THE FUTURE OF NEW TESTAMENT LEXICOGRAPHY: REMODELING RELATIONAL SEMANTICS AND COMPONENTIAL ANALYSIS THROUGH DISTRIBUTIONAL CORPUS ANALYSIS

Ryder Wishart
McMaster Divinity College, Hamilton, ON, Canada

Introduction

Lexical semantics over the last quarter century has been marked by significant developments in various directions, including a number of approaches that Dirk Geeraerts has termed neostructuralist. Neostructuralist lexical semantics attempts to maintain structuralist insights, while exploring new methods of qualitative and quantitative analysis. When it comes to lexical semantics of an epigraphic language, qualitative methods have always been the norm. However, in light of new developments in corpus analysis, new avenues of quantitative research have become available. Not only are new tools available, but there are also opportunities to make use of past methods that have shaped the discipline of New Testament lexicography, such as componential analysis and relational semantics. A neostructuralist approach to both of these methods could, I would argue, avoid common methodological pitfalls while building on past achievements in New Testament lexicography. Therefore, I argue the following thesis: biblical studies ought to take a quantitative approach to lexicography using distributional corpus analysis as a framework within which both componential analysis and relational semantics can be remodeled. Before describing in more detail how these methods could be remodeled, I will first offer a generalized description of both methods and their roles in New Testament lexicography. Secondly, I will explain the key obstacles of New Testament lexicography and how distributional corpus analysis can overcome these obstacles, with special reference made to word space models. Finally, I will propose a distributional, corpus-based remodeling of componential

analysis and relational semantics in a way that upholds the motivating values of qualitative structuralist semantics.

Componential Analysis and Relational Semantics[1]

Componential analysis and relational semantics have played important roles in shaping the direction of Greek New Testament lexicography, despite significant drawbacks with each method. I will first describe lexical semantics as it pertains to biblical studies, followed by an outline of the problems typically associated with componential analysis and relational semantics.

Lexical Semantics and Biblical Studies

Following more general trends in lexical semantics, lexicography of the Greek New Testament has shown significant development since the advent of modern linguistics. Whereas semantics is more generally the study of meaning, lexical semantics is the more specific study of the meaning of lexemes, that is, the headwords one might find in a dictionary. Lexical semantics has played a key role in biblical studies, especially over the last century as linguistics has grown into a discipline capable of standing on its own. Dirk Geeraerts describes the history of lexical semantics as a series of movements beginning with historical-philological semantics. Historical-philological semantics focused largely on identifying authorial intention in the analysis of epigraphic languages.[2] Geeraerts explains,

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[1] The following accounts of both componential analysis and relational semantics are not exhaustive or comprehensive. Information on either method can be found in numerous places; the following are some examples. For more detailed information about componential analysis, see Murphy, *Lexical Meaning*, 43–79; Wierzbicka, *Lexicography and Conceptual Analysis*, 59–69; Nida, *Componential Analysis*; Hanks, *Lexical Analysis*, 70–72; Saeed, *Semantics*, 259–304; Lyons, *Linguistic Semantics*, 107–17; Lyons, *Semantics*, 1:317–35; Ruhl, *Monosemy*, 181–82. For more detailed information about relational semantics, see Lyons, *Semantics*, 270–317; Cruse, *Lexical Semantics*; Murphy, *Semantic Relations and the Lexicon*, 133–236; Croft and Cruse, *Cognitive Linguistics*, 141–92; Storjohann, "Sense Relations."

[2] In this paper an epigraphic language, also called a "dead" language, is one which no longer has native speakers, restricting linguistic analysis to the texts and records of that language. For information about the unique challenges attending corpus analysis of epigraphic languages, see Bamman and Crane, "Structured Knowledge," 1–2.

> Because [historical-philological] linguistic semantics is a historical discipline, its primary material consists of texts from dead languages or from previous stages in the development of a living language. Its basic methodological procedure is therefore the *interpretation* of those texts. Only afterwards can changes between periods (and the mechanisms guiding them) be recognized, classified, and explained. The primary methodological step of the historical semantician is that of the historical lexicographer and the philological scholar: to interpret historical texts against the background of their original context by trying to recover the original communicative intention of the author.[3]

Because the texts were ancient artifacts, historical semanticists needed first to interpret the texts, and only then could they do the work of lexicography.

The second movement Geeraerts describes is the rise of structuralist semantics. Building largely upon insights from the father of modern linguistics, Ferdinand de Saussure, structuralist semantics views language as a system governed by an autonomous set of rules. That is, meaning is generated in language by means of a set of rules. Just like the pieces on a chess board may be carved into virtually any set of distinguishable shapes, it is not the real-life features of the pieces, but the rules governing them that determine their relative values. As Geeraert's explains regarding language as a system, "the fact that we describe the linguistic sign as being part of such a system implies that we characterize the sign *within* the system, in its relations to other signs in the system."[4] Structuralism, therefore, changed the way many researchers analyzed lexical semantics. This change in theory about language inspired the development of new tools and methods of analysis. Two of these in particular, relational semantics and componential analysis, will be discussed further in this paper.[5]

Structuralist semantics has also had a significant impact on biblical studies, though the impact was not immediate. As one surveys key works such as Silva's *Biblical Words and Their*

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[3] Geeraerts, *Theories of Lexical Semantics*, 14.

[4] Geeraerts, *Theories of Lexical Semantics*, 49.

[5] For a discussion of the role of relational semantics in the broader movement of structuralist semantics, see Geeraerts, *Theories of Lexical Semantics*, 80–91. Geeraerts's discussion of componential analysis is primarily located in his discussion of generative semantics (101–17) and neostructuralist semantics (esp. 124–56).

