The semantics of syntactic structures

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Over the past 15 years, both linguists and psycholinguists have shown a growing interest in the idea that syntactic structures can carry meanings that are independent of the meanings of specific words. This article considers how this idea relates to traditional notions of compositionality in generative grammar, and examines two modern theories that, although based on different starting assumptions, both readily allow syntactic structures to bear independent meaning. We review work from psycholinguistics suggesting that observation alone is often insufficient to support the efficient learning of word meanings, and that some of the ‘slack’ left by observation can be picked up by the semantics of the syntactic structures in which words appear. We argue that this convergence between linguistic theory and psycholinguistic experimentation should be no surprise, because language must be learnable.

The nouns, verbs and adjectives in this famous piece of verse are all inventions, products of Lewis Carroll’s febrile imagination. And yet as readers we have a sense – imprecise, perhaps, but real nonetheless – that we know what is going on in this poem. Take the first two lines. It is plain that two or more creatures of some kind (theslithy toves) are engaged in a couple of different activities (gyring and gibbling), while remaining in a fixed location (in thewabe). Why is Carroll’s prose not utter gibberish? How are we able to extract meaning from it? The answer is that meaning can be inferred from the syntax of these lines, independent of the words that appear in those structures.

The past 15 years have seen a blossoming of interest in the semantics of syntactic structures. This interest has taken two related forms: among linguists, as an intensified examination of the role that syntactic structures play in the composition of sentence-level meaning; and among psycholinguists, as a proposal for how children might overcome some of the serious problems associated with word learning. This article aims to review these two lines of work and show how they relate. Although we are not the first to note this connection, we believe this article offers the first synthesis of this work grounded in both linguistics and psycholinguistics.

What are the semantics of syntactic structures (TSOSS)?

By ‘syntactic structures’, we mean large units of syntax, in particular noun phrases (NPs) and verb phrases (VPs). By ‘semantics’ we mean abstract notions such as objecthood, substancehood, causation, motion and mental activity. TSOSS are carried independently of the open-class content words (nouns, verbs and adjectives) that inhabit these structures (although certain closed-class words such as prepositions and the plural marker ‘s’ are also integral to TSOSS). For now, we offer some concrete examples of these structures and their semantics, deferring more-detailed discussion until the next section.

Mass nouns and count nouns, for example, characteristically appear in different NPs. The mass noun milk generally appears as a bare noun, as in ‘Mary bought milk’. The count noun glass, by contrast, typically appears with a determiner of some kind, as in ‘Mary fetched three glasses’. Critically, count nouns and mass nouns are not prohibited from syntactic cross-dressing; when such cross-dressing occurs, however, the resulting semantic interpretation is a function of the dress, not of the wearer. Compare ‘Mary bought glass’ with ‘Mary fetched three milks’. Here, the structure of the NP acts as the engine of construal, guiding one to imagine either a non-individuated substance (milk, glass) or a countable entity (three glasses, three milks).

Much as NPs can guide the construal of objects, VPs can also guide the construal of events. Consider the effects of placing the verb kick in a variety of syntactic environments. In the sentence ‘Susan kicked the ball’, the verb denotes an event involving contact or causation; in ‘Susan kicked the ball to Bob’, it denotes an event of transfer; in ‘Susan kicked her way out of the locked closet’, it denotes an event of motion by kicking. Where do these different construals of the kicking event come from? One answer is that each use of these uses of kick represents a different sense of the verb. Another answer – the one that we pursue in this article – is that the VP itself carries semantic content, and it is these semantics that effect the appropriate construal.

TSOSS and linguistic theory

Modern notions of syntactic structure date back to Noam Chomsky’s early work. Within the framework of his Aspects of the Theory of Syntax, transformations served to map deep structures generated by the rules in the base of the grammar to surface structures that could then be pronounced by the phonetic–phonological system. To take an example, the basic structure ‘Elvis shot the television’ served as the deep structure for both the simple active sentence ‘Elvis shot the television’ and the passive sentence ‘The television was shot by Elvis’. According to Chomsky, semantic interpretation took place on the configuration of ‘deep structure’. The subject of a verb was interpreted as the ‘doer’ (later called the Agent), while its direct object was interpreted as the ‘done to’ (later called the Patient). Transformations re-arranged elements and made essential structural modifications (for example, adding the preposition by).
to the passive), but did not affect the truth-conditional semantics of the sentence. As a result, the NP ‘dog’ assumed the same logical role in both the active and passive sentences cited above, despite occupying different surface positions in the two cases.

