

Language and Cognition

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Cognitive scientists have long debated whether language and cognition are separate mental faculties, or whether language emerges from general cognitive abilities.

INTRODUCTION

0559.001 What is the relationship between language and cognition? Do people who speak different languages think differently? Is a certain level of cognitive development required for language acquisition? These questions were of keen interest to thinkers in the early twentieth century and remain important in anthropology, linguistics and psychology. However, the cognitive revolution of the 1950s brought a new question about the relationship between language and cognition: is language the same type of mental entity as other cognitive abilities, or is it fundamentally different?

0559.002 A hallmark of modern cognitive science is the goal of developing a theory of cognition powerful enough to encompass all human mental abilities, including language abilities. A long-standing controversy concerns two ways of conceptualizing the architecture (or basic design) of cognition. One approach proposes that general-purpose processes and mechanisms provide a foundation for all varieties of human intelligence. We can refer to this as 'general purpose' cognition. Examples of possible universal processes are the ability to induce a category from exposure to examples (category induction), and the ability to mentally complete a known pattern when confronted with a piece of it (pattern completion). Cognitive scientists frequently attempt to precisely specify their proposed mechanisms by implementing them as computer algorithms which can be tested in artificial intelligence (AI) programs. Researchers have tried to use AI programs to show that the same principles that can explain general problem-solving can also explain aspects of language acquisition and processing.

0559.003 The second way of conceptualizing human cognition emphasizes the differences between language and other abilities. A key idea is that many distinct domains of cognition exist and must be learned separately, using different mental mechanisms. This approach is referred to as the 'modularity of cognition' or 'mental modules' approach. At first glance it may seem contrary to the interdisciplinary spirit of cognitive science and to the possibility of a unified theory of cognition. However, the unifying theory is the thesis of distinct mental modules, which are believed to have evolved to accomplish specific tasks relevant to mammalian evolution, such as visual exploration, or relevant to human evolution, such as language use. Much of the appeal of this approach comes from findings in neuropsychology showing that distinct areas of the brain serve distinct functions such as vision, language processing, motor coordination, memory, and face recognition. The interdisciplinary spirit is maintained because advocates of this approach reach out to biological scientists and evolutionary theorists. Those favoring modularity embrace the principle of converging methodologies: a theory must have explanatory power in the distinct academic disciplines that compose the cognitive sciences. These two approaches to the architecture of cognition developed out of different philosophical traditions, and have evolved considerably during the half-century history of cognitive science.

CONCEPTS OF COGNITION AND LANGUAGE

0559.004 Why are there two different views on the relationship between language and cognition? At the dawn of the cognitive revolution, in the late 1950s, there were two distinct ideas about the nature of mind. Discussed first are the views of linguist Noam Chomsky and the field of generative linguistics

which he developed, because the underlying philosophy has remained fairly constant over the intervening years.

0559.005 Chomsky's major innovation was to conceive of language abilities as akin to a mental organ. According to this view, children are born with a 'language acquisition device' and with specific linguistic knowledge. This knowledge is thought to include the concepts of noun, verb, grammatical subject, and structures that constrain possible grammatical rules. In contrast to the views of the dominant psychological theory of the 1950s, behaviorism, Chomsky argued that children do not learn to speak by imitating adults. His key evidence was that children spontaneously use incorrect forms they could not have heard, like 'goed' and 'breaeked'. Linguistic overregularizations like these suggest that children are extracting rules from the language they hear, not merely imitating. Theorists at that time found it noteworthy that parents do not generally tell children that their utterances are ungrammatical. Because the language input to children is full of mistakes, stops and restarts, Chomsky felt that children could not learn language using general purpose problem-solving or regularity-extraction skills. They needed to come to the task with a rich set of expectations about the nature of language. These expectations were believed to be specific to language, and thus did not share commonalities with other aspects of cognition. This set of language-specific abilities has been variously called the 'language acquisition device' (the historically early term) and 'universal grammar' (a more recent term). Chomsky's approach to linguistics is called 'generative linguistics' because its early goal was to describe mental structures that can generate all the grammatically valid sentences of a language.

