Linguistics emerged as a science in the mid 1950’s when Noam Chomsky, a young professor in the MIT Research Laboratory of Electronics, gave a series of lectures which culminated in his book: *Syntactic Structures* (1957). In the then broad field of linguistics, which mainly studied bible translations, language variation, the Indo-European and other language families, historical linguistics, animal communication, bee languages, and sundry other topics, his book, actually a small soft-cover monograph of about 100 pages, fell almost stillborn from the press. A brave publisher, Mouton, printed several hundred copies, and Chomsky’s contract required him to buy all the unsold copies after a year or two.

In the MIT Research Lab of Electronics, his book caused reverberations, which, to get ahead of our story, resulted in *Syntactic Structures* selling tens of thousands of copies and being translated into dozens of languages. How and why did his book electrify the nascent fields of what became computational linguistics, cognitive psychology, signal processing theory, and computer science? George Miller, a close friend and colleague of Chomsky, presents a readable version of the early history and impact on psychology and education (“The Cognitive Revolution,” *TRENDS in Cognitive Sciences* Vol.7 No.3 March 2003). When I first read *Syntactic Structures* (1963) I was working on a PhD in electrical engineering to develop a ‘computational typewriter’ such that one would speak into it and it would type your text. After reading the book, I told my advisor that the device could never be built using the incorrect (finite state grammar) model we were using. I simultaneously applied to the MIT Linguistics Department to work with
Chomsky. I joined the MIT Linguistics Department, graduating in 1968 with a PhD advised by Chomsky.

In 1964 I earned a Master of Science degree at Dartmouth College Thayer School of Engineering where we used the GE 235 computer, probably one of the biggest in the world at that time, to solve problems in vibrating systems, and in particular, how to dampen vibrations in battleships when the big guns went off, the shaking in airplanes during turbulence, the steering of submarines and torpedoes, and so on. General Electric, Dartmouth, and MIT (as well as others) teamed up to develop the first ‘time-sharing computer’. It had 60 or so remote terminals linked to it by coaxial cables, and a person a mile or so away could do all computations remotely and have the results transmitted back to their local printer. Prof. John Kemeny headed the project. The early history of the 235 time-sharing project led to interdisciplinary work between almost all departments of all the universities involved. Circuit design and power supplies dominated my engineering work, and early on they had me doing the ‘interfacing’ of keyboards, printers, and plug-boards. The operating system of the GE 235 was called multics, or MULTIX. After the project was killed, two young men took the basic idea to Bell Labs and called their project UNIX.

Early computers did have ‘languages’, but much of the ‘programming’ constituted itself as ‘running wires from here to there’, or plugging cables into holes. Look up the German Enigma Code machine and you can see what type of ‘cutting edge’ devices we thought about. Some early thinkers, Alan Turing, John von Neumann, Claude Shannon, and Norbert Wiener, all of whom had an enormous influence on me and the groups I worked with, thought very little (very, very little) about ‘hardware’ such as ‘wires’, ‘switches’, and ‘plug-boards’. They
talked about ‘computer languages’, which at the time seemed an arcane concept. Alan Turing, often called the ‘father of modern computing’, developed a computer (often called ‘computational engine’) during WWII that cracked the German Enigma Code machine that secretly directed the operations of the Luftwaffe and the German submarine fleet.

In September 1940, England, fearing a German invasion, decided to send to the USA all of its military secrets, secret weapon plans, and researchers. The readable article, Groupthink (Jonah Lehrer, The New Yorker, January 30, 2012), lays this out in some detail, and indicates that many, even most, of the English scientists and engineers took up residence at MIT and did their research in MIT Building 20. Groupthink shows how this group defined the Research Laboratory of Electronics, and details how Chomsky’s Linguistic Studies grew out of the rarified, heady air of the forms of computation and symbolisms that gave rise to radar, sonar, artificial intelligence, and expert systems. In short, Chomsky offered a theory, called Generative Grammar, which provided a conceptual framework, detailed notation, and methodology to take all of the formal systems thinking and image processing ideas from radar and sonar and express them in a way that offered a clear exposition for some aspects of human language thinking and language use.

In this era (1950-1960, 61…) no clear concept existed of ‘computer language’ or how to program a computer to do anything. The ideas of Alan Turing (illustrated well in the movie, The Imitation Game, starring Benedict Cumberbatch and Keira Knightley) came to dominate all thinking over the past decades. Turing wrote little, and what he wrote, aims to educate experts. No sugar coating exists anywhere. John von Neumann, one of the world’s most brilliant mathematicians,
offers a view of Turing’s work that relates directly to the ideas of Chomsky, and probably the work of just about everyone else that mentions Turing and computers. People may argue, but the current ideas of ‘computer’ and ‘computer language’ derive almost totally from John von Neumann’s writing, which range from the popular (The Human Brain) to the outlandishly complex (Theory of Self-Replicating Machines). The best introduction to John von Neumann exists in his voluminous publications and the writings of his ubiquitous students. The best introduction to Turing for beginners exists in von Neumann’s writing about what he thought Turing accomplished.

