment 1, Japanese and English adults demonstrated near-ceiling performance (Japanese adults: 99.0%; English adults: 98.3% overall average correct). And as before, children's success rate was significantly below that of the adults (Japanese: 53.3% overall correct, $t(47) = 7.40$, $p < 0.0001$; English: 44.2% overall correct, $t(37) = 8.45$, $p < 0.0001$), although the children performed well on the Neutral trials (Japanese: 81%, English: 77%). In this experiment, however, the overall percentage correct does not reveal much about the exact nature of the children's responses.

To analyze children's responses for response type and a potential conjunction interpretation, we began by identifying all children who had correctly rejected at least two of the three Neutral trials, since accepting these trials would indicate that a child was not accessing any of the candidate interpretations (i.e., differential,

absolute, conjunction). This process left us with 18 of the 23 English children and 28 of the 33 Japanese children. Interestingly, three of the excluded English children and four of the excluded Japanese children accepted the statements on the Differential, Absolute-taller, and Neutral trials, but rejected them on the Absolute-shorter trials—the only trials where the subject did not exceed the standard—indicating that they may have been ignoring the MP altogether and attending just to the comparative GA in making their judgment. In other words, they appeared to interpret *X is MP taller than Y* as 'X is taller than Y'. At least one child's justifications reflect this possibility, since this child mentioned the animal in subject position being taller. We will refer to this type of non-adult interpretation as a *Simple Comparative* interpretation.

Let us now turn our attention to those children who accurately rejected the statement on the Neutral trials and displayed no response bias (English: n = 18, Japanese: n = 28). There was one group of children who appeared to access a correct, adult-like differential interpretation of the test sentences: they *accepted* the statements on the Differential trials and consistently *rejected* them throughout the other trials (where the differential interpretation was always false). Four English children and seven Japanese children patterned in this way; they appear to have the target syntax-semantics representation of these sentences at this point.

The remaining bulk of the responses (13 English and 21 Japanese children), however, reflected an Absolute interpretation, in that the children rejected the statements in the Differential and Neutral trials, but accepted them in the Absolute-taller and Absolute-shorter trials. That is, these children only accepted the puppet's statement when the MP reflected an absolute measurement of the individual in subject position, and they accepted such a statement regardless of whether this individual's height exceeded the standard or not. For all of these children, it is clear that they are *not* consistently accessing a conjunction interpretation. If they were, then they would have accepted the statements in the Absolute-taller trials (as in Experiments 1 and 2) but rejected them in all of the other trials. In fact, none of the English children appeared to pattern in this way, and only five of the 33 Japanese children did so.

Finally, there were three English children and six Japanese children whose response patterns did not lend themselves to classification. The responses for these children appeared to reflect a variable treatment of the target statement within the experimental session, in that the child sometimes appeared to be comparing the subject individual to the other individual indicated in the standard phrase, and sometimes to be accessing an absolute interpretation. However, our efforts to categorize such children neatly into the categories in Table 1 was in vain.

We present the complete categorization of responses in Table 1.

6.4 Discussion

The results of Experiment 3 demonstrate that children are by and large *not* appealing to a conjunction strategy when interpreting MP comparative constructions. When they are not accessing an adult-like interpretation, the most frequent interpretation they appear to access is the Absolute one, although other interpretive

Table 1 Response types exhibited by child participants in Experiment 3

Response type	English	Japanese	Total
Simple Comparative ('taller')	3	4	7
Differential (correct)	4	7	11
Absolute ('MP tall')	13	11	24
Conjunction ('MP *and* taller')	0	5	5
Unclassifiable	3	6	9
TOTAL number of children	23	33	56

strategies appear to have manifested themselves across a subset of children. What is particularly important here is the number of children who accepted the test sentences in the Absolute-taller trials and in the Absolute-shorter trials: their non-adult response patterns cannot be due to the conjunction strategy, because if they had resorted to that strategy they would have rejected the test sentences in the Absolute-shorter trials. Given that the Absolute response pattern represents the largest subset of children, and neither mis-parsing nor conjunction interpretation explains this type of response for both languages, we need an independent account for this type of non-adult interpretation. We propose such an account in the general discussion below, in Sect. 7.

