

Representing measurement: The view from nominal polysemy

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1 Introduction

Semantic analyses of gradability and measurement grounded in measurement theory have been very successful, but they are highly abstract.¹ Solt (2016) suggests ways to connect such analyses to facts about the mental representation of quantity and measure. The goal of this paper is similar in mission, with the novelty of drawing on polysemy data involving English *-th* nouns related to adjectives expressing measurable dimensions (*breadth*, *depth*, *height*,² *length*, *width*, *warmth*), as well as *weight*, related to the verb *weigh*, which has similar relevant properties.

All of the *-th* nouns considered here describe measurable properties and appear in identical syntactic constructions either as the complement to an appropriate measure phrase or with a measure phrase as complement, as shown in (1):

- (1) a. 2 meters in breadth / a breadth of 2 meters
- b. 2 meters in depth / a depth of 2 meters
- c. 2 meters in height / a height of 2 meters
- d. 2 meters in length / a length of 2 meters
- e. 2 meters in width / a width of 2 meters
- f. 2 degrees in warmth / a warmth of 2 degrees
- g. 2 kilos in weight / a weight of 2 kilos

However, all of these nouns also have other, interestingly diverging senses. For example, *heights* and *depths* can describe geographic locations; *weights* can describe physical objects. In contrast, none of the other measure nouns name physical entities in the absence of an overt or implicit complement. *Lengths of rope*, *breadths of sand*, and *widths of fabric* can all describe physical objects with a particular measure, whereas *heights of poles*, *depths of water*, and *weights of yarn* only describe measures. *Warmths of wood*, in contrast, are neither objects nor measures, but rather properties.

I argue that these patterns can be better understood by taking into account whether the properties described by *-th* nouns can be measured according to ratio scales, and if

¹Thanks to Stephanie Solt for many interesting discussions, meals and excursions over the years, especially during my stay in Berlin in 2017-2018. Thanks also to Nicole Gotzner and Uli Sauerland for the opportunity to contribute to this volume, to Giorgos Spathas and Beth Levin for comments and suggestions, and to Scott Grimm and the Quantitative Semantics Lab at the University of Rochester for creating the noun database and Lexometer data visualization tool that facilitated this study. This work has been supported by FFI2016-70645-P (AEI/MINECO/FEDER) and an ICREA Academia award.

²As the Merriam-Webster Online Dictionary and other sources note, in some cases, the suffix has simplified from [θ] to [t].

they can, how the “zero” value for the scale is determined. I will further suggest that the correlation between these measurement properties and the polysemy of the corresponding noun indicates that, despite their abstractness, formal scales do mirror cognitively salient aspects of measuring.

I begin by presenting a brief overview of the measurement-theoretic characteristics of the properties described by the different *-th* nouns. I then discuss the polysemy behavior of these nouns, drawing mainly on data from the Corpus of Contemporary American English (COCA, Davies 2008). Finally, I close with some comments on the correlations between measurement and polysemy and what might explain them.

2 Measurement-theoretic characteristics of *-th* nouns

The *-th* nouns are a very small class; I present the entire list I have been able to find in (2). Most are deadjectival (see (2-a)), although there are also some deverbal examples (see (2-b)), and two denominal examples ((2-c); see Broselow 1977 for discussion of the history of this class).

- (2)
- a. broad/breadth, dear/dearth, deep/depth, dry/drought, foul/filth, high/height, long/length, merry/mirth, warm/warmth, sly/sleight, slow/sloth, strong/strength, true/truth, wide/width, young/youth, wrath/wrath
 - b. bear/berth, bear/birth, blow/blowth, grow/growth, heal/health, spill/spilth, steal/stealth, weigh/weight
 - c. thief/theft, weal/wealth

Some are archaic (*blowth*, *spilth*) or related to words that are now archaic (*wealth*, related to *weal* \approx a prosperous state; *wrath*, related to *wroth* \approx *angry*). Here I focus only on those derived from non-archaic stative predicates that can denote conventionally measurable properties, as evidenced by productive combinability with measure phrases; this limits the set to the examples presented in (1).³

Let us consider the measurement-theoretic characteristics of the properties described by the *-th* nouns of interest. All of them with the exception of *warmth* are typically measured using ratio scales, for which meaningful ratios can be established between the individual values on the scale, thanks to the combination of measurable differences between those values and the existence of an absolute zero value (Stevens 1946). Thus, if A is a cube-shaped box that measures one meter along all dimensions, and B is another

³Although searches of the internet uncover examples of *strength* with measure phrases, such as in (i), no comparable examples are attested in COCA.