One could say that Chomsky’s views of generative grammar and Syntactic Structures reflect John von Neumann’s views of Turing’s research. Let us just take one idea discussed at length by von Neumann: Any computer of any interest always has two different languages, and, the main function of the computer is to translate sentences from one language into the other. (I believe this is the best way of thinking about Turing.) The two languages may use the same symbols {a, b, c..., space, period, question...}, but each language defines a different set of sentences. A machine that translates from English to German, or vice versa, fits this system. The German Enigma encoding/encryption machine input a ‘normal’ German sentence, scrambled the letters, and produced an encoded sentence of apparently random letters. When Turing entered the encrypted sentence into his Turing machine, the output constituted the original unencrypted sentence.

In Turing’s system, the only thing a computer does is convert one string of symbols written in alphabet X into another set of symbols written in alphabet Y, where X and Y may or may not be the same alphabet. Here is an ‘in-joke’ among Turing aficionados: The German Enigma machine converted a ‘plain-text’
German sentence into a random string of letters from the German alphabet; *but*, and this is a giant ‘but’, in the encoded text, no letter could be encoded at the original letter in the plain-text. So, if the input contained the letter ‘a’, the random output encryption could not have an ‘a’ to represent the encrypted ‘a’. This was an Achilles Heel enabling Turing to ‘break into the Enigma’ system. Turing said: *A is not A* to the *Enigma*. This is a contradiction. From a contradiction we can derive any conclusion. This was Turing’s way of saying that the *Enigma* had a flaw, a keyhole, an Achilles heel. I thought it was funny when I heard it. Turing made great use of this fact, but his argumentation tends towards the difficult.

What came to be called *cognitive studies* took over this perspective and assumed the Turing/von Neumann computer could model some aspects of the human mental capacities. In many, perhaps most, studies, the Chomsky interpretation of the Turing/von Neumann computer view dominated. Chomsky argued that the grammar of a human language defined the speaker’s knowledge of the language. The grammar, being realized as neurons and assorted brain input-output mechanisms (ears, hands, mouth, tongue…) defined a computer. Hence, following our discussion, the human brain/computer might in fact have two different formal computer languages defining its operation.

In this discussion, the term *language* (a technical term with a specific definition: ‘a sequence of elements’) includes all what are called *Natural Languages* (such as English, French…), and often these are called *Languages*, with a capital ‘L’. But language also includes the language of telephone numbers (there are valid phone numbers and invalid ones). It includes all chemical formulae, all computer languages, and so forth.
The term *Language* (English, Chinese…) actually decomposes into many different *languages* (lower case ‘l’), and these ‘languages’ represent specific capacities of a normal speaker of a language. Since *Syntactic Structures* first appeared, the use of terminology has become under control, and instead of talking about ‘many languages’, most people say ‘components of the mind’: a sound component, a syntactic component, a meaning component, and so on. Internal to each component is some formal system of representation, and this formal system of representation is a ‘language’. Look in the beginning of a large dictionary and there will be a ‘pronunciation guide’ using about 150 symbols, each defining a specific sound. Then each word in the dictionary has these symbols in a string to show you how to pronounce with word you look up. The pronunciation guide defines a language similar to that in the phonetic component of a Chomsky grammar.

A school for actors, translators, or opera singers may teach only spoken Italian, German, Russian, and so on for people that do not care about meanings or even making simple sentences. They simply want to sing the opera with perfect pronunciation. Phonetics studies the ‘language’ of basic sounds and how they go together. *Phonetics* defines the study of the sounds of a human language, completely independent of any meanings or interpretations. Speech therapists, opera trainers, and others study and teach phonetics. The Professor in ‘My Fair Lady’ was a phonetician.

Descartes and Pascal back in 1660 argued about whether or not one should move the lips and make sounds while praying. Not a big deal to most people today, but in 1639, when the Catholic Church declared the works of St. Augustine, the founder of the Catholic Church, to be heresy, the wrong answer could get you
killed. Descartes said, no lip sync, the ideas going through your head led to salvation and blessedness, not the sounds you make. Pascal in his *Pensées* denounced Descartes as a heathen for his concepts of silent prayer. Their mentor, St. Augustine, gave; sermons indicating that one might start a prayer in one language, switch to another, and then end it in a third. The flow and sequence of ideas coursing through the mind led to salvation, not the particular sounds or mouth movements. Semantics has traditionally been the study of the meanings expressed by languages, and in a particular language, independent of the sounds or sound sequences in the language. So, in English, *Sue wondered whether or not to go* and *Sue wondered whether to go or not* have the same meaning (are synonymous), but differ in the sequence of sounds. Going back centuries (Descartes) and millennia (St. Augustine) Chomsky’s ideas would agree with those that said the ‘sounds’ of the prayers were divorced from the ‘meaning’, or ‘healing power’, or ‘salvation power’ of the prayer. Many religions are not like this: You must exactly pronounce the prayers as they did hundreds of years ago.

According to Chomsky, each human Language has a *Grammar*, but this can be factored into parts. For a Language with its Grammar, there exists a theory of phonetics (a sub-grammar of phonetics) and a theory of semantics (a sub-grammar of semantics). So, following von Neumann, a human Language has a mental representation in a brain as a Grammar, but the Grammar consists of two sub grammars (often called *components*), The *phonetics component* defines the sounds of the Language; and this relates to the (sensor-motor) parts of the brain that control the ears, mouth, and hands (sign language). The semantics component defines the conceptual correlations, or semantic representations, of the Language. How the semantic information of Language exists in the brain has always been a mystery that has spanned disciplines. However, almost all agree that the words and
sentences of a Language point to things, actions, and events in the world in some ways.

