

## **Cognitive Science: Shifting Patterns of Interdisciplinary Collaboration**

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Cognitive science is the interdisciplinary study of mind and intelligence, embracing psychology, artificial intelligence, philosophy, neuroscience, linguistics, and anthropology. Since its beginnings in the 1940s and 1950s, cognitive science has experienced numerous important phases of interdisciplinary research, involving differing combinations of the six core disciplines. I will examine some of the most important historical phases of cognitive science research, including early cybernetics, computational psychology, connectionism, and computational neuroscience. Each of these phases has involved combinations of disciplines that succeeded because of interconnections of people, ideas, and methods.

Although the term “cognitive science” was not coined until the mid-1970s, the field can trace its origins to the 1940s when visionaries such as W. S. McCulloch and Alan Turing began exploring ideas at the intersection of logic, computation, and neuroscience. The combination of early ideas about neuroscience and computing was called cybernetics. The most important collaboration in this period was between McCulloch, who was a neurophysiologist, and Walter Pitts, who was a highly eccentric logician. For this and the other phases of cognitive science to be discussed, I want to try to answer questions such as the following. Who were the key contributors, and how did their individual and collaborative interdisciplinary backgrounds contribute to intellectual

progress? How did these researchers produced novel combinations of ideas and methods to make interdisciplinary contributions?

The second phase of cognitive science began in the 1950s with research by Alan Newell and Herbert Simon on computational models of high-level human thinking such as problem solving. This work combined psychology and computer science, the subfields that are now known as cognitive psychology and artificial intelligence. The intersection of these fields is still a highly productive part of cognitive science. I will describe how Newell, Simon, and later contributors to this tradition such as John Anderson combined individual and collective interdisciplinary expertise to generate new ideas about mental mechanisms. This phase also constructively blends the psychological method of behavioral experiments with the computational method of simulations.

The third phase of cognitive science, connectionism, has its origins in McCulloch and Pitts' neural network models, but only blossomed in the 1980s. Researchers such as David Rumelhart, James McClelland, and Geoffrey Hinton showed how to apply improved models of artificial neural networks to a wide range of psychological phenomena. I will describe how ideas and methods blended to constitute a research program with continued successes.

Even more recently, the field of computational neuroscience has arisen to tie neural networks more closely to actual brain structures, employing researchers from backgrounds as diverse as neurophysiology, computer science, physics, and philosophy. Like the other phases of cognitive science, computational neuroscience has required individual and collective efforts that cross fields through interconnections of people, institutions, ideas, and methods.

These four phases of interdisciplinary research in cognitive science are excellent illustrations of the kinds of connections between fields that are found in the “cognitive science hexagon” pictured below. To conclude, I will discuss why some of the potential interdisciplinary connections shown in the hexagon have not been as fruitful as others.

