older infants assign more weight to stress: a pattern that reflects a move from reliance on universal cues (transitional probabilities are a cue to word boundary across languages) to language-specific ones (stress patterns differ between languages). Other studies focus on the kinds of distributional relations children can (and cannot) attend to. Language has dependencies that hold between nonadjacent words, like the dependency between auxiliaries and inflectional morphemes *(is running)*. Rebecca Gomez's work shows that children are able to learn such relations in an artificial language but only when there are many different intervening elements (like the many different verbs appearing between the auxiliary and the *–ing* morpheme). The combined experimental and computational findings show that many aspects of language structure have distributional correlates and that these distributional patterns are attended to by human learners.

In the past, the main question was whether infants track distributional information at all. Now that infants' ability to do so has been well documented, the focus is on how this information is used in actual language learning. How do infants integrate the different cues they attend to? Experimental studies often present infants with only one distributional cue, but real-life learning involves multiple cues, some of which may point to different generalizations. Behavioral studies and computational simulations are used to ask how infants detect, weigh, and integrate different sources of distributional information. Much of our knowledge about the use of distributional information comes from artificial language learning studies. Yet, it is not clear how well that maps onto real language learning and use. Examining correlations between performance on artificial language learning tasks and language processing is one way to address this question. Another open question is the degree to which the use of distributional information differs in humans and nonhumans. By comparing distributional learning in humans and nonhumans, researchers hope to uncover the unique aspects of human language learning. Additional research asks how inductive biases affect what is learned from distributional information: What makes humans prefer certain generalizations over others, and how is this is related to the way languages have evolved over time?

Conclusion

To conclude, numerous studies have documented the role of distributional information in language learning. The challenge for future research is to spell out the mechanisms that allow children to reach the correct generalizations while integrating and attending to the multiple cues found in real-life learning.

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See Also: Auditory Sequence/Artificial Grammar Learning; Computational Models of Language Development; Frequency Effects in Language Development; Grammatical Categories; Induction in Language Learning; Metrical Segmentation; Multiple Cues in Language Acquisition; Statistical Learning; Word Segmentation.

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Domain Specificity

Domain specificity in cognitive science refers to the specificity of the substrates of a particular cognitive domain, such as language. That is, if language is domain specific, at least certain of its underpinnings in the mind or brain are dedicated to language (or aspects of language) and subserve nothing else. In contrast, if language is not domain specific, this means that its substrates underlie not just language but other domains as well. This is usually referred to as domain generality or domain independence. More generally, the question as to whether or in what ways language (or other aspects of cognition) might or might not be domain specific is referred to as the issue of domain specificity. It is difficult to demonstrate domain specificity, and at this point, there is no strong evidence that language depends on domain-specific substrates; indeed, evidence suggests that aspects of language depend at least in part on domain-general systems in the mind and brain.

What Domain Specificity Is Not

Historically, the claim of domain specificity has been associated with an assumption of innate specification. In this view, language depends on substrates that are not only specific to language but also have genetic bases that evolved for this particular domain. Thus, the questions of domain specificity and innateness have been closely bound. However, this is not a necessary linkage, and substrates may be specific to language without being innately specified. For example, such domain specificity could emerge from domain-general substrates during learning and development.

Domain specificity should also be distinguished from three other notions: separability, species specificity, and specialization. If language shows separability, different aspects of language depend on different substrates. For example, if grammar and lexicon are separable, they rely (at least in part) on distinct underpinnings. Although the issues are often confounded, separability does not imply domain specificity. Indeed, grammatical and lexical abilities appear to depend at least partly on different neurocognitive systems, though neither of these systems seems to be dedicated to language.

Similarly, species specificity does not entail domain specificity. If language or some aspect of language such as grammar is specific to humans, its substrates could still subserve functions other than language, including other functions that might be largely specific to our species. Indeed, this is the position taken by Marc Hauser, Noam Chomsky, and Tecumseh Fitch, who have argued that recursion in language is specific to humans but that its underpinnings also subserve recursion in other domains (e.g., social relationships or navigation), and indeed they may have evolved for such nonlanguage purposes in humans. Conversely, if an aspect of language turns out not to be unique to humans, as indeed has been argued for recursion (e.g., claims have been made for nonlanguage, grammar-like recursion in starlings), this would not disprove either the innateness or the domain specificity of this capacity in humans. For example, other species may solve the problem, or appear to do so, in a manner that is computationally different and relies on distinct (and possibly domain-general) substrates from humans.

