

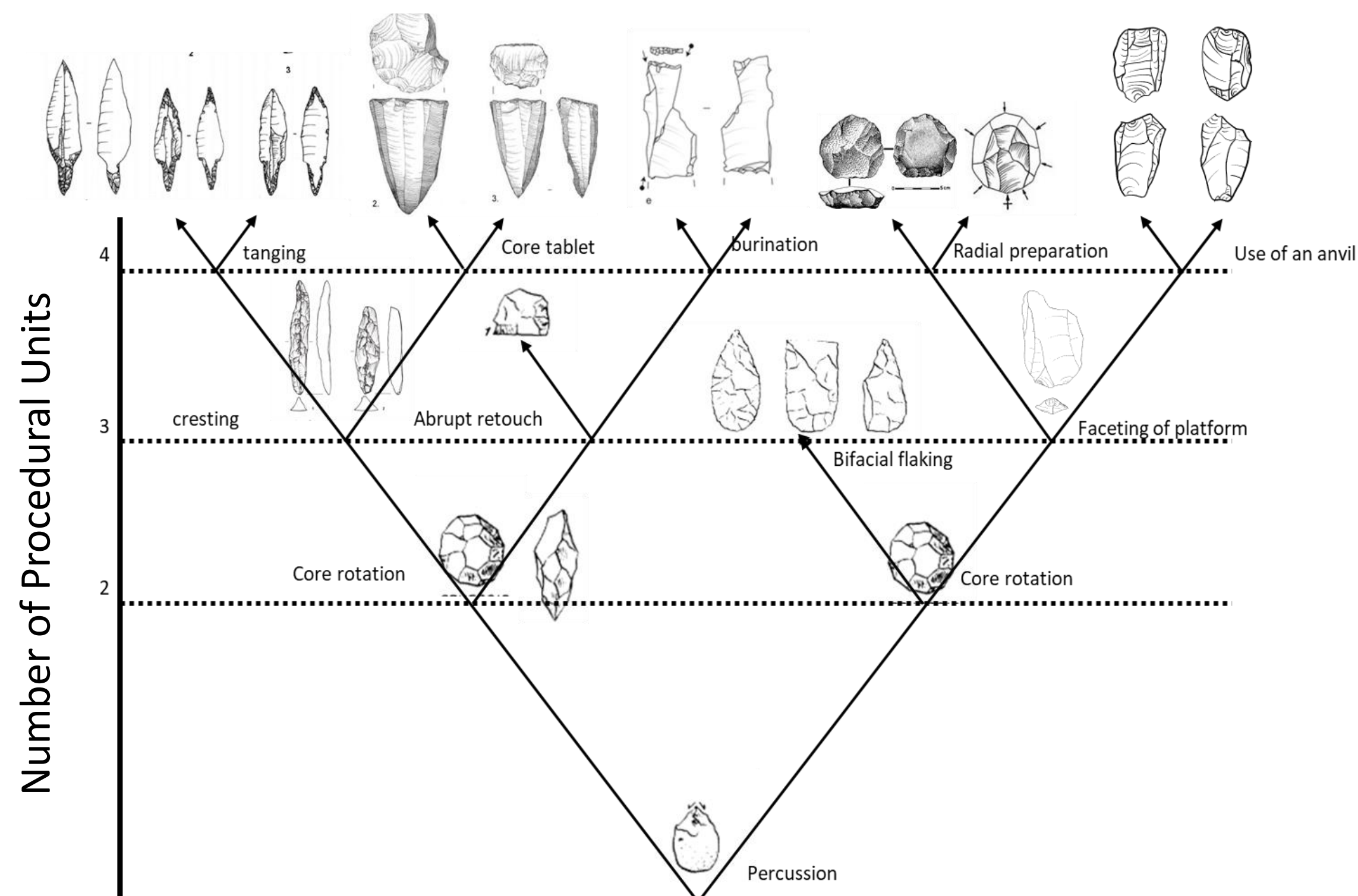
# The Evolution of Cumulative Culture in the Hominin Lineage

