An Ontological Semantic Account of Relative Quantification in English

Whitney R. Vandiver

Purdue University
Linguistics Program
West Lafayette, Indiana
wvandive@purdue.edu

Abstract

This paper proposes a linguistic analysis of the semantic behavior of relative quantifiers in English, those for which an absolute value cannot be determined, with attention to the differences in properties and meaning between individual quantifiers and the semantic subclasses created by these quantifiers. Represented formally within Ontological Semantic Technology (OST), the semantic nature of such relative quantifiers is also described for computational purposes, with consideration of the related mathematical qualities of quantification that must be captured for adequate description. Among the English quantifiers considered here are *few, a few, little, a little, a bit, some, several, many, much, most, a lot*, the comparative forms of *more, less,* and *fewer*, compositions of combined relative quantifiers, such as *much more*, and the intensification of quantification with *very* and *too*.

Quantification in English can occur in two forms, as absolute with numerical equivalents or as relative with variable, inconsistent values that appear to be contextually dependent. Relative quantification, the focus of this paper, has been commonly treated with syntactic analyses, with quantifiers seeing little in the way of meaningful semantic descriptions. A large portion of these syntactic accounts aim at describing quantification through solely formal mathematical and logical representations (Keenan 1973; Partee 1978; Barwise and Cooper 1981; Keenan and Stavi, 1986), despite both realms failing to produce any definable subclasses or conclusive semantic properties for further application due to their inabilities to represent the syntactic relationships of natural language and the minor distinctions of quantifier meaning (Nirenburg and Raskin 2004). However, existing linguistic descriptions of quantifier behavior has provided some insight into their semantics. Jespersen's earlier work (1933) is absent of the term *quantifier*, discussing instead only indefinite numerals and totality, the latter in keeping with Sapir's (1930) discussion of the meanings of *all*, with some consideration of *each* and *every*. While Jespersen's (1969) later description contributes adjectival modification (*few women, three students*), he shows the beginning of a semantic characterization with the note that quantifiers vary from syntactically similar adjectives in that they do not mark anything about kinds, only numbers. Quirk et al. (1985) set up a more detailed syntactic description regarding quantifiers' nominal co-occurrence but provide little toward semantic descriptions. Keenan and Stavi (1986) touch on the semantics of quantifiers in their description of natural language determiners of *some, several, few* and *most*, but view them in light of determiner behavior for a limited analysis which gives more attention to the behavior of the syntactic class rather than the semantic phenomenon of quantification. In their work on the psychology of quantifiers, Sanford, Moxey, and Paterson (1994) consider two classes of relative quantification—though, oversimplifying the task greatly—as denoting only small or large amounts, leaving middle-range quantifiers in their overlapping boundaries and awkwardly classified as a result. However, there lies in English quantification more than simple proportional comparisons and syntactic descriptions.

The simplest case of English quantification is that provided by numerals, which give exact amounts[1], and their lexical and morphological equivalents, such as singular nouns. However, some English quantifiers offer a relative quantification for which a numerical equivalent cannot be consistently established (Bradburn and Miles 1979; Routh 1994; Wright et al. 1994). Consequently, some researchers argue that the conceptual definition of a linguistic quantifier should be no more than a variable reference point (Sanford, Moxey, and Paterson 1994), eliminating the general notion of a lexical class (Nouwen 2010). Contrary to this belief, the behavior of relative quantifiers can be shown to create a cohesive netting of lexical items with similar semantic meaning. When

[1] For a similarly computational account of numerals, see Taylor et al. (2010).

analyzed purely semantically, relative quantification reveals two classes of behavior, both of which can be determined by how a relative quantificational range may vary its boundaries with respect to a domain. Each domain may be represented as a scale of possible quantification, and each possible range of a quantifier remains fixed to a scale. Such ranges create the consistent interpretations of each relative quantifier regardless of context, eliminating what Barwise and Cooper (1981) term the "fixed context assumption" (p. 163) and with which they dismiss the need to account for the variable meaning of "non-logical" (p. 163) quantifiers.