- (i)
- a. mixtures were used ranging from 37 MPa [megapascals, LMcN] to 85 MPa in strength [http://germann.org/lokcapo-test-publications]
 - b. S-glass has a strength of 700,000 pounds per square inch (4,800 MPa) [https://en.wikipedia.org/wiki/Strength_of_glass]
 - c. the reformatory man appears to be below the Amherst student’s average ten pounds in weight, ...thirty pounds in strength of chest, ...and two dips in strength of arms [https://en.wikisource.org/wiki/Page:Popular_Science_Monthly_Volume_50.djvu/733]

Note that the measures in the first two examples are not exactly comparable with the third, since the first two involve a highly technical measure of tensile strength, while the third appears to involve a relatively heuristic measure of the amount of weight a set of muscles can move or support without collapsing. Given the evident complexities involved in measuring strength and the length limits on this contribution, I leave *strength* out of the study.

cube-shaped box that measures two meters along all dimensions, all of the statements represented in (3-a) will be true. Similarly, if A holds one kilo of contents and B holds two, (3-b) will be true.

- (3) a. B has twice the breadth / depth / height / length / width of A.
b. B holds twice the weight that A holds.

Warmth, a temperature-related property, is different: as Stevens observed, temperature is generally measured on an interval scale. Interval scales resembles ratio scales in providing measurable differences between the individual values on the scale but differ from them in (typically) having an arbitrary, rather than absolute, zero value, which renders proportional measurement meaningless. Thus, for example, if it is 10 degrees Celsius in Berlin and 20 degrees Celsius in Barcelona, we cannot conclude that the temperature in Barcelona is twice that in Berlin. Unsurprisingly, then, expressions such as *half/twice/double/triple/n times the warmth* are vanishingly rare in corpora. There are no such examples in COCA describing physical warmth (as opposed to emotional warmth, which is presumably not measurable even on an interval scale), and only the following two examples unambiguously describe physical warmth in the much larger enTenTen15 corpus (13 billion words, <https://www.sketchengine.eu/ententen-english-corpus/>).

- (4) a. A former UK chief scientist once calculated that [the Gulf Stream] delivered 27,000 times the warmth that Britain’s power stations could supply and, as a consequence, the UK is on average 5°C warmer than it might be, given its latitude. [enTenTen15]
b. Offering twice the warmth of other uninsulated sleeping pads, internal baffling reduces convection heat loss between a warm body and cold ground much like a dual-pane window [enTenTen15]

Neither of the above examples measures warmth on a standard temperature scale. (4-a) measures warmth in terms of units of heat generation, and (4-b), in terms that are frankly not entirely clear. However, this latter example is representative of others one can find on the internet, in which an assertion of some ratio measure of warmth is supported by the presence of the corresponding multiplier of sources of that warmth, together with the implicit assumption that each source supplies a similar amount of warmth.

With these basics in hand, I now turn to the polysemy facts.

3 The polysemy of *-th* nouns

Given that the *-th* nouns form a semantic family insofar as they all describe measurable properties, one might expect at least some similarities in the polysemy they manifest. This is indeed the case, but there are also interesting differences. Most strikingly, as noted in the introduction, all of the nouns except for *warmth* have a countable sense describing a physical object. Given that *warmth* has just been shown to be associated with different scalar measurement properties from those of the other nouns, the question arises as to whether some of the polysemy behavior of these nouns might be correlated with (or, indeed, conditioned by) these measurement properties. Such a correlation would not be surprising if, in addition, the formal measurement properties also correlated in some way with features of the way humans intuitively measure breadth, depth, etc.

In order to address this question, I carried out a preliminary exploration of the *-th*

	<i>n</i> Total	<i>n</i> Singular	<i>n</i> Plural	% Singular	% Plural
<i>breadth</i>	923	921	2	99,8	0,2
<i>depth</i>	6848	5011	1837	73,2	26,8
<i>length</i>	10660	9123	1537	85,6	14,4
<i>height</i>	6717	5553	1164	82,7	17,3
<i>width</i>	1458	1332	126	91,4	8,6
<i>warmth</i>	2906	2906	0	100	0
<i>weight</i>	19250	17568	1682	91,3	8,7

Table 1: Number and proportion of singular vs. plural *-th* noun tokens in the COCA corpus.

nouns in COCA.⁴ All tokens corresponding to each noun in this study were extracted with a window of up to five words on either side (limited to a within-sentence context), and duplicates were removed. Descriptive statistics were then collected on the proportion of singular and plural forms for each noun. The reason for focusing initially on singular vs. plural forms was heuristic: Abstract nouns often have distinct non-count and count senses (contrast, e.g., *a bit of kindness*, where the non-count *kindness* describes a property, vs. *many kindnesses*, where the count counterpart describes a set of acts; see also Grimm 2012, 2013), so examining the plural forms in particular might be expected to reveal senses other than that of a measurable property.