What is also striking is that the two groups patterned by and large the same, indicating that whatever interpretive strategy is being recruited is apparently not a language-specific one.[15] Thus, regardless of the cross-linguistic differences between English and Japanese (i.e., the presence/absence of comparative morphology, word order, and the range of interpretations that the MP+GA combination allows), children in both languages display a similar response pattern. In what follows, we argue that this pattern may in fact emerge because these children are driven by a common interpretive source, stemming from the syntax-semantics of the MP.

7 General discussion

We began this paper by asking how children acquiring English and Japanese interpret MP comparatives. The answer to this question sheds light on children's acquisition of the syntax-semantics mapping of comparative constructions and their ability to integrate measurement expressions into such constructions. Across three experiments, we found that children representing each language diverged noticeably from adults in that they did not robustly access the intended differential comparative interpretation. Furthermore, children from both languages patterned similarly, despite the fact that English and Japanese display different patterns of syntax-

[15] The one exception to this observation may be the five Japanese children who appear to have accessed a conjunction interpretation. It is possible that this pattern arose from the word order difference between the two languages: because the standard precedes the MP and GA in the Japanese sentences, children may have represented the standard phrase, but then failed to integrate the rest of the lexical material into the correct syntactic structure and therefore resorted to conjunction.

semantics mapping in MP comparatives. Children consistently accessed an absolute—and *not* a differential—interpretation of the target construction, regardless of any cues to the intended differential interpretation: a salient visual standard referenced explicitly in the task, the presence of *-er* comparative morphology in English, or the presence of a linguistically explicit *than/yori* standard phrase.

In fact, we are not the first to uncover children's non-adult-like interpretation of an MP comparative. Donaldson (1963) and Duthie (1963) (later referenced by H. Clark 1970) observed anecdotally that children sometimes seem to interpret sentences such as (37) as expressing that Tom is four years old.[16]

(37) Tom is four years younger than Dick.

Our study, however, is the first (to our knowledge) to systematically investigate children's interpretation of such MP comparatives through formal, systematic experimentation and to bring cross-linguistic data to the field. Furthermore, recent advances in the linguistic analysis of measurement expressions permit us to be the first to appeal to contemporary theoretical devices as we attempt to explain children's non-adult-like response pattern.

Let us now turn to our proposal of why children might pattern the way they did in our experiments. This proposal crucially relies on the theoretical assumptions outlined earlier, that the Deg head *Meas* requires its internal argument to have a salient measurement system and imposes a selectional restriction on the predicate it combines with—namely, that the GA has a minimal element (Svenonius and Kennedy 2006; Sawada and Grano 2011). Following S&G, we assume that this selectional restriction of *Meas* is universal. The lexical entry for *Meas* is repeated here as (38):

(38) $[\![\textit{Meas}]\!] = \lambda g_{\langle e,d\rangle}$: g is a function from objects to measurable degrees and g has a minimum element $\lambda d_{\langle d\rangle}.\lambda x_{\langle e\rangle}.\ g(x) \geq d$