Even specialization and domain specificity are at least partly independent. A computational or biological substrate of language could become specialized for this domain (either phylogenetically or ontogenetically; i.e., through either evolution or development) and then be co-opted for other functions (much like the opposite has been claimed for recursion), as described above. Indeed, claims along these lines have been made for music.

What Domain Specificity Could Be

So now that this entry has discussed what domain specificity is not, can we say more about what it might be? First, as mentioned above, this entry emphasizes that domain specificity could in principle apply not just to language as a whole but instead perhaps only to certain aspects of this capacity. Indeed, where domain specificity for language is invoked, it is generally claimed in a circumscribed manner that is limited to particular language subdomains, such as syntax or aspects of syntax.

Second, domain specificity could exist at multiple levels. Most work on the domain specificity of language has focused on its cognitive or neuroanatomical bases. For example, in *Modularity of Mind*, Jerry Fodor made claims about domain specificity largely in terms of cognitive modules, independent of any specific underlying neurobiology. Similarly, Heather van der Lely has argued that some children with the developmental disorder of specific language impairment (SLI) have deficits only in aspects of grammar without making claims about neural particulars. Yosef Grodzinsky has suggested that Broca's area, or a portion of it, may be dedicated to aspects of syntax. And along the same lines, Evelina Federenko and colleagues have presented evidence that the cortex in this region may only or primarily underlie aspects of language.

However, this focus on the cognitive and anatomical bases of language ignores many other substrate levels. In principle, language or its parts could depend on domain-specific brain networks (of various sizes), oscillatory patterns, cell types, genes, and so on. These levels are largely ignored in research on domain specificity (indeed, language research more generally is only beginning to pay attention to some of these). Domain specificity could also be restricted to interactions between substrates. For example, even if no cell type or region (defined cytoarchitectonically or otherwise) is dedicated to language, it may be that, within a particular region, a certain cell type underlies only language.

Third, domain specificity may change over the course of development. For example, syntax may depend on dedicated circuitry during certain periods of the life span but not during others. Indeed, it appears, according to Michael Ullman, as though aspects of syntax are performed by different neurocognitive systems at earlier and later periods of learning and proficiency, both in a first (native) language and in later-learned second languages, with any domain specificity perhaps more likely in the system relied on in later stages (see below).

Fourth, the domain specificity of language may vary across individuals. Analogously to changes in its neurocognitive substrates during development, Ullman suggests that aspects of grammar may depend on different substrates in different individuals and groups. This variability seems to be found both in healthy populations (e.g., males versus females) and in disorders. For example, individuals with SLI or agrammatic aphasia appear to rely heavily on the same system (declarative memory; see below), by way of compensation, that normal learners rely on in early stages of development.

Complications in the Study of Domain Specificity

All of these issues complicate the study of domain specificity. Even worse, the demonstration of domain specificity may be methodologically intractable. To show that a particular substrate is dedicated to language, one must demonstrate (e.g., via double dissociations) not only that it underlies language but also that it does not subserve any other domain. Given the large number of potential domains that a given substrate could subserve (and moreover that constructs of domains often change over time; e.g., short-term or working memory), and the infinite number of ways a domain could be probed, it is extremely difficult to convincingly demonstrate—and impossible in principle—that a particular substrate only subserves language.

Note that it is also difficult to demonstrate domain generality, although for different reasons. A lack of dissociations between language and any given nonlanguage domain (e.g., in aphasia or in a functional magnetic resonance imaging [fMRI] study) does not necessarily imply that the two are subserved by a single substrate. Such a finding could be due to various factors, including insufficient power or insufficient specificity; for example, fMRI activation in Broca's region, or even in posterior pars opercularis, in language as well as nonlanguage tasks, does not preclude smaller neural networks or cell assemblies that differentially subserve these tasks. Likewise, demonstrating domain generality at one level (e.g., anatomically) does not obviate the possibility of domain specificity at another (e.g., genetic).