The numbers and percentages of singular and plural tokens of each *-th* noun in this study appear in Table 1. Though the absolute frequencies of the nouns vary considerably, a few initial observations jump out. First, the variation in absolute frequencies is not especially correlated with variation in percentages of singular and plural forms. Second, the variation in percentages of singular vs. plural, while considerable, is nonetheless somewhat clustered. *Warmth* and *breadth* are never or virtually never attested in the plural form. *Width* and *weight* have a very similar percentage of plural uses (which are, incidentally, not only fairly close to the mean for this sample of nouns (9,6%), but also to the mean of the preset sample of 10 abstract nouns in the Lexometer data visualization tool that was used for exploring the corpus (8,4%)). Finally, *length*, *height* and *depth* all appear in the plural rather more frequently than the other nouns, although the variation in percentages in this group is greater.

On the hypothesis that the differences in plurality distribution might be indicative of semantic differences, I will use that distribution to help organize the presentation of the polysemy patterns.⁵ I begin with *depth* and *height*, which have the greatest proportion

⁴Specifically, the study drew on a database of nouns constructed at the University of Rochester Quantitative Semantics Lab from a local installation of COCA. The database used the Fiction, Popular Magazines, Newspaper, and Academic genres in the corpus (the Spoken genre was not included), which total about 350 million words. The corpus was tagged and dependency parsed using the Stanford CoreNLP tools (de Marneffe et al. 2014), and information both from the parse and from the CELEX database (Baayen et al. 1995) was added to the database. Note that all local installations of COCA have a random 5% of the corpus tokens removed for copyright protection purposes, and sentences containing html code or that were beyond a certain length were also excluded from the database creation pipeline because they posed parsing difficulties; see Grimm and Wahlung (to appear) for further details. Thus, the numbers cited here would differ slightly if based on searches of the relevant sections of COCA using the interface at <https://www.english-corpora.org/coca/>.

⁵Unless otherwise indicated, all examples in this section are drawn from COCA. Most of the nouns have metaphorical uses in addition to those discussed in the text; the examples in (i) are illustrative.

of plural uses. Based on a qualitative examination of the corpus I associate both nouns with three senses which, while related, can be differentiated.⁶ Obviously, both denote measurable properties of entities, as in (1); these can be found in both singular and plural forms, as the following examples show.

- (5)
 - a. The water depth at just 6 miles out is 400 feet; at 50 miles, it's 5000 feet
 - b. It will come in varying concentrations to fill wrinkles of different depths
 - c. Depth readings given above refer to depths to the sea floor
- (6)
 - a. I prefer a heel the height of the Eiffel Tower or a shoe as flat as a pancake
 - b. intervertebral disc heights are maintained without evidence of disc degeneration
 - c. The surveyors had given him lots and lots of different heights all over the mountain

In these cases, the values in question are determined by measuring from the base or exterior of the entity in question to a relevant coordinate. Typically, for depth, the measurement involves starting from an exterior point on an object and measuring perpendicular to a tangent or plane corresponding to that exterior of a volume in an inward direction,⁷ until the unique most distant coordinate on the object is reached. For height, the measurement involves taking a perpendicular from the base of an object to the unique coordinate on the object most distant in an upwards direction from that base; the base is effectively defined as parallel to the Earth's surface. Plural forms of the nouns reflect dependent plurality, as in (5-b)-(6-b). However, an entity with a sufficient large extension and irregular contours, such as a lake or a mountain or mountain range, can be associated with multiple depth or height measures, justifying the use of the plural in examples like (5-c)-(6-c).

In a related but distinguishable sense, both singular and plural forms of the nouns describe the coordinates themselves associated with a measure with a particular orientation – downward or inward with respect to the perspective of the speaker, in the case of *depth(s)*; upward, in the case of *height(s)*.⁸ This sense can be distinguished from the previous one because the measurement does not involve the traversal of an entity along the dimension in question; that is, it is not an entity that is measured. Rather, the measurement starts at what I will refer to as a deictic location or reference point – often, but not always, the surface of the Earth or, in the case of *depth*, the exterior of a volume

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- (i)
 - a. an intertextual reading helps to reveal the semantic depths of the text
 - b. individuals...who are “aspiring to new heights in human achievement”
 - c. a multidimensional politician, understanding the depth and width of political reality
 - d. A huge weight had lifted off my heart and soul
 - e. Yet it still often captures the characteristic Brucknerian warmth and grandeurs
[<https://worldradiohistory.com/Archive-All-Audio/Archive-High-Fidelity/60s/High-Fidelity-1960-Oct.pdf>]

Due to space limitations, I will leave such uses out of the discussion, except for very briefly when I turn to *breadth* and *width*.

⁶I will not take a position here on how best to model polysemy. See e.g. Vicente and Falkum (2017) for an overview of different possibilities.