Meaning, or Cotterell and Turner's *Linguistics and Biblical Interpretation*, the structuralist approach to lexical semantics stands out as an important factor for biblical studies. In 1961, James Barr's *The Semantics of Biblical Language* directly challenged the way biblical theologians of his day were doing lexical semantics. He argued that they made use of a faulty method, beginning with untested hypotheses and allowing those to dominate the data.[6] In an attempt to remedy popular views of word meaning and introduce those in biblical studies to the field of linguistics, Cotterell and Turner, Silva, and Black created introductions to linguistics meant to help students and scholars in biblical studies to adopt methods that avoided the pitfalls of the biblical theology movement so severely criticized by Barr. In seeking to adopt a more structuralist approach to language analysis, these authors argue for a relational semantics approach to word meaning, and describe the benefits of componential analysis in determining the exact relationships that hold between word senses. These methods constitute significant advances in methodology, and should be considered indispensable tools for biblical studies today. These two tools, relational semantics and componential analysis, provide useful conceptual frameworks by which we can think about and articulate key aspects of lexical semantics, such as the relatedness of word meanings. However, one of the drawbacks of both structuralist and historical-philological semantics has been the over-reliance on intuition or introspection; all too often, conclusions are drawn from insufficient data. This problem, though, is remedied by more recent developments in what Geeraerts describes as neostructuralist semantics.

Neostructuralist semantics represents a cluster of approaches that maintain the basic insights of structuralist semantics—specifically the choice to view language as a system. Geeraerts divides these neostructuralist approaches into a decompositional approach to meaning

[6] Barr, *Semantics*, 22.

and a relational approach.[7] A decompositional approach assumes that meaning, for example word meaning, is composed of smaller building blocks, variously referred to as primes, primitives, or components. A relational approach, on the other hand, claims that meaning is a matter of paradigmatic contrast. A linguistic feature, for example a word, has meaning only in relation to its near-neighbours—its synonyms, antonyms, hyponyms, etc. Both the decompositional and relational approaches that characterize neostructuralist semantics have direct ties to structuralist semantics, and both have played a significant role in the development of New Testament lexicography, especially in Louw and Nida's lexicon based on semantic domains.[8]

Louw and Nida's lexicon based on semantic domains makes use of these two tools of analysis, relational semantics and componential analysis. The lexicon is organized into clusters of words that correspond to 93 domains of meaning, which include subdomains under each category. Within a single domain Louw and Nida placed words that have related meaning, whether synonyms or antonyms. The use of terms such as synonymy, antonymy, as well as others, reflect an attempt to describe the relational semantics of the lexicon by categorizing words into paradigmatic relationships. That is, words with related meanings can be said to share a paradigm, and users of the language select words on the basis of (among other considerations, such as syntax) their paradigmatic contrast to other words. Louw and Nida's lexicon, however, does not describe these relationships directly, but rather the categories or domains by virtue of which words have these relationships—thus a lexicon "based on semantic domains." Their task is one of classification, as they explain, "A dictionary based on semantic domains is in many ways like a classification of flora or fauna based on families, genera, and species. One may say

[7] Geeraerts, *Theories of Lexical Semantics*, 124–25.
[8] Louw and Nida, *Greek-English Lexicon*.

that the domains constitute families of meanings, the subdomains are the genera, and the individual entries are the species."[9] The decompositional approach of structuralism and neostructuralism is evident, in that the "primary basis for classification of meanings into domains," which will be examined in more detail below, is componential analysis. If a set of words share a feature or set of features, they can be said to occupy a similar domain of meaning. However, the relational approach is also evident, because the lexemes are grouped together with words that they relate to paradigmatically. In a review of the lexicon, Lyons claims that their lexicon can better be described as a "bilingual thesaurus (organized conceptually . . .)."[10]

However, one of the problems with Louw and Nida's use of semantic domain theory is its subjectivity in actually identifying and classifying those domains. They explain that "Certain distinctions in classification are always subject to possible differences in treatment."[11] For example, it is unclear on the face of the matter just how specifically lines of distinction should be drawn. Divergence on the nature and extent of semantic distinctions in Hellenistic Greek are bound to be multiplied, simply for the fact that lexicographers have no recourse to elicitation of information from native speakers.[12] What Louw and Nida attempt to do is to classify the thought patterns of ancient Greeks, the cognitive structure of a language for which we have only written texts. They therefore admit, "There is no easy way to resolve such [problems] of classification, since we really do not know precisely how native speakers of Hellenistic Greek thought about such matters."[13] Louw and Nida's lexicon represents an important step forward for New Testament lexicography, nevertheless, because they not only acknowledge the insights and advances of structuralist linguistics, but they attempt to actually incorporate those insights into

[9] Nida and Louw, *Lexical Semantics*, 8.
[10] Lyons, "Review," 204.
[11] Nida and Louw, *Lexical Semantics*, 112.
[12] Nida and Louw, *Lexical Semantics*, 109–10.
[13] Nida and Louw, *Lexical Semantics*, 114.

the very structure of their lexicon.[14] Thus, to attempt to create a new lexicon or lexical database that does not explicitly incorporate the relational semantics of Hellenistic Greek would be an unfortunate step backward. Louw and Nida's lexicon is doubtless the most significant advance in recent lexicography of the Greek New Testament.[15] Thus, it follows that some of the most noteworthy achievements in this area have been the result of a structuralist/neostructuralist approach to linguistics, including both a relational view of meaning and a componential approach to word meaning. Next, I will briefly outline some of the critiques levelled against both of these methods.

Critique of Componential Analysis and Relational Semantics

Though their impact on biblical studies has nevertheless been substantial, both componential analysis and relational semantics have been strongly criticized. Both methods exhibit diversity as actually implemented by linguists, yet some general issues can be identified that apply to most of these various iterations.