0559.006 Chomsky felt that the aspect of language that is unique is syntactic ability. An example of specifically syntactic knowledge is illustrated by the sentence, 'Colorless green ideas sleep furiously'. Although the words in this sentence contradict each other and do not correspond to a possible reality (green is not colorless, ideas cannot sleep furiously), speakers nevertheless recognize the sentence as having a correct grammatical structure. Chomsky used this sentence as an example of how syntactic structure represents information independently from the meaning of the words in the sentence. He argued that syntax is a unique, independent human capacity and not derivative from other abilities. The proposal that syntax is not influenced by the meaning of the words in the sentence

or speakers' communicative goals came to be called the 'autonomy of syntax' hypothesis.

0559.007 Chomsky's innovations developed in tandem with the dawn of the cognitive revolution. With the birth of computer science a new way of conceptualizing human cognition arose, using the metaphor of the brain as a computer and the mind as software. Much of Chomsky's early work depended on this metaphor: he conceived of grammar as a set of rules for generating novel combinations of words, just as a computer program could generate a string of symbols according to a formula. Thinking of mental operations as akin to steps in a computer program allowed psychologists and workers in the new field of artificial intelligence to begin to subdivide mental tasks, such as arithmetic or language comprehension, into a series of steps in a computer program. Their research evolved in a different direction from Chomsky's. Computer scientists and psychologists such as Alan Newell, John Anderson, Roger Schank and Patrick Winston began to describe a range of human abilities – from visual object recognition and general problem solving, to metaphor use and story understanding – in terms of a set of internal representations and processes that transform those representations. A key aspect of this approach to cognition was that the theorist could write computer programs that would provide a formalizable theory of mental operations. A rigorous test of the theory could be performed by running the program and seeing if output matched human output.

0559.008 Many of the early successes of this field involved language, including sentence comprehension, story understanding and metaphor use. An important aspect of the language and cognition relationship is that the AI models of language did not draw on language-special algorithms or knowledge structures. The new AI tradition and the information processing movement within psychology emphasized learning, particularly general-purpose learning, and was thus opposed to the emphasis on innate knowledge structures that was part of Chomsky's new linguistics. Psychologists drawn to the information processing movement were frequently inspired by the work of Swiss psychologist Jean Piaget, whose works began to be translated into English in the 1960s. Piaget also emphasized the commonalities between language and cognition, and proposed that language emerged out of the same broad cognitive changes that transform the sensorimotor processing of infants into the formal and logical mind of adults.

In the 1970s and 1980s, among those researchers who aligned themselves with the interdisciplinary

field of cognitive science, there was a tendency for linguists to emphasize the specialness of language and cognition, and for psychologists to emphasize commonalities between language and cognition. However, there was considerable variation in viewpoint within psychology and linguistics, which continues to this day. Three scientific developments during the 1980s and the 1990s had implications for theories of the language–cognition relationship: connectionism, cognitive linguistics, and the cognitive neuroscience movement. The development of these movements is summarized in Table 1.

CONNECTIONISM

0559.010 The ‘connectionist revolution’ was launched in the mid 1980s. A new computational metaphor emerged to explain both language and cognition, based not on the Von Neuman computer, but on the idea that sophisticated computations emerge from massive networks of simple processing units, in which the units are akin to idealized neurons.

0559.011 In the early 1980s several groups of cognitive scientists became dissatisfied with the AI systems being used to model cognition. These rule-governed systems employed databases containing knowledge of common situations, such as what one does at a restaurant; ‘if–then’ rules specified the action that an expert would take in a specific situation. This expert knowledge thus constituted intelligent reasoning. Critics noted that these expert systems were brittle and frequently failed to generalize beyond the bounds of their circumscribed database. Real human cognition seemed intuitively to involve not the application of fixed rules to a specific situation, but the satisfaction of many soft constraints, some of which could be ignored. Categories were not logical sets of necessary and sufficient conditions, but were graded groupings which shared ‘family resemblance’, as had been argued earlier in the century by Wittgenstein. To the mathematical and cognitive psychologist David Rumelhart, flexible and creative reasoning seemed to be similar to the motor process involved in reaching for a cup behind a pencil-holder on one’s desk – or at least, more similar to this type of planning than to rule-governed algebraic reasoning.