What Does the Evidence Suggest?

So what does the evidence actually suggest? Overall, and perhaps not surprisingly given the complex nature of the issue and the difficulty in demonstrating either domain specificity or domain generality, the findings do not suggest a simple answer. For example, as mentioned above, one line of evidence comes from van der Lely, who has argued that some children with SLI have deficits only of grammar, perhaps specifically of syntax, morphology, or phonology, and that this suggests the domain specificity of these subdomains. However, these children have not been systematically assessed on a wide range of nonlinguistic tasks—indeed, not even on some tasks that would test particular domain-general hypotheses (e.g., that the grammatical deficits in SLI derive at least in part from procedural learning deficits), as has been suggested by Ullman. Thus, evidence from SLI at this point in time does not demonstrate domain specificity in language. Similarly, although Federenko and colleagues tested a number of other domains apart from language, this list was by no means exhaustive.

In contrast to the lack of clear evidence for domain specificity, some evidence suggests that at least certain aspects of language depend on particular domain-general neurocognitive systems, which moreover are also found in other species and indeed are well studied in rodents. In particular, converging evidence from a range of behavioral, neurological, electrophysiological, and neuroimaging approaches published by Ullman and colleagues seems to suggest the following, according to Ullman. Idiosyncratic aspects of language (such as the simple word *cat* and irregular morphological forms such as *dug*)—that is, what must be stored in the lexicon—are learned in the declarative memory brain system. This system—rooted in the hippocampus and other medial temporal lobe structures—is known to underlie the learning of a wide range of information across domains and modalities. In contrast, grammatical aspects of language, and possibly rule-governed combinations in particular (e.g., *walk* + *-ed* and *the + cat*), are learned to a great extent in the procedural memory system. This system, which is rooted in frontal and basal-ganglia circuits, underlies the acquisition of motor and cognitive skills and habits, such as riding a bicycle or typing. However, as aspects of rule-governed grammatical functions can also be learned in declarative memory—for example, complex forms can be stored as chunks (*walked* and *the cat*), one can learn rules explicitly in this system as well. Thus, both domain-general memory systems appear to play important roles in language, though somewhat differently across different linguistic subdomains.

Of particular interest to development and language learning, these two memory systems appear to play somewhat different roles over the course of acquisition. This is especially well studied by Ullman in second language learning. Although lexical knowledge always appears to be learned in declarative memory, grammar relies more on this memory system at lower second-language exposure and proficiency but increasingly depends on the more automatic procedural memory system at higher exposure and proficiency. Similarly, in first language acquisition, children may depend initially for aspects of grammar on declarative memory and only later rely on procedural memory, which underlies grammar in most adults.

Importantly, it is possible that portions of one or both of these domain-general systems may show further specialization and even domain specificity for language—whether due to phylogenetic or ontogenetic processes. For example, the frontal and basal-ganglia circuits underlying procedural memory are known to show functional segregation, leaving open the possibility that (sub)circuits might be dedicated to aspects of grammar. Thus, the dependence of language on domain-general systems in no way precludes domain specificity within these systems (let alone in addition to them). Note that, as the relative dependence of grammar on each of the two memory systems seems to change over the course of language development, the domain specificity of grammar may also change, in particular to more domain-specific substrates (e.g., functionally segregated frontal and basal-ganglia circuits) underlying procedural memory.

Conclusion

In conclusion, the domain specificity of language, and any changes in domain specificity over the course of its development, is an issue whose complexities are often underappreciated and is difficult to test. Not surprisingly, the evidence thus far does not lead to clear conclusions. On the one hand, no clear evidence for domain specificity seems to exist. In contrast, converging evidence suggests that, at least to some extent, language depends on general-purpose neurocognitive systems, though this does not preclude additional domain specificity.

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See Also: Chunk-Based Language Acquisition; Executive Functions and Language Development/Processing; Genetic Basis of Language Development and Impairment; Grammatical Development in Children With Language Impairments; Interrelationship of Language and Cognitive Development (Overview); Neural Basis of Language Development; Processing Deficits in Children With Language Impairments; Specific Language Impairment (Overview).

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