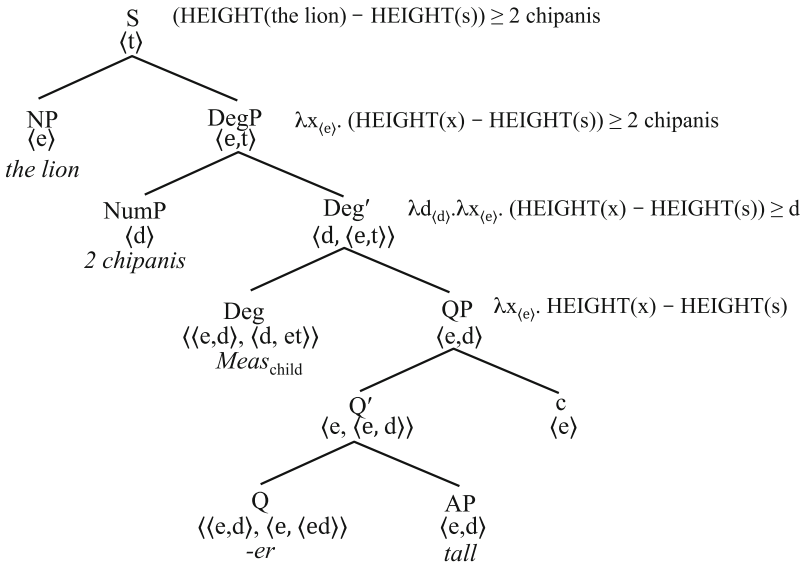
We further assume that both English- and Japanese-speaking children's grammatical/semantic knowledge is nearly adult-like, with the exception of one small difference with respect to the selectional restriction of *Meas*. Specifically, we propose that children's *Meas* not only selects for a measurable scale with a minimal element, but also *requires the minimal element to be 'absolute zero'*, as defined in (39):

(39) $[\![\textit{Meas}_{\text{child}}]\!] = \lambda g_{\langle e,d\rangle}$: g is a function from objects to measurable degrees and *g's minimum element is absolute zero* $\lambda d_{<d>}.\ \lambda x_{<e>}.\ g(x) \geq d$

[16] Of course, this particular example also raises questions of how the adjective *young* is being interpreted, and whether substituting negative polar adjectives for positive ones (e.g., *short* for *tall* or *long*) would influence children's performance. We leave this very interesting question aside here.

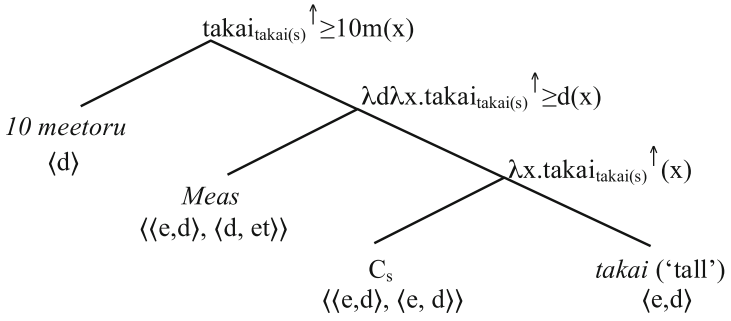
Let us now consider how this version $Meas_{child}$ might account for children's non-adult behaviors. First, let us turn to the test sentences that did not feature an overt standard phrase (i.e., the target sentences from Experiment 1). Under our assumption, children's grammar generates the logical form in (40) for the sentence *The lion is 2 chipanis taller*.

(40)



We assume that Japanese children have essentially the same logical form, except that the covert coercion operator C_s, instead of the comparative morpheme *-er*, is combined with the GA. Recall (25), repeated here as (41).

(41)