Formal Semantic Representation with OST

Ontological Semantic Technology[2] (OST; Nirenburg and Raskin 2004, superseded by Raskin, Hempelmann, and Taylor 2010) is the implementation of the formal representation of lexical meaning and respective word classes for computational purposes. OST results in the production of text-meaning representations (TMRs) that become the basis for reasoning and inferencing processes to imitate the meaning-driven competency of the human mind[3], providing the tools and format necessary to describe natural language meaning[4]. The primary resources of OST are a language-independent ontology and a language-dependent lexicon. The structure of the former captures the relationships between events, objects, and properties of concepts to represent the world knowledge necessary in natural language understanding. As a lattice of concepts, each defined as a set of properties, the ontology uses hundreds of properties that may be combined to describe any semantic structure (sem-struc) of a lexical sense and thereby represent differences in meaning.

All lexical entries of a language are collected in a language's lexicon, which is a representation of each word sense's individual sem-struc, along with additional pertinent information such as a syntactic structure (syn-struc). In formal representation, each concept and its relative properties can be combined to describe different meanings so that each sense in a lexicon will have a different meaning or be represented as a synonym of another entry with identical sem-strucs. These combinations of concepts and properties are given to the OST analyzer in the form of sem-strucs, along with all the other information in each lexical entry, for the production of TMRs to show the possible interpretations of a text, providing it with the information necessary to discern in meaning of the words in the input text.

The semantic properties of relative quantifiers in English are easily represented in OST by providing each quantifier with a quantificational range for describing a particular property. The scale is determined by the domain being quantified with each quantifier's range being unique to an individual quantifier's use so that no two quantifiers necessarily provide the same quantification. Semantically, relative quantifiers select a range of possible quantification while being imprecise about which value in that range is actually quantifying the objects, i.e. *some books* may mean two, three, or four books. These inexact values produce one of the primary obstacles for a computational analysis of scalar quantification, but this property of flexible quantification is adequately captured in OST.

Semantic Analysis of Relative Quantification

Relative quantifiers are unique in that they create vague quantifications yet are capable of being used in a variety of contexts. The possible values that a relative quantifier may represent are in part reliant on what values other relative quantifiers may represent on the same scale (in the same domain) while the relationship between each relative quantifier will always remain the same[5], i.e. *little* involves less than *some*, which involves fewer objects than *many*. Regardless of the domain, the semantic behavior of relative quantifiers is always consistent in interpretation. Two subclasses of relative quantification may be delineated based on semantic behavior: stationary quantifiers have a definite range with unmovable boundaries, while drifting comparative quantifiers have ranges that are anchored with one endpoint and move along different values on a scale in comparison to another known value.

Stationary Quantification

Stationary quantifiers have a definite range of quantification that cannot be adjusted along a given scale of quantification. Relative quantifiers that represent the smallest amounts of stationary quantification are *(a) few, (a) little,* and *a bit*. It is significant to note that, regardless of their relative nature or the domain in which they are used, these lexical items will always be used at the lower end of the spectrum to communicate relatively smaller amounts in English. Semantically, *(a) few* and *(a) little* are synonyms and represent the same values of quantification, with the only difference being that the former modifies count nouns (*cars, books, students*) while the latter modifies only non-count or mass nouns (*coffee, tea, excitement*):

(i) Mary brought a few books with her
(ii) Mary brought a little coffee with her

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[2] See Raskin et al. (2010) for theoretical revisions and implementational deviations from initial notions.

[3] The goal of OST is not to describe what the human mind accomplishes in the way of representations and processes but to represent meaning and process it with results equivalent of human abilities (Nirenburg and Raskin 2004).

[4] For description of OST tools, see Nirenburg and Raskin (2004) for the preliminary development or Taylor, Hempelmann, and Raskin (2010) for updated methods and uses in automatic acquisition.

