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Measurements, Numerals and Scales

Essays in Honour of Stephanie Solt

Edited by
Nicole Gotzner
Uli Sauerland

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To Stephanie Solt

Acknowledgments

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Contents

List of Figures

Modified Numerals, Vagueness, and Scale Granularity

She is Brilliant! Distinguishing Different Readings of Relative Adjectives

Numerals Denote Degree Quantifiers: Evidence from Child Language

Quantifying the Register of German Quantificational Expressions: A Corpus-Based Study

A Novel Probabilistic Approach to Linguistic Imprecision

List of Tables

Modified Numerals, Vagueness, and Scale Granularity

She is Brilliant! Distinguishing Different Readings of Relative Adjectives

Numerals Denote Degree Quantifiers: Evidence from Child Language

Representing Measurement: The View from Nominal Polysemy

On the Status of Post-nominal Q Superlatives in Romanian

Quantifying the Register of German Quantificational Expressions: A Corpus-Based Study

Modification of Measure Nouns

Introduction

Nicole Gotzner and Uli Sauerland

1 Stephanie Solt: Her Influence as a Researcher, Colleague and Mentor

The inspiration for this volume stems from our long and fruitful working relationship with Stephanie Solt. Since her Ph.D. in linguistics in 2009, Stephanie has created a rich and intricate body of work that has proven to be deeply insightful and inspiring for many in the field. The contributions in this volume attest to the powerful influence her ideas have

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in three of the central areas of current semantic theory: measurement, numerals and scales.

In her dissertation, Stephanie Solt developed a semantic account of quantity expressions. She became a pioneer in integrating insights from the psychology of measurement and numerical cognition with formal semantic analyses. Her first postdoctoral position was in a project on vagueness, approximation and granularity at the ZAS, followed by a position in a project on indefinites at the University of Amsterdam. Since then, Stephanie has acquired an impressive number of grants on scale structure, degree expressions, polarity and situation-specific uses of quantifiers and numerical expressions. With her ground-breaking work in several areas relating to measurement, quantity and scales, Stephanie quickly established herself as a leading researcher in formal and experimental semantics.

Both on an academic and a personal level, we could not imagine the field of semantics without Stephanie Solt. She has provided invaluable mentorship to many colleagues and has inspired junior researchers to pursue a career in academia. These are two among many reasons why she deserves the title of a Jedi Master. Her colleagues value her for her insightful feedback and her combination of linguistic theory with experimental investigations, as witnessed in the following quotes.

Heather Burnett: 'What makes Steph's work really special is how she combines high level experimental work with subtle, well-grounded (almost "no nonsense") analyses, a combination which always moves linguistic theory forward in a significant way. She is also a very open, generous colleague, and I am so happy to have had the chance to collaborate with her!'

Chris Cummins: 'Thanks to the largesse of Euro-XPRAG, Stephanie was the very first person to make an academic visit to me, which was when I was a Ph.D. student in Cambridge in 2010. My hosting of that visit wasn't exactly a success, in that, just before it was due to end, that Icelandic volcano erupted (https://en.wikipedia.org/wiki/2010_eruptions_of_Eyjafjallaj%C3%B6kull) and all the flights were grounded.

Stephanie eventually made the trip back to Berlin overland, by train and ferry, which took about 24 hours door-to-door.'

Nicole Gotzner: 'I am indebted to Stephanie for training me and for inspiring me to pursue a career in experimental semantics and pragmatics. More than ten years after being her research assistant, Stephanie is still the first person I am seeking out for advice. She is a great source of inspiration to me on many levels.'

Louise McNally: 'Stephanie is very tough to convince, and almost always has an insightful counterexample up her sleeve, which she generally prefaces with sort of a squint and a very mild-mannered "Yeeeah...well...I don't know..." before offering what can amount to a definitive blow to an analysis. I always look forward to questions from Stephanie.'