How does the phonetics component relate to the semantic component? That is, how does a Grammar link specific sound sequences (like *The dog bit Sue*) to specific meanings that we can judge to be true or false about events in the world?

Dr. Tarnawsky focuses on this problem: How do the sequences of sounds (or written letters and words) relate to meanings, and these meanings relate to observable objects and events in the world?

When he wrote his dissertation, almost everyone in the world thought that each sentence of a Language had a *phonetic representation* (like the pronunciation given in a dictionary using special symbols) and also a *semantic representation*, which would be some graphic representation that related directly to some explicitly definable conceptual scheme. Unfortunately, as Dr. Tarnawsky points out, no one ever offered any type of plausible scheme for representing meanings in any language for any wide range of concepts. Some progress had been made for representing some aspects of meaning using formal logic and various theories of quantification using numbers. These offered insights, but the representations did not seem to be ‘representations of meaning’ in any broad sense. They were simply a shorthand representation in no specific formalism of any generality.

In 1982, usually examples presented in the literature pointed up problems with ‘meaning’ inconsistencies in a human language, and then tried to show that some specific notational convention for semantic representations could show or clarify the anomaly. Most examples did not show any ‘meaning’ in the abstract,
but offered ways to understand why some sentences were strange or did not have the meanings they should have. Consider an example.

Suppose there is one telephone, but two people involved: Tess and Tracy. One can say: Either Tess or Tracy does not have a telephone. But one cannot say: *Either of them does not have a telephone. One can say: Tess does not have a telephone, but Tracy does. Or, Either of them can use the telephone. Why is the one sentence odd? It is perfectly good English and has a phonetic representation. But semantically, somehow, the logic does not work out. This is a failure in the semantic component.

Suppose there is a room containing a lot of people and I look in. I might say: Some of the people are taller than others. Or, Some of the people are shorter than others. But it is odd to say: *Most of the people are taller than others, or *Most of the people are shorter than others. Both of them are true. If there are 20 people of different heights, then 15 are either taller or shorter than the other 5.

Much work in ‘formal semantic studies examines such constructions (which occur with similar problems in all languages). Usually the researcher offers some method/procedure to convert the sentence into some formal logical notations and try to show the formal notations lead to contradictions. Dr. Tarnawsky argues that while some such studies may produce insights in some narrow areas of language (those using logical words like each, all, some, most, not...), the work offers no general concept of semantics to apply to nouns, verbs, and general vocabulary.

A lot of research focused on types of ambiguities. For instance, the string of words: John decided on the boat contains an ambiguity: Either John decided to
choose the boat or John, on the boat, made his decision. Chomsky’s theory offers two syntactic structures for the one sentence: *John (decided on) the boat*, with the complex verb *decide on* as a unit; and also, *John decided (on the boat)*, with *on the boat* a description of location. The semantic difference arises from the different syntactic structures the grammar assigns to a single string.

So far, almost everyone working up till 1957, when Chomsky published his work, would pretty much agree with the above general outline. Chomsky argued that in addition to a phonetic representation (the sound) and a semantic representation (the meaning), each sentence had a *syntactic structure*, which indicated how the phonetic representation was broken into individual sounds/letters, how they were syntactically grouped into words, how the words grouped into phrases, and these phrases into sentences. To make a long story short, Chomsky showed rather conclusively that precisely the computational mechanisms and notations used by Alan Turing, John von Neumann, and Claude Shannon were ideally suited to define the syntactic structures of any human language.

Chomsky persuasively argued that each sentences of every human language could best be thought of as having a graphic representation (formally, a branching network structure in computer theory) and if we knew this ‘abstract’ structure, we could read off of it the phonetics (sound) and semantics (meaning) of a sentence. Traditional linguists and semanticists criticized him mercilessly. The most interesting and witty critique came from an English literature professor with the title *Syntactic Strictures*, mocking Chomsky’s book title *Syntactic Structures*. Chomsky won the day, and today a human language is considered to be a set of syntactic structures, each of which corresponds to a sentence, and it gives all
properties of the sentence relating to sound, pronunciation, meaning, and pragmatic usage.

Dr. Tarnawsky’s work offered crucial evidence to support the overall view that syntactic structures, these actually rather abstract mathematical and computation objects, were ‘real’ and not simply a convenient fiction. How did he do this? By showing that the level of semantic representation could be done away with.

While most (perhaps all, including me) people believed that each sentence was divided into three different components (phonetic representation, semantic representation, and syntactic structure), Dr. Tarnawsky advanced the view that we could abandon the level of semantic representation and answer any and all questions (that existed at the time) being asked, using only the syntactic structure and the phonetic representation. This not merely offered a ‘simplification’ of the theory, but gave a profound insight into the organization of human language. While meanings play a crucial role in human language design, they are not to be considered as a part of the human Grammar. They arise when the human brain/mind pragmatically applies the sentences (syntactic structures) to observations looking for appropriateness and usefulness of the sentence in specific situations and contexts.

