The acquisition of semantics

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This review piece looks at how children acquire various elements of linguistic meaning. It considers issues in the acquisition of word meaning, argument structure, tense and aspect, and quantification and scope. For each of these areas, it considers the problems they pose for the acquisition process in general, reviews basic findings from the field of acquisition, and identifies outstanding questions in the field. © 2010 John Wiley & Sons, Ltd. *WIREs Cogn Sci* 2010 1 519–526

Semantics is the study of how linguistic elements carry meaning. It sits squarely at the intersection between language and cognition, inextricably linked to the linguistic system which conveys meaning and the conceptual system which interprets it. In order to acquire the semantics of a language, a child must do three things: first, she must identify the relevant linguistic items, second, she must identify (and understand) the meanings these link to, and third, she must learn how the forms connect to the meanings. Moreover, the child must find the mapping between form and meaning at a time in her life when both of these elements are moving targets; as children age, they become better at parsing forms and structures and also improve their conceptual grasp of the world. Not surprisingly given these complexities, investigations of children's semantics often consider a range of factors, from syntax to pragmatics to non-linguistic cognition. The following sections cover a selection of topics that are central to the study of semantics and considers them from an acquisition perspective. What special problems does each element of meaning pose for the child? The process of acquisition follows different paths depending on the specific nature of meaning involved as well as on the way the meaning is instantiated in language.

WORD MEANING

Perhaps the most obvious way that language conveys meaning is through words. Every language contains thousands of vocabulary items that refer to concepts ranging from the concrete and mundane (*bottle*, *ball*) to the abstract and unusual (*ponder*, *perplex*). The primary challenge for acquiring word meanings is

the problem of reference, or how symbolic elements such as word forms are linked to elements in the world and our specific concepts of them. The essential nature of reference is one that has been much discussed by philosophers (including Refs 1–3, *inter alia*) and its fundamental mechanisms are still very much in dispute. Children do seem to appreciate the core dimension of reference, namely that things in the world correspond to words in language, and the rapid pace of their word learning (e.g., 5-year-olds often have vocabularies in excess of 10,000 words) attests to the ease with which they can make the link between word and meaning.[4] However, at the very earliest stages of language development, children learn words very slowly—it takes approximately 18 months for children to acquire their first 50 words in their production vocabulary—and it is possible that children do not fully grasp the referential nature of words initially.

Beyond understanding that reference happens, children must also make correct links between linguistic forms and their meaning—sometimes called the 'mapping problem'. Moreover, given the speed at which children acquire words, they must be able to make these mappings in an efficient manner. Finding correct mappings, however, poses special learning problems. Most notably, the world grossly underdetermines the meaning of any particular word. In a famous thought experiment, Quine[5] asks us to imagine that a child sees a rabbit running past and hears the scene labeled with the word *gavagai*. In principle, there are a variety of things that this word can mean, including familiar concepts such as running, rabbit, and dinner, as well as less familiar ones such as rabbit running and undetached rabbit parts. The child must figure out which of these many concepts the word should be linked to.

One strategy children could use is tracking the way the word is used over many different contextual scenes, or what has been called cross-situational

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observation. Over time, the variation in the scenes would eventually allow the child to identify the particular referent for each word. This process is surely part of the solution to Quine's problem, but it cannot be the entire solution for both principled and practical reasons. At the principled level, there are some words that are virtually never differentiated in the world: pairs such as *buy* and *sell* almost always happen at the same time so that whenever one sees a scene of buying, one also sees a scene of selling (see Ref 6 for discussion of this, and additional principled problems with learning through observation). Equally important is the practical problem. Children acquire word meanings extremely rapidly and they simply cannot wait for very many situations to settle on a meaning.

Thus, in addition to cross-situational observation, children must have other means at their disposal for quickly and correctly making referential mappings. Researchers have found evidence to support several other such means that range throughout cognition and language. For example, children are highly sensitive to the social nature of reference—that is, that reference depends on human intentions—and consider social and intentional cues such as eye-gaze and a speaker's purposefulness when learning words (e.g., Ref 7; see Ref 8 for a review). Moreover, there appear to be cognitive biases in what children prefer to consider as possible referents for words. All else being equal, children assume that novel count nouns will refer to whole objects rather than parts of objects, and to category kinds rather than individuals.[9] In addition, children consider the syntactic context in which a word occurs to determine its general class of meaning.[10,11] Further discussion of how children learn that argument structures carry meaning will be taken up in the next section. These various tools are not mutually exclusive, and it is their collective use that allows for children's extremely rapid pace of word acquisition.