0559.012 Rumelhart and other cognitive scientists such as Terrence Sejnowski and Stephen Grossberg agreed that mental functioning involves computation, but asked what type of computation would be carried out by an organic structure like the brain, composed of massive numbers of simple processing

units (neurons), linked together in a complex network of fiber tracts, with many units firing simultaneously. This movement was labeled ‘connectionism’ because intelligent behavior was posited to emerge from large numbers of neuron-like processing units, connected together into networks in ways that fostered parallel processing. One early success story was a connectionist model that could learn English past tense forms given the present tense of a verb. The domain of English past tense was provocative because it contained both rule-like behavior (past tense forms are generated by adding ‘-ed’ to a present tense form), and exceptions which themselves congregated into patterns, such as that emerging from considering ‘grow/grew’, ‘blow/blew’, ‘know/knew’. Both connectionist networks and adult second-language learners are likely to make the error of generating ‘glew’ for the past tense of ‘glow’, presumably through analogy with this subregularity within the past tense system. Other connection language models explored how ambiguous words are understood in their sentence context (such as ‘bat’ in ‘The boy hit the bat’), and how abstract categories such as noun and verb can emerge from distributional regularities in text (such as the fact that nouns tend to occur in similar sentence positions). Because the basic system of processing units under these connectionist language models was the same as those used to model visual and motor behavior, successes like the past tense model were taken as support for a common computational architecture underlying both language and cognition.

COGNITIVE LINGUISTICS

0559.013 A subset of linguists disagreed with Chomsky’s emphasis on the uniqueness and specialness of language, then generally accepted. The field of cognitive linguistics emerged in the late 1980s and helped initiate a flood of work connecting language and cognition. One source for the cognitive linguistics movement was an older tradition within linguistics called ‘functionalist’ linguistics. This held that constraints on the form of language (where ‘form’ means the range of allowable grammatical rules) derive from the function of language. The goals of using language include serving efficient communication. Thus the function of diverse syntactic forms, such as subject versus object and main clause versus subordinate clause distinctions, serve communicatory goals such as conveying which information is most important and which is background or context. However, the goals of

conveying the relevance and background/foreground structure of the message are outside the language system. The proposal that the form of grammatical rules is influenced by communication is thus inconsistent with the autonomy of syntax hypothesis. That hypothesis specified that syntax was its own system, not shaped by the need for efficient processing or other exigencies of communication.

0559.014 Functionalists linguists as well as other linguists were dissatisfied with the range of linguistic phenomena excluded by generative linguistics. They rejected the Chomskyan view that the most important aspect of language was a mechanical device for generating only legitimate grammatical sentences. They wanted to understand language in all its diversity, including narrative, discourse, dialects, sociocultural influences on language use, and metaphor. Some functionalist linguists even proposed that rule use is just a minor aspect of language. Linguists such as Dwight Bolinger and Charles Fillmore argued that speech utterances, not rules for generating utterances, are what is mentally stored. They noted that every language speaker has memorized huge numbers of odd coinages, colloquialisms, idioms and collocations, many of which share patterns. An example is the phrase 'know by heart' which has the variation 'learn by heart'. Rules, partial regularities and rule exceptions appear to differ in degree, occupying a continuum from fully idiosyncratic, to partially regular, to fully rule-governed. This idea made researchers in this nascent linguistic movement sympathetic to the connectionist movement, although the commonalities have not yet been fully explored.

0559.015 Although trained in the generative grammar tradition, linguists such as George Lakoff and Ronald Langacker noted that one could not describe which sentences are syntactically valid and which are invalid without reference to nonlinguistic concepts. They pointed to the tendency for the same words describing movement in space to be used to describe movement in time ('This meeting runs until 3 o'clock'), and emphasized the necessity of incorporating the cognitive psychology of human category formation into linguistics. This approach to linguistics came to be called 'cognitive' linguistics because aspects of general cognition – such as how we construe the meaning of a grammatical construction – were proposed to be important for describing linguistic structure. For example, one descriptive problem of grammar is to account for why some sentences, but not others, can undergo the 'passivization' transformation. The sentence 'John was hit by Mary' sounds fine, but 'John was

known by Mary' does not. To fully describe which transitive sentences can undergo passivization, one needs to invoke the notion that the subject and direct object are in dynamic interaction with each other. Thus, one cannot passivize a sentence like 'John left the auditorium' because John is not acting on the auditorium in a way that has consequences for it; but the sentence 'John left the auditorium unguarded' can be transformed into 'The auditorium was left unguarded by John', presumably because John's action affects the status of the auditorium.

By 2000 the cognitive linguistics movement had grown into an enduring subfield, but it has remained outside the mainstream of linguistics. While some cognitive linguists have remained focused on specific linguistic questions, others have addressed questions in an interdisciplinary manner, drawing on experimental psychology, brain science, and category induction performed by artificial neural networks.