Dr. Tarnawsky offered conclusive arguments in his dissertation, but they tend to be subtle and involved. They do not hinge on properties of his notations, or those that existed in the 1980s, and are as valid today as then.
Dr. Tarnawsky’s work possessed implications beyond the narrow range of examples presented in the literature of the time. His dissertation helped cause a shift in the balance of power among research departments. Basically Noam Chomsky attempted to make the ‘underlying formalisms’ of linguistic theory derive from the computational theories of Turing, von Neumann, and Shannon, all workers in the MIT Research Laboratory of Electronics, and all workers on war projects such as radar, sonar, submarine detection, and code cracking. The bulk of the researchers Dr. Tarnawsky argued against derived their ‘underlying formalisms’ from 19th century philosophers and logicians. Those that advanced ‘semantic theories’ in opposition to Dr. Tarnawsky’s tended not to come from ‘centers of computation’ but from philosophy departments, Literature departments, and clinical psychology research centers. Most of the opposition was from ‘traditional psychology’ and classical philosophical views. Dr. Tarnawsky’s formalisms were firmly in the computational views of symbolic algebras of the Research Laboratory of Electronics.

*Knowledge Semantics* offers a clear view of Dr. Tarnawsky’s basic thesis, and his examples, drawn from several languages, illustrate his ideas perfectly. Let us examine some of the problems clarified by the dissertation.

*Pronoun co-reference (anaphora)* defined main problem in extracting meanings from the *syntactic structures*. Very often, two almost identical sentences not only had different meanings, but the references of the pronouns became convoluted. Consider these sentences:

(1) John appeared to Mary to perjure himself.
(2) John appealed to Mary to perjure herself.
(3)  *John appeared to Mary to perjure herself.
(4)  *John appealed to Mary to perjure himself.

In these next sentences, which are equivalents of the above, with *Bill and *himself replacing, respectively, *Mary and *herself, italics mean that the words refer to the same person; they are *co-referential:

(5)  John appeared to Bill to perjure himself.
(6)  John appealed to Bill to perjure himself.
(7)  John appeared to Bill to perjure himself.
(8)  John appealed to Bill to perjure himself.

Dr. Tarnawsky did not only offer a new way of thinking about such problems, and a new type of notation for expressing them, but he offered novel argument structures and types of arguments for justifying any analysis that attempted to ‘unify’ a view of syntax and semantics.

For instance, when he wrote, almost all linguists would contend that sentences 1-4 posed problems in *noun-antecedent agreement of masculine/feminine pronouns, and that the problem was one of syntax, not semantics. But for Dr. Tarnawsky, the problems posed by 5-8 are identical to those posed by 1-4, and also have a syntactic solution. The distribution of data is described by syntactic mechanisms of agreement with no concern for meanings.

Those with a level of semantic representation argued that while 1-4 were *syntactic agreement, 5-8 were *pronoun referent problems and the antecedent of a pronoun was determined in the semantic component. But clearly, the syntactic mechanisms can treat 1-8, and other sentences like, *We appeared to you to perjure
ourselves, *We appealed to you to perjure ourselves, and so on as simple syntactic agreement problems.

No motivation exists to set up a whole new level of semantic representation just to handle cases where the pronouns happen to be of the same person, number, and gender, such that we can label this a problem of ‘co-reference’. Syntax defines ‘antecedent’ and ‘referent’ and this does everything in all cases. In English syntactic and semantic gender tend to be the same. But in some language, like German, one has das Mädchen (the girl) which licenses the pronoun es (it) not sie (her). Sentences involving such words must be handled by syntactic agreement since the semantics is irrelevant.

The view of the syntax-semantic interface offered by Knowledge Semantics goes beyond the insights obtained by studying simple paradigms of words and sentences. Dr. Tarnawsky has always exhibited keen interest in problems of translation and the ‘expressive limits’ imposed on us by our languages and vocabularies. Chomsky argued that the main thrust of ‘Linguistic Research’ was to explain the concept of ‘linguistic intuition’ both as it shows up in sentence structures, but more profoundly, how it shows up in the nature of the overall structure of the Grammar that defines and constrains the Language. Consider some ways the constraints on vocabulary discussed in Knowledge Semantics helps us understand difficulties in translations.

Mark Twain, during part of the 1890’s was the music critic of the New York Herald Tribune. New York opera buffs were solidly pro-Italian, and Wagner had been given short shrift in the tabloids. Twain, asked to review Wagner’s Ring, opened his essay, Wagner’s music is not as bad as it sounds. This sentence has two
syntactic structures, and two meanings: *it is not happy on the ears*, and, *not as bad as people say*. Twain’s sentence translates directly into German and preserves the ambiguity: *Wagner’s Musik ist nicht so schlimm wie es klingt*. But it does not translate into French as a single sentence with the same ambiguity. What does this mean? How does this relate to intuitive grasp of a Language and Grammar?

How can one know it does not translate into French as a single sentence? A non-native speaker might have to search for a word in the dictionary and eventually give up. A fluently bilingual French-English speaker knows immediately, via intuition, that it cannot have a single sentence translation. But a fluently bilingual French-English linguist familiar with syntax and semantics can assert that not only is there no existing translation, but there can never be given the syntactic structures of French. There cannot be any new French word ‘invented’ that can support the syntactic structures simultaneously needed to preserve the ambiguity in translation.