Componential Analysis

There are two important critiques of componential analysis: (1) the use of an arbitrary descriptive metalanguage; and (2) a reductionist approach to meaning. Componential analysis is a decompositional method of analyzing lexical meaning. A good example is furnished by contrasting the English words *girl*, *woman*, and *man*. These words can be analyzed on the basis of whether certain marked features—components—are present or not in the semantics of a lexeme.

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[14] Lee, *History of New Testament Lexicography*, 177–78.

[15] Lee, *History of New Testament Lexicography*, 155. Or "one of the most significant," according to Porter, *Linguistic Analysis*, 47.

Girl	– adult	+ female	+ human
Woman	+ adult	+ female	+ human
Man	+ adult	– female	+ human

On the basis of these marked features or components of these lexemes, these words could be defined as follows:

Girl: female human non-adult

Woman: female human adult

Man: non-female human adult

Obviously, the number of components could be easily multiplied. In fact, one suspects that the process in fact happens in reverse most of the time. As Riemer points out, "anything that can appear in a definition can be converted into a component, and . . . there are therefore no a priori constraints on components other than constraints on what can be expressed in a metalanguage."[16] Most linguists who attempt componential analysis claim that the components only superficially mirror English terms—by intent they are actually meant to represent language neutral concepts. However, because these terms almost always correspond to the target language (whether that be English, German, Spanish, etc.), the alleged metalanguage appears to be an arbitrary imposition on the lexis of the source language. There is no way to prove that the components are actually metalinguistic rather than simply English words.

The second issue has to do with the theory of meaning motivating componential analysis, decompositional semantics. According to Riemer, "Decompositional approaches to lexical content, which proceed by analysing meanings into smaller components, are a highly common

[16] Riemer, "Lexical Decomposition," 214.

explanatory strategy in semantics."[17] Despite this commonality, there are significant problems; as Riemer explains, "The considerable heuristic utility of decompositional approaches to meaning is offset by the no less significant problems that attach to decomposition as a theory of underlying semantic structure."[18] He outlines a number of difficulties inherent in a decompositional approach to lexical meaning. First, "There are, in particular, numerous areas of the vocabulary which seem ill-suited to a decompositional approach."[19] Second, it is likely that any semantic information associated with a lexeme is revisable under the right circumstances—meaning that components cannot, after all, be truly necessary or even criterial (on a prototype view). Third, it has so far proved impossible to create paraphrases of any kind that are completely substitutable for the words they purport to define. That is, each lexeme in a vocabulary is a prime, not precisely reducible to a set of components.[20] Fourth, there is a lack of constraints on the use of metalinguistic terms. As he explains,

> we can only apply primitive metalinguistic terms objectively (or, at least, in a manner that commands intersubjective agreement) by *identifying* them with the object-language terms whose meaning we want an account of—and we do not get one simply by reinstating these very object-language terms in the metalanguage, even if we dress them up in small capitals, surround them with brackets, or employ other kinds of typographical signal to designate them as metalanguage terms."[21]

Fifthly, word meaning typically seems to exhibit Gestalt phenomena. That is, we perceive word meaning not by seeing the parts and then deducing the whole but rather by first grasping the whole, which then enables us to infer the parts; "In other words, identification of the *component* seems to depend on prior identification of the *whole concept* . . . but this is exactly the opposite

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[17] Riemer, "Lexical Decomposition," 213.
[18] Riemer, "Lexical Decomposition," 213.
[19] Riemer, "Lexical Decomposition," 221. Also pointed out by Silva ("Semantic Domains," 166): "componential analysis . . . works better for some portions of the vocabulary than others."
[20] Cf. Ruhl (*Monosemy*, 201), who says, "What is often overlooked is that each word is a primitive: posited primitives are often simply English words."
[21] Riemer, "Lexical Decomposition," 225.

of the direction required by a decompositional approach."[22] While decompositional semantics are useful and popular, they tend to inaccurately reduce lexical meaning in another language to nothing more than a set of words in English (German, Spanish, etc.).

Thus, a remodeling of componential analysis should at least be able to explicitly justify use of a descriptive metalanguage, or—even better—operate without a metalanguage at all, and also provide meaningful descriptions of lexical meaning that are not reductionist but rather take into account the semantic complexity of utterances and contexts.

Relational Semantics

Regarding relational semantics, one issue stands above the rest: the semantics–pragmatics divide.[23] Semantics, typically, is understood as intralinguistic, stable, or context-independent meaning. The semantics of a word can be thought of as its meaning apart from any contextual modulation. Pragmatics, on the other hand, generally refers to extralinguistic, transient, or contextually dependent meaning. This distinction becomes an issue of much debate when it comes to creating definitions for lexemes—how much contextual, or pragmatic information should be included in a definition? This difference can also be described as the semantic–encyclopedic divide.

In lexical semantics, it is typical to describe two opposite ends of a spectrum when it comes to ways to define words: on one side is the dictionary approach; on the other is the thesaurus approach. A dictionary approach tends to include more encyclopedic information, including, often, many of the real-life references made with the lexeme. By contrast, a thesaurus approach does not include encyclopedic information, defining words instead on the basis of their

[22] Riemer, "Lexical Decomposition," 226.