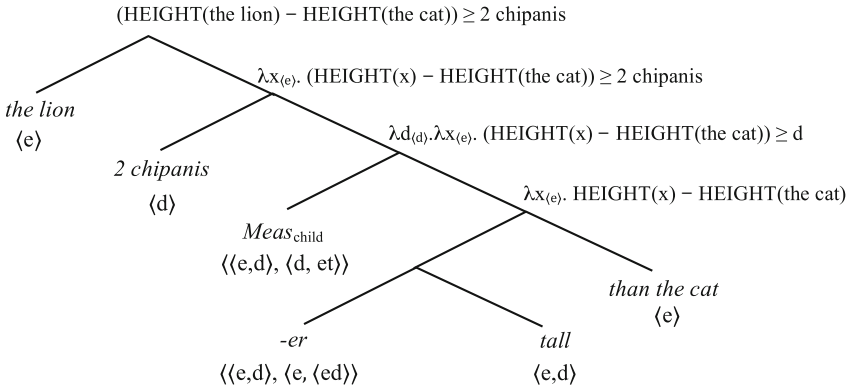


In (40), HEIGHT(s) stands for the height of the contextually determined standard, and *taller* will seek out such a standard. The interval between the height of the first individual and the height of the second should therefore have this standard as its minimum. However, the selectional restriction of $Meas_{child}$ requires the minimum point of this scale to be the absolute zero. The only way to satisfy this requirement is

to set HEIGHT(s) = 0, disregarding the presence of an accessible standard in the context. This results in an 'absolute' interpretation: children take the MP as measuring the difference between the height of the subject and the absolute zero.

When children are presented with test sentences with an overt standard phrase (as in Experiments 2 and 3), the explicit *than/yori*-phrase supplies the standard of comparison, as illustrated in (42):

(42)



Once again, $Meas_{\text{child}}$ requires the minimal point on the scale between HEIGHT(x) and HEIGHT(the cat) to be the absolute zero. Setting the value for HEIGHT(the cat) to be zero, however, wildly contradicts children's world knowledge as well as the visual and linguistic input, which indicates there to be an individual serving as the contextual standard. Furthermore, under our assumption that children's grammatical/semantic knowledge is the same as that of adults except for $Meas_{\text{child}}$, children would be prevented from searching for some contextual standard that would satisfy the relevant selectional requirement, because the principle of *Interpretive Economy* as stated in (42) would block such a move:

(42) *Interpretive Economy* (Kennedy 2007b, p. 66)
Maximize the contribution of the conventional meanings of the elements of a sentence to the computation of its truth conditions.

We assume, following Kennedy (2007b) and Sawada and Grano (2011), that this principle regulates various aspects of semantic computation. In the current case, the derived minimal element (i.e., the height of the cat) should be chosen as the standard of comparison, but $Meas_{\text{child}}$'s semantic requirements are at odds with this situation, requiring instead absolute zero. As a result, the child is prevented from directly generating a coherent interpretation of the test sentences.

Upon encountering such a situation, the child then deploys some sort of ad hoc strategy for interpretation. This strategy might be expected to vary from child to child, as the child attempts to reconcile ostensibly conflicting linguistic information under the duress of memory and/or processing load. Below we list several possibilities for such strategies.

One possible strategy—and indeed the one that may be the default—is to ignore the *than/yori* standard phrase and interpret the test sentence as having the logical form in (40), which yields an absolute interpretation. Our experimental results suggest that this is the strategy that was deployed by the majority of children. This makes sense, because of the linguistic salience of the MP and the call to count that numerals signal for children of this age. Note that this account does not claim that children fail to process the overt standard phrase; rather, it is precisely because they compute the compositional meaning of the whole sentence that a conflict between the selectional restriction of $Meas_{child}$ and the meaning of the overt standard phrase is detected, leading children to reanalyze the sentence using this strategy.

Another strategy would be to ignore the MP, and hence interpret the test sentences as simple comparatives (e.g., *The lion is taller than the cat*). Without an MP, the functional head that hosts it, namely $Meas_{child}$, is not introduced into the structure, and therefore there is no push for setting the minimal element to be the absolute zero. If the child deploys this strategy, she would accept the test sentences as long as the subject is taller than the comparison standard, regardless of the absolute height of the subject.[17]

We did find several children who behaved this way in Experiment 3, as we reported in Sect. 6.3. Furthermore, some of the children who were excluded from the analysis of Experiment 2 due to what appeared to be 'yes bias' might also have relied on this strategy. If children interpret the test sentences in Experiment 2 as simple comparatives, then those sentences would be judged true in all of the three conditions. This would explain why the number of children who we had to exclude due to a 'yes' bias was significantly larger in Experiment 2 than in Experiment 1 (16 vs. 3). In Experiment 1, the target sentences did not include the overt standard phrase, and therefore children could have interpreted them without having to resolve the conflict between $Meas_{child}$ and the overt standard. In Experiment 2, however, the conflict was inevitable, and so more children were led to ignore the MP in order to construct a coherent logical form.