Uli Sauerland: 'I have learned and continue to learn from Stephanie about linguistics, about leadership and about life in general. Her evident love of studying language and engaging in discussions of it from the oddest angles has many times drawn me in and made me enjoy so much more what I am doing.'

The chapters in this collection address three core topics centered around Stephanie's work: measurement theory, the meaning of numerical expressions and scales in semantics and pragmatics. We briefly summarize the main findings presented in this volume and how they relate to the core areas of Stephanie's work in the following.

2 Measurement Theory

Solt developed an account of partitive phrases as partial measure functions, restricted by their nominal complement (Solt 2018a). This account is based on data indicating that partitives with 'many' force proportional readings while partitives with 'more' makes both proportional readings and direct comparisons accessible. In his chapter 'Partitives, Comparatives and Proportional Measurement,' Alan Bale provides novel data

showing that proportional scales are accessible in both partitive and non-partitive constructions, which challenges Solt's original proposal. He extends this proposal by arguing that partitive phrases always relativize their degree interpretations to an underspecified scalar limit. This novel view has important ramifications for the denotations of mass nouns, which might have a lower bound (as suggested in Chierchia 1998, 2010).

Giorgos Spathas' chapter entitled 'Domain restricted measure functions and the extent readings of relative measures' also follows up on Solt's account of proportional readings with 'many' and 'most' (Solt 2018a, b). Spathas discusses degree readings of percentages and proposes a unified analysis of percentages in predicational structures. Together with Solt, he argues that the availability of extent readings crucially relies on domain-restricted measure functions.

Louise McNally's chapter on 'Representing measurement: The view from nominal polysemy' argues that semantic analyses of gradability and measurement grounded in measurement theory have been very successful, but they also suffer from a high level of abstractness. McNally highlights Solt's contribution in 2016, where she suggested ways to connect such analyses to facts about the mental representation of quantity and measure. McNally's paper is in a similar spirit and it suggests an analysis of polysemy data for English nouns ending in -th such as 'depth' and 'warmth.' McNally argues that the formal scales underlying such nouns mirror cognitively salient aspects of measuring, as evident in the correlation between measurement properties and the polysemy of the corresponding noun.

As observed by Solt (2009, 2014a), measure phrases have the same distribution as quantity adjectives like 'much' and 'many,' which are functional categories. In 'Modification of measure nouns,' Cameron Wilson points out that Solt's analysis of quantity adjectives as degree-operators enables a unified account of their diverse uses. Wilson presents a corpus analysis on adjectives in measure noun modification. This research indicates that measure nouns are polysemous with a distinction between container nouns vs. unit and temporal nouns. Wilson also points to several other innovations in semantics that were inspired by Solt's account, for example in the area of quantity superlatives (Wilson 2018; Coppock et al. 2020).

Nicolae and Scontras investigate the distribution and the interpretations of quantity superlatives in Romanian. They also built on Solt's (2014a) work on quantity adjectives as quantity superlatives are built from quantity adjectives like 'many.' 'On the status of post-nominal Q superlatives in Romanian' reconciles seemingly contradictory claims in the literature. By showing that both post-nominal quantity and non-quantity superlatives are sensitive to how context sets the comparison class, Nicolae and Scontras offer a unified analysis of post-nominal superlatives in Romanian.

3 Numerical Expressions and Approximation

Solt has shown that numbers are anything but boring and several contributions of this volume follow up on her results. The rich variety of grammatical and semantic properties of numerical expressions that Solt has uncovered shows itself with vagueness, modifiability, polarity and social meaning. The vagueness of numerical expressions can either be inherent, especially for round numbers like 'sixty,' or it can be managed by explicit approximating modifiers such as 'around sixty.' Extending her earlier dissertation work on vague quantification, Solt has made substantial contributions to both types of vagueness. In joint work, she showed that roundness affects the interpretation of modified numerals like 'more than n' and 'less than n' (Cummins et al. 2012). A major contribution of Solt's has been to demonstrate in concrete experimental studies cognitive benefits of round numbers to explain the preference for approximation (Solt et al. 2017). The rich study by Solt (2014b) examines the properties of numerals in comparatives. Just one striking discovery of her work is that modified numerals in comparatives frequently lead to polarity items. Among approximating expressions, Solt and Stevens furthermore show that English 'some,' as in 'some 60 years,' has been wrongly included in this category by Sauerland and Stateva (2007), and instead should be treated by an extension of the indefinite meaning of 'some'. More recent work of Solt's addresses (in progress) also the social meaning and

polarity of numerical expressions, the latter of which we come back to in the following section.