⁷Note that describing the direction as inward covers not only the intuitive association of *depth* with downwardness, when the exterior corresponds to the Earth's surface, but also cases in which the direction involved is upward into the interior of a volumetric space, as when one talks about the depth of a ceiling.

⁸See Umbach and Leßmöllmann (2019), starting at min. 32:57 for a wonderful exemplification by Manfred Bierwisch of the role of perspective in the description of dimensional properties.

–, and ends at the coordinate referred to by the *depth/height* nominal. Representative examples appear in (7) and (8).

- (7) a. Excavate the entire walkway area to a depth of 8 in
- b. Had the comet contained denser, more strongly bound material, the bullet wouldn't have penetrated to a depth of 30 m
- c. The D10 is waterproof to depths of 33 feet
- d. Most permafrost loss will take place at shallow depths
- (8) a. teachers can instruct students to 'jump over the part of the slanted rope at a height that is just right for you'
- b. A broader path led up toward Paltz Point, rising above the hotel to a height of 1500 feet
- c. People have tried catching baseballs dropped from ridiculous heights
- d. the devices collect dust samples at various heights above the ground, usually up to 3 feet

Note that depending on, for example, whether the verb is dynamic or stative, what is inferred is either a distance traversed or simply a location. However, crucially in these cases the depth or height measure does not have to (and typically does not) equal the corresponding dimensional measure of any specific entity. For example, (7-c) does not entail that any body of water in which the D10 can be safely immersed must be 33 feet deep or shallower. The water itself can be of any depth; rather, it is the coordinate point in the water to which the D10 can be immersed that cannot exceed 33 feet.

Finally, *depth(s)* and *height(s)* have a third sense describing a physical location, most often, though not exclusively, the deepest part of a body of water or the highest regions of hills or mountains, as shown in (9)-(10).⁹

- (9) a. Their sense of sight and hearing is very acute and when alarmed, they dash for cover into the depth of a rocky cleft or under boulders
- b. Batman lands in the cement sinking into the depth of it
- c. Nutrients and fish circulate from the depths to the shallows on an ongoing basis
- d. I sank into the depths of a generous marble tub
- e. From the depths of the house, my father's voice rings out
- (10) a. Or we would watch them, worn and weary, scaling the whole height and width of a mountain, with not a single Huk in the area
- b. Lion-tails once flourished in the tops of rain forests in India, using their naturally dark coloring to disappear into the height of the jungle
- c. There were many more houses on the heights and along the curving beach
- d. The mountains rolled around us like great waves; below us the dark expanse of a river cut through a gorge; mist clung to the heights

⁹Giorgos Spathas (p.c.) observes that the adjectives *deep*, *high*, and *long* – but not the rest of the adjectives related to the *-th* nouns discussed here – also seem to have such an interpretation.

- (i) a. The ship lies/is deep in the ocean
- b. The cave lies/is high on the eastern side of the mountain
- c. The payoff lies/is long in the future

How best to analyze such examples is an interesting question for future research.

- e. Then his gaze swiveled around the chamber they stood within – scanning its walls and peering up into its heights with growing puzzlement

The fact that this sense is frequently associated with two geographical formations that often happen to have multiple deep/high points, together with the fact that the sense supports a frequent corresponding metaphorical use, illustrated in footnote 5, may account for the higher proportion of plural forms for these nouns, although additional quantitative work is needed to confirm this initial impression.

Given that a coordinate can function to locate an entity, one might ask whether the coordinate and location senses could be unified. Though the question cannot be resolved definitively here, there are a few reasons to be skeptical. First, the plural uses of the coordinate sense are necessarily distributively interpreted, whereas *heights* and *depths* can have a *pluralia tantum*-like interpretation describing a single location, as in (9-d) or (10-e). Second, the coordinate sense takes a measure as its complement, whereas the location sense takes a physical object. Finally, we will see immediately below that *length* has both senses, and that they are quite clearly distinguishable.

I now turn to *length*, which can be associated with the same three sorts of senses as *depth* and *height*, but which manifests a related set of differences of detail. First, though the measurable property sense appears in both singular and plural (see (11)), the plural form rarely, if ever, describes multiple measures of the same entity.

- (11) a. The length and width of each leaf were also measured
- b. Draped around her neck are five or six beaded necklaces of varying lengths

Possible explanations for this and the other distinctive characteristics of *length*'s senses will be offered in the next section.

Second, *length* has a sense corresponding to the coordinate sense of *depth* and *height*, although this use is largely confined to idiomatic expressions describing metaphorical distance, as in (12-a).¹⁰ In contrast to what one finds with *depth* and *height*, examples with numerical measures are rare even in internet searches, although they do exist, as shown in (12-b).

