Percussive technology in human evolution: an introduction to a comparative approach in fossil and living primates

Ignacio de la Torre and Satoshi Hirata

1 Institute of Archaeology, University College London, 31 – 34 Gordon Square, London WC1H 0PY, UK
2 Kumamoto Sanctuary of Wildlife Research Center, Kyoto University, 990 Ohtao, Misumi, Uki, Kumamoto 869-3201, Japan

Percussive technology is part of the behavioural suite of several fossil and living primates. Stone Age ancestors used lithic artefacts in pounding activities, which could have been most important in the earliest stages of stone working. This has relevant evolutionary implications, as other primates such as chimpanzees and some monkeys use stone hammer-and-anvil combinations to crack hard-shelled foodstuffs. Parallels between primate percussive technologies and early archaeological sites need to be further explored in order to assess the emergence of technological behaviour in our evolutionary line, and firmly establish bridges between Primatology and Archaeology. What are the anatomical, cognitive and ecological constraints of percussive technology? How common are percussive activities in the Stone Age and among living primates? What is their functional significance? How similar are archaeological percussive tools and those made by non-human primates? This issue of *Phil. Trans.* addresses some of these questions by presenting case studies with a wide chronological, geographical and disciplinary coverage. The studies presented here cover studies of Brazilian capuchins, captive chimpanzees and chimpanzees in the wild, research on the use of percussive technology among modern humans and recent hunter-gatherers in Australia, the Near East and Europe, and archaeological examples of this behaviour from a million years ago to the Holocene. In summary, the breadth and depth of research compiled here should make this issue of Philosophical Transactions of the Royal Society B, a landmark step forward towards a better understanding of percussive technology, a unique behaviour shared by some modern and fossil primates.

1. Introduction

It is Springtime for studies of tool use in primates. Great progress has been achieved since Goodall [1] pioneered research on chimpanzee (*Pan troglodytes*) material culture, and the variety of animal tool use is widely recognized and subject of renewed interest (e.g. [2,3]). Probably no other field within studies of primate material culture has expanded its research niche more than that investigating stone tool percussive technology. The use of stone tools to process foodstuffs was first recognized in non-human primates by Portuguese traders and priests in the sixteenth and seventeenth centuries, who reported chimpanzees in Sierra Leone using stone hammers to crack open nuts such as oil palm nuts [4]. Research in recent decades has documented this technical behaviour among a number of chimpanzee communities across West Africa [5,6], attesting to the variability of chimpanzee culture in Africa [7]. In the past few years, such percussive technology has also been observed among South American capuchin monkeys (*Sapajus libidinosus*; e.g. [8]) and Southeast Asian long-tailed macaques (*Macaca fascicularis*; [9]), considerably expanding the geographical and species diversity of this primate behaviour.

While studies on the ecology [10], cognitive [11] and motor [12] requirements of the hammer-and-anvil technique investigated the evolutionary foundations of
percussive behaviour in the human lineage, pioneering comparisons between chimpanzee and human material cultures (e.g. [13–15]) provided a referential framework to evaluate similarities and differences between living primates and the Early Stone Age record. The blossoming of such comparisons began when archaeological techniques were first applied to chimpanzee material culture [16], also providing a time depth to chimpanzee percussive technology [17]. Recent years have seen a true blooming of interdisciplinary approaches to primate material culture (e.g. [18,19]), leading to the branding of a new discipline, Primate Archaeology [20], which aims to produce a comparative framework where non-human extant primate datasets can be used to interpret the Stone Age record.

From the perspective of the archaeological record, significant advances in the analysis of percussive technologies have also been achieved in recent years. Previous interest in the relevance of pounded tools in earlier [21,22] and more recent [23,24] prehistoric sites has been renewed, and reported significant battering activities in the Stone Age record [25–27]. In parallel, the pendulum swing of paradigms, which from the 1970s had constrained stone tool technology to the Genus Homo [28], has now shifted owing to new archaeological discoveries [29] that push stone tool making back in time and in our evolutionary lineage.