[23] Because this is such a highly debated issue, there are bound to be divergences in terminology. The definitions offered here are not meant to be representative of the numerous perspectives, but rather generally valid construals for the sake of situating the following critique.

near neighbours. A word and its neighbours are said to occupy a paradigm, domain, or field. The thesaurus approach reflects most clearly the insights of relational semantics. A clear distinction between semantics and pragmatics is assumed, insofar as the relationships between lexemes are intralinguistic, and make no necessary reference to extralinguistic reality or encyclopedic information—thesaurus entries are constrained to semantics. However, lexical semantics has by and large abandoned such a tidy distinction, opting instead for a functionalist approach to meaning.[24]

Croft and Cruse, for example, claim that pragmatics are integral to sense relations. They reject construing hyponymy, incompatibility, and antonymy as logically transitive or entailment relationships.[25] That is, they deny that sense relations are a stable feature of lexemes. As an alternative they hold a "dynamic construal approach," and claim that "sense relations do not hold between words as such, but between specific construals of words."[26] Their position entails, therefore, that "while the paradigmatic viewpoint is accepted as valid, the items in the paradigm are not lexical items but contextual construals of lexical items, and the relationships are relations between a particular construal of the item actually chosen and potential construals of other items that might have been chosen in that context."[27]

Thus, while relational semantics has not become obsolete, the tidy semantic descriptions of a thesaurus approach have come into question in most quarters. Similarly, componential analysis has in turn become a more strongly polarizing issue. However, I would argue that both of these methodological approaches to analysis can be helpfully remodeled within a

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[24] On the rejection of the semantics–pragmatics divide in cognitive semantics, see Geeraerts, *Theories of Lexical Semantics*, 182. Halliday and Matthiessen (*Construing Experience*, 12) describes the same phenomenon in systemic functional linguistics. A functionalist approach to meaning is introduced in Thompson, *Introducing Functional Grammar*, 1–13.

[25] Storjohann, "Sense Relations," 260–61.

[26] Croft and Cruse, *Cognitive Linguistics*, 143.

[27] Croft and Cruse, *Cognitive Linguistics*, 145.

distributional corpus framework. Before examining how this might take place, though, I will first describe distributional corpus analysis and its potential for overcoming the main obstacles faced by New Testament lexicographers.

Distributional Corpus Analysis and Word Space Models

Due to the difficulties and pitfalls of New Testament lexicography, new approaches need to be explored. One such approach, which builds upon the insights of structuralism/neostructuralism, is distributional corpus analysis.[28] Distributional corpus analysis, while avoiding key obstacles to New Testament lexicography, provides promising new directions for automated or semi-automated lexicography using word space models. I will first describe the obstacles to lexicography, then I will describe distributional corpus analysis.

New Testament lexicography faces three key obstacles, which correspond to the main problems with lexicons outlined by John Lee.[29] First there has always been an undue reliance on previous lexicographical work. Lee meticulously traces the histories of many modern lexicons, identifying in every case liberal recycling of previous material. "The whole history of New Testament lexicography," says Lee, "is one of reliance on predecessors and transmission of older material with varying degrees of revision. If all were well with the tradition, there would be no cause for concern . . . But this is hardly the case."[30] The lexicographers, however, can hardly be blamed for this. Lee points out that were one to fully analyze one word each day, every day of the year, it would still take roughly 13.7 years to cover even the roughly 5000 lexemes contained in the New Testament, and even that time frame is idealistic.[31] Secondly, the material itself, which has been transmitted from revision to revision for centuries, "has employed a method of

[28] Geeraerts, *Theories of Lexical Semantics*, 165–78.
[29] Lee, *History of New Testament Lexicography*, 40–41.
[30] Lee, *History of New Testament Lexicography*, 11.
[31] Lee, *History of New Testament Lexicography*, 5.

indicating meaning, the archaic gloss method, that is intrinsically weak and deceptive."[32] Offering glosses, which are effectively translation substitutes, has been the dominant practice of lexicons, though this situation is changing.[33] Thirdly, Lee demonstrates numerous examples of instances where either Latin or vernacular translations have exercised undue influence on the glosses included in lexicons. There is a cyclical process at work (which Lee refers to as "a clandestine affair")[34] between translations and lexicons, each providing the other with justification for particular glosses. Thus, from Lee's analysis, it is clear that there is a need for original research that does not simply reformat the glosses of previous lexicons and translations. However, such a research project is not without its own potential problems, but faces the following obstacles: inconsistency, subjectivity, and logistics.

Inconsistency

First, when it comes to offering definitions, there is a lack of controls in place that could provide a greater degree of consistency to the task of creating definitions.[35] Porter offers an extended discussion of this inconsistency in BDAG. First, Porter notes that BDAG sometimes simply has the wrong meaning for a lexeme. However, apart from examples of actual usage, there is very little objective data that can be pointed to (such as the quantified vectors mentioned below) in order to justify or overturn a given interpretation of that data. Secondly, some entries are unclear in their distinctions or ordering, sometimes apparently reflecting the divergent shades of nuance in the English glosses, rather than the actual Greek term. Data that strictly reflects usage of the Greek terms would help remedy this problem. Thirdly, words of the same part of speech are

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[32] Lee, *History of New Testament Lexicography*, 40–41.
[33] Porter, *Linguistic Analysis*, 49–50.
[34] Lee, *History of New Testament Lexicography*, 31.
[35] As Lee (*History of New Testament Lexicography*, 178) says, "Not that everything in the tradition is wrong: much of the material, certainly much of what is vital, is sound. But consistent reliability is what we seek."

often treated in very different ways.[36] "What seems to be lacking," explains Porter, "is any kind of a systematic way of quantifying meaning [within the definitions]. There is no apparent means by which components of meaning are defined and articulated."[37] There are other issues Porter identifies, but these suffice to illustrate the nature of the problem.

Consistency could be promoted by subsuming lexis—and lexical semantics—within grammar. That is, a lexicon cannot continue to focus merely on the words of a language as if they operated in isolation. The myopic focus on words as isolated units of meaning is likely part of the reason the theological lexicography denounced by Barr can still be found in our lexical resources over half a century later.[38] Rather, the lexicon should be remodeled to explicitly treat words as grammatical features of the broader system, the lexicogrammar, of Hellenistic Greek. Porter suggests precisely this kind of remodeling of the lexicon:[39]

> What I am suggesting is a serious rethinking and expansion of the categories by which we conceptualize the language of the New Testament, one that incorporates lexicography, yet much more besides, including what is traditionally called grammar, and all of that within the larger world of Hellenistic Greek usage.[40]

Distributional corpus analysis, however does not necessitate a hard distinction between lexis and grammar, viewing both systems as statistical patterns.