It is also possible that children might turn to some kind of non-compositional interpretation, rather than ignoring some parts of the test sentences and then compositionally computing the meaning of the resultant structure. If this is the case, we cannot specify children's response strategies post-hoc, since there are too many logical possibilities. Nonetheless, we speculate that at least some of the 'conjunctive' and 'unclassifiable' children in Experiment 3 fall into this category.

Finally, some children seem to have correctly allowed the derived minimal element determined by the overt standard to be the standard of comparison, yielding an adult-like differential interpretation. We assume that this move—prompted perhaps by increased salience or focusing of the contextual standard, or recognition

[17] Under the theoretical model that we are following here, in the absence of *Meas* a comparative GA must combine with *pos* in order to express a property of individuals (Kennedy and Levin 2008; Sawada and Grano 2011). Thus, if the child decides to disregard the MP and *Meas*, she will need to insert *pos* to resolve a type mismatch. We assume that children have no problem with this process, given previous evidence that children correctly interpret GAs in their plain, positive, and comparative forms elsewhere (see, e.g., Syrett et al. 2010).

of a different approach to reconciling incompatibility with real-world knowledge—is what leads children to revise their lexical entry for *Meas*, thereby allowing them to acquire adult-like grammatical/semantic knowledge. In other words, under this account children achieve the target grammar and arrive at the correct lexical entry for *Meas* on the basis of positive evidence alone: their initial assumption is too restrictive, requiring not only a minimal element but also that this minimal element be absolute zero, and so positive evidence in the input—MP comparatives with overt standard—helps them identify exactly where the problem resides.

Recall from our CHILDES corpus search results that comparatives with a standard phrase are not very frequent in the input. Moreover, we can attest that although numerals are frequent in the input, they are most often encountered in other linguistic environments, such as count lists, and not in the form of an MP in a differential comparative expression (Syrett et al. 2012). Thus, although children are indeed getting evidence that a GA need not be accompanied by a standard phrase to have a comparative interpretation, they are not getting sufficient evidence early on in development that MP comparatives should be interpreted as differential comparatives (with comparison relative to a contextual standard), and are therefore not getting positive evidence early on about the semantic conflict that would force them to revise $Meas_{\text{child}}$ so that it no longer requires absolute zero as its minimum. Perhaps the absence of such robust evidence is why many children from both languages are still accessing non-adult-like interpretations of the target structures well into age 5–6. It takes time for children to accumulate the relevant positive evidence and surpass the threshold that they encounter around age 3;6–4, when they seem to have mastered the cardinality principle of numerals and can begin to engage in more sophisticated quantitative operations and measurement.

Thus, an important advantage of our approach based on $Meas_{\text{child}}$ is that not only does it allow us to derive various non-adult behaviors in children from a single assumption, but it also does not create a learnability problem. Under our approach, all that children have to do is to learn to revise their lexical entry for *Meas* by relaxing the selectional requirement, and that learning process only requires gathering the relevant positive evidence, which they will eventually encounter.

Our approach also raises an important question regarding the origin of $Meas_{\text{child}}$. That is, why do children assume a more restrictive selectional requirement for *Meas* than adults? At this point, we can only speculate on the answer to this question. One possibility is that the absolute zero is the most salient and useful minimum value for children. It is consistent across contexts, and the vast majority of counting and measuring events have absolute zero as their minimum value. Given this privileged status of the absolute zero, children might be led to include it in the lexical entry for *Meas*. Another possibility that is not mutually exclusive with this first idea is that children are biased to adopt the most restrictive, 'subset' hypothesis. Such a learning bias should help children acquire linguistic knowledge in general, because starting out with the most restrictive hypothesis allows them to obtain the correct knowledge on the basis of positive evidence alone. We are not sure, however, whether children actually rely on such a bias when they learn the semantics of lexical items, especially functional categories. We leave this question open for future research.