- (12) a. Mr. Dole has gone to some lengths to protect the industry
- b. To supply tracer gas, the schedule 40 1-1/4 in. supply line connected to gasper 6B was replaced with 3/4 in. schedule 40 PVC to increase the air velocity and turbulence of the air being supplied to the gasper...In order to create proper mixing with the turbulent flow, the injection point was placed at a length of 0.61 m (24 in.) away from the actual gasper [Anderson 2012: 41]

Third, *length(s)* has a use in describing a physical location, but with the difference that it is necessarily linear in shape – the location corresponds to an area contiguous with,

¹⁰The idiomatic temporal expression *at length* also has a coordinate-like use to describe a point in the future, as in (i-a); however, this use is less frequent in COCA than the use of the same expression to describe an extension of time, as in (i-b).

- (i) a. at length she died, after he had settled in Calcutta
- b. She knows when to let them speak for themselves at length

I speculate that the temporal extension use is related to the physical location use described immediately below.

and fairly close to, the longest (non-diagonal) line traversing the surface of some entity, rather than an area around a point or a set of points, as with *depth* and *height*.

- (13) a. my grandfather...removed his shoes, and paced the length of the patio in worn socks
- b. For safety, sturdy, high, stainless-steel rails run almost the length of the boat
- c. The two side straps are attached to stiffened wings that distribute the pressure along the length of the bag
- d. electrodes are situated in a longitudinally-alternating configuration along the lengths of the respective wires [enTenTen]

This interpretation is sharply different from what we see in (12-b), where *length* clearly identifies a point.

Finally, *length(s)* has a sense not shared by *depth* and *height*, similar to that of a unit classifier noun such as *head* (of cattle) or *bottle* (of water), which together with an overt or understood complement describes a piece or portion of some specific entity (as in the case of (14-a)) or type of entity.

- (14) a. Wrap the length of the ponytail around its base to form a bun
- b. The homeless man wakes suddenly and sees a two-foot length of pipe slide out of the tall man's sleeve
- c. she took sizzling lengths of sausage and spread a good gob of mustard
- d. peasant household-production strategies would have given each family enough time to produce about twenty-seven lengths of plain cloth
- e. Multicolored lengths of bent metal are threaded with different styles and colors of beads

To conclude with the nouns describing linear dimensions, I consider *width* and *breadth* together, because the Merriam-Webster online dictionary (www.merriam-webster.com) defines the main senses of each of these, if with minor variation in the details, in terms of the other:

- (15) a. Definition of *breadth*
1: distance from side to side : WIDTH
- b. Definition of *width*
1: the horizontal measurement taken at right angles to the length : BREADTH

Indeed, in their most basic measure-related sense, shared with the previous *-th* nouns we have discussed, the two appear to be interchangeable; there would be little or no appreciable difference in meaning if *breadth* were substituted in (16), or *width*, in (17).

- (16) a. Here, the Mediterranean Sea narrows down to a width of just 10 miles
- b. their scalps bare save for a strip down the middle, three finger widths across, running from forehead to nape
- (17) a. One country, for example, may press its demands for a twelve-mile territorial sea, and yet possess only ten miles of seacoast, while another, holding to the three-mile breadth, may border on the ocean for thousands of miles
- b. Mattress toppers are supplied in various breadths [enTenTen]

It is therefore striking that their singular/plural distributions are quite different. The

nuance of difference in the definitions and a qualitative observation of the data in COCA point to two arguably related factors. First, width intuitively implies a linear perpendicular to length, while breadth implies a planar perpendicular to length; in a sense, a breadth can be viewed as a set of widths. This difference, though subtle, emerges when we compare the second sort of sense the two nouns share with *depth*, *height*, and *length*, namely, that describing a location. As with the other nouns, these can be found both in singular and in plural, as shown in (18)-(19).

- (18) a. a short, bushy hedge runs the width of the house
 b. Miss Fiona Fairchild paced the width of her cousin’s parlor
 c. Purple Solid Dupatta With Lace Detail Running Along The Widths
 [https://in.pinterest.com/pin/6755468162917325/]
 d. the slabs behaved as wide beams with minor variation in longitudinal bending moments across the widths of the slabs
 [https://ascelibrary.org/doi/10.1061/40513%28279%29137]
- (19) a. He’d been on the road for seven days, across the breadth of England
 [https://ludwig.guru/s/across+the+breadth+of]
 b. The crack...growing along the breadth of the beam starting from one edge
 [https://ludwig.guru/s/along+the+breadth+of]
 c. Long ago he’d filled his days by tending to the space station, walking its lengths and breadths, inspecting, repairing and...keeping it clean [enTenTen]
 d. The generous breadths of Broadways and Main Streets were alive with commerce [enTenTen]

The location sense of *width* appears to be entirely analogous to that of *length*: an area contiguous with and fairly close to a line traversing an entity (typically, the longest such line) that is perpendicular to the length axis. In contrast, *breadth* suggests a location that consists not just of an area contiguous with a line, but rather a much bigger area perpendicular to the length axis. This difference is evident in the contrast between (18-a) and (19-a), for example, where swapping the nouns would change the respective inferences: a hedge running the breadth of the house is simply difficult to imagine, at least for this speaker of American English, while a trip across the width of England implies less area covered than the area implied by (19-a).