The combination of new discoveries in primatology (e.g. stone pounding by capuchin monkeys and long-tail macaques) and archaeology (an earlier age for the first stone artefacts, recognition of pounding tools) and considerable methodological advances in both disciplines (e.g. development of Primate Archaeology initiatives, application of new analytical techniques) seems to qualify our opening statement about the Springtime that the study of percussive technologies is witnessing. This makes comparisons between the primate and archaeological percussive records more pertinent than ever, which is the rationale driving this issue.

Nonetheless, comparisons between human and non-human primate percussive technologies should be based on a clear understanding of the similarities and differences between the two. Human percussive lithic technology primarily includes pounding, grinding and flaking. Non-human primate percussive lithic technology is mostly limited to pounding, using a hammer and/or a hammer-and-anvil technique in order to crack open foodstuffs. Although apes can be taught to knap [15], comparisons between non-human and human percussive activities should bear in mind the differences and not confound formal similarities with homological mechanisms [30,31]. That is why, even though freehand knapping is the most pervasive activity observed in the Stone Age archaeological record, this issue of Philosophical Transactions B is mostly constrained to case studies where percussive activities involve a hammer-and-anvil technique. As reviewed in this issue, the variety of activities undertaken with hammer and anvils is considerable, and depends on biological, anatomical, cognitive, ecological, functional and cultural factors. The interplay of these constraints and the wide range of geographical areas (from Brazil to Africa and Australia), periods (from the Pliocene to the present), biological species (from capuchin monkeys to chimpanzees, Australopithecus, early Homo and modern humans) and disciplines (e.g. evolutionary psychology, primatology, ethnography, physical anthropology, archaeology) covered by this issue aim to contribute towards setting the ground for long-standing comparisons across species and between different research disciplines and periods.

2. Anatomical and cognitive constraints of percussive technologies

The first section of this issue explores the physical and mental requirements necessary for stone tool use in an evolutionary context. Kivell [32] reviews the fossil evidence for artefact manipulation in early hominins, focusing on the biomechanics and morphology of the hand. Her results suggest that the arboreal locomotion of early hominins could have been accompanied by anatomical adaptations to tool use, hence triggering further evolutionary changes towards improved dexterity. Manual dexterity is also studied by Bril et al. [33], who approach the subject from an experimental perspective; they compare functional requirements of nut-cracking and stone flaking in modern humans, and highlight the substantial differences in the required degree of manual dexterity between the two activities. Bril et al. [33] also recognize the relevance of cognitive parameters involved in percussive technology, which is precisely the focus of the paper by Hayashi [34]. Hayashi [34] emphasizes the necessity for sequential analysis of actions involved in nut-cracking, instead of action-based analysis, to understand behavioural strategies adopted by chimpanzees. She also infers from her sequential analysis that the use of a wedge stone (that is, a stone used to stabilize another stone to be used as an anvil) is not an intentional behaviour of the chimpanzee but a by-product after trial and error.

3. Percussive technology cultures in non-human living primates

Although Hayashi [34] focuses on individual behavioural strategies, Luncz et al. [35] and Whiten [36] look at nut-cracking in chimpanzees from a social perspective. Both papers discuss social learning by introducing cases of wild [35] and captive [36] chimpanzees. Luncz et al. [35] employ archaeological methods to infer chimpanzee tool selection behaviour that could not be observed directly by researchers. They argue that wild chimpanzees show conformist tendencies in tool selection. Whiten [36] reviews experimental studies of tools used to crack nuts in captive chimpanzees. He concludes that social and individual learning progress step-wise, and interactions between them play an important role in chimpanzee nut-cracking skill acquisition. Visalberghi et al. [37] compare nut-cracking tool use in wild capuchin monkeys and chimpanzees. Considering phylogenetic relationships among primates, it appears that percussive technology emerged independently in certain groups of capuchin monkeys, long-tailed monkeys and chimpanzees. Visalberghi et al. [37] suggest that differences in chimpanzee and capuchin monkey stone tool use largely depend on variability in ecology, morphology and sociality, and also acknowledge the need for future work on the role of cognitive differences between groups of stone tool-using primates.