Faced with evidence that deep structure, as outlined in Aspects of the Theory of Syntax, could not yield a full semantic interpretation, syntacticians in the 1960s pursued two different tasks. Generative Semantics greatly enhanced deep structure so that it contained a large number of abstract elements not pronounced in surface structure (such as the meaning CAUSE); prior to pronunciation, these elements were replaced by words, although often not in a one-to-one fashion (CAUSE-DIE, for instance, would be replaced by kill3). Interpretive Semantics, by contrast, posited additional levels of representation, each of which captured a different component of meaning. Despite their differences, these two theories both adhered to a strict view of compositionality, wherein words (or unpronounced abstract elements) were the sole meaningful units in language. Some modern incarnations of Interpretive Semantics have incorporated the Generative-Semantic notion of abstract meaningful elements.

Importantly for our purposes, no theory descended from Aspects of the Theory of Syntax has posited rules that refer to syntactic structures as such. Instead, the descendents of this work derive complex structures from the interaction of a small set of universal principles and language-specific parameters. To the extent that syntactic structures remain, they are seen as epiphenomenal products of these interactions, with no independent contribution to the composition of sentence-level meaning.

Some recent developments in linguistic theory have taken an altogether different approach, rethinking, among other things, the links between syntax and semantics, and the nature of compositionality. In what follows, two modern linguistic approaches consonant with our notion of TSOSS are examined in depth: that of Ray Jackendoff and that of Adele Goldberg. Many linguists would disagree strongly with the positions we review. Nonetheless, we think it striking that two linguists working from different starting points have come to similar conclusions about the meaningfulness of syntactic structures. This convergence, in our view, lends further credence to the notion that TSOSS have an important role to play in language interpretation.

Jackendoff’s approach

Despite being one of the first proponents of Interpretive Semantics, Jackendoff has broken with that tradition in several ways. Nonetheless he continues to share its commitment to building a grammar around the minimum number of logically necessary components. In Jackendoff’s theory of Representational Modularity, syntax is not the only, nor the most central, generative linguistic capacity. Rather, the theory accords equal status to syntax and to its companion linguistic capacities, phonology and semantics. All three modules are generative, have their own unique principles of design and function, and are linked by sets of ‘correspondence rules’, which register information in one module with information in another. Words themselves are correspondence rules, linking the phonological, syntactic, and semantic modules. To take a simple case, the word ‘dog’ is a triple of information: the phonological form /dog/, the syntactic category COUNT NOUN, and the semantic entity DOG. Each module has access only to its own type of information, and is blind to information in other modules. The word ‘dog’ exists to link these three pieces of information.

‘Theories of compositionality must take into account not only the meanings of words, but also the meanings of syntactic structures.’

Correspondence rules do not always work so simply. For example, the preposition of in English is a pronounceable word and has a syntactic category, but it is not registered to anything in the semantic module. It exists merely to satisfy the requirement that all nouns be assigned case. In order to explain how some words can have syntactic properties but no meaning, it is essential for Jackendoff that intermodular correspondence not be exhaustive. Once in place, the failure of total correspondence opens the door to TSOSS. For example, in the idiom ‘kick the bucket’, neither the verb nor the NP is registered separately to a unit of semantics. Only the VP as a whole corresponds to the meaning DIE.

In this example, the meaning of the idiom depends on the particular content words in the structure (‘kick the pail’ has a completely different meaning), but nothing in Jackendoff’s theory requires that particular content words be present in order for a structure to be registered to something in semantics. The mechanism required to link the whole VP ‘kick the bucket’ to the meaning DIE can just as easily link a more abstract VP such as ‘verb then noun’ to a meaning like ‘ACT on ENTITY so that it is AFFECTED’. In fact, the non-exhaustive nature of the correspondence rules predicts the existence of meaningful, but lexically ‘poor’ phrases and clauses – in other words, TSOSS. So while Jackendoff himself has not argued for the existence of TSOSS, we believe they follow quite naturally from the architecture he has proposed.

