

Foundations of cumulative culture in apes: improved foraging efficiency through relinquishing and combining witnessed behaviors in chimpanzees (*Pan troglodytes*)

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Evidence for culture in non-human species continues to grow, yet there are few candidate examples of cumulative culture outside of humans' distinctively complex achievements. Prerequisites for cumulative culture include not only the ability to build on established behaviors but also to relinquish old ones and flexibly switch to more productive or efficient alternatives. Here, we established an inefficient solution to a foraging task in five groups of captive adult chimpanzees (N=19 - 4 male, 15 female; average group size of 8 individuals) living at the Michale E. Keeling Center for Comparative Medicine and Research. Three groups were subsequently seeded with a conspecific model who demonstrated an alternative, more efficient, solution to the same task. When participants could still successfully forage with their previously established behaviors, the majority of individuals did not switch to this more efficient solution; however, when their foraging method eventually became highly inefficient relative to that of the available alternative, nine chimpanzees with socially-acquired information (four of whom were exposed to additional human demonstrations) relinquished their old behaviors in favor of the more efficient one. In contrast, only one individual in a control group that did not witness a knowledgeable model was seen to do this (One-tailed Fisher's exact test, $p < .01$). Individuals who switched were later able to combine behavioral components of these two techniques to produce a more efficient solution than their extensively used original extractive method (One-tailed Wilcoxon signed-rank test: $Z = -2.410$, $N = 10$, $p < .01$, $r = -0.54$). This suggests that the ability to combine independent behaviors to produce a superior compound technique, thought to be a major driving force of cultural evolution in hominin history, may have been inherited from an ancient ancestor shared with chimpanzees.