4. Percussive technologies in modern and early humans

Owing to preservation issues inherent in the Stone Age record, archaeologists are often unable to ascertain the functional and
production techniques of stone tools from Palaeolithic sites. Hayden [38] uses observations of stone tool making and use by Australian aborigines to reflect on the function of the earliest lithic artefacts, placing particular emphasis on bipolar technology as a potential link between chimpanzee hammer-and-anvil technique and typical freehand Oldowan flaking. The paper by Roda Gilabert et al. [39] specifically addresses bipolar tools through the study of this flaking technique in the Mesolithic site of Font del Ros (Iberia) and discusses technological criteria to identify bipolar artefacts in archaeological assemblages. In the earlier context of the Near Eastern Epipalaeolithic, Dubreuil & Nadel [40] conduct a use-wear analysis of percussive artefacts to assess the role of pounding tools during the development of plant food processing among the Late Pleistocene hunter–gatherer societies from Ohalo II. The Levant is also the subject area of the study by Goren-Inbar et al. [41], who introduce a new type of stone anvil from the Acheulean of Gesher Benot Ya‘aqov, thus reinforcing the view that battering activities, which include nut-cracking (see also [25]), were relevant and varied at this site. It is precisely the notion of Acheulean variability that Gowlett [42] discusses in his contribution, which he uses as a case study to reflect on the creation of a referential framework to interpret cultural variation in living chimpanzee material culture. Lastly, Barsky et al. [43] present the results of their study of battered tools from the earliest archaeological sites in Europe, those of the Orce region in southern Iberia, which again highlights the qualitative importance of non-flaking percussive activities among early humans.

5. Conclusion

The classic conception of the first human technologies assumed that early stone tool making focused on getting cutting edges, mainly through flakes obtained from knapping. However, there is an increasing recognition of the fundamental and broader role of percussion processes apart from knapping, such as pounding and battering activities, which could have been the most important ones in the earliest stages of stone working. This has important evolutionary implications, as some living primates use stone hammer-and-anvil combinations to crack hard-shelled nuts, as well as anvils to smash open hard-shelled fruits. Parallels between primate percussive technologies and early archaeological sites need to be further explored in order to assess the emergence of technological behaviour in our evolutionary line, and in the past few years bridges between primatology and prehistory are becoming firmly established (e.g. [18,20,44–47]). In the wake of these initiatives, it is the ultimate goal of this issue to contribute to a better understanding of the biomechanical, cognitive, functional and ecological contexts of percussive technologies in past and present primates, and to showcase the relevance of interdisciplinary collaborations for the understanding of the evolution of technology in the human lineage.

Competing interests. We declare we have no competing interests.

Funding. Funding from The Leverhulme Trust (IN-052) for the organization of the conference that led to this volume is gratefully acknowledged.

Acknowledgement. We thank all the contributors for their efforts to make this issue happen.

Guest Editor profiles

Dr Ignacio de la Torre is a Professor at the Institute of Archaeology, University College London. As a Palaeolithic archaeologist, he is particularly interested in lithic technology and the study of Pleistocene site formation processes. His interest in early stone tools has led him to publish extensively on the African Oldowan and to collaborate with primatologists in order to better understand the origins of percussive technology. He has directed archaeological excavations in Middle and Upper Pleistocene sites in Spain, Ethiopia and Tanzania, and is currently co-director of the Olduvai Geochronology Archaeology Project, which is investigating the transition from the Oldowan to the Acheulean at Olduvai Gorge (Tanzania).

Dr Satoshi Hirata is a Professor at the Wildlife Research Center of Kyoto University. He has been conducting research on chimpanzees and other great apes from a comparative cognitive perspective to better understand the evolutionary origins of human behaviour and cognition. Particularly, he has explored social intelligence in chimpanzees, including tactical deception, cooperation and social learning. He has also investigated the process of acquisition and learning of tool use for nut-cracking in captive chimpanzees. He is currently Director of the Kumamoto Sanctuary of Kyoto University, where ex-biomedical chimpanzees are housed. In addition to his research, he is engaged in activities to enhance the welfare of captive primates.

References