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## Background

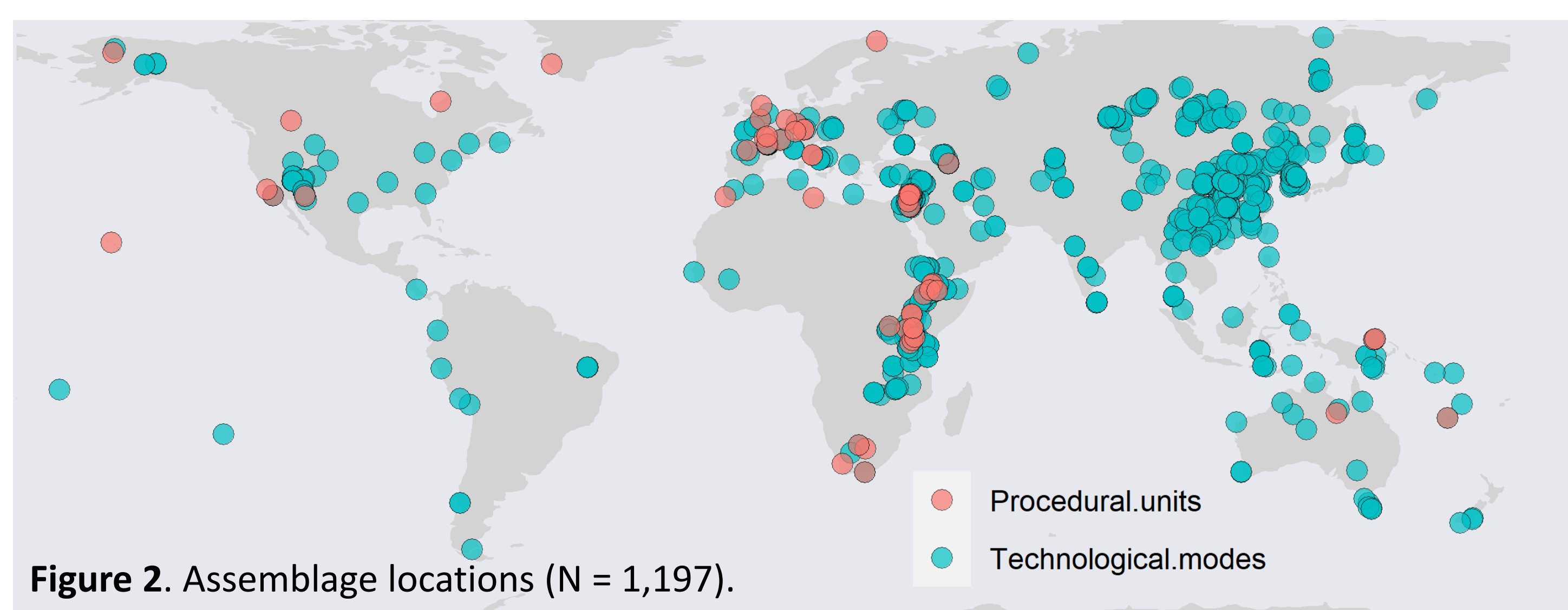
Cumulative culture is the ability to accumulate, new, modified, and increasingly complex practices across generations (Mesoudi and Thornton 2018). It was likely a significant driver in the evolution of hominin brain size, life history, and body shape (Boyd et al. 2011). However, the evolutionary history of cumulative culture is not well understood (Corbey et al. 2016, Tennie et al. 2017). We identify when hominins began relying on tool production sequences so long, and technological repertoires so extensive that it is unlikely that hominins could develop and maintain those technologies without some form of cumulative culture.



**Figure 1.** Different flintknapping techniques, or “procedural units” can be performed one after the other to produce many different kinds of chipped stone technologies. The cultural accumulation of procedural units is part of how hominins have explored diverse technological practices over the course of 3 million years. The number of procedural units required to produce a technology (y axis), and the number of distinct kinds of technological practices is a measurement of technological complexity.

## Collecting Stone Tool Data

- Performed a meta-analysis of published descriptions of lithic assemblages, and existing databases, spanning the Plio-Pleistocene through late Holocene.
- The total number of procedural units, or the distinct flintknapping techniques involved in making stone tools (fig 1), were collected from 71 assemblages.
- The total number of technological modes, or distinct kinds of tools and cores, were collected from published datasets (Shea 2016, 2020), *PaleoAsiaDB* (Nishiaki et al. 2021) and from the literature (1,126 assemblages).