Subjectivity

One of the ways subjectivity becomes a problem is in theoretical disagreement, which introduces a unique set of issues. Investing in the production of a new lexicon or lexicogrammatical database is a huge undertaking, and requires alignment between researchers regarding how

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[36] In BDAG, for example, under ὅτι, the fifth sense is not a meaning at all, but simply a catch-all category of usages that do not seem to fit under the first four meanings.

[37] Porter, *Linguistic Analysis*, 69.

[38] Porter, *Linguistic Analysis*, 77; Barr, *Semantics*, 263; Black, *Linguistics for Students*, 123; Silva, *Biblical Words*, 22–32; Fewster, *Creation Language*, 15–16; Lappenga, *Paul's Language*, 6–18; Cotterell and Turner, *Linguistics and Biblical Interpretation*, 178–81.

[39] Porter, *Linguistic Analysis*, 77–78.

[40] Porter, *Linguistic Analysis*, 80.

lexical semantics is to be approached. For example, there is disagreement as to what is the difference between homonymy and polysemy, or whether words should be treated as monosemous signifiers. Because there are many different ways to do linguistic analysis there are bound to be theoretical differences and disagreements as to the best way to do the analysis undergirding a lexicon. Disagreements about theory cannot be totally eliminated; however, radical divergence need not be the final word when it comes to creating tools that everyone can use. For instance, automatically generating the data may relieve some of the tension, because there is less time and money at stake. In the past, lexicographers would find their data by reading and interpreting individual instances of words. However, using automated statistical natural language processing (NLP) will make the task of gathering data more objective. While it will still be necessary to interpret automatically generated data, the data itself is significantly more objective and theory independent than simply using individual interpretations of single passages.

Logistics

Besides the issues of inconsistency and subjectivity, original lexicographical work faces the not insignificant obstacle of logistics. As mentioned above, the creation of a lexicon is an enormous task. It is one thing to suggest ways that lexicography can be done rightly; it is quite another to actually undertake to do the task. While corpus-based methods of analysis provide substantial advantages for lexicography, the task of compiling and especially of annotating corpora is quite literally compendious. For these reasons, it would be expedient to automate as much of the process as possible. As Ravin explains

> It has recently become clear, however, that if machines are to ‘understand’ natural language, they must have recourse to extensive lexical databases, in which a wealth of information about the meaning of words and their semantic relations is stored. To create such databases manually is not feasible. The task is too time consuming and labor intensive. Instead, current research in lexical semantics concentrates on the extraction of semantic information from sources available on-line, such as dictionaries and thesauri in

> machine-readable form . . . This information is then being used to create lexical databases for NLP [Natural Language Processing] systems.[41]

Although currently the tools for doing this kind of work require knowledge of programming languages and use of command line tools that most people are unfamiliar with, "Automated lexicon construction," McEnery and Wilson point out, "is a goal which seems increasingly realistic thanks to corpus-based NLP systems."[42] Statistical NLP, as will be seen below, is capable not only of providing syntagmatic information, like a 'key word in context' concordance search, but also of providing paradigmatic information about related lexemes such as synonyms, and, theoretically, hyponyms and hypernyms.

Next, I will describe distributional corpus analysis and its potential for avoiding the problems just outlined.

Distributional Corpus Analysis

Distributional corpus analysis is part of a broader movement of neostructuralist semantics and maintains some of the key values of structuralist semantics. This approach views lexical meaning as a set of discernible patterns mined from large text corpora, and it represents a more rigorous and data-driven approach to relational semantics, using natural language processing (NLP).

Geeraerts describes two different types of NLP, symbolic NLP, which was more prominent from the 1950s until the 1990s, and statistical NLP, which became dominant during the 1990s.[43] Symbolic NLP uses a formal or logical metalanguage to encode language for computer processing. In this approach words, phrases, and constructions are generalized and then replaced with variables. For example, all noun phrases might receive the symbolic designation NP, all predicators might receive the designation P, etc.; other grammatical features such as

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[41] Ravin, "Synonymy," 397.
[42] McEnery and Wilson, *Corpus Linguistics*, 144.
[43] Geeraerts, *Theories of Lexical Semantics*, 157.

clause types or dependency relationships might be replaced with other types of designations. Once the language data is translated into a metalinguistic symbolic language, it becomes easily readable by machines. By contrast, though, statistical NLP eliminates the intermediate step of translating language into a symbolic metalanguage. This latter approach is represented by the methods of distributional corpus analysis. Statistical NLP is a diverse set of approaches to corpus analysis, including a wide variety of methods which open up many new possibilities. One of these methods that I will mention below is word space modeling.

Distributional semantics was not entirely novel in the 90s; it reflects the intuitions of earlier thinkers. Zellig Harris, for example, in a 1954 article outlines a number of points about distributional structure: (1) distribution patterns are meaningful, (2) such patterns are consistent, (3) description of this kind can be entirely intralinguistic as distribution of a given element can be described relative to another element, without reference to 'outside' information, and (4) distributional restrictions can be described by a network of generalized rules. "In other words," Harris says, "difference of meaning correlates with difference of distribution."[44] Harris's views are similar to Firth's notion of collocation,[45] which has played a significant role in corpus linguistics in general, and has been incorporated into models of systemic functional linguistics.[46]

Geeraerts explains that while symbolic NLP focuses primarily on the paradigmatic relations within a lexicon, statistical NLP, by contrast, focuses more specifically on the

[44] Harris, "Distributional Structure," 156.

[45] Cf. Sinclair, *Corpus, Concordance, Collocation*.