As *Knowledge Semantics* makes abundantly clear there is a fundamental underlying architecture of the syntactic structures and another equally fundamental architecture underlying the semantic patterning that exists in any language, and in some cases, like those elaborated in the book, they correlate. But in general, the correlations require only a level of syntactic structure to be defined, not any level of semantic representations.

To step back and look broadly at *Knowledge Semantics*, it elaborates on what is probably the main theme of Chomsky’s revolutionary *Syntactic Structures*: the concept of a *level*. What we have called ‘components’ and ‘languages at those components’ were called ‘levels’ in the opening lines of *Syntactic Structures*. It is
not that one is ‘higher’ or ‘lower’ in any sense, it is rather that they are abstract ways of thinking about the same thing: Grammar and the Language it defines.

Consider maps describing the surface of the earth. There are at least three. At the most basic level, we have the map of the giant plates of hardened lava that float on the molten center core of the earth, the plate tectonic map. We also have a geographic topological map showing mountains, valleys, rivers, and so on. The third represents the political map, showing cities, states, nations, and lines like meridians and equators imposed by human vanity on a system basically indifferent to human values.

These three maps define abstract views of the very same object. Similarly, the syntactic structure, the semantic/pragmatic views, and the phonetic view are advanced as three views of a single object: a sentence.

It appears that the three different abstract maps of the earth are here to stay. Each view treats a qualitatively different problem. Plate tectonics describes earthquakes and volcanoes. The topological map described landslides and flooding in tidal marshes as well as glaciers and ice at the poles. The political map accounts for the locations of wars and human migrations.

But the three views of a sentence, which have dominated linguistics for centuries, are not as certain. As Dr. Tarnawsky points out, no reason exists to have a semantic level, since any task that was to be solved by the semantic representations can be solved by the syntactic level using mechanisms independently motivated, such as ‘agreement’. The semantic level is an anachronism left over from earlier, pre-Turing computational, times.
Knowledge Semantics shows rather elegantly using persuasive arguments and data from different languages that we lose nothing by abandoning the level of semantic representations. Rather, we gain a more coherent view of the overall structure and architecture of human language. And, if Chomsky’s mantra, ‘Language is the Mirror of the Mind’, is correct, then we gain a greater understanding of the operation of the human brain.

Dr Tarnawsky’s thesis took very strong stands on many controversial issues, hotly debated in the fields of linguistics, cognitive psychology, philosophy, computational data base studies, and any discipline concerned with offering a logical or mathematical model of human knowledge and language understanding. He laid out the issues clearly, in the necessary detail, and treated all opposing theories fairly and explicitly. The overall theoretical perspective would require reading the whole dissertation. Here we touch on the types of issues raised, and indicate the contribution of the thesis.

A basic focus of all Chomsky’s generative grammar was displacement, the fact that in the semantic interpretation of a sentence, sometimes a word or phrase is understood to be the subject or object of a verb quite far from it in the sentence. In these sentences, John is the subject of please for eager, but the object of please for easy. Sentence (10) means, it is easy to please John, not that John pleases. This is an example of displacement, or often called ‘movement’ in 1982.

(9) John is eager to please.
(10) John is easy to please.
Some verbs, like *ride*, can take a direct object (*a horse*) or a prepositional phrase object (*on a horse*):

(11) It is easy to ride a horse.
(12) It is easy to ride on a horse.

Sentences (12) and (13) illustrate another type of displacement. Notice that they are synonymous, but *a horse* can be displaced from the *on* prepositional phrase to the beginning of the sentence, and in fact, to the subject position, where *a horse* replaces the pronoun *it*.

(13) A horse is easy to ride on.

Very strict rules—which everyone agrees are pure Chomsky-type syntax—govern where displacement phenomena can occur. So, for instance, while *what*, which is a noun phrase can ‘move’ to the front and replace the *it*, under no circumstances can the prepositional phrase *on what* move and take the place of the pronoun *it*.

(14) What is easy to ride on?
(15) What is it easy to ride on?
(16) On what is it easy to ride?
(17) *On what is easy to ride?*

One of Dr. Tarnawsky’s fundamental contributions to linguistics as a science arose from two insights. (1) If we abandon the concept of a separate level of semantic representation and instead utilize the formal computationally defined entity he calls a knowledge base, which today might be called a data base of syntactic linguistic knowledge, then, we (2) can extend the concept of
displacement phenomena—well defined in syntax—to account for what had traditionally been called ‘scope of quantifiers’ in semantic theory. The arguments are developed systematically throughout the thesis, but especially in chapters 5 and 6 where he discusses the works of others.

Dr. Tarnawsky’s grammar which considers ‘scope of quantifier interpretation’ to be defined by the same syntactic mechanisms called ‘displacement’, predicts that there is no sharp break between syntactic examples and semantic examples. One can see this from examples like the following involving the lexical item whether or not. The whether can be separated from the or not by long stretches of words and phrases, usually by syntactic movement rules. The same syntactic mechanisms that determine movement in examples like the above, define the correct interpretation of these sentences with no need for any level of semantic description.

(18) Mary cannot decide whether or not to go.
(19) Mary cannot decide whether to go or not.
(20) Mary cannot decide whether to go with the boy or not.
(21) Mary cannot decide whether to go to NY with the boy or not.
(22) Mary cannot decide whether … or not.
   Where … can be long.