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THE COGNITIVE NEUROSCIENCE MOVEMENT

The field of cognitive neuroscience emerged from work in neuroscience and cognitive science. Cognitive neuroscience differs from basic neuroscience by having the goal of explaining complex cognitive abilities, but rejects the tradition of artificial intelligence (and much of cognitive science) that one can understand cognition abstractly, without reference to its neural underpinnings.

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In the 1990s some cognitive neuroscientists argued that basic aspects of the language–cognition relationship, such as the autonomy of syntax hypothesis and the innateness and modularity of language, could be evaluated from the neuroscientific point of view. Neurobiologists have noted that developing neural tissue is very plastic. For example, the auditory association areas of the brains frequently represent visual and gestural language in individuals who are born deaf. The regions of the brain that mediate language use appear to be especially malleable. Like other aspects of cognition, language acquisition is heavily dependent on experience.

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R-A Mueller has remarked that regional specialization in the brain is beyond doubt, but modularity of cognitive functions, including language, is highly debatable from the view of neurobiology and evolution. Functional specialization of brain areas most probably emerges because some brain areas are near to the site of sensory input, such as

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sensory systems for vision and audition. Scientists such as Jeffrey Elman, Elizabeth Bates and their colleagues note that however closely one looks at the anatomy and physiology of the brain, there is no evidence of cortical structures unique to language or unique to humans. These researchers argue that language has an 'epigenetic' not a 'genetic' origin. Epigenetic development is the proposal that behavior results from a complex dynamic evolution of genes and environmental forces during prenatal and postnatal development. The concept of epigenesis dates back to psychologist Jean Piaget, who argued that cognitive abilities emerge from a biological structure which evolves, both before and after birth, in tandem with environmental forces. Contemporary researchers who embrace the epigenetic view point out that there are too few genes in the human genome to code directly for outcomes such as the ability to use language. Like other brain regions, the language areas in the adult brain are the end product of complex chains of interactions with internal and external environments. These sequences of events are based probabilistically on genes rather than being rigidly determined by the genome.

0559.020 The neurobiological evidence thus may run counter to what would be expected under the autonomy of syntax hypothesis. There is no known way that genes could encode for concepts like 'subject' and 'verb'. Thus the most parsimonious perspective is that language is similar to other aspects of cognition in terms of emerging out of a brain which evolved to have an oversized frontal cortex (relative to other primates) and an elongated period of childhood, which privilege the role of learning.

0559.021 Cognitive neuroscientists share a view of language that resonates with the cognitive linguists: they emphasize the joint development of language and perceptuomotor processes, with language acquisition understood to be semantically driven and embodied. The neurological representation of grammar is continuous with the representation of other language 'components' and the neural substrate.

CONCLUSION

0559.022 In the first half of the twentieth century the main question about the relationship between language and cognition was whether the grammatical structure or vocabulary of our language influenced thought processes. Cognitive science introduced a new question: are language and cognition similar or distinct human abilities? The last 50 years have seen considerable controversy on this question,

mirroring the development within cognitive science of two fundamentally different conceptions of the cognitive architecture. The tradition of artificial intelligence emphasized general-purpose problem-solving abilities, while the tradition of linguistics and philosophy led to an emphasis on distinct mental modules.

The four different theoretical perspectives on the language-cognition relationship were summarized in Table 1. The view at the beginning of the twenty-first century appears to be best captured by the idea that cognition and language have complex similarities and differences, and both develop over the human life span from genetic factors constrained by environmental input and cultural learning. New possibilities for synthesis continue to emerge, especially as cognitive scientists pay more attention to evolutionary, neurobiological and cultural factors. It may be possible to set aside the question of whether language is distinct from cognition and whether the brain is composed of distinct mental modules. The theorist Howard Gardner has noted a growing consensus about the importance of a new set of questions about how to divide up the grand areas of mind and brain. Scientists are emphasizing the distinction between areas of human ability that are available to all humans and played a part in the evolution of our species (such as language and basic number use), and areas requiring cultural elaboration (such as algebra and the ability to play musical instruments). The era of simplistic statements about the language-cognition relationship is drawing to a close, as cognitive scientists begin to deliver on the promise of a truly interdisciplinary approach to understanding the mind-brain.