Goldberg’s approach

Goldberg approaches the relation of syntax to semantics from a direction precisely opposite to that of Jackendoff. Whereas Jackendoff begins with a small number of necessary premises and derives from
Although Jackendoff and Goldberg begin from very different theoretical positions, each favors a relationship between syntax and semantics that resonates strongly with our own conception of TSOSS. We should emphasize, however, that neither linguist would fully endorse our particular conception of this relationship—nor we theirs. For Jackendoff, relations of syntax to semantics are too complex and language-particular for lexically poor units of syntax to contribute in any interesting way to sentence-level semantics. We believe that such relationships, while imperfect, are regular enough to be semantically potent. For Goldberg, our conception of TSOSS is too limited. In her view, every syntactic unit—words included—can be assigned semantics in a formally equivalent way. For a variety of reasons, we do not believe it makes sense to treat syntactic structures like words. And unlike Goldberg, we do not believe that verb-construction pairings are constrained only by cognitive factors such as whether an action can be construed as the means of caused motion. Indeed, we are convinced that formal lexical-syntactic properties (such as aspect) play a fundamental role in determining which verbs can appear in which structures. Despite these differences, there is nonetheless a striking convergence of opinion on the relation of syntax to semantics, thus lending credence to the idea that theories of compositionality must take into account not only the meanings of words, but also the meanings of syntactic structures.

**TSOSS and word learning**

Word learners must solve numerous problems. One key problem is knowing what to pay attention to in a world that frequently provides complex scenes open to multiple construals, some more salient than others. Another is learning words whose referents cannot be observed. In this section, these problems are considered as they apply to nouns and verbs, and how TSOSS might help learners to overcome them is discussed.

### Learning the meanings of nouns

Languages have three types of nouns: proper, count and mass. These nouns can be distinguished according to their distributional properties. In English, count nouns appear with determiners such as a and every, and they pluralize. Mass nouns, by contrast, appear bare, with determiners like some and much, and they do not pluralize. Both count and mass nouns can appear with the determiner the, and the latter can be converted into the former by the use of classifying phrases such as a bottle of X and a grain of Y. Proper nouns are names and appear with no determiners at all.

This section focuses on experiments that explore the mass-count distinction, although equivalent experiments have been conducted with proper nouns and show similar results. The fundamental question for these noun-types is which noun appears in which syntax. On the face of things, it seems plausible to say that the world determines how a
The notion that syntax might assist the language learner was first explored by Roger Brown in his now classic study of word learning. Brown showed children ranging from three to five years old a scene that depicted a woman kneeling confetti in a stripped bowl. As he showed the picture, he said, ‘In this picture, you can see sibbing/some sib/a sib’. Brown then showed the children three additional pictures, each of which reproduced a separate component of the original scene – the substance, the container and the motion – and asked them to show him ‘another picture of sibbing/some sib/a sib’. Children’s responses varied with the form of the question: asked to show sibbing, children pointed to the hands; asked to show some sib, they pointed to the confetti; and asked to show a sib, they pointed to the bowl. Thus, the syntactic context of the novel word influenced the interpretation children gave to it.

At the time, Brown was not explicitly interested in the relation of syntax to semantics, or in the role that syntax plays in lexical acquisition. Rather, he took the study as evidence for an effect of language on thought – the form of language that children heard influenced their conception of the complex scene. Indeed, the title of Brown’s paper – ‘Linguistic determinism and the part of speech’ – makes plain his interpretation of this work. Whether these results should be seen as Whorfian in nature remains unclear. What is clear, however, is that Brown uncovered a powerful phenomenon, which, over the past decade, has achieved great prominence among researchers studying lexical acquisition.