[5] This is in disagreement with Nouwen's (2010) argument that relativity among quantifiers suggests their independency.

Additionally, both quantifiers, unlike *a bit*, may operate with or without the determiner *a*. Moxey and Sanford (1986) touch on the difference between *few* and *a few,* offering empirical evidence that the two quantifiers experience a divergence in communicating a speaker's expectations. *A few*, they argue, is a quantification without expectation, while *few* implies that a speaker expected a larger amount. Compare (i) with (iii):

(iii) Mary brought few books with her

While (i) is a simple quantification, (iii) carries the possibility that the speaker is expressing that she expected Mary to bring more books than she did. The same difference exists between *little* and *a little*. This difference in expectation does not remove the relative nature of the quantifiers and their meaning of a relatively small amount. It is interesting to also note that *little* and *a bit* may be combined for a restriction (or perhaps, intensification) of a measurement: *a little bit*. However the reverse modification is ungrammatical: **a bit little*.

OST easily captures this behavior when it is noted that members of the stationary class have a fixed range of quantification that can be represented as a crisp (as opposed to 'fuzzy') set along a given scale. To account for the consistent interpretation of their quantification, a definite range can be determined for each quantifier, with its range remaining the same regardless of the domain. In OST, the crisp set is expressed formally by the numerical fillers of the facets EQUAL-TO,GREATER-EQUAL, GREATER-THAN, LESS-THAN, and LESS-EQUAL, in the description of the given property, RELATIVE-NUMBER in the case of *(a) few* and RELATIVE-AMOUNT in the case of *(a) little*, which represent the maximum and minimum values of a quantifier's [0, 1] range. Therefore, taking *a few* as an example:

(rel-number (greater-than (0))(less-equal (0.2)))

As this sem-struc illustrates, the semantic properties of *a few* give a relative quantification that is greater than 0 (which are the representative values for the quantifiers *no*/*none*) but is either less than or equal to 0.2 on the scale of quantification. It is significant to note here that the values in the sem-struc are not representative of the numerical equivalent of a quantifier but the values on a scale with which other quantifiers are compared—therefore, the ranges represent the consistent relationship that each quantifier has with other members of its class. This definite range will remain the same regardless of the domain because the fixed range is used in respect to other quantifiers on the same scale. Because *a little* and *a bit* may be used interchangeably to quantify non-count/mass nouns just as *a few* quantifies count nouns, the sem-strucs of the former two will look identical because they have the same semantic properties, differing from *a few* only in which property is quantified[6]:

(rel-amount (greater-than (0))(less-equal (0.2)))

To capture the difference in expectation created by the loss of the article, a precondition of an event is added formally, represented here as *A* and to which a comparison is made. Consequently, the sem-strucs of *few* and *little* differ only in the quantified property:

(rel-number (greater (0))(less-equal (0.2)) (precondition (value (A))))
(rel-amount (greater (0))(less-equal (0.2)) (precondition (value (A)))))

Similar to quantifiers of smaller quantities and amounts, the relative stationary quantifier *some* may also represent a small amount bordering on the values of *a few* or *a little*, but this quantifier may also touch the rims of larger quantities, offering a broad range of quantification. The difference in its range may be seen in comparing (vi), (vii), and (viii):

(vi) Mary bought a few books, and John bought some
(vii) Mary bought some books, but John bought a lot
(viii) Mary bought some books, and John bought several

The interpretation of *some* in (vi) is that John brought more books than Mary, while its interpretation in (vii) and (viii) is that Mary bought fewer books than John. In both examples, the quantifier communicates a vague amount whose comparative range is determined by the co-occurring quantifier in the other clause. Consequently, the sem-struc for *some* is constructed using the same facets as with its smaller relative quantifiers to capture the definite range of quantification of both its use with count and non-count nouns, respectively:

(rel-number (greater-equal (0.3))(less-equal (0.6)))
(rel-amount (greater-equal (0.3))(less-equal (0.6)))