Much of the research on word learning has focused on children's acquisition of basic open class vocabulary items (such as nouns and verbs). However, there are subdomains of meaning that pose unique issues for the learning process, such as the subdomain of space. Spatial language has received a great deal of attention because there is a distinctive structural organization to its linguistic expression and possibly to our conceptual representation of it as well.[12,13] However, languages vary in precisely how they map these concepts into language, and the child must determine how her language will organize the structured concepts into linguistic units. For example, the distinction between containment and support

is critical in English (cf. the distinction between the prepositions *in* and *on*), while in Korean the distinction between tightly fitting and loosely fitting is more prominent (cf. the distinction between the verbs *kkita* and *nohta/nehta*). Children acquire the English and Korean spatial language systems with equal speed and facility,[14] suggesting that they are equally open to a variety of ways to map words into concepts, at least within this domain.

One important outstanding issue in the domain of word learning is how children coordinate all the different strategies available to them. How do children know which strategy to deploy in a given situation, and what do children do when the strategies conflict with each other? There is some evidence[15] that children may weight strategies differently at different ages; in particular, children's ability to effectively use syntactic context improves as their syntactic competence improves. It also appears that different situations may encourage children to consider different kinds of information. For example, Gleitman et al.[11] discuss how children's ability to learn the meanings of novel mental state terms appears to be helped both by syntactic information (e.g., the presence of a sentence complement structure) and by situational information (e.g., the presence of a false-belief situation). Nevertheless, given the range of cues that appear to help children learn word meanings, the task of coordinating them all is quite substantial. It is still largely unknown exactly how children do this in the service of their very rapid word learning.

ARGUMENT STRUCTURE

Argument structure refers to the linguistic structure that a word (usually a verb) projects into the syntax by virtue of its meaning. The reason that the word *give* takes three arguments in a sentence is because the meaning of the word directly involves three key participants (the giver, the receiver, and the item given). Moreover, different syntactic positions in a structure carry different semantic implications. For example, the subject of a transitive sentence is likely to be agentive in some way while the subject of a passive sentence is not. The mapping between syntactic positions and semantic roles is by no means transparent, but it is also far from arbitrary (see Ref 16 for discussion).

The systematic links between form and meaning in argument structure have been argued to be critical for the language acquisition process. Pinker[17] argued that children could use their knowledge of verb meanings to help them figure out syntactic representations: knowing about the three participants

of *give*, the child is in a good position to determine how their language syntactically orders and marks agents and recipients. More recently, however, researchers have focused on how children can extract meanings from the argument structures themselves, meanings which can be used to aid in the process of word learning. This inferential process from syntactic form to word meaning has been termed 'syntactic bootstrapping',[6,10] and there is strong empirical support for children's ability to use syntactic information, including the argument structure of a sentence, to help them deduce the meaning of a word by mapping sentences onto events. For example, Naigles[18] showed that by 2 years of age, children acquiring English link a novel word in a transitive (2-argument) sentence frame to a causal action but do not do so for a novel word in an intransitive (1-argument) frame. Children also understand the semantic implications of specific roles at an early age. Gertner et al.[19] found that even before children are 2 years old, they know that the subject of an English sentence should be mapped to an agentive semantic role.

The knowledge that syntactic arguments should parallel semantic arguments appears to be deep and fundamental. Even before infants can speak, they have grasped the underlying conceptual insight of semantic arguments, namely the fact that events have designated key participants. In Gordon,[20] 10-month-old infants noticed when a key participant was removed from a scene (e.g., when a boy gave a girl a toy giraffe, infants noticed if the event proceeded without the giraffe) but failed to notice the removal of a non-key participant (e.g., when a boy gave a girl a hug holding the giraffe, infants did not notice the giraffe's removal). Moreover, children seem to naturally translate their prelinguistic understanding of events into linguistic structures. Studies of deaf children who are forced to create their own languages (called home-sign systems) systematically use syntactic position to signal semantic roles.[21] Obviously, children who are acquiring an existing language will have to learn the specific mappings between the semantic arguments and the syntactic forms, but the data from prelinguistic infants and from children creating home-sign systems suggest that they are primed to do so.