Reference
This finding is especially striking in light of results from a control condition often conducted in these studies, in which the child is introduced to the novel noun with no syntax at all. Under these circumstances, construal is shaped by the inherent properties of the entity: entities apparently shaped with intent (for example, Nivea with gravel shaped into an L) evoke more shape-based responses than do entities whose shape reflects no obvious intent (for example, a blob of Nivea with gravel). Regardless of which construal an entity affords without syntax, its construal can be shifted by the appropriate syntax. Syntax can thus help to overcome the shape–object bias as well as what might be called the ‘blob–substance’ bias.

In summary, we have laid out the behavior of count and mass syntax, and the problems faced by the learner. Distributionally, a massive correlation holds between count syntax and objecthood, on the one hand, and mass syntax and substancehood, on the other. And indeed, entities in the world usually afford a single construal based upon (for example) whether they appear to have been assembled with intent. These two facts together on the face of things equip the learner to acquire nouns readily. In fact, syntax seems to be an unnecessary cue in the acquisition of many nouns. However, speakers often talk about aspects of an entity that contradict the perceptually salient construal (the substance of artifacts, the shapes of substances). To acquire words whose meanings contradict the most perceptually natural interpretation, learners must have an escape from the ‘trap of salience’. TSOSS provide that escape.

Learning the meanings of verbs
One of the most striking facts about word learning is that verbs are learned later than nouns. This delay is not surprising when we consider the many problems that confront the child. For example, verbs and the events that they describe do not line up particularly well in time. In one corpus, the verb open was uttered in the presence of opening only 37% of the time; more often than not, open occurred with no opening in sight. In principle, this problem could be overcome with sufficient opportunity for cross-situational observation. It is probably the case that the event most frequently associated with the verb open is, in fact, opening. Other problems, however, cannot readily be solved no matter how many observational opportunities the learner has. Consider that events frequently afford multiple construals. Every event of giving is equally an event of taking; likewise, every event of buying is equally an event of selling. Because of this entailment, the learner will never (or nearly never) witness them decoupled, and so will be unable to disentangle one construal from another. Even more seriously, the referents of verbs are generally more abstract than those of nouns, especially in the early input to children. Indeed, many common verbs (for example, think and believe) refer to events that cannot be observed at all. On top of all these problems, learners also show a bias in verb learning parallel to the object bias in noun learning. Given an event, learners prefer an agentive interpretation, where the most active participant is assigned to the thematic role of Agent and, consequently, to subject position. It would seem a daunting task for learners to overcome these various obstacles to successful verb learning. TSOSS provide the support necessary to do just that.

How might TSOSS help learners to overcome these problems – the ambiguity of the world, abstract referents and the agency bias? First of all, the syntax of a VP must systematically reflect the meaning of the verb. And indeed, work in both linguistics and psycholinguistics indicates that abstract semantic properties such as causation, motion, transfer, and mental activity ‘project’ systematically from a verb’s lexical–semantic structure into the syntax. Second, children must actually make use of TSOSS. In one experiment roughly parallel to the NP experiments discussed above, three- and four-year-olds were shown an event ambiguous between two interpretations (for example, chasing and fleeing). The event was described either with a lone nonsense verb (‘Look! Gorping!’) or with a full sentence containing a nonsense verb (‘The bunny is gorping the skunk’/ ‘The skunk is gorping the bunny’). The task was to paraphrase these novel verbs. When the verbs were presented with no syntax or with a syntax that supported the agency bias (with the more active participant named in subject position), participants consistently offered an Agent-oriented construal (‘chasing’). However, when the syntax opposed the agency bias (with the less active participant named in subject position), children provided Patient-oriented construals (‘running away from’). Here again, TSOSS provide an escape from the trap of salience, resolving both the ambiguity of the world and overcoming a bias that can interfere with successful word learning.