The contributions in this volume explore the full richness of terrain laid out by Solt's work. Three contributions primarily concern modified numerals. Paul Egre in the chapter 'Around "around"' follows up on Solt's (2014b) work on the approximator 'around.' He proposes a refined account of the meaning of 'around' more aligned with the spatial basis of the word 'around.' Two contributions develop theoretical accounts of the empirical results of Cummins et al. (2012) on the upper bound inferred from modified numerals like 'more than n.' Chris Cummins' chapter 'Uncertainty, quantity and relevance inferences from modified numerals' focuses on competing considerations in the speaker's choice of an utterance. Anton Benz and Christoph Hesse discuss novel data that extend the results of Cummins et al. (2012) in their chapter 'Modified numerals, vagueness, and scale granularity.' Remarkably, both contributions to this volume agree that the approximate number system plays the central role, while the role of linguistic factors such as roundness is lower.

Of the three contributions relating primarily to bare numerals, Chris Kennedy and Kristen Syrett present experimental data from children concerning the interpretation of bare numerals in root modal sentences. In 'Numerals denote degree quantifiers: Evidence from child language,' they show that the interpretation assigned are adult like as expected from the theoretical account of Kennedy (2014). In the chapter 'Unknown numbers,' Rick Nouwen addresses summative readings of bare numerals as in 'Sue had three husbands,' and relates that the adjectival properties of numerical expressions discovered by Solt (2009). Robert Pasternak examines the various uses of money phrases like 'five dollars' in the chapter 'Some speculative remarks on the semantics of money phrases.' He suggests that all uses of money phrases should be derived from a denotation to an abstract entity of the monetary unit.

Two contributions on numerals also take sociolinguistic aspects into account. In 'Number, Numbers and the Mass/Count Distinction in Daakie (Ambrym, Vanuatu),' Manfred Krifka examines the dual and paucal in Daakie with particular attention to two sociolinguistic aspects, namely honorific uses of the dual and affiliative uses of the paucal.

Uli Sauerland's chapter 'Quantifying the register of German quantificational expressions: A corpus based study' investigates the connection between vagueness and formality using corpus evidence and finds some confirmation for a correlation between the two.

4 Scales and Polarity

A number of further chapters address Solt's work in the area of measurement scales, entailment scales and polarity. In collaborative work, Solt developed an informativity-based account for the polarity sensitivity of different modifiers (Solt 2018c; Solt and Waldon 2019; Solt and Wilson, 2020).

Berit Gehrke and Elena Castroviejo relate to this work by focusing on the Catalan modifier 'ben.' Their chapter 'Evaluative intensification and positive polarity: Catalan WELL as a case study' targets the modifier's meaning when combined with different adjectives and its behavior in entailment-canceling contexts. They argue that Solt and Wilson's account (2020) correctly explains why true degree modifiers (e.g., 'fairly') behave like positive polarity items. Catalan 'ben,' on the other hand, calls for a different analysis as it appears to express degree intensification without manipulating degrees directly.

In 'Amazing hodo,' Eri Tanaka discusses the polarity sensitivity of the Japanese equative marker 'hodo,' following up on joint work with Stephanie Solt (Tanaka et al. 2019, 2020). Tanaka et al. (2019, 2020) showed that this equative marker behaves like an NPI in some contexts but is polarity insensitive in other contexts. Tanaka provides new data, which suggest that 'hodo' exhibits the full range of polarity sensitivity, including PPI uses. She argues that the PPI-hood of both 'amazing'-hodo and amazingly-adverbs should be attributed to their 'extreme' semantics, which renders negated propositions involving 'hodo' less informative than its alternatives.

