Evolutionary links between the development of language and stone tool technology

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19 November 2013

Charles Darwin, in his *Descent of Man* (1871), speculated about an evolutionary connection between the development of language and the manufacture of tools. In his insightful essay "The Part Played by Labor in the Transition from Ape to Man", Fredrick Engels (1876), proposed that labor and language were linked. Recent research lends support to the idea of a close cognitive connection between these two key human characteristics.

Multiple experiments indicate that stone tool manufacture and speech use the same regions of the brain. This suggests that the increasing sophistication in stone tool technology over the last several million years may be used, roughly, as an indicator to gauge the evolution of language capacity. Since language does not fossilize, such a connection, if upheld by further research, would provide valuable insights into not only the pace, but also the pattern of language development, and the evolution of the capacity for abstract thought more generally.

In an article published in the online scientific journal *PLoS ONE* (30 August 2013), Natalie Thaïs Uomini and Georg Friedrich Meyer report research in which they used sophisticated ultrasound technology to measure blood flow in the brains of subjects while they manufactured replicas of Acheulean stone tools (a technology dating back approximately 1.76 million years) and as they performed linguistic tasks. The results indicate that the same regions of the brain received increased blood flow during both of these activities. Increased blood flow is indicative of heightened neural activity.

This is not the first research into the correlation in brain function between language and physical actions. Over the past decade, a number of studies have provided evidence of such a correlation. One study, by Dietrich Stout and Thierry Chaminade (*Cambridge Archaeological Journal*, Vol. 19. No. 1, 2009), using MRI and PET scans, showed results consistent with this hypothesis.

Stone tool technology has undergone dramatic increases in sophistication since the earliest known stone tools, the Oldowan industry, dating to 2.6 million years ago. Oldowan tools were simply flakes struck off a core by use of a hammerstone. Nevertheless, the manufacture of even these crude tools required the mastery of a variety of concepts, including the selection of suitable stone materials, an understanding of fracture mechanics, and the ability to plan the use of force and angle to strike the appropriate blow with the hammer on the raw material (the core) to release a flake of the desired size and shape. In sum, the craftsman had to assemble a complex sequence of cognitive steps in order to create an object (the tool), which was then to be used in a different activity (butchering an animal, for example).

Chimpanzees make tools, but without a complex manufacturing sequence. They may choose a suitable cobble to use as a hammer to crack open nuts, or strip the leaves off a small twig to make a probe useful to withdraw termites from their nest. However, the form of the final tool is already discernible in the raw material.

Human manufacture involves a structured set of actions which must be followed in order to achieve a desired goal—the creation of a tool with characteristics (size, shape, edge angle) which make it suitable for accomplishing a specific task. The knapper (a person who makes chipped stone tools) must have a mental image of the desired tool and then decide on the sequence of steps needed to produce the intended product. Furthermore, the knapper must be flexible in the application of these actions, since both the materials and conditions may not behave in the expected manner. Adjustments and refinements lead by experience to a more detailed understanding of all of the factors involved.

Of central importance is the fact that stone tool manufacture as it developed through the millennia was not idiosyncratic. It was not reinvented "de nouveau" by each new knapper. Rather, it depended on a set of skills that were acquired by learning from experienced practitioners and passed on, generation to generation. It was shared, cultural knowledge. And, as the complexity of the technology increased, so would the selective advantage in being able to use better communication skills in order to pass it on more effectively.

The assembly of a linguistic statement appears to bear fundamental similarities to the manufacture of stone tools. A variety of available sounds (raw material) must be assembled according to a set of rules (grammar), which is held in common by both parties in the conversation. The construction of the verbal utterance has the intent of eliciting a desired response from the other party. Therefore, the speaker must consider how

the listener may react and each party will continue to make adjustments as the conversation proceeds.

The modeling of the anticipated thoughts and actions of another individual in one's own mind is referred to as "Theory of Mind." Much research indicates that this is what underlies learned social behavior. It is hypothesized that the dialectical interactions between an individual and either other individuals or physical objects which are being modified both require this sort of mental modeling of the "behavior" of the other. Raw materials, tools, and other aspects of the physical world "behave" according to their own rules. The ability to engage in a "dialog" with these objects requires an understanding of these rules and the ability to apply them in an effective and flexible manner.

Major innovations in stone tool technology (e.g., the development of the Acheulean biface [aka handaxe], Mousterian prepared cores, Upper Paleolithic blade tools) represent qualitative leaps in the complexity of the manufacturing process. They indicate the ability to employ complicated sequences of actions which create tools that have no obvious resemblance to the original form of the raw material or even the intermediary steps in manufacture.

The construction of complex linguistic statements, with elements that modify other elements in such a way as to alter or even completely transform their original meanings, is arguably analogous in a cognitive sense to a complex manufacturing sequence. Each speaker in a group must have the same basic linguistic tool kit so that they produce verbal utterances which the others can understand and, at the same time, have the skill to adjust their practice of speech as the conversation evolves. The construction of speech involving whole sentences and the equivalent of paragraphs requires the mental ability to combine many different elements in both temporal sequence and organizational hierarchy, just as in the assembly of a complex sequence of steps to make stone tools (see, for example, Ambrose 2001 "Paleolithic Technology and Human Evolution", *Science*, Vol. 291: 1748-1753).

The level of sophistication of various stone tool traditions that have appeared through time has progressively increased. However, the rate of technological evolution has not been consistent. Especially during earlier periods, traditions such as Oldowan and Acheulean appear to endure for tens or even hundreds of thousands of years with only slow change, based on the available archaeological evidence. The same may be said of human physical evolution.

Very roughly speaking, Oldowan tools (2.6 to 1.7 million years ago), first described by archaeologist Mary Leakey, may be correlated with the earliest form of the genus *Homo–Homo habilis*. Acheulean technology (earliest known at 1.76 million years ago) is more or less contemporaneous with *Homo erectus*. Acheulean industries include the manufacture of tools called "hand axes", which require a significantly higher level of knapping skill than Oldowan tools as well as expressing an aesthetic sense of symmetry, especially in later forms. The Stout and Chaminade study, cited above, appears to indicate an increased correlation between linguistic and tool-making brain activity from Oldowan to Acheulean.

In more recent times, in particular since about 200,000 years ago, more sophisticated technologies, such as Mousterian, appeared along with newer human populations, including the Neanderthals. Mousterian technology included a multi-stage manufacturing process, which employed what is known as the Levallois technique, consisting first of the production of relatively uniform flakes from prepared cores, followed by the creation of a variety of tools by modification of those flakes (an early form of standardized manufacture). Thus, there is a hierarchy of manufacturing stages, the intermediate steps of which do not obviously prefigure the form of the final tool. An analogy can be suggested between the hierarchical structure of the Mousterian manufacturing process and the assembly of complex sentence structure or even paragraph-level linguistic constructs.

Following the appearance of anatomically modern humans (*Homo sapiens*), perhaps with some time lag, the archaeological record reveals the presence of highly complex stone tool technology, termed Upper Paleolithic, which includes the manufacture of exquisitely produced bifaces (spear points and hafted knives) and of compound tools made from mass produced blades. This technology, along with the appearance of artwork, such as the cave paintings of Europe, is thought to mark the development of fully abstract thought and modern language.

Much more research is needed, first to confirm that these two activities, tool making and speech, are mentally correlated and, second, to determine to what degree language structure can be modeled using stone tool technology.