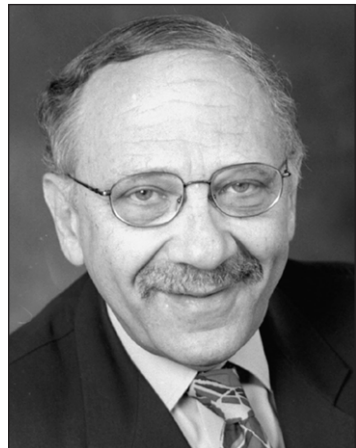


Research Shows that Non-human Primates Can Become List Learners Without Language

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language. With Brannon's help, he showed that monkeys could learn to order numerical stimuli in an ascending or descending order. The experiment reported in *Psychological Science* carries that research one step further by showing that monkeys can learn to order unrelated photographs.

The monkey's task was to touch, in a particular order, seven photographs that were presented simultaneously on a touch-sensitive video monitor. From trial to trial, the positions of the photographs were varied randomly to prevent



RECORD PHOTO BY EILEEN BARROSO
Herbert Terrace

the monkeys from learning the required sequence as a series of rote motor responses. Four monkeys were trained to learn four 7-item lists in this manner. The odds of guessing the correct order in which to touch the photographs was less than one in 5,000. The monkeys not only learned, at a high level of accuracy, the correct order in which to respond to the photographs on each list, but became progressively more efficient at deducing the correct order with each new list.

"This is the equivalent of a child memorizing, for example, the seven days of the week, the first seven letters of the alphabet, the names of the first seven numbers and the first seven months of the year, reciting each sequence in the correct order, and learning each sequence more rapidly than the previous one," said Terrace. "That is a complex problem for humans,

even with verbal labels such as, 'first,' 'second,' 'third,' etc."

After the monkeys learned four 7-item lists, they were given another challenging task. Subjects were tested with all possible pairs of the 28 photographs that were used to construct those lists (336 pairs in total) to see if they could choose which of the two photographs occurred earlier on the lists from which they were drawn. (Photographs that occupied the same position on different lists were excluded.) The monkeys responded correctly to 91% of the pairs of photographs drawn from different lists on the first trial on which each pair was presented.

Of particular interest were the monkeys' reaction times to the first item of each pair. The larger the gap between the original ordinal positions of the photographs, the shorter the reaction time. This 'distance effect' is also observed when human subjects are asked to order pairs of randomly selected letters from the alphabet, e.g., which comes first, l or f, f or r, c or d, etc. The further apart the letters, the shorter the reaction time. It seems that both monkeys and humans position each member of a pair on a mental line and then compare their positions on that line to decide which came first. The bigger the separation, the easier it is to make that judgment.

"The sequences that these monkeys learned are by far the most difficult lists mastered by a non-human primate, including those trained in experiments on their linguistic and numerical abilities," Terrace said.

"We believe that the upper limit of a monkey's serial expertise is even higher," noted Professor Son. "The ease with which the monkeys learned 7-item lists and the steady decrease in the number of sessions they needed to master new lists suggests that they could learn such lists more rapidly and also master longer lists."

Son played a central role in conducting and analyzing the experimental data, which involved direct interaction and observation of the rhesus macaques during the extensive two-year project, which was supported by grants to Terrace from the National Institute of Men-



Rosencrantz, above and below, one of four rhesus macaques that participated in Herbert Terrace's learning experiment, demonstrates his ability to identify correctly the order of 7-image lists even when they appeared in different spatial configurations on the computer screen.



tal Health, and a fellowship to Brannon from the National Science Foundation.

The researchers believe their experiment demonstrates that the monkeys use a precursor of what

investigators of human cognition refer to as declarative knowledge—knowledge acquired rapidly and logically. This is in contrast to procedural knowledge, which is inflexible and acquired slowly through repetitive training on a particular problem.

"Although the subjects of this study lack the ability to declare their knowledge verbally, the breadth of their serial expertise suggests that they have all of the other features of human declarative knowledge," Terrace said.

Boston College's Bob Shoop Aims to Put Columbia Football at Top of Ivy Heap

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have to work hard to revive a Columbia program that has won only seven games in the last three years, but the former Yale wide receiver seems confident in his ability to produce victories.

"I left a good job to come here," said Shoop. "I wouldn't have come if I didn't think we could get it done."

Columbia's Athletic Director Jonathan Reeves agrees.

"Bob has advanced quickly through the coaching ranks because of his hard work and dedication," said Reeves. "He has been associated with some of the best football minds in the country. Bob is the perfect man to lead the Lions to the next

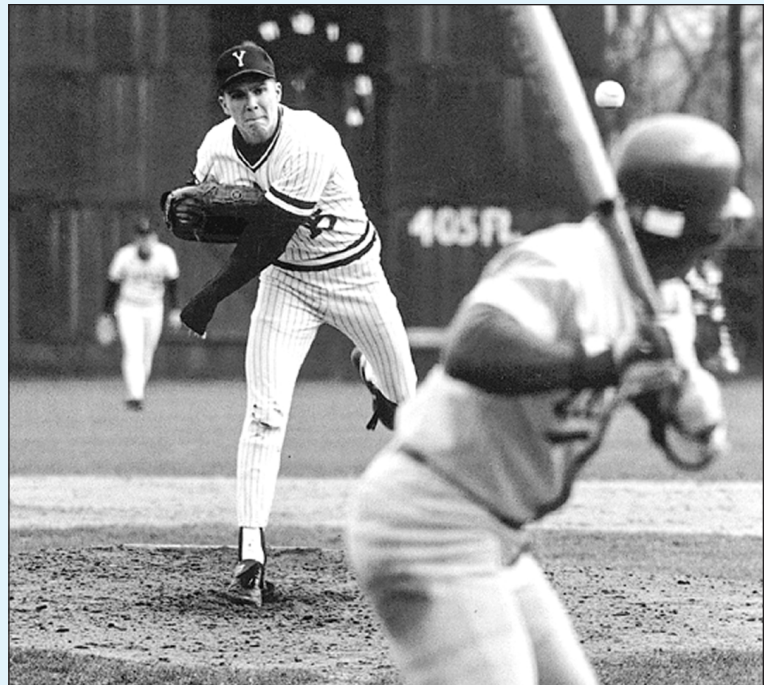
level."

Indeed, Shoop has been mentored by some of the top strategists. While at Virginia in 1990, he served as a graduate assistant under George Welch, the ACC's all-time win leader. In 1989 and 1994-96, he was an assistant coach under Yale's legendary hall of fame coach, Carmen Cozza. Most recently, he worked with Tom O'Brien who has made Boston College a top-25 team while boasting the highest football graduation rate in the Big East Conference.

"Our players and staff will miss Coach Shoop, and I am grateful for the outstanding job he did for us," said O'Brien. "I think he is a perfect fit to lead Columbia football."

Graduating from Yale in 1988, Shoop brings experience as a two-sport student athlete in the Ivy League. He earned Yale Football's prestigious Robert Gardner Anderson Memorial Award for team spirit, dedication and leadership. Off the gridiron, he captained the Bulldog baseball team, twice receiving the Ducky Pond Award for most outstanding pitcher. Shoop believes that his undergraduate experiences in New Haven provide him a special insight into the athletes he will be coaching.

A native of the Pittsburgh suburbs, Shoop and his wife, Maura, have two children: Tyler, 5, and Jay, 3. His brother, John Shoop, is the offensive coordinator for the Chicago Bears.



Bob Shoop, pitching, played varsity football and baseball during his undergraduate years at Yale.