One outstanding issue that has not been resolved in this area concerns cross-linguistic differences. Linguists generally assume that the parallelism between semantics and syntax in terms of number of arguments is universal, falling out from more general linguistic properties (e.g., Chomsky's[22] theta criterion). However, even if this link is a true universal, it is still the case that languages vary widely as to whether it is obligatory to express various arguments. Some languages systematically omit many subjects (so-called null subject languages, including Italian and Mandarin), and some languages allow for frequent omission of direct objects (e.g., Mandarin, Japanese). Children acquiring these languages may therefore find it harder to identify particular syntactic argument structures that can be linked to semantic arguments. Other links between argument structure and semantic information are certainly not cross-linguistically universal. For example, there are at least two prominent systems for linking syntactic positions to semantic roles across the world's language. In the nominative–accusative system (used in English, among other languages), the subjects of both transitive and intransitive sentences are marked in a similar way and are contrasted with the objects of transitive sentences. In the ergative–absolutive system (used in Hindi, among other languages), the subjects of intransitive sentences and the *objects* of transitive sentences are marked in a similar way, and both contrast with the *subjects* of transitive verbs. It is simply not known whether one of these two systems is more natural for children, or what kinds of evidence are necessary for children to settle on one or the other system. It is interesting to note, however, that children creating the home-sign systems[21] overwhelmingly opt to create semantic links more in line with an ergative system.

An additional outstanding issue in this domain concerns the gap between children's apparent knowledge as measured by comprehension studies and by production studies. In comprehension studies, such as those of Naigles[18] and Gertner et al.,[19] children seem to demonstrate a robust and general understanding of argument structure; they are even able to extend their semantic knowledge of different structures to help them interpret novel verbs describing novel events. However, studies that focus on children's production of novel verbs in different syntactic structures often find that children are far less flexible. Tomasello[23,24] reviews a variety of studies showing that young children tend to be quite conservative in their use of novel verbs, and often do not extend them to different argument structure contexts even when they are semantically licensed to do so. It is unclear precisely what causes this gap in ability between the domains of comprehension and production, and which domain represents the best measure of children's true semantic understanding. It is even possible that this gap is actually an illusion, reflecting only the differences in methodology used in testing comprehension and production. It should be noted, however, that this general phenomenon, in which children demonstrate greater flexibility and stronger knowledge in comprehension

over production, is not unique to argument structure (see next section) or even language acquisition itself.

TENSE AND ASPECT

Tense and aspect are abstract temporal elements that indicate when an event happened and how it unfolds through time. Tense locates an event in time (past, present or future) and aspect signals the speaker's perspective on the event: is it being viewed as a completed whole (perfective) or as open and ongoing (imperfective)? One part of the child's acquisition problem in this domain is simply that the meanings involved are quite abstract. Children find it much easier in general to consider the here-and-now from their own perspective and so the essential semantics involved in tense and aspect are comparatively difficult for young children.

Cross-linguistically, all languages mark at least one of these temporal elements grammatically, but there is wide variation in their precise expression[25,26]; some languages mark only aspect (Mandarin) and others only mark tense (Modern Hebrew); sometimes languages separate tense and aspect into distinct morphemes (as in the English progressive construction which marks tense in the auxiliary verb and imperfective aspect in the—*ing* morpheme) while at other times they are conflated within morphemes (as in the French *imparfait* form, which combines past tense and imperfective aspect in a single verb form). A critical part of the acquisition problem for the child, therefore, is simply determining which morphemes are marking which dimensions of meaning in this domain.

An additional difficulty for the acquisition process is the fact that the meanings of tense and aspect are related and align into two natural classes. The first class consists of present tense and imperfective aspect; the present moment is necessarily an open and incomplete one and so is naturally described with both present tense and imperfective aspect. The second class consists of past tense and perfective aspect; the identification of completion can only be done if the completed moment is past and so a description in perfective aspect will likely also require past tense. These two classes also link to the lexical property of boundedness (also sometimes called lexical aspect or telicity). Predicates that describe bounded events (e.g., creation events such as *build a house*) class naturally with past tense and perfective aspect because the event boundary helps define the completion point for perfective aspect. Predicates that describe unbounded events (e.g., activities and motion manners such as *run, jump, slide*) class with present tense and imperfective aspect as their unbounded nature

is naturally aligned with the open perspective of the imperfective (see Ref 27,28 for discussion).