**Figure 2.** Assemblage locations (N = 1,197).

Mesoudi, A., & A. Thornton. (2018). “What Is Cumulative Cultural Evolution?” *Proceedings of the Royal Society B: Biological Sciences* 285 (1880)

Corbey, R., A. Jagich et al. (2016). “The Acheulean Handaxe: More Like a Bird’s Song Than a Beatles’ Tune?” *Evolutionary Anthropology* 25 (1): 6–19.

Lesnik, J. J., Sanz, C. M., & Morgan, D. B. (2015). The Interdigital Brace and Other Grips for Termite Nest Perforation by Chimpanzees of the Goulougo Triangle, Republic of Congo. *American Journal of Physical Anthropology*, 157(2), 252–259.

Moore, M. W., & Perston, Y. (2016). Experimental insights into the cognitive significance of early stone tools. *PLoS One*, 11(7)

Nishiaki, Yoshihiro, K. Tamura, M. Suzuki, M. Nakamura, et al. (2021). “Spatiotemporal Variability in Lithic Technology of Middle-to-Upper Paleolithic Asia: A New Dataset and Its Statistical Analyses.” *Quaternary International* 596: 144–154

Sanz, C., Call, J., & Morgan, D. (2009). Design complexity in termite-fishing tools of chimpanzees (Pan troglodytes). *Biology Letters*, 5(3), 293–296.

Shea, J. (2016). *Stone Tools in Human Evolution: Behavioral Differences Among Technological Primates*. Cambridge University Press

Shea, J. (2020). *Prehistoric Stone Tools of Eastern Africa: A Guide*. Cambridge University Press.

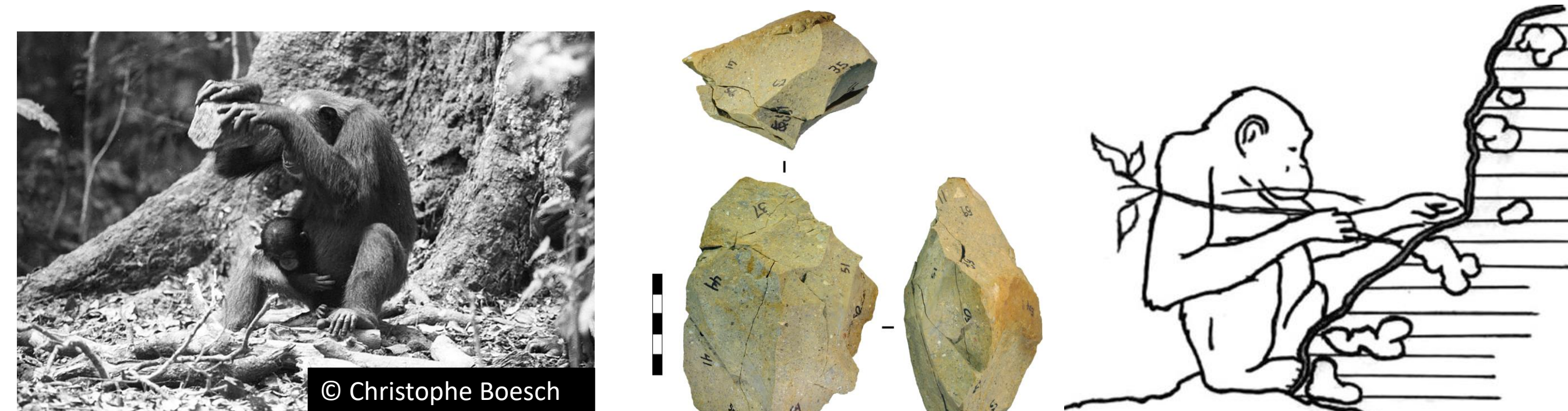
Tennie, C., L. S. Premo, et al. (2017). “Early Stone Tools and Cultural Transmission: Resetting the Null Hypothesis.” *Current Anthropology* 58 (5): 652–72

Visalberghi, E., Sirianni, et al. (2015). Percussive tool use by Tai Western chimpanzees and Fazenda Boa Vista bearded capuchin monkeys: A comparison. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1682).

## Establishing Baselines. How complex can technologies be without cumulative culture?

We established three baselines representing technological complexity achievable without cumulative culture.