[46] For bibliographic references see Halliday and Matthiessen, *Halliday's Introduction*, 60, note 2. For discussion, cf. Fewster, *Creation Language*, 58–68. The potential of corpus linguistics for biblical studies has been systematically outlined by Matthew Brook O'Donnell (*Corpus Linguistics*), and his discussion of the requirements for both a balanced and representative corpus should be duly applied in any distributional semantic analysis of Hellenistic Greek. However, word space models work better with higher amounts of data, and so experimentation should be done to determine the ideal number of words to include in a corpus for a given study.

syntagmatic relationships within texts. However, the combination of multiple complementary tools within a distributional approach can be used to provide both syntagmatic and paradigmatic information. Because statistical NLP provides a more rigorously empirical basis for analyzing large corpora, and does so at speeds that no lexicographer could have matched in the past, there is new potential for generating accurate information that can be used for semantic description of lexemes.

Geeraerts describes distributional corpus analysis as a convergence of neostructuralist and cognitive semantics. That is, this approach to linguistic analysis attempts to maintain some of the key insights of structuralism—for example, a systemic view of language—while also maintaining the view that meaning is a psychological phenomenon.

This convergence is what makes distributional corpus analysis a useful tool for biblical studies. On the one hand, semantic analysis need not be reductionist, attempting to account for all meaning according to strictly formal analysis. Meaning is fuzzy and transient in many ways, and a code view of language does not adequately account for all of the data.[47] However, taking a psychological view of meaning presents certain difficulties for the study of epigraphic languages. For example, attempting to discern prototypical meaning or prove sense differentiation within a lexeme is problematic, as we cannot sample or elicit data from native speakers, and thus we cannot "check" our results when we try to identify the cognitive structure of meaning in Hellenistic Greek. Distributional corpus analysis, however, provides an objective analysis, not of the ancient Greek mind, but of the actual instances of linguistic usage. We can only conjecture as to why certain language was used, but we can nevertheless mine the language itself for information.

[47] On the distinction between code and inference see Clark, *Relevance Theory*, 14–18.

On the other hand, using distributional corpus analysis provides us with concrete data regarding the formal side of language. Using computational analysis of large samples of data, we can actually generate meaningful data and draw accurate generalizations about the systems at work in the extant texts. While we must still interpret the data we generate, the data itself tends to be much more objective.

Automated or semi-automated lexicography, I would argue, needs to be considered as a more objective alternative to prevalent word study methods. Automation tools are already developed for a number of different processes for Modern Greek, such as lemmatization, morphological tagging, syntactical annotation of dependency relationships, as well as several others.[48] However, I want to describe one method in particular that should be further developed: word space tools.

Word Space Modeling

Distributional semantics recognizes the key role of collocation in word meaning. A word's syntagmatic relationships create the meaning of that word in a context. Thus, the rationale behind the computational approach of distributional semantics as that two words that have similar meanings will have similar contexts. To put it conversely, similar distribution equals similar meaning. We can tell that *run* and *walk* are similar is they are often used in the same kinds of sentences: 'I'm going to *run* to the store'; 'I'm going to *walk* to the store.' Rather than seeing these words as possessing the absolute value of synonymy, however, it is far more useful to compute the degree of similarity between them.

Where analysis of collocations has always played a role in corpus-based studies, pointwise mutual information can be used to simply and automatically calculate the significance

[48] Prokopidis et al., "Natural Language Processing Tools for Greek."

of a given collocation, what Church and Hanks call "the *association ratio*" between two words.[49] They explain, "mutual information compares the probability of observing *x* and *y together* (the joint probability) with the probabilities of observing *x* and *y independently* (chance). If there is a genuine association between *x* and *y*, then the joint probability $P(x,y)$ will be much larger than chance $P(x)\ P(y)$, and consequently $I(x,y) \gg 0$ [the mutual information of *x* and *y* will be greater than zero]."[50] However, when it comes to identifying and quantifying synonyms or related words, not only collocations but more specifically colligations are an important piece of data.[51] Whereas collocations are typical words that co-occur, colligations are typical grammatical patterns that co-occur with given words.

Typically, both collocations and colligations are identified using a key word in context, concordance search. However, the basic key word in context analysis, while useful for some tasks, cannot tell us about words or constructions that, though they may be similar, never actually occur together in the data. Instead, we can use a statistical NLP tool typically referred to as a word space or vector space model.[52] One can think of a word space model as a large network of connections, which is a matrix of extremely high dimensionality. Each word is like a point or node in the network, and each word is related to each other word; every word is connected to every other word in the network. In this network, each word is treated as a vector, that is, a value with magnitude and direction. By vectorizing words, they can be meaningfully compared to one another. There are a wide variety of variables in vector space models, including (1) type of matrix, (2) method of weighting the data, (3) method of reducing the dimensionality of the

[49] This method was first developed in Church and Hanks, "Word Association Norms."

[50] Church and Hanks, "Word Association Norms," 23. Note, however, that they do draw a distinction between mutual information, which is symmetrical, and association ratio, which is asymmetrical (i.e. the order of the collocations matters in the latter).

[51] Halliday and Matthiessen, *Halliday's Introduction*, 59–61; Thompson, *Introducing Functional Grammar*, 40.

[52] Geeraerts, *Theories of Lexical Semantics*, 174–76. For a general introduction to the word space approach (specifically latent semantic analysis) see Landauer et al., "Introduction."

matrix, and (4) method of comparing the resulting vectors.[53] I will briefly explain each of these variables, corresponding to the steps involved in such an analysis.

(1) The first step in generating a vector space is creating a word-by-feature matrix. This is essentially a table where rows represent individual words, and columns represent "features." These features can be words, documents, contexts or search proximities (such as sets of ten adjacent words), or even dependency relationships. Each word is counted up based on its occurrence within each context. Different features are used for different purposes. If you want to summarize a document based on its key concepts, a word-by-document matrix works best.[54] If you want to analyze the relationships between lexemes, a word-by-context matrix can provide the needed data.