The sem-struc above, when compared with those of *a little, a few*, and *a bit*, reveals that the quantificational range of *some* is in a consistent relationship with other quantifiers when applied to the same scale. Additionally, the use of the conjunction in (vi) and (viii) demonstrates how *some* may share in the meaning of a small quantification closing in on the range of *few* while also sharing the boundaries of a larger quantification such as *several* in (viii). However, the disjunction in (vii) illustrates that the range of

[6] Some distinctions in the use of *fewer/less* are disappearing in current American usage, especially in the comparative degree, as in *there are less students in my class*.

quantification must fall somewhere between the two ends of relative quantification, perhaps with overlap of what constitutes *some* and what constitutes *a lot*. Interestingly, the grammatical combinations of conjunction and disjunction do not exhibit the same patterns between quantifier clauses, with conjunction always being grammatical while disjunction has the restriction of requiring that the comparative quantifier ranges not be overlapping:

(ix) Mary bought a few books and/*but John bought some books
(x) Mary bought several books and/*but John bought some books
(xi) Mary bought some books and/*but John bought a few books[7]
(xii) Mary bought some books and/but John bought many/several/a lot of books

As (ix)-(xi) shows, *some* may not be used in disjunction with other quantifiers if their ranges have overlapping values, except in constructions like (xii) where the overlap occurs with a higher range.

These examples show that *some* quantifies a relatively broad range of possible amounts—something greater than *few* but commonly less than *many* or *a lot*. This scalar property allows for overlap to occur between the ranges of different quantifiers. In other words, there is no definitive answer for where the range of *a little* ends and the quantification of *some* begins, and this semantic feature must be accounted for computationally.

This is accomplished with the RELAXABLE-DOWN-TO (REL-DOWN-TO) and the RELAXABLE-UP-TO (REL-UP-TO) facets[8], which create an overlap of quantifier ranges and allow an extension of a definite range[9]. Therefore, a *few* becomes

(rel-amount (greater-than (0))(less-equal (0.2)) (rel-up-to (0.3)))

Its range is therefore allowed to extend to a larger value to compensate for the quantifier's use beyond its definite range to account for the inability to distinguish, even within a single domain, the exact endpoint of a relative quantifier. Likewise, the same facets may be used with *some*:

(rel-amount(rel-down-to(0.2))(greater-equal(0.3)) (less-equal (0.6))(rel-up-to (0.7)))

With the relaxable facets, the ranges of *a few* and *some* overlap with the range of [0.2, 0.3], meaning that they both may quantify within this range.

Some might be thought of as having the greatest relativity in quantification because of its two possible interpretations, such as those with (xiii):

(xiii) I know John bought some books, but I don't know how many

In the case of (ix), rather than quantifying how many books John bought, the speaker is meaning that she knows John purchased books with no idea of how many. *Some* is instead being used to assure the listener of John's purchase. Here, a new sense of *some* is used with only a minimum limit, at least one, which is also easily represented as a simplification of its sem-struc above:

(number (greater-equal (1)))[10]

The ability to distinguish which interpretation is correct with the use of *some*, the remainder of the discourse must be taken into consideration, such as the second clause in (xiii). Such information identifies the attitude of the speaker toward the information and may provide clues as to which sense of the quantifier is meant.

Still within the class of stationary relative quantifiers, we find larger quantifiers with *several, many, much*, and *a lot*. These quantifiers represent greater values that border on the higher end of *some* but stop just shy of *all*. As with *(a) few* and *(a) little*, the differences between *several* and *many* with *much* is the matter of quantifying count and non-count/mass nouns:

(xiv) Many/several students attended the workshop
(xv) Much attention was paid to the issue

However, *a lot* may be used to quantify both count and non-count nouns and, therefore, may replace the quantifiers in both (xiv) and (xv). Again, keeping with the same facets, the sem-strucs for *several, many, much,* and *a lot*, respectively, are represented below:

(rel-number(rel-down-to (0.5))(greater-equal(0.6)) (less-equal (0.7))(rel-up-to (0.8)))
(rel-number(rel-down-to(0.6))(greater-equal(0.7)) (less-equal (0.8))(rel-up-to (0.9)))
(rel-amount(rel-down-to(0.6))(greater-equal(0.7)) (less-equal (0.8))(rel-up-to (0.9)))
(rel-number(rel-down-to(0.7))(greater-equal(0.8)) (less-equal (0.9))(rel-up-to (0.95)))

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7 The reading of (xi) with disjunction may be made grammatical with the addition of "only" before the quantifier, which restricts the quantifier range so that it does not overlap with *some*.

8 These facets are based on the RELAXABLE-TO facet (Nirenburg and Raskin 2004), which allows the domain of a property to include concepts that are uncommon fillers or contradict the ontology but which may occur in natural language.

9 For a discussion of how OST computes imprecise and/or fuzzy semantic information, review Taylor and Raskin (2010), and Raskin and Taylor (2009).

10 NUMBER as opposed to RELATIVE-NUMBER is the property for absolute quantification, used here to show that exactly one object is being quantified.

The quantifier *most* is sometimes included as a relative quantifier but behaves slightly differently than other relative quantifiers, in that *most* is a proportional quantifier. Compare (xiv) with (xvi):

(xvi) Most students attended the workshop

This quantifier is synonymous with the meaning of *the majority*. While it is still relative, *most* acts differently because it creates a proportion of another set. In the comparison of (xiv) with (xvi), both give a larger quantification, but *most* gives a meaning that a relative quantification of a set is being given for the creation of a new, smaller set. Other relative quantifiers, such as *many,* do not have this proportional property. Regardless of this difference, *most* is still capable of being represented similarly in OST with the variable range boundaries by making them relative to the larger known set, the domain:

(rel-number(rel-down-to(0.51))(greater-equal-to(0.75))(less-equal(0.95))(rel-up-to(0.99)))

As the sem-struc shows, *most* creates a range of at least 75% up to a maximum of 99% of a larger known set—which allows it to apply to both absolute cardinal values, such as *most of the forty*, and relative quantities, such as *most students attended*—relaxable down to 51% of the set. Relating the sem-struc to (xvi), the domain would be the number of possible students that could have attended the workshop, with *most* representing a large proportion of this set for the creation of a new set—those students who did attend the workshop. Depending on the domain, its cardinality may be stated explicitly in the text and added in during processing for an exact value of the domain, or it may be implicit to result in an implied value of the domain.

Additionally, English quantifiers may be intensified semantically with the modifier *very* to strengthen the quantification and further restrict the range of possible values, i.e. *very little*. Two phenomena are worthy of note regarding the use of intensifiers with quantifiers. First, *very* does not result in an increase of quantification when combined with all relative quantifiers and may be used with some quantifiers and negation to lessen quantification:

(xvii) We had very few students attend the workshop

(xviii) We didn't have very many students attend the workshop

(xix) ?We had very many students attend the workshop

(xx) Did very many students attend the workshop?

As (xvii) illustrates, the intensification of *very* on a negative quantifier[11] results in a lesser quantification (fewer objects than simply *few*), while *very* creates a greater quantification with a positive quantifier (more objects than simply *many*) as in (xix). The occurrence in (xix), however, is awkward without an emphatic stress and is more acceptable with the replacement of *a lot*, which may be interpreted as a higher quantificational range equivalent to an intensified *many*. The intensification within a question, as in (xx), is grammatical, while the intensification within the scope of negation reduces the value.