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Further Reading

- Baars BJ (1986) *The Cognitive Revolution in Psychology*. New York: Guilford Press.
- Dromi E, ed. (1993) *Language and Cognition: A Developmental Perspective*. Norwood, NJ: Ablex.
- Edelman GM (1992) *Bright Air, Brilliant Fire*. New York: Basic Books.
- Elman JL, Bates E, Johnson MH *et al.* (1996) *Rethinking Innateness: A Connectionist Perspective on Development*. Cambridge, MA: MIT Press.
- Gardner H (1985) *The Mind's New Science: A History of the Cognitive Revolution*. New York: Basic Books.
- Gumperz JJ and Levinson SC (1996) *Rethinking Linguistic Relativity*. Cambridge, UK: Cambridge University Press.
- Harris CL (1990) Connectionism and cognitive linguistics. *Connection Science*.
- Lakoff G and Johnson M (1999) *Philosophy in The Flesh*. New York: Basic Books.

- Langacker RW (1987) *Foundations of Cognitive Grammar*, vol. 1, Theoretical Prerequisites. Stanford: Stanford University Press.
- MacWhinney B, ed. (1999) *The Emergence of Language*. Mahwah, NJ: Erlbaum.
- Morris RGM, ed. (1989) *Parallel Distributed Processing: Implications for Psychology and Neuroscience*. Oxford: Oxford University Press.
- Muller RA (1996) Innateness, autonomy, universality? Neurobiological approaches to language. *Behavioral and Brain Sciences* 19: 561–610.
- Newell A (1990) *Unified Theories of Cognition*. Cambridge, MA: Harvard University Press.
- Pinker S (1994) *The Language Instinct*. Cambridge, MA: MIT Press.
- Rumelhart D and McClelland J (1986) *Parallel Distributed Processing: Explorations in The Microstructure of Cognition*, vols 1 and 2. Cambridge, MA: MIT Press.

Glossary

- Architecture of cognition** General term for the design of the human cognitive system. Specific proposed architectures may differ in their structure, such as the types of memory and processing structures.
- Artificial Intelligence** The field of study dedicated to understanding how intelligence emerges from computational systems such as computer programs.
- Behaviorism** The dominant paradigm in psychology from the 1930s through the 1950s. Behaviorists claimed that human and animal behavior could be understood by analyzing the relationship between stimuli presented to an animal and its response.
- Cognitive revolution** The two decades beginning in the 1950s when the dominant behaviorist paradigm floundered and gave way to new ways of thinking about

human psychology and the mind, including the use of the computational metaphor of mind, and the idea that language consists of a mental grammar which is a set of unconscious rules.

Epigenetic Resulting from a complex dynamic evolution of genes and environmental forces during prenatal and postnatal development.

Generative linguistics The dominant paradigm in linguistics from the 1960s to the early twenty-first century. The name refers to Noam Chomsky's proposal that the goal of linguistics should be to understand how novel sentences are generated.

Language acquisition device Linguistic relativity hypothesis The proposal that different languages are incommensurate systems of communication and thus utterances in one language can only be understood relative to the broader language system. Related to the Sapir–Whorf hypothesis, which is that the form of language influences thought. Named after the anthropological linguistics of the first half of the twentieth century who wrote the uniqueness of different language and the necessity of evaluating a culture on its own terms (cultural relativity).

Regularity extraction General term for inducing the dominant statistical tendencies in a set of data.

Information processing A view of human cognition emphasizing the analysis of large tasks into their subcomponent processes and information structures, analogous to steps in a computer program.

Von Neuman computer The original computer architecture consisting of registers in which arbitrary information bits could be stored, and a centralized processor which serially moved information between register locations.

Keywords: (Check)

cognitive revolution; cognitive linguistics; Chomsky; language acquisition; connectionism

05591001 **Table 1.** Theoretical perspectives on the language–cognition relationship

<i>Timeline</i>	<i>Movement</i>	<i>Main source of constraints</i>	<i>Language/cognition</i>
1957–present	Chomskyan linguistics	Innate	Language unique, unlike cognition
1960s–1990	Artificial intelligence	Learned	Subject to same principles
1980s–1990	Connectionism	Learned	Subject to same principles
1980s–present	Modularity of mind	Innate	Language unique, unlike cognition
1990s–present	Cognitive neuroscience	Dynamical interaction	Complex similarities and differences