(2) The second step involves weighting the data. Common methods include an analysis of the term-frequency in relation to the inverse-document-frequency (TF-IDF), when using a word-by-document matrix; and pointwise mutual information (PMI) when looking at the relationships between words. What these methods accomplish is the assignment of a value to the words; tabular word counts are turned into statistical probabilities.

(3) The third step is to reduce the dimensionality of the matrix. In such a large analysis, using perhaps thousands of documents and tens of thousands of words, there is bound to be a lot of blank spaces in the table—that is, the matrix is sparse. In order to isolate the most relevant or significant information, the matrix must have its number of dimensions reduced. This can be accomplished in a number of ways while still maintaining the integrity of the data in the matrix, for example using singular value decomposition (SVD).

(4) Now that the data has been rendered down to a manageable size, the values of each word, the vectors, can be compared using a variety of methods. The most popular method is calculating the cosine relationship between the two vectors. Imagine the vectors are like lines on a graph, and the angle of their relationship is the relationship between the words in the word space. The more similar the number, the more similar the contexts of the words are, and thus the more similar the words themselves are according to a distributional view of meaning.

The key to this analysis is that it is automatically generated by computers with only minimal user input. Performing a very large analysis may take a computer a number of hours, but as a corpus typically consists of tens of millions of word occurrences, a similar analysis would take a lexicographer a lifetime. Thus, word space models have potential for overcoming the key

[53] For an overview, see Geeraerts, *Theories of Lexical Semantics*, 174–76.
[54] Landauer et al., "Introduction," 19–20.

obstacles of New Testament lexicography. They can be used for automating many of the tasks of lexicography, and doing so in a more objective and consistent way than was possible in the past.

Word space modeling of Hellenistic Greek would have a not inconsiderable impact on New Testament studies. Imagine a database that provides consistent information regarding the relationships between lexemes, as well as relevant syntactic information based on the dependency relationships those lexemes participate in.[55] Word space modeling In the next section I will describe how the structuralist methods of componential analysis and relational semantics can be remodeled to interface with distributional corpus analysis.

Remodeling Componential Analysis and Relational Semantics Distributionally

Although componential analysis and relational semantics are generally out of favour, they have played an important role in biblical studies,[56] and with some modifications their underlying structuralist values could be fruitfully interfaced with distributional corpus analysis. These tools, I would argue, should be considered important assets for answering research questions about the Greek of the New Testament, because they are motivated by two of the key values of structuralism, systematicity and decompositionality.

A central goal of lexicography is the compilation of lexical entries that express the semantics of lexemes. Distributional corpus analysis, as we have seen can be used to identify the near neighbours of words as they are actually used in the corpus, those words that share the

[55] Kintsch and Mangalath ("Construction of Meaning") outline a two-tiered method of analyzing both the generalized meaning of a lexeme, the "gist," and the syntactic information. They demonstrate how different word space models may be combined to compound the results.

[56] Componential analysis shows up in many of the introductory books on linguistics and biblical interpretation. Black (*Linguistics for Students*, 140) for instance, claims that "through the principles of componential analysis, linguistics can provide a rational and demonstrable basis for the understanding of the crucial components that constitute the meanings of key terms." Cotterell and Turner (*Linguistics and Biblical Interpretation*, 173) explicitly promote Nida's method of componential analysis (Nida, *Componential Analysis*). Silva's (*Biblical Words*, 134) discussion of componential analysis describes its roots in phonological analysis, but he also raises some important concerns. Specifically, he points out that using componential analysis it is difficult to avoid encyclopedic (rather than semantic) definitions, because components typically reflect the features of referents, rather than lexical units.

closest vectors. Since statistical distributional models of meaning do not attempt to describe the lexical content of items, though, but only their distributional facts, these models can hardly be called semantic. It would therefore seem that a distributional approach would not be useful for compiling semantic lexical entries. By contrast,, componential analysis is a tool that is ideally suited to this task: as Riemer notes, "As long as one approaches semantic analysis with the aim of distinguishing a variety of semantic properties within a lexeme, some form of decomposition is the most likely theoretical model."[57] Both tools, componential analysis and relational semantics, are tightly connected in Louw and Nida's lexicon; componential analysis determines the domains into which words are placed, and thus it also determines the relational semantics of the lexicon.[58]

The question, then, is how to incorporate componential analysis into a distributional corpus analysis, given that componential analysis provides useful semantic information regarding lexemes, and distributional analysis provides a more objective method of assessment. What I propose is that we remodel componential analysis as a tool to aid in the process of generating lexical entries on the basis of distribution. The way we should remodel componential analysis is by viewing the vocabulary of a language as a hierarchy: the more abstract or general lexemes occupy the upper regions of the hierarchy, and the more concrete or specific lexemes occupy the lower.[59] Lexemes can then be partly defined on the basis of their near neighbours. A given lexeme will have, among its near neighbours, hypernyms, that is, words with similar but more general meaning, and it will also likely have hyponyms, which are words with similar but

[57] Riemer, "Lexical Decomposition," 229.

[58] Nida and Louw (*Lexical Semantics*, 109) note, "The primary basis for classification of meanings into domains and subdomains is the existence of shared features."

[59] This perspective on the lexicon is based on the pioneering work in monosemy by Charles Ruhl, *Monosemy*, 173–206.

more specific meaning.[60] A lexeme's semantic meaning can be partly derived on the basis of its hypernyms. For example, car>Toyota>Corolla: a Corolla is a type of Toyota, which is a type of car. Viewed in this way, a lexeme's components of meaning are specifically its hypernyms.[61] This approach to componential analysis is actually a certain perspective on hyponymy and the way lexemes relate to one another.[62] Viewing hyponymy this way, then, allows us to take a componential approach to semantic meaning, but to do so on the basis of the distributional facts present in the corpus.