Note that under our approach, children are almost always faithful to the selectional restriction of *Meas* when interpreting MP comparatives. This entails that children interpret an MP comparative construction compositionally, rather than directly associating it as a whole with a differential interpretation. This point relates to a question about form-meaning mapping in acquisition in general: do children assign meaning to subparts, which are then composed in the syntax-semantics, or does a process of associating phrasal 'constructions' with their meanings characterize young children's acquisition of semantics, as proposed in some versions of Construction Grammar (e.g., Goldberg 2006)? In the input data, children should encounter utterances and corresponding contexts that would allow them to associate the relevant phrasal forms with the differential semantics (e.g., hearing "I want one more X" when the speaker has more than one X, or comparing how many more Xs one's sibling has to the number of Xs one has oneself). Our experimental data suggest that children do not immediately take advantage of such an opportunity with MP comparatives in English or Japanese.

The crucial component of our account for children's non-adult-like semantic interpretation is Sawada and Grano's (2011) assumption about the selectional restriction of *Meas* and how it figures into semantic composition. This theoretical device was originally proposed to account for a cross-linguistic puzzle in adult language, and we incorporated their insight into child language acquisition research. The idea that *Meas* imposes a semantic restriction on its complement allows us to isolate the cause for children's non-adult interpretations, thereby minimizing the difference between children and adults. Furthermore, the theory of *Meas* also allows us to account for the fact that children's non-adult interpretations are restricted to MP comparatives and do not extend to comparative constructions or gradable predicates in general, because the theory provides a way to associate the presence of an MP with a unique functional head. Since, as we assume, the functional head *Meas* does not appear in constructions without an MP, children do not face any problem in interpreting such structures. Finally, the assumption that the selectional restriction of *Meas* is universal allows us to invoke the same mechanism to explain the parallel behavior of English and Japanese children.

Our approach to resolve this puzzle is therefore in line with previous language acquisition studies that have referred to an independently proposed theoretical device in order to account for children's non-adult behavior. For example, Hyams (1986) used the *pro*-drop parameter (e.g., Rizzi 1986) to account for the observation that young English-speaking children often omit the sentential subject. Grodzinsky and Reinhart (1993) and Chien and Wexler (1990) invoked the distinction between a bound variable and coreference, originally proposed by Reinhart (1983), to account for children's apparent insensitivity to Condition B violations. Although these approaches have subsequently faced serious challenges (e.g., Valian 1990; Hyams 1992; Conroy et al. 2009), their contributions are nonetheless invaluable, because they significantly advanced our understanding of the nature of language acquisition and linguistic knowledge by bringing data from language acquisition research to bear on issues in theoretical linguistics. We hope that our account of children's interpretation of MP comparatives might engender similar productive debate in

semantics and enrich our understanding of the representation of comparatives and Measure Phrases.

8 Conclusions

In this paper we have argued, based on our experimental results from English and Japanese differential comparatives, that children and adults share the same Degree Phrase structure, in which *Meas* selects for a GA that has a minimal scalar element. The difference between children and adults lies in what constitutes this minimal value: in for children, $Meas_{\text{child}}$ selects for a minimal value of absolute zero. As a consequence, children wind up with an incorrect, absolute interpretation of MP comparatives in both languages. Regardless of the language they are acquiring, they appear to initially ignore any linguistic or contextual information that would override this minimal value. Future research may shed more light on this phenomenon by examining the time course of children's developing interpretations and judgments, and by expanding the investigation to languages such as Spanish, Korean, and Russian, which are likely to further reveal both cross-linguistic variability and similarities in the interpretation of MP constructions.

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