In a different experimental setting, two-year-olds were shown a videotape of two actions performed at the same time. One action was causal (a person costumed as a duck made a person costumed as a bunny squat down by pushing on his shoulders) and the other was non-causal (both the duck and the bunny twirled their arms, the duck being non-causal). At the same time, they heard either a transitive sentence (‘The duck is gorping the bunny’) or an intransitive sentence (‘The duck and the bunny are gorping’). The events were then separated, one to a screen, and the children were asked to ‘find gorping’. Children looked reliably longer at the causal event after hearing the transitive sentence, and at the non-causal event after hearing the intransitive sentence. Since the verb was unfamiliar, these preferences must have
been driven by the structures of the sentences. In a related experiment, three- and five-year-old children were able to match a novel verb to one of two scenes based on the kind of sentence frame the verb had appeared in, even when all the NPs were pronouns (‘She’s pilking her’ versus ‘She’s pilking’)17. These experiments show that TSOSS can guide the attention of children to the scene most likely to correspond to the meaning of a novel verb.

In a test of the degree to which observation can support word learning, adults were shown videotaped clips of mothers interacting with their young children. With the sound turned off, participants had to guess the meanings of nouns and verbs uttered during those interactions. Participants saw six instances of each word, with beeps placed at the appropriate spots. Although participants successfully guessed many nouns, they failed to guess most of the verbs (an effect of participants successfully guessed many nouns, beeps placed at the appropriate spots. Although participants saw six instances of each word, with

In summary, there is an ever-growing wealth of evidence that TSOSS are widely used in acquisition15,38,39. What’s more, recent work with specific language impairment children suggests that an inability to take advantage of TSOSS might lead to difficulties in word learning (see Box 2).

Conclusions

Two recent linguistic theories, beginning from rather different starting assumptions, both readily permit syntactic structures to carry meanings apart from the words that appear in them. Work on the acquisition of word meanings suggests that meaningful structures are frequently helpful – and sometimes indispensable – for the learning of words, especially those that cannot easily be learned from observation. In our view, this convergence between theoretical and experimental work should not be surprising. One of the most profound insights of the Chomskian program is that grammars must be learnable. We might extend this observation further: language, in general, must be learnable, and if the world by itself does not provide sufficient support, then help must come from elsewhere. On this view, language has its particular properties not just so that learners can acquire syntax, but also – just as importantly – so that they can acquire words. We have focused on TSOSS because there is substantial evidence for their existence and for their usefulness in language acquisition. More generally, this article can be seen as an effort to link the domains of linguistic theory and language acquisition. Language structure and language acquisition are two halves of the same whole: each reflects the other, and neither can be properly understood alone.

References

Outstanding questions

- To what extent are verb-structure pairings constrained by formal properties of language, and to what extent are they constrained by conceptual factors? The sentence ‘Susan thought the book to J ohn’ strikes most people as highly peculiar at best. One explanation for the oddity of this sentence is that the verb think, because of its formal, linguistic properties, is not permitted in a structure that is typically reserved for verbs of transfer. Another is that the event that it describes is not possible in the world as we know it. But if this sentence is preceded by a sort of science-fiction context specifying that Susan has the power to move objects with her mind, its acceptability improves considerably. How easily can judgments of acceptability be manipulated with context?

- There are good reasons to believe that the mappings between meaning and form are at least partially innate, but there is also a good deal of cross-linguistic variability in the details of these mappings. How, then, do early learners exploit these mappings when they have not yet mastered the surface properties of their native language (such as how the subjects of sentences are grammatically marked)?

- When do children acquire enough syntactic knowledge to be able to exploit it for word learning? Can we predict what words will enter a child's vocabulary by knowing what words can be learned without TSOSs, what words require it, and how children's knowledge of TSOSs develops?

- The syntax of noun phrases is more variable cross-linguistically than that of verb phrases: while there are languages that do not make the mass–count distinction, there are no languages that do not have different morpho-syntactic structures for transitive and intransitive verbs. Similarly, TSOSs appear to be more crucial for acquiring verbs than for acquiring nouns. What is the relationship between these two facts? Is the first a cause of the second?

- How are TSOSs represented and accessed? One possibility is that their semantics are computed in real time by applying in reverse the rules that link the semantics of lexical items to their associated syntax. Alternatively, syntactic forms might come to bear meanings directly, such that listeners can look up the semantics of a syntactic structure much as they would the semantics of a word. What kind of evidence would help to distinguish these two representational models?

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