The chapter 'She is brilliant! Distinguishing different readings of relative gradable adjectives,' addresses the interplay between measurement scales and Horn scales in the area of gradable adjectives. Gotzner and Kiziltan follow up on Solt's (2015) paper on scales in semantics and

pragmatics and the studies by Gotzner et al. (2018a, b) on scalar implicature and negative strengthening. Gotzner and Kiziltan show that, under negation, the interpretation of weak scalar terms is asymmetric: positive terms (e.g., 'not large') are strengthened more than negative ones (e.g., 'not small'). Strong scalars, on the other hand, receive a middling interpretation independent of polarity. These findings are in line with Horn's (1989) account of the Division of Pragmatic Labor. Overall, this research indicates that adjectival meaning should be modeled by integrating multiple factors such as the properties of measurement scales, complexity of alternative expressions and factors relating to the social context.

5 Concluding Remarks and Wishes

Stephanie Solt has conducted ground-breaking work on measurement, numerical expressions and scales. As shown by the contributions to this volume, she has shaped and tremendously impacted formal and experimental semantics. Dear Stephanie, we would all like to thank you for your amazing contributions to our field, your inspiration, and your friendship. We feel honored to know you and to celebrate your special anniversary with you.

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Partitives, Comparatives and Proportional Measurement

Alan Bale

1 Introduction

As the literature on partitives has slowly grown over the last three decades, the puzzles they pose for grammatical theories have only deepened. Beyond traditional distributional problems discussed in the early literature (Jackendoff 1977; Selkirk 1977; Abbott 1996; Reed 1996; Hoeksema 1996; de Hoop 1997), partitive phrases also seem to limit the way that elements in nominal denotations are measured and compared (see the discussions in Partee 1989; Ahn and Sauerland 2015; Ahn and Sauerland 2017; Penka 2018; Solt 2018). In this chapter, I focus on the interactions between partitive constructions and the grammar of measurement. In particular, I review, analyze and re-imagine some of the generalizations and theoretical proposals advanced in Solt (2018). My reasons for focusing on Solt (2018) are twofold. First, Solt (2018) is one of the few researchers who

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thoroughly discusses how the grammar of measurement relates to partitive constructions. In particular, she outlines an interesting puzzle that I will dub *Solt's Generalization*, namely that partitive constructions force proportional readings when they combine with *many* and *few* but crucially not when they combine with *more* or *fewer*. Second, Solt's analysis elegantly accounts for this generalization (along with other well-known partitive facts) via one semantic mechanism, namely functional restriction. In Solt's theory, functional restriction both presupposes the sub-part relationship and forces proportional interpretations in certain grammatical contexts. However, her analysis is not without its weaknesses. Solt's theory relies on the hypothesis that proportional scales are derived from restricted (non-proportional) measure functions. Yet, evidence from non-partitive comparative constructions suggests that there is a much wider variety of proportional scales than those discussed in Solt (2018), including those that cannot be derived from a restricted measure function (Bale and Schwarz 2020).

In this chapter, I will explore whether Solt's theory can be altered while still preserving its account of Solt's Generalization. I will attempt to keep the core aspects of her theory intact, particularly functional restriction, while making some fundamental changes to how restricted measure functions relate to proportional scales. One of the key features of this reanalysis is that partitive constructions are predicted to "factor out" the effects of most types of proportional measures. As we will see, this prediction has some empirical support. Non-partitive constructions allow for a greater variety of proportional comparisons than their partitive counterparts. In the conclusion of this chapter, I will discuss some of the consequences of adopting this revision. In particular, if this revision is on the right track, then it follows, based on the behavior of mass nouns in comparative constructions, that all mass nouns have minimal parts, or at least minimal "measurable" parts (c.f., Chierchia 1998; Chierchia 2010).