Examples like these involve quantifiers, since whether and or not are quantifiers. It follows from Dr. Tarnawsky’s thesis and reasoning that there should be a ‘continuum’ of problems of quantifier interpretation and scope, and they all can be treated by the same syntactic, not semantic, mechanisms that define the properties of displacement.
Sometimes the displacement is not overt, that is, no words seem to move or be in the ‘wrong place’, but the interpretation shifts somehow from one part of the sentence to another (the scope of quantifier problem). Consider these examples:

(23) How did you know to wash the car?
(24) How did you want to wash the car?

The answer to the first question could be Mary told me, but not with a sponge. The answer to the second question could be with a sponge, but not, Mary told me.

In the first sentence, the how (a quantifier) is understood to link with the verb know, not the verb wash. In the second, how links with wash in the lower clause and not the want in the first clause.

The syntactic mechanisms of Knowledge Semantics treat cases like these where there is no overt movement or overt displacement by the same rules that define the semantics of all cases discussed above.

Dr. Tarnawsky’s fundamental underlying thesis, which gives the title Knowledge Semantics to his work, stems from his insight that the goal of sentence interpretation is not to obtain some ‘level’ of formal notations called a semantic reading, but instead to show that the mechanisms that actually relate a sentence to the human’s knowledge base are independently defined syntactic operations. The insight is that the meaning, or lack of meaning in some cases, derives from what knowledge the speaker brings to the interpretation process. The focus is on the
‘processes’ of interpretation, not on some final ‘data structure’ that we might call ‘the interpretation’.

There are cases in which a sentence, which one might suspect should have a ‘meaning’, in fact does not seem to have the expected or in fact any meaning. Those against Dr. Tarnawsky’s views would argue that such cases have an anomalous semantic structure. Dr. Tarnawsky argues the rules that try to match the sentence to the speaker’s knowledge base ‘jam up’ and fail to function. Examples of such phenomena abound. Dr. Tarnawsky provides a perspective and tools to deal with them.

The basic ideas of Knowledge Semantics defined a fruitful area for further research into murky areas. So I will pose to you a question. Think for instance, of what reasons can be given for the ill-formedness of *I don’t know why to go, given that many other quantifiers form interpretable sentences. Having read and understood Dr. Tarnawsky’s proposals, I suspect it has to do with trying to fit the question into my knowledge base and not some quirk in some abstract logical semantic structure.

(25) I don’t know how to go.
(26) I don’t know when to go.
(27) I don’t know whether or not to go.
(28) *I don’t know why to go.
(29) I don’t know why I should go.

PhD dissertations usually focus on one or two narrow issues that people in the discipline believe can resolve a problem and put research into a channel that will produce more insightful theories in the future. So far, we have focused on the trees,
specific mechanisms and data structures of ‘Linguistics’, but now let’s focus on the forest: How does ‘Linguistics’ as a science relate to other sciences and broader concerns in the philosophy of language? In doing so, we can see how Dr. Tarnawsky’s ideas about scientific research, the goals of research, the methods of research, and the ‘utility’ of research increase insight into the formal processes of human language, which Chomsky linguists generally believe are ‘syntactic processes’ which link sounds with meanings.

Suppose we ask a chemist, ‘What is sulfur?’ or ‘What is iron?’ She might put a lump of yellow powder in front of you and call it ‘sulfur’, and place a cube of metal on the table and label it ‘iron’. One might say these physical objects are the ‘representations’ or the ‘meanings’ of ‘sulfur’ and ‘iron’. Perhaps after this you could decide if something is, or might be, ‘sulfur’ or ‘iron’. In general, this style of thinking has been called ‘ostensive definition’. But this only scratches the surface. Sulfur bears the properties yellow (eye), soft (touch), and smelly (nose) while iron tends to be shiny, hard, and odorless. Certainly these properties of how ‘objects’ and ‘words’ relate to our senses must be part of the sounds and meanings here. Also, people often build things out of iron, but few things out of sulfur. So part of the sounds and meanings must have to do with ‘use’ and ‘function’. The meanings of things and words do not seem absolute in some ways: Can one be a vegetarian and eat fish, shrimp, and oysters? Is a crawfish ‘meat’ or ‘vegetable’? Probably somewhere in between for some vegetarians. For those that eat anything on the menu, the question makes no sense, and, insofar as it does, the answer has no pragmatic significance since it will not affect behavior.

In the 1980’s, there existed two main viewpoints, usually hot button issues in philosophy departments, and simply issues in other departments. In linguistics
departments following the ideas of Noam Chomsky, most linguistic research assumed the ‘semantic representation’ viewpoint, then espoused by Katz, Postal, Fodor, and Jackendoff, among most others. It was the prevalent view of MIT style linguistics. The main alternative view in the 1980’s followed the ideas of Hilary Putnam, a Harvard philosopher, who argued that semantic representations may or may not, and probably did not, exist and were quite irrelevant to studying language as a sound-meaning correlation. Everyone agreed that meanings exist, but one group (Katz, et. al.) argued they have formal representations in some logical type notation, the other group (Putnam) said they do not.