This intensifier behaves differently depending on whether it is acting on a positive or negative quantifier, but its semantic behavior is consistent for both situations[12] and is, therefore, captured in the sem-strucs below representing the intensification of negative and positive intensification, respectively:

(rel-number (value ($var1^2)))
(rel-number (value ($var1^(1/2)))

The description of quantifier intensification introduces mathematical operations into the sem-strucs, primarily square and square root. The intensification of quantifiers is dependent on the polarity of the intensified quantifier (Vandiver, forthcoming) which is what determines whether a quantifier is termed positive or negative. The use of the square and square root functions intensify the polarity of a quantifier on its given scale of quantification.

As shown in sem-strucs, when a negative quantifier is intensified, the original value of the greater values in the range are restricted by squaring their original values. The intensification of positive quantifiers, however, restricts the lesser range values by taking the square root of such values. Examples of the resulting ranges in TMRs are shown in the last section of this paper.

Secondly, the modifier *too* may also be used with relative quantifiers but, while making use of the same mathematical operations, creates a different meaning than the intensification of *very*. Rather than simply restricting the range of quantification, *too* means that quantification occurs by surpassing a limit or expectation, either a minimum or maximum, as with (xxi) and (xxii):

(xxi) Too many students registered for the workshop

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[11] The terms *negative and positive quantifier* are used here to refer to the polarity of a quantifier's range in respect to a given scale, which has a direct relationship with a quantifier's intensified range. A negative quantifier is one whose range represents values lesser than those of *some*, while a positive quantifier is one whose range represents values greater than the same boundary. This is reinforced by the inability for *some* to be intensified due to its overlap with lesser and greater ranges, as is also exemplified in relative frequency quantifiers, such as *sometimes*.

[12] This treatment acknowledges Zadeh's (1976) analysis of *very* as the square of the initial linguistic value; however, it also adds the square root calculation for positive quantifiers, which Zadeh says is specifically for the behavior of *more* and *less*.

(xxii) We have too little coffee left to give everyone a refill

However, this pre-determined limit is contextual and does not affect the semantic structure of the intensifier; therefore, the sem-struc for *too* will be similar to that of *very* and make use of the same mathematical operations, only in reverse relationships with negative and positive quantifiers, respectively, as shown below:

(rel-number(value(var1^(1/2)))
(rel-number(value(var1^2)))

The sem-strucs above for *too* show only the calculation of the amount, while the comparison with the known limit will be reflected in the TMR. In this way, *too* and *very* have similar ways of restricting quantification, but *too* does so in relation to a known limit or expectation.

Finally, debunking the classification of some quantifiers as adjectives (Jespersen 1933, 1969; Quirk et al. 1985), not all quantifiers that are used with adjectives may be used with quantifiers, such as *really, entirely, totally, absolutely, utterly,* or *completely*.

Drifting Comparative Quantification

English also has relative quantification that is not only contextually variable but is created in comparison to another known amount rather than in respect to other vague quantifiers, creating the class of drifting comparatives. This is accomplished with *more (than), less (than),* and *fewer (than)*, which create a relative range by comparing the unknown value to an already established value. As above, there is a distinction in use between quantification of count and non-count/mass nouns:

(xxiii) John drank less tea than Mary
(xxiv) John ate fewer cookies than Mary
(xxv) John drank more coffee/cups of coffee than Mary

Additionally, *more (than)* may quantify both kinds of nouns, as in (xxv).

Drifting quantification continues to modify the property of relative quantification as with stationary quantifiers and is represented with the same range-defining facets. The difference with this class is that the range of quantification may have one endpoint that is moved along the scale because the values are established in comparison to another value. This predetermined value, represented here as B, designates the only anchored value of a comparative quantifier's range and will be readjusted with each new domain. Therefore, the sem-struc of the comparative *more* is formulated in reference to the value of B:

(rel-number (greater-than (B)))

This sem-struc describes the value of *more* as being anchored at the known value of B and having a range of any value greater than this variable. Depending on the value of B, the minimum endpoint of *more* will vary with each domain. In this way, *more* is a drifting quantifier because its range of possible values drifts along the scale depending on where the endpoint is anchored. For example, the anchored values of B in (xxvi) and (xxvii) represent different values on which *more* is anchored:

(xxvi) Mary bought more books than John
(xxvii) Greta drank more tea than Leo

In (xxvi), B represents the number of books bought by John, and it becomes the minimum value after which the range of *more* will begin. Likewise, in (xxvii), B represents the amount of tea drank by Leo, which becomes the anchoring minimum value for *more*. Because the range of *more* anchors at its lowest end and quantifies upward, it is a positive quantifier.