There is another benefit to this type of componential analysis, in that the components of a word are limited to actual lexicogrammatical features of the language itself. Typically, decompositional approaches to lexical semantics "do not necessarily presuppose that the semantic components into which meanings are analysed are themselves lexicalized in individual words."[63] That is, the components are assumed to be metalinguistic. However, if a word's components are specifically its hypernyms—actual words in the lexicon—there can be more consistency in the types of features used to decompose the meanings of lexemes. While this

[60] Calculating specificity of meaning would be an interpretive step based on the data, although there may be ways of automating this task as well.

[61] There have been a number of studies attempting to automate the identification of hyponyms and hypernyms from a corpus. For example, Zhou et al. ("Learning Hierarchical Lexical Hyponymy," 206) have proposed a semi-automatic method for extracting hyponymous relationships between concepts, which they call lexical hyponymy relationships, in Chinese using very large web corpora. Acosta et al. ("Extracting Definitional Contexts," 50) note that most methods of extracting hyponym–hypernym relationships rely on a predetermined set of lexico-syntactic data that is provided by lexicons, thesauri, or direct input. They therefore propose a method of automatically extracting this 'seed set' from a specialized corpus, such as medical texts, in order to expedite and improve the results when analyzing other corpora.

[62] Automatic extraction of lexical relations is not limited to hyponymy, either. Recent work in antonymy of the English language by Jones et al. has proven to generate highly precise results. However, Jones's original work relied on a corpus of 280 million words, and in Jones et al. this data base was supplemented with other corpora as well as data gathered through elicitation (Jones, *Antonymy*; Jones et al., *Antonyms in English*, 17). By comparison, the *TLG* corpus, when limited in range to the centuries 4 BC through 4 AD consists of just over 49 million words. Jones's work, however, has demonstrated the potential of identifying antonyms through syntactic frames, or typical contexts in which antonyms co-occur (such as "*x* as well as *y*").

[63] Riemer, "Lexical Decomposition," 219. However, he points out that Natural Semantic Metalanguage theory assumes this very thing.

approach would not describe what it is that makes a lexeme more specific than its hypernyms, it would provide a parsimonious description of some key semantic information about a lexeme.

Statistical natural language processing, a sub field of distributional corpus analysis, then, provides an avenue for analysis that is likewise motivated by the values of structuralism. As mentioned, two key values are (1) systematicity and (2) decompositionality. When it comes to systematicity, a distributional or statistical approach requires no semantic content to be contributed to the analysis by the user; all of the data comes directly from the corpus itself. Words are quantified and treated as vectors related by statistically deduced patterns. The vectors relate to one another within a vector space, which is a purely intralinguistic representation. Thus, on a distributional model of componential analysis the relationship between the two tools is reversed. Whereas in Louw and Nida's lexicon componential analysis determines the relational semantics, on a distributional approach the quantified vector relationships between lexemes determine their components, which are viewed as inheritance relationships where hyponyms inherit the semantics of their more general hypernyms.

Therefore, when it comes to the second value, decompositionality, word space models are ideal tools of analysis, as these models are explicitly based on the assumption that the meaning of a given context is composed of the smaller meaningful units it is composed of. As Landauer et al. explain, "LSA [latent semantic analysis, a word space method] represents the meaning of a word as a kind of average of the meaning of all the passages in which it appears, and the meaning of a passage as a kind of average of the meaning of all the words it contains."[64]

In summary, distributional relational semantics views lexical relations as statistical regularities that hold between vectors. Distributional componential analysis, in turn, views the

[64] Landauer et al., "Introduction," 6. For a more recent discussion of how LSA and topic modeling can be integrated, see Kintsch and Mangalath, "Construction of Meaning."

decomposition of lexemes as a matter of semantic inheritance within a hierarchical, lexicogrammatical network.

Future Directions

To my knowledge the tools of NLP have yet to be applied systematically to analysis of Hellenistic Greek.[65] Nevertheless, statistical NLP holds promise for biblical studies, because it evades many of the typical problems associated with the word studies that populate most commentaries. As mentioned above, using word space models of analysis provides consistency and objectivity to the data—all words can be included in a word-by-feature matrix; the process can be partially or even fully automated as more tools are developed; and divergent theoretical positions can be accommodated as different types of word space analysis can answer different questions about meaning. One of the obstacles faced in this respect, however, is the difficulty of obtaining access to the corpus itself. While *TLG* can be accessed online, word space analysis cannot be performed on the corpus, because the data needs to be processed through separate software. It would therefore be advantageous to develop an automated lexicogrammatical database through OpenText.org, freely accessible, where word space tools could be compiled and prepared, facilitating new research and answering new questions for New Testament studies. However, issues of licensing are an unfortunate problem, though the texts in question are simply digitised reproductions.[66]

[65] Though there has been some work regarding Classical Greek. See the Classical Language Tool Kit (CLTK): http://docs.cltk.org/en/latest/greek.html.

[66] For more on this discussion, see the chapter "Who Owns the Greek Text of the New Testament?" in Porter, *Linguistic Analysis*, 17–28.

Conclusion

Quantitative approaches to lexical semantics have made valuable advances over the last quarter century. This paper outlines the potential of a distributional approach to both componential analysis and relational semantics. This neostructuralist approach to both methods, I argue, avoids the common methodological issues of past achievements without dispensing with those achievements in New Testament lexicography. Biblical studies, to reiterate, ought to take a quantitative approach to lexicography using distributional corpus analysis as a framework within which both componential analysis and relational semantics can be remodeled. One of the first and most important steps in this direction will be the compilation and organization of a representative word space for Hellenistic Greek, to the end that many previously unanswerable questions may then be explored in a more objective, consistent, and logistically feasible way.

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