Manual dexterity and the human brain evolved together

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A century and a half ago, Frederick Engels, in an unpublished 1876 essay titled, *The Part Played by Labor in the Transition From Ape to Man* (International Publishers 1950), identified the evolution of the hand as a key component of human evolution. He proposed that the development of bipedality, walking upright using the hind limbs only, freed the hands to perform labor: "*the hand had become free* [emphasis in the original] and could henceforth attain ever greater dexterity and skill… Thus the hand is not only the organ of labor, *it is also the product of labor"* [emphasis in the original].

Engels went on to say that the evolution of the hand did not occur alone but was part of the coordinated development of other associated body parts.

A newly published study ("Human dexterity and brains evolved hand in hand," Joanna Baker, Robert A. Barton and Chris Venditti, *Nature communications biology*, 26 August 2025) provides new insights into the coevolution of the hand and the brain.

In the newly published study, the authors report that they found "a significant relationship between relatively longer thumbs—a key feature of precision grasping—and larger brains across 95 fossil and extant primates…" Furthermore:

> most hominins [modern humans and their evolutionary ancestors], including *Homo sapiens*, have uniquely long thumbs, yet they and other tool-using primates conform to the broader primate relationship with brain size. Within the brain, we surprisingly find no link with cerebellum size, but a strong relationship with neocortex size, perhaps reflecting the role of motor and parietal cortices in sensorimotor skills associated with fine manipulation.

Enhanced manual dexterity is key to the refined control necessary for stone tool production, a key technological adaptation by the human lineage. Although the authors recognize that numerous evolutionary modifications of the human hand contribute to increased dexterity, "an increased ability to manipulate small objects is enhanced by long thumbs—particularly relative to the index finger. Longer relative thumbs facilitate greater opposability—and *Homo sapiens* is noted to have both longer thumbs compared with other apes as well as enhanced manipulative ability." Opposability refers to the ability to bring the tip of the thumb into contact with the tips of the other fingers of the hand, allowing a high degree of control over objects being held.

However, although other primates possess varying degrees of thumb opposability and exhibit some degree of tool use, only humans have the highly refined precision grip which allows them to perform the uniquely refined and delicate manipulations necessary for stone tool production. The authors propose that this is only possible based on a highly developed sensorimotor control originating in the brain, the result of co-evolution between the two. They hypothesize that this difference "may explain some of the marked variation in relative brain size among primates and the trend for this to increase through time."

The authors propose to test this along with two alternative possible explanations regarding the observed variation in thumb length verses brain size. If long thumbs are specifically the result of hominin tool manufacture, then they would expect the relationship between thumb length and brain size only among that group (i.e., not among other primates). On the other hand, if there is in fact no correlation between thumb length and brain size, then some other factors must be considered as responsible for each independently.

These alternate hypotheses were tested by statistical analyses using data from 95 fossil and contemporary primate species spanning the full range of primate diversity.

· The first hypothesis posited that "[i]f fine manipulative abilities require enhanced sensorimotor control with an associated neural processing cost [enlarged brain], then we would expect to see a general co-evolutionary relationship between thumb length and brain size across the primate order." In other words, there would be a consistent degree of evolutionary correlation between brain size and thumb length across primates in general.

· The second hypothesis was that a correlation between brain size and thumb length exists only among hominins and/or tool users and not in other primates.

· Thirdly, "…it is possible that brain size and thumb length coevolved across all primates, but there is a shift in the intercept [a qualitatively greater degree] of the relationship between hominins and/or other tool-using species, which might be the case if there was some reorganization of the neuro-behavioural basis of manipulation."

Based on statistical analysis it was found that:

1. "As expected, hominin thumbs are significantly longer than those of other primates. The general primate-wide relationship predicts hominin species to have much shorter thumbs than are actually observed."

2. The researchers found that there is a "significantly positive relationship between relative thumb length and brain size … as well as thumb length and finger length … across all non-hominin primates." In other words, the correlation between thumb length and brain size is not exclusive to hominins.

3. A significant correlation was also found between thumb length and documented tool use in both hominin and non-hominin primates (e.g., chimpanzees).

Among the results, the researchers concluded that there is a strong association between brain size and manual dexterity. However, they go on to caution that although thumb length is only one factor in dexterity, other features also contribute. These include "(among others) relative proportions and morphology of other digits, bone shape and structure and bone traits associated with soft tissues such as muscle attachment sites."

An additional, analysis was conducted examining manual "workspace," "… the range of motion a small object can be freely moved between the thumb and index finger—and thumb length." The study found that, "…thumb length significantly predicts peak manipulation workspace." Furthermore, analysis found that, "…brain size is a significant predictor of peak workspace."

The researchers concluded that, "on the basis of both our thumb length and workspace analyses, we interpret our results to indicate sustained historical coevolution between brain size and dexterity across the primate order, reflecting significant neural costs of manipulation behaviours and helping to explain the rapid increases in brain size observed in hominins." Enhanced workspace would be a notable advantage in both tool manufacture and use.

Finally, "…our results demonstrate coordinated change in both hands and brains and therefore confirm…" the initial hypothesis.

The authors then refer to "[r]ecent evidence [that] has even demonstrated possible functional and anatomical overlap in brain activation patterns involved in both tool-use and language processing." Other researchers, including Charles Darwin, have explored this correlation.

This study provides an important contribution to our understanding of the complex, dialectical process of human evolution. The proposed relationship between tool-use and language supports the insight proposed by Engels a century and a half ago that the "explanation of the origin of language from and in the process of labor is the only correct one."