Similarly, the sem-strucs of *fewer* and *less* are also anchored by a known value but are in a reverse relationship with B. Instead of being anchored to a minimum amount, they are anchored to a maximum amount with B. The sem-strucs for *fewer* and *less*, respectively, are shown below:

(rel-number (less-than (B)))
(rel-number (less-than (B)))

In this way, the difference in quantification in (xxviii) and (xxix) is accomplished by anchoring the range of *less* and *fewer* to different amounts, in addition to their difference in quantification of count and non-count/mass nouns.

(xxviii) Mary bought fewer books than John
(xxix) Greta drank less tea than Leo

Anchoring them on their highest amounts, these two quantifiers act as negative quantifiers. In this way, the behavior of drifting quantifiers may be seen as a recalculating of one end point of their ranges while maintaining the mass inclusion of the remaining values of one side of this anchored value.

Interestingly, as (xxx) and (xxxi) exemplify, drifting quantifiers have the ability to maintain their comparisons within the phenomenon of simple syntactic ellipsis, a common occurrence in English:

(xxx) Mary brought more books
(xxxi) Mary brought more books than John

Ellipsis is the process by which information is omitted from a sentence and left to be filled back in by contextual information. With (xxx) and (xxxi), *more* is building a larger value on top of the known value, the amount of books brought by John. The accompaniment of *than* signals that the known value of B is explicitly stated in the sentence; consequently, the *than* phrase is optional in English in such constructions, and its absence has no direct effect on the meaning of the quantifier or its formal representation.

Composites

Relative quantifiers may also combine with each other for the creation of composites:

(xxxii) Chicago received much more snow than Boston

(xxxiii) A few of the many students who enrolled in the course submitted their papers early

These combinations allow for the quantification of another quantifier's range. Such composites maintain the relative quality of providing an imprecise amount or value, though they produce the most intense form of relative quantification in English. This semantic phenomenon occurs when one quantifier is established and then is either restricted or intensified by another relative quantifier, similar to intensification with *very*. In other words, the same quantification as above occurs, but one quantificational range is modifying another for a double-quantification rather than a restricted single range. Individual sem-strucs for composites are not needed because each quantifier will have its own sem-struc, and the composite aspect will be captured in the TMR.

Text Meaning Representation of Quantification

The quantification of objects in English is translated into a TMR for sentential meaning. Given *The woman bought a few books* and *The woman bought several books*, the analyzer will produce the following TMRs to distinguish between the differing relative quantification:

(buy(agent(sem(human(gender(value(female))))) (theme(sem(books(rel-number (greater-than(0))(less-equal(0.2))(rel-up-to(0.3))))))))

(buy(agent(sem(human(gender(value(female))))) (theme(sem(books(rel-number(rel-down-to(0.5))(greater-equal(0.6))(less-equal(0.7))(rel-up-to(0.8))))))))

Conclusion

Despite arguments that quantification cannot be described as a cohesive class, a purely semantic account of quantification in English is captured here by the Ontological Semantics Technology. Their behavior can be described consistently as the determination of overlapping ranges of quantification within a given domain with each relative quantifier maintaining a consistent relationship with the next or a single anchored point. Range restrictions can be imposed by intensifiers, and the strongest quantification may occur as compositions of quantifiers. While this analysis focuses on English, relative quantification in other languages are likely to be found to exhibit similar behavior and may be described similarly in Ontological Semantic Technology formal representation for computational purposes.

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