In their early production, children's use of tense and aspect morphology appears to be strongly guided by these two natural classes and leads to a widespread underextension in their use of temporal morphology. Early on, children tend to use past tense and perfective morphology only with bounded predicates (e.g., in English, they say *made* and *broke* but not *rode* or *played*) and present tense and imperfective morphology only with unbounded predicates (e.g., they say *riding* and *playing* but not *making* or *breaking*). This pattern of underextension is widespread across languages, and has been documented in the utterances of children acquiring languages including English, French, Italian, Polish, Hebrew, Mandarin, and Japanese, among others.[29–36]

However, as seen in other domains, children show more sophisticated knowledge when their comprehension is tested as opposed to their production abilities. Comprehension studies demonstrate that children have a more flexible and general ability to understand a variety of temporal forms. First, there is ample evidence that children do in fact understand various temporal meanings and at least some of their modes of expression. In perhaps the most straightforward demonstration, Valian[37] showed that even 2-year-old children can distinguish past from present when it is expressed in a copula verb; that is, they can choose between the bear that *was* on the chair and the one that *is* on the chair. Children also distinguish the future tense from both past and present tenses by age 3 years.[38,39] In terms of aspectual information, children reliably distinguish perfective and imperfective aspect sometime between the ages of 3 and 4; that is, they can choose between the girl who *was drawing a flower* and the girl who *drew a flower*.[27,38] Of particular interest is how well children comprehend combinations that do not fall within the natural classes of temporal forms they prefer to produce. Several investigators[27,37–40] have examined children's understanding of past imperfective morphology (e.g., *was doing*) which incorporates elements from both classes. Overall, results suggest that children can understand these forms by the age of 4, although they are somewhat more difficult for children to understand than forms that lie within the natural classes.

Currently, the most prominent explanations of the persistent influence of these natural temporal classes appeal to computational considerations, either in the representations of the temporal elements themselves[28] or in our ability to arrive at truthful interpretations of them.[27] Aligning temporal information within a natural class appears to ease the

computational burden; thus children are preferentially producing the easier forms. Given the complexity involved in this domain in terms of finding the right meanings and mapping them to the right forms, it is perhaps not surprising that the mechanisms that do this work would interact with the acquisition process. Children's computational abilities appear to be particularly vulnerable to these complexities, but adults also show similar (though weaker) preferences for the same easier forms in their production,[30] in their comprehension and processing[27] and in second language acquisition.[41]

A key outstanding issue in this domain concerns cross-linguistic comparisons. Studies of children's acquisition of tense and aspect do have a long tradition of incorporating cross-linguistic data. As noted above, the production patterns have been documented in many languages, and seminal comprehension work[38,40] has compared children acquiring Polish, Finnish, and English. However, the existing data suggests that children's acquisition is influenced by the particular form of expression (e.g., copula verbs vs. verb endings) as well as the particular combination of semantic meanings within each form (e.g., children acquire the French imparfait form comparatively late, cf. Ref 31). Because there is cross-linguistic variation in precisely how temporal concepts are mapped into linguistic forms, investigations of multiple languages are critical for understanding exactly the computational considerations that influence acquisition in this domain.

QUANTIFICATION AND SCOPE

Quantifiers and their scope interpretations pose several difficulties for the language learner. The first problem is simply one of abstraction: the meanings of quantifiers such as *every* and *some* or even numerical quantifiers such as *four* refer only to quantities (or relations among quantities); they are not tied to concrete referents and can be applied to any noun, with only a few constraints. In addition, their meanings are highly contextually defined. Even a single phrase like *every girl* will pick out a different set of girls and a different number of girls depending on whether the context of discourse is the people in my class or the people in my family. Quantifier interpretation requires the child to keep track of more than just the local context (the noun modified by the quantifier) but also the larger context of the sentence and sometimes even the global discourse context. Moreover, the meanings of the quantifiers overlap and in many cases are only distinguished pragmatically. For example, *some* picks out a subset of *every*, so that

any time that the phrase *every girl* is true, the phrase *some girl* is also true; similarly, *two* is a subset of *three* so that any time that someone knows three languages, it is also true that they know two languages. It is pragmatically inappropriate[42] to use the weaker terms (*some*, *two*) when the stronger terms are true, but it is not strictly speaking semantically false. Children must therefore learn not only the meanings of quantifiers but also their pragmatic implications.