The difference corresponding to a linear vs. planar perpendicular is, unsurprisingly, less salient in the third sense shared by these nouns, analogous to the unit classifier sense we saw for *length* in (14), illustrated with singular and plural examples in (20)-(21). Since the entities denoted by the full nominals containing the *-th* nouns correspond to two- or three-dimensional objects, whether one of the relevant dimensions is described in terms of widths or breadths will make little practical difference.

- (20) a. Then I cut a width of silk a few inches longer
 [https://sewcloud.wordpress.com/tag/18th-century/]
 b. [shaping] a width of board without waste
 [https://www.lumberjocks.com/topics/65866]
 c. Making pinch pleated draperies. I will use 5 to 6 widths of the fabric...Or do I match the motifs and hope the drapes hang straight? [enTenTen]
 d. Soft grey tones and shimmering widths of ice and water [enTenTen]
- (21) a. The book, together with “The Yellow Emperor’s Four Canons” in four chap-

ters following it, was written on half a breadth of silk

[<http://61.187.53.122/collection.aspx?id=1342&lang=en>]

- b. a path cut through tall dune grasses, over the knoll to a breadth of sand, wider and longer than I have ever seen
[<https://trifargo.com/2019/04/24/travel-in-the-islands-of-scotland/>]
- c. taking the two sleeves, cutting them straight after ripping them open, and joining them across the top of the breadths [enTenTen]
- d. the whole face of the waters was changing..., whitening in some places, yellowing in others, where breadths of sand began to be exposed [enTenTen]

This difference between *width* and *breadth* might not by itself account for the extremely low number of plural forms of the latter, but it is correlated with a second factor that is perhaps more important: A strong division of labor between the two nouns in literal vs. figurative uses. At least in COCA, figurative uses of *breadth*, such as in (22), predominate.¹¹

- (22) Our goal is to produce students with both breadth and depth in the areas of basic psychology

If, for accidental reasons, *breadth* has become specialized for figurative use and is, correspondingly, rarely used as a unit classifier for physical objects, one important source of plural forms, namely to describe multiple units of such objects, will be missing.

Interestingly, *width* and *breadth* lack the sense attested with the previous *-th* nouns describing a spatial coordinate. We do not talk at width or go to great breadths. It is equally odd to refer to something being, e.g., at a breadth or width of 10 centimeters from something else. I will suggest an explanation for this fact in the next section.

I now turn to *weight*, the last *-th* noun with a non-negligible number of plural uses. As with *length*, *width* and *breadth*, both singular and plural forms of *weight* can describe measures, with the plural measure tied to there being a plurality of entities. Under normal conditions, a single entity is not ascribed more than one weight at any given time.

- (23) a. Know your baby's weight or have a scale handy so you can weigh her
b. The failure at this level of information processing characterizes the participant as misjudging the...heights and weights of teammate(s)

Weight has two additional senses, both attested in singular and plural forms. One describes the specific physical force associated with a given entity, something in a sense transferrable to and thus able to interact with other physical objects. Examples appear in (24).

- (24) a. shorten your steps, keeping your weight over the arch of your front foot
b. The barn roof sagged under the snow's weight
c. The boy's muscles went utterly limp, no longer resisting the pull toward the hollow in the mattress created by their weights, and he was falling toward her

This sense can be differentiated from the measure sense because it entails the involvement of the entity that has the weight in question, not just the amount of weight itself. For

¹¹ *Width* would sound very odd in such examples, presumably because it lacks the areal implications that support the metaphorical extension to e.g. fields of knowledge.

example, (24-a) would not be true if the subject of the clause weighed 50 kilos and kept a 50-kilo weight somehow over the arch of their front foot, but not their own body.

The other additional sense of *weight* describes a physical artefact whose function is to exert such a force, as exemplified in (25). This sense is unique among the *-th* nouns.

- (25)
- a. While holding a 10-pound weight, extend your right arm
 - b. Slip a “bullet” or “worm” weight (a cone-shaped lead weight with a hole through the center) onto the line
 - c. By day’s end the store will have run out of the hem weights used to make dresses hang gracefully
 - d. Remove pie weights and foil, prick bottom of crust with a fork, and bake

Finally, consider *warmth*. Some additional examples of uses to describe a measurable property appear in (26). Although COCA contains no plural uses of the noun at all, a few examples can be found on the internet, similar to those attested for the other *-th* nouns.