- The number of procedural units involved in using a hammerstone and anvil among Tai chimpanzees (fig. 3 left, Visalberghi et al. 2015).
- The number of procedural units, and different kinds of technological modes that can be produced through a randomized flaking algorithm (fig. 3 middle, Perston and Moore 2013).
- The number of procedural units involved in the production of termite mound perforators and probes among Chimpanzee groups in the Goulougo Triangle (fig. 3 right, Lesnik et al. 2015, Sanz et al. 2009).

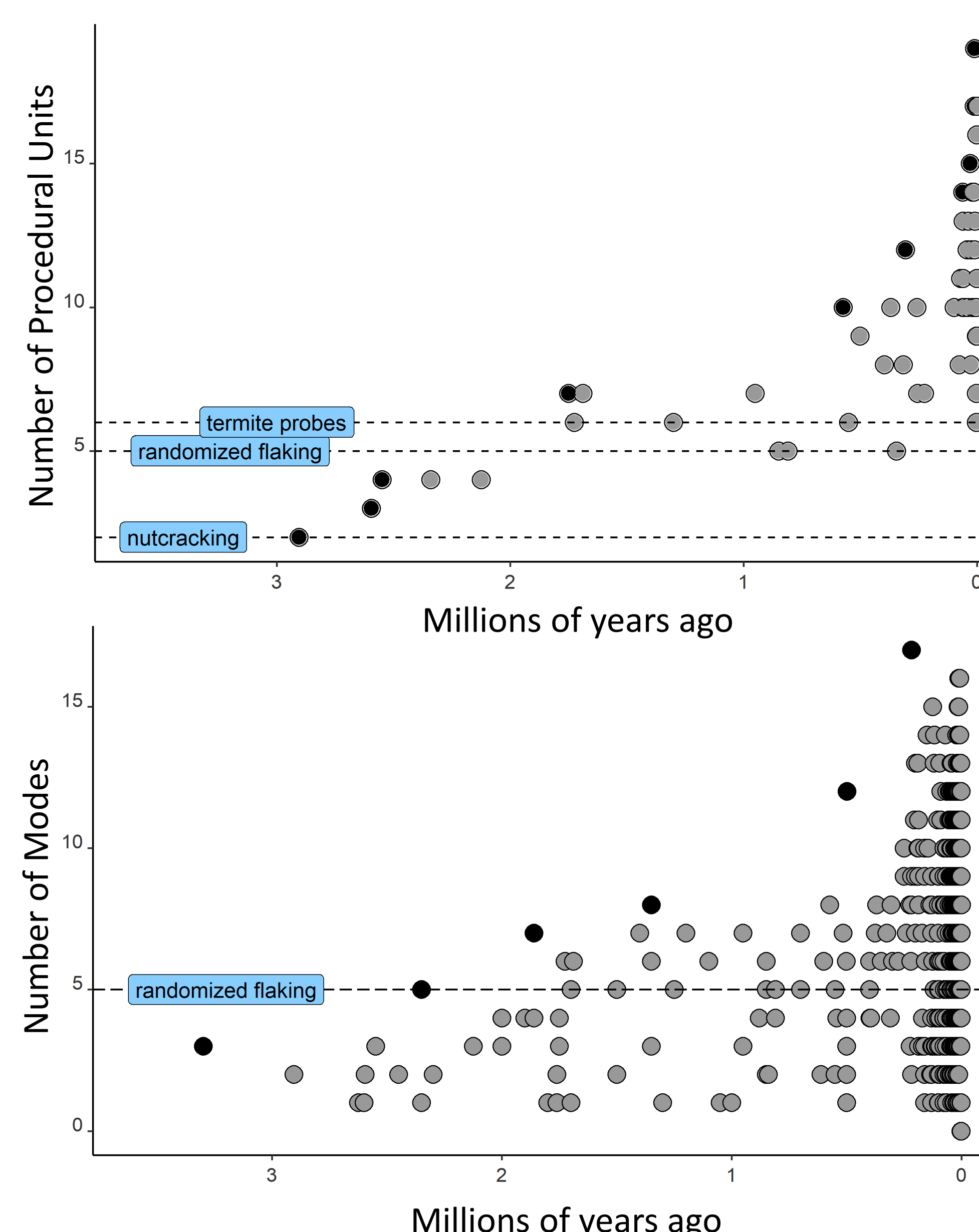


**Figure 3.** Non-human primate technology, and randomized flaking baselines.

## Result 1: Technological complexity above baselines after ~2mya

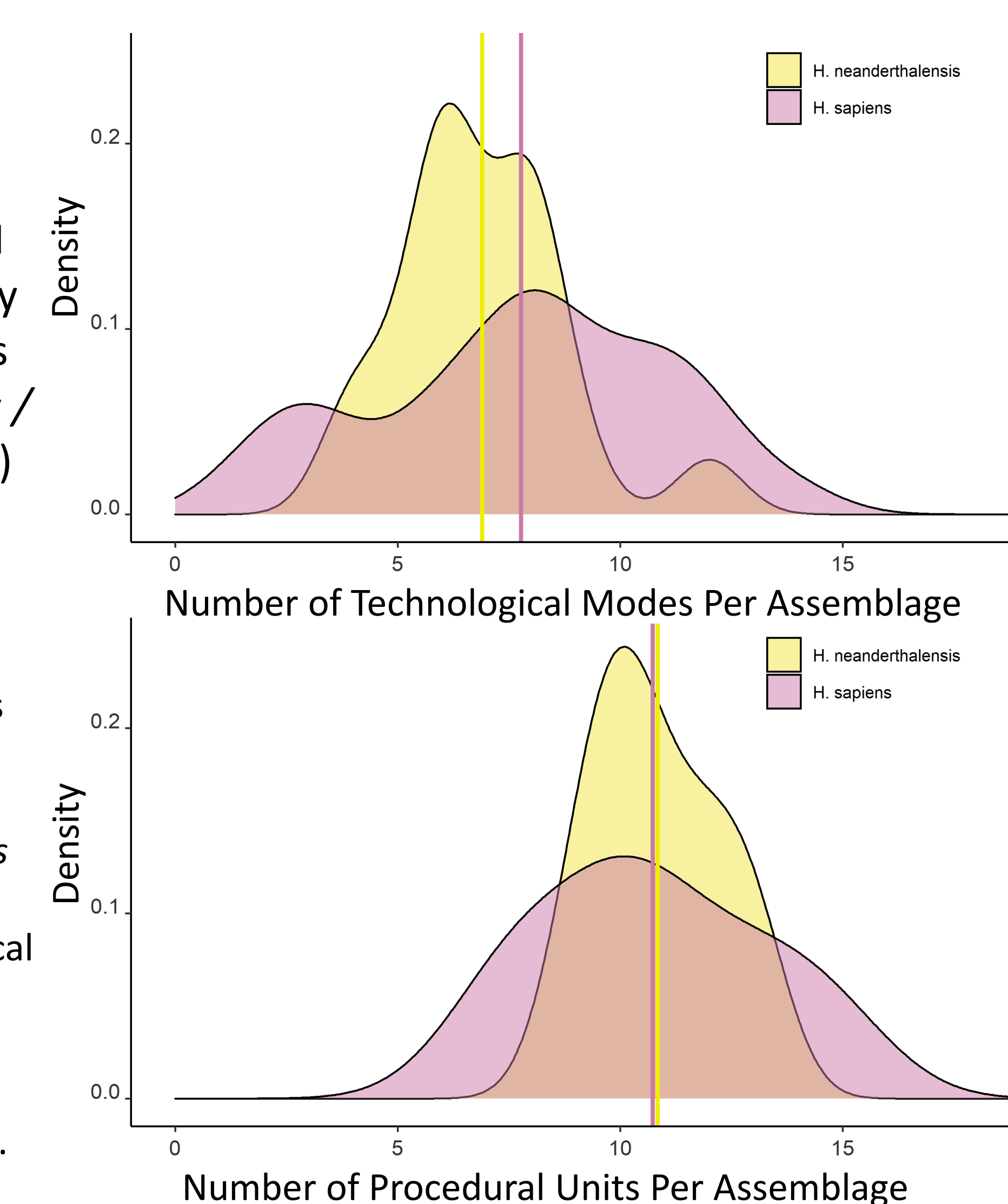