To use an analogy, Katz et al., somewhat like the chemist who placed two objects on a table, argued that the formal objects they represented in their notations were ‘real’ and constituted the ‘meaning’ of a sentence; Putnam is like the chemist who would argue that the objects only tell a part of the tale. The objects indeed are a representation, but only a part of the whole representation. We must also consider how the objects appear to the senses, how they function in human context, as well as where they come from, and many other things. For Putnam, there exists no single thing (physical or as a formal abstraction) that we can point to and call it the ‘meaning’ of a sentence.

Putnam, an excellent writer, said that he did not know the difference between an elm and a beech tree, but he could use the words ‘meaningfully’ to differentiate two ill-defined concepts. His theory had a distinct ‘social’ aspect: Putnam said he could use the terms confidently because there were ‘experts’ in the English-speaking world that did know the difference. It made a difference in their usage of the words, but not in his usage.
Dr. Tarnawsky’s dissertation, with its strong emphasis on the ‘social and contextual usage’ of sentences falls squarely into the camp of Putnam, who was rarely discussed by Chomsky MIT linguists. Dr. Tarnawsky’s dissertation ran counter to 99 percent of semantic research in the Chomsky MIT school of linguistics. It was revolutionary in offering a novel perspective and a detailed computational theory that merged Chomsky’s and Putnam’s views.

To use an analogy, one of Dr. Tarnawsky’s criticisms of the ‘semantic representation’ group argued that all they did was ‘translate’ from one notation into another, but gave no insights into what a ‘meaning’ could be. Consider numbers and how they might be represented in various notations. Alan Turing would count using symbols like these: \{0, 1, 10, 11, 100, 101, 110, 111, \} Romans used these: \{I, II, III, IV, V, VI, \}. Fibonacci introduced the Arabic numerals which we use today: \{1, 2, 3, 4, 5, 6, \}. With the advent of computers, binary numbers achieved popularity: \{1, 10, 11, 100, 101, 110, 111, \}. Which notation is ‘true’ or ‘correct’? The question makes no sense since they all stand for the same things—numbers.

A single young lady named Jane Bloom marries John Doe and instantly becomes Jane Doe for legal and economic purposes, such as taxes, health insurance, and the right to stay in their rent controlled apartment if John Doe, the leaseholder dies. These label changes simply follow from the translation laws of the marriage legal code. We have not learned anything about the lady represented and probably, except that she may now have a ring on her finger, she remains otherwise unchanged. We know that Señora Jane Doe qualifies for a green card and USA citizenship, but Señorita Jane Bloom does not.
Reflecting on the understanding of the concept ‘number’ in the different representational notations above, we know ‘numbers’ no better than before, but we now have different ways to write down numbers. Each ‘representation’ has its advantages for specific reasons, and pragmatically one may surpass the others. But these representations are simply ‘notational variants’ of each other. If the Chinese and Japanese abandon their graphic scripts and use the Cyrillic or Roman alphabets to represent words in their languages, some simplicity may or may not be achieved (easier to learn to read and write), or some functional simplicity (can use the standard ASCII symbol system on the internet), but there exists no concept of ‘truth’. We would not achieve any deeper ‘insight’ into the syntax and morphology of the languages.

To summarize Dr. Tarnawsky’s criticisms in one sentence: Basically, all proposed semantic representations (as presented by Katz, et. al.) are simply systems that translate from one syntactic notation into another.

More complex mathematical examples give more complex analogies, like those discussed by Putnam and his followers. Following Rene Descartes, \(x^2 + y^2 = 1\), an algebraic expression in the domain of numbers, defines a circle in Cartesian coordinates in the geometric domain of Euclid. Descartes showed that many standard geometric shapes have a representation as polynomials. But this is simply ‘translation’ from one notation into another. These ‘translations’ simply relate synonymous expressions and give no insight into what the reality underlying the various notations might be. To understand the broader implications of these issues examine the Church-Turing Hypothesis.
Dr. Tarnawsky, with his strong computational and electrical engineering background, understood all the examples discussed by the Putnam group of philosophers and mathematicians. Considering his background of NYU graduate school coursework, research at IBM, and our many one on one personal discussion, it became obvious to us both that he could write a dissertation discussing the various views of the sound-meaning correspondences, do it at the full level of mathematical/logical depth required, and further, offer a significant formal representation of a Putnam-type semantics linked to a Chomsky generative grammar syntax. He did a great job.

Following Putnam’s views Dr. Tarnawsky develops a systematic and coherent perspective in which to present ‘meaning’ as a process that defines ‘correlations’ of sentences with complex systems that may not be ‘symbolic systems’ like human language. For Dr. Tarnawsky semantic interpretation involves more than pencil and paper ‘translations’ into other notations. Consider two widely discussed ‘correlations’: one involving ‘action’, the other ‘social integration of meanings’. Neither of these was discussed in Chomsky linguistic circles. Dr. Tarnawsky’s work defined a ‘bridge’ to integrate them into the Chomsky syntactic grammar perspective.