- (26)
- a. an extra set of baffles...serves as another layer of core insulation...It adds about 15 degrees of warmth for just 10 ounces
 - b. Jackets with the same fill weights of Primaloft Black, ThermalQ Elite and Polartec Alpha will all have slightly different warmths and heat retention [<https://www.gearx.com/blog/2014/10/03/gear-guide-insulated-jackets/>]

In addition, the property of tactile warmth resembles weight in being in some sense transferrable to its perceiver. This yields uses that are reminiscent of those in (24), as in (27).

- (27)
- a. The night was gorgeous and mild as the rock radiated its stored warmth
 - b. while we are snuggled in the warmths of our homes... [<https://iblog.dearbornschools.org/mehrhok/2020/01/20/celebrate-fairness-kindness-and-love-it-is-martin-luther-king-day/>]

However, there is a difference with respect to weight: warmth can be perceived without direct or indirect physical contact with the attributed source of the warmth. Even if the warmth is transferred from a radiating object, such as the rock in (27-a) to the air, we do not normally thereby attribute the warmth to the air. This separability of the property from its conventionally identified source may account for the fact that, in some cases, such as happens in (26), the entity to which the warmth property is ascribed is not itself (tactilely) warm. It may also play a role in explaining the fact that, as noted above, *warmth* diverges from the other *-th* nouns in lacking a countable sense describing a physical object, nor does it function as a unit classifier.

Table 2 provides a summary of the *-th* nouns discussed here and their interpretations. Though much more detail could be offered on their polysemy, the preceding discussion will be sufficient for our purpose of exploring the extent to which the polysemy patterns can be correlated with measurement-theoretic characteristics of the properties the nouns describe, and as well as possible connections between the latter characteristics and perceptible features of the measured properties.

	Measurable property	Coordinate	Physical object bearing property	Unit classifier	Transferrable force
<i>depth</i>	Y	Y	Y (Location)	N	N
<i>height</i>	Y	Y	Y (Location)	N	N
<i>length</i>	Y	Y	Y (Location)	Y	N
<i>breadth</i>	Y	N	Y (Location)	Y	N
<i>width</i>	Y	N	Y (Location)	Y	N
<i>weight</i>	Y	N	Y (Artefact)	N	Y
<i>warmth</i>	Y	N	N	N	Y

Table 2: Summary of *-th* noun polysemy.

4 Measurement-theoretic characteristics and polysemy in a broader perspective

It should be obvious that some of the differences in polysemy observed in the previous section derive from the fact that *depth*, *height*, *length*, *breadth* and *width* describe properties of linear measure, while *weight* and *warmth* do not. I begin this last part of the discussion with the former category.

We saw that *depth* and *height* differ from the other linear measure nouns in having a sense that describes conventionalized geographic locations, as well as areas defined around a point or set of points, as opposed to areas defined around a line or a plane. They also contrast with *length*, *breadth* and *width* in lacking a unit classifier sense. In contrast, *depth* and *height* together with *length* differ from *breadth* and *width* in having a sense that describes a spatial coordinate. As all of the properties described by linear measure *-th* nouns can be measured on ratio scales, and since ratio scales have an absolute zero, we can ask whether the way in which that zero point is identified might have something to do with the attested variation in polysemy.¹²

As noted above, the zero point for depth and height measures often corresponds to the surface of the Earth. None of the other linear measures have this characteristic. This fact plus the salience of mountains and bodies of water as affording high and deep points with respect to the Earth’s surface offers a natural explanation for the specialized sense of *height(s)* and *depth(s)* describing geographic locations.

Length shares with *depth* and *height* the possibility of a zero value corresponding to what I referred to as a deictic location. *Width* and *breadth* do not have this feature: the zero point for both is always one end of the object to which width or breadth is attributed, and that end is necessarily defined in terms of a perpendicular to the length axis of the object, rather than in terms of any point external to the object. The possibility of defining a deictic zero might explain the fact that *length*, like *depth* and *height*, has a sense describing a coordinate. However, in the case of *length* this point is not the ground

¹²As Giorgos Spathas (p.c.) points out, the differences in the way the zero point is determined effectively correspond to differences in the measure functions we can associate with each noun; fully formalizing these measure functions would therefore almost certainly yield additional insights into the polysemy patterns. For example, we might consider different strategies for underspecifying the way the initial endpoint marking the linear distance is identified in the case of *depth*, *height* and *length*, and not underspecify this aspect of the semantics for *breadth* or *width*, as an approach to capturing the difference between these sets of nouns.

but rather the position of some entity, for example, the gasper in (12-b) or the referent of the subject of (12-a). The fact that such entities are not necessarily permanently fixed makes such deictic zeros poor reference points for identifying a stable geographic locations, such as the top of a mountain or the bottom of a sea.