A final, and perhaps more difficult problem posed by quantifiers is the fact that their interpretation also depends on the scope they take in a sentence. Scope itself is often ambiguous and does not depend on the linear order of elements in a sentence. For example, a sentence such as *Every student knows three languages* has two interpretations depending on the scope of the phrase *three languages*. If the phrase is interpreted with narrow scope (corresponding to its actual position in the sentence), the sentence means that every student knows three languages, but not necessarily the same ones (e.g., Billy knows languages A, B, and C while Suzy knows languages D, E, F, and so on). However, the sentence can also be interpreted so that *three languages* has wide scope in which case the sentence means that there are three particular languages (A, B, and C) and every student knows them. Knowledge of scope requires children to understand and interpret semantic relations that go well beyond the physical form of the sentence.

Research on children's interpretation of quantifiers has suggested that they possess a range of biases for how to interpret them. One of these biases concerns scope directly: children prefer a surface structure interpretation of scope[43] such that the first quantifier in the sentence gets wide scope and quantifiers later in the sentence get narrow scope. For example, 4-year-old children preferentially interpret a sentence such as *Every horse didn't jump* to mean that for all the horses in the game, none of them jumped, where the first quantifier in the sentence (*every*) has wide scope and the negation (*didn't*) takes narrow scope. Adults get this interpretation as well, but they also find it easy to interpret the sentence so the first quantifier has narrow scope and negation gets wide scope: not all the horses jumped, but a few of them did. Another bias that has been found in children's quantifier interpretations is a general desire to spread their meaning throughout the sentence.[44–46] For example, 4-year-olds preferentially interpret the sentence *Every boy is riding a donkey* as if the quantifier *every* should be applied to all the nouns. Thus, they will correctly claim that the sentence is false if there is a boy who is not

riding a donkey, but will also incorrectly say the sentence is false if there is a donkey that no boy is riding. This interpretation has been called 'symmetric' because the children require both nouns in the sentence to have an equivalent relationship to the quantifier. Note that this interpretation is quite different from the adult semantic interpretation.

The precise cause of these biases is still very much in dispute, but they appear to depend, at least in part, on children's difficulty in integrating contextual information in their interpretation. Experiments in which particular contexts are specially highlighted can help children get what are otherwise dispreferred interpretations. For example, Crain et al.[46] were able to break children of their preferred symmetric reading for sentences like *Every boy is riding a donkey* by telling a story which emphasized the choice of each boy (some boys seriously considered riding animals other than donkeys). Such a result suggests that by age 4 years children may in fact have the semantic meanings of quantifiers in place, but continue to have difficulties in knowing just how to apply those meanings in different situations.

Investigations of children's understanding of the pragmatic implications of quantifiers similarly suggest that children's real difficulties lie in contextually appropriate uses of quantifiers. For example, when children are asked to distinguish *some* from *all*, they primarily have difficulty in knowing that *some* is appropriately restricted to situations where *all* cannot apply.[47] However, as with the other biases, experimenters can improve children's performance by specially emphasizing the relevant context. In this case, it helps if the target sentences are evaluating someone's performance. In that context, children correctly restrict a sentence like *She fixed some of the chairs* to situations where not all the chairs were fixed.

Despite the fact that researchers seem to be able to intuit contexts that help children generate dispreferred interpretations of quantifiers, perhaps the largest outstanding question in this area is precisely how children make use of contextual information. How can we *a priori* identify the situations that will help children get their dispreferred interpretations? To put the issue a different way, what is driving children's preferred interpretations in the absence of special contexts? Because the meaning of quantifiers are inextricably linked to pragmatic and contextual factors, it will be critical for researchers to articulate how children's knowledge of these factors develops alongside their knowledge of quantification.

CONCLUSION

The structure of semantics is as complex and as broad as the range of concepts we can think about. The acquisition of any particular area of semantics depends on the specific nature of the meaning involved as well as the way that meaning is mapped into linguistic forms. In some areas, such as word learning, children's primary challenge seems to be identifying the specific concepts being targeted from among all the possible meanings available. In other areas, such as argument structure, children appear to have a good idea of what the possible meanings could be and need to learn how those are properly mapped into various structures. In the areas of tense and aspect and quantification, children's semantic knowledge is closely linked to other parts of cognition, including their computational abilities and their ability to assess the larger situational context. The acquisition of semantics, therefore, is not a unified act but requires children (as well as the researchers who study them) to draw on a varied range of concepts, strategies, and abilities to be successful.

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