‘The blocks world is one of the most famous planning domains in artificial intelligence. Imagine a set of cubes (blocks) sitting on a table. The goal is to build one of more vertical stacks of blocks. The catch is that only one block may be moved at a time: it may either be placed on the table or placed atop another block. Because of this, any blocks that are at a given time under another block, cannot be moved.
‘The simplicity of this toy world lends itself readily to symbolic or classical AI approaches, in which the world is modeled as a set of abstract symbols which may be reasoned about.’ (Wikipedia, Blocks world)

The researchers that developed the natural language interface to the blocks world and the structure of the blocks world and movement therein were Terry Winograd and Patrick Winston. Their initial studies appeared around 1970 and developed in several places for the next ten+ years. If one typed in: ‘Put the red block on top of the blue block’, the system would perform the simple movement, or, if the blue block had something already on it, the program would remove the object and then place the red block on top. If initially the red block laid under the blue block various movements would occur. This type of semantic-pragmatic process aligns well with the ideas of Putnam and Dr. Tarnawsky’s systematic analysis. A sentence correlates with certain movements in the blocks world with well-defined start and end states.

To consider one analysis that became quite popular: Suppose you are wearing pants with pennies in the back right pocket and nickels in the front right pocket. You must switch their positions. You will need two hands. Empty the right rear pocket with the right hand and put the pennies into the left hand. Move the nickels to the back pocket using the right hand. Then move the pennies from the left hand to the right hand and into the front pocket. Of course, you could start with the front pocket, so pragmatically at the level of robotic actions, the command to ‘switch the contents of the pockets’ has a functional ambiguity given the context.

Suppose the pennies are in the left front pocket and the nickels in the right front pocket: You must switch them. This is difficult (impossible) unless there
exists a ‘storage location’ for one hand to place its contents so the hands can switch coins from one to the other. The command: ‘Switch the pennies and nickels from one pocket to the other’ differs radically in ‘computational complexity’ given the physical situation. In the 1990’s some economists picked up on ‘blocks world’ thinking to analyze how to switch ‘wealth’ in dollars into various European and Asian currencies, vice versa, and perhaps using gold as an intermediate storage mechanism. A physical paper hundred dollar bill has no more intrinsic value than a paper one dollar bill, and functions only as a symbol of wealth. Not so with gold, which in its physical form, constituted wealth. The issues are somewhat like converting from potential to kinetic energy. Putnam’s research reached into many fields. Many of the ‘modern’ issues concerning ‘electronic money’, such as bitcoins, were hashed out by Putnam’s students and colleagues decades ago.

Dr. Tarnawsky’s ‘social meaning’ approach lines up completely with Putnam’s views on how meanings seem to be held by ‘groups of people’. Vast amounts of articles, lectures, and books discuss this in many domains of inquiry. Suppose one goes to the doctor with some painful ailment. The patient describes the problem using simple English: ‘I suffer sharp pains in the big toe after eating triple crème cheeses and washing them down with Merlot’. The doctor correlates several thoughts into a diagnosis, cure, and prognosis. Probably gout inflammations. (Indicative) Stop feasting on cheese and wine and start eating salads and drink water! (Imperative) Are you on Medicare?; if so, you must take these pills. (Ostensive: handing over of pills) Do you have a solid gold health insurance?; if so, go to a spa in France. (Speculative future action). Another doctor or nutritionist might give totally different responses. A religiously inclined advisor (Pascal) might say ‘Welcome the pain. Suffering brings us closer to God.’ Notice the patient’s simple indicative sentence has ‘meanings’ that are questions,
imperatives, ostensive definitions… and many more types of verbalizations and actions.

Many people after visiting a doctor visit a pharmacist who gives them pills with unpronounceable names and instructions on how many to eat, when, and with or without food. Some go to X-ray facilities or other places with complex machines they might have to climb into. All of the above concepts add up to give the meaning of the patient’s claim about ‘sharp pains….’ Here we think of Putnam’s discussion of elm versus beech trees. We have no clear ideas in our heads about the objective reality of chemicals and machines that relate to our pains. We only have the subjective knowledge of the pains, and of these, we can rank them for intensity, type (sharp, dull…), and along other dimensions. To reflect on more complex systems: What does it mean to yell ‘Fire!!!’? Why did Chief Justice Oliver Wendell Holmes argue that ‘freedom of speech’ does not include the right to yell ‘fire’ in a crowded room if there is no ‘physical fire’ present? Smoldering cigars and pipes, while burning substances, did not qualify as ‘fire’ for this utterance, and could not legitimize the exclamation.

Dr. Tarnawsky’s work appeared as ‘rebellious’ within the Chomsky linguistics researchers at MIT, who all favored ‘interpretive semantics’ and ‘representations’, all of which involved translations between symbol systems. Since Dr. Tarnawsky’s dissertation, much computational linguistic work has followed in paths laid down by Putnam. Dr. Tarnawsky’s dissertation might well have been the first work to integrate Putnam’s and Chomsky’s approaches into one formulation. Work has continued in this direction. Let us look at one recent development.
Nisan and Schocken’s *The Elements of Computing Systems: Building a Modern Computer From First Principles* (2005) provides a modern example, albeit somewhat conceptually difficult. In this brilliant book, they describe how one can—within the system they describe—take an English sentence and convert it to a logical notation. They then correlate this notation with transistor and electronic circuitry to form very basic logical/electrical functional computational systems. Then they analyze these somewhat complex functional units into the lowest level of computational units, NAND gates. Then, from the most elemental NAND gate, they show how to construct a complete modern computer (a Turing machine) that has an input and an output and can solve problems of all sorts. Nisan and Schocken’s book represents one of the finest conceptual schemes to arise from the types of thinking in Putnam’s philosophy and in the semantic action and social systems discussed by Dr. Tarnawsky.

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