However, we have seen that *length* also shares two characteristics with *width* and *breadth*: 1) When these nouns describe locations, these are defined with respect to a line (or in the case of *breadth*, a plane), rather than around a fixed point or set of points, as with *depth* and *height*; and 2) all three have a unit classifier sense. The failure to describe an area around a point might be attributable to the fact that the zero is not fixed independently of the measured object itself or, in the case of *length*, is not fixed in a sufficiently permanent location. Nonetheless, the linear dimensions along which the measurements are made still provide a metonymically connected area for the nouns to describe.

More puzzling, perhaps, is the failure of *depth* and *height* to be able to describe locations defined by the linear dimensions along which they are measured. A full explanation for why this should be requires further research, but one hypothesis is that such measures often pass through empty space, and the measures by definition ignore any surface contours associated with the measured object. In other words, depth and height measures are not transparently connected to the measures of physical surfaces.¹³

As for the unit classifier sense, it is pragmatically easy to see how it could arise for *length*, *breadth*, and *width*, given that these values are uniquely defined for any given object (i.e., one object is typically assigned one length, width, and breadth) and potentially standardizable. In contrast, we observed that a single, sufficiently large object with sufficiently varied contours can be associated with multiple depth or height measures. This fact may make these latter *-th* nouns poor choices for unit classifiers.

Now consider *weight*. We identified two additional senses alongside the measurable property sense. One describes the (physical) force associated with a specific entity; the other, (physical) artefacts whose function is to exert such a force. The force of weight differs from linear dimensional properties in being effectively transferrable to or able to act on other entities; this difference likely underlies the lack of a counterpart to the first of these senses with the nouns describing linear dimensions. In contrast, the latter, artefact sense is similar to the location sense associated with the linear dimension nouns, insofar as both rely on an inextricable connection between the property and its bearer.

There is perhaps not much of great interest to be said in measurement-theoretic terms about the physical object sense of *weight*, other than that the existence of an absolute zero for weight measures – a value defined by the absence of any transferrable force – allows weights to be precisely compared across entities, facilitating, for example, the development of weights as artefacts for exercise or other purposes. Perhaps more interesting is the fact that no unit classifier sense was associated with *weight*, in contrast to *length*, *width* and *breadth*: No examples such as *a weight of flour* were attested in COCA. The apparent absence of such a sense may be due to the fact that weight is not reliably correlated with unit volumes, making the noun *weight* a poor standardized measure in contrast to precise, conventionalized unit classifiers based on weight, such as *pound*.

As noted at the beginning, *warmth* is the only *-th* noun in this study that has no sense describing a countable physical entity. Plausibly, *warmth* lacks a unit classifier sense for

¹³Length might arguably be measured by ignoring surface contours, but unlike height and depth, it is not *necessarily* measured by ignoring them.

the same reason that *weight* does. But why should *warmth* lack an artefact sense, that is, why do we not call entities like the baffles inserted in sleeping bag for insulation *warmths*, the way we call the pieces of lead that are put in the hems of curtains *weights*? Here I suggest that the crucial difference is that warmth, while transferrable like weight, exerts a much less predictable effect when transferred, one that does not depend solely on the source of the warmth – that is, the entity to which we conventionally attribute the property.¹⁴ We are typically more concerned with the transferred effects of warmth – those we perceive – rather than with the inherent warmth of the bearer, and as it is arguably difficult to standardize artefacts according to the effective warmth they provide (in contrast to the case of weight, which is, as noted above, inextricably and reliably connected to the entity to which we attribute the weight property). Therefore, *warmth* is perhaps less likely to be an informative choice of name for any such artefact. If this reasoning is correct, we might expect to find similar patterns of polysemy to those discussed here in other nouns, both in English and in other languages, that describe properties with similar characteristics.

A further interesting question for speculation is whether the characteristics that I have suggested make *warmth* a poor choice for an artefact name – particularly the lack of the same sort of reliable relation between the property bearer and the practical effects of the property – are also ultimately responsible for the fact that, outside of scientific contexts, we do not measure warmth on a ratio scale, and that ratio scales for temperature have emerged only very recently in human history. Solt’s (2016) observations about how our understanding of the formal characterizations of scalar measurement can be enriched by insights from studies of cognition and conceptual representation should lead us to expect a positive answer. But I leave this question for her (or others) to figure out.

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¹⁴Of course, the perception of weight depends on, e.g., gravity or atmospheric pressure, but these factors are more predictable, especially across a set of humans in the same environment, than those influencing temperature perception.

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