2 Background Assumptions on Decomposition

Within the literature on degrees and numerals, there is much debate over whether measurement is something that is built into the meaning of a variety of lexical items (e.g., adjectives, numerals, comparative morphemes etc.), or whether measurement is associated with a grammatical morpheme that is part of a more complex morpho-syntactic structure. Although this debate is important, the differences between these two perspectives will not be discussed in this chapter. However, for the sake of exposition, I am going to adopt a decompositional point-of-view when it comes to measurement, such as the one advocated in Solt (2018). However, the reader should keep in mind that many of the points I make can be re-imagined through a non-decompositional lens.

An essential part of the decompositional treatment of measurement is the assumption that certain operators provide the "glue" between degrees and NPs. For example, under such an assumption, phrases like 'four rabbits' might be decomposed into something like *[[four* MEAS*] rabbits]*, where MEAS is a phonologically null morpheme that takes a degree argument before modifying the NP *rabbits*, restricting it to subgroups of rabbits whose cardinal measure is 4. A full DP results when this modified NP combines with the phonologically null existential determiner $\lambda.P.\lambda Q.\exists x.P(x)\ \&\ Q(x)$. For the sake of simplicity, I will use $\exists$ to represent this determiner.

Under a decompositional analysis, phrases with numerals are not the only grammatical constructions that require this kind of "glue." Nominal comparisons critically involve degrees which restrict NPs through some type of grammatical measurement. For example, a sentence such as *[More students passed this term than last]* is often interpreted using the same comparative operators as adjectives (i.e., *more* = *many/much+er*, see the arguments in Bresnan 1973). The comparative operator originates in a degree argument position, connected to the NP via the MEAS operator. The comparative morpheme moves at LF, leaving a trace degree variable and triggering the creation of a degree predicate. The 'than'-clause also creates a degree predicate, as shown in (1).

(1) [-er [than λd. [$\exists$ [d MEAS students] [passed last term]]] (than-clause)
[λd. [$\exists$ [d MEAS students] [passed this term]]]] (main clause)

The truth conditions of the entire comparative is determined by comparing these two degree predicates (e.g., (1) is true if and only if the maximal value in the main-clause predicate is larger than the maximal value in the than-clause predicate).

Similarly, sentences with quantificational terms like *many* are also routinely analyzed with operators that take degree predicates as arguments (once again on analogy to adjectival expressions). For example, under a decompositional analysis, computing the truth conditions for a sentence like *[Many students passed this term]* often involves an operator labelled POS (von Stechow 1984; Kennedy 1999). In such an analysis, a measure operator mediates the relationship between a degree argument and a nominal expression within the degree predicate. See the structure in (2).[1]

(2) [POS [λd. [$\exists$ [d MEAS students] [passed this term]]]]

The truth conditions of the sentence is determined by the application of this POS operator to the degree predicate (e.g., the sentence is true if and only if the maximal degree in the degree predicate is greater than a contextually set standard).[2]

A benefit of this decompositional perspective is that it highlights and isolates the role of measurement in sentences with nominal comparisons. In this chapter, I am going to focus on the role of measurement, in particular Solt's (2018) hypothesis that the partitive morpheme itself is one of these measurement operators. To facilitate this discussion, I will assume that measurement operators are a part of the "functional" lexicon. In order not to lose the trees for the forest, I will only vaguely discuss the compo-

[1] Solt (2015) argues that there is an additional operator in these types of constructions that captures the differences between *many* and *few* on the one hand and *much* and *little* on the other. The details are relevant for the overall semantic theory but pull us slightly off topic in terms of the focus of this chapter. For the sake of simplicity, I will not include such operators in the syntactic or semantic representations here, nor will I review the arguments for this additional operator.

[2] For now, I will leave it open whether MEAS is sometimes phonologically realized as *many/much* (as argued in Bresnan 1973) or whether it is always phonologically null (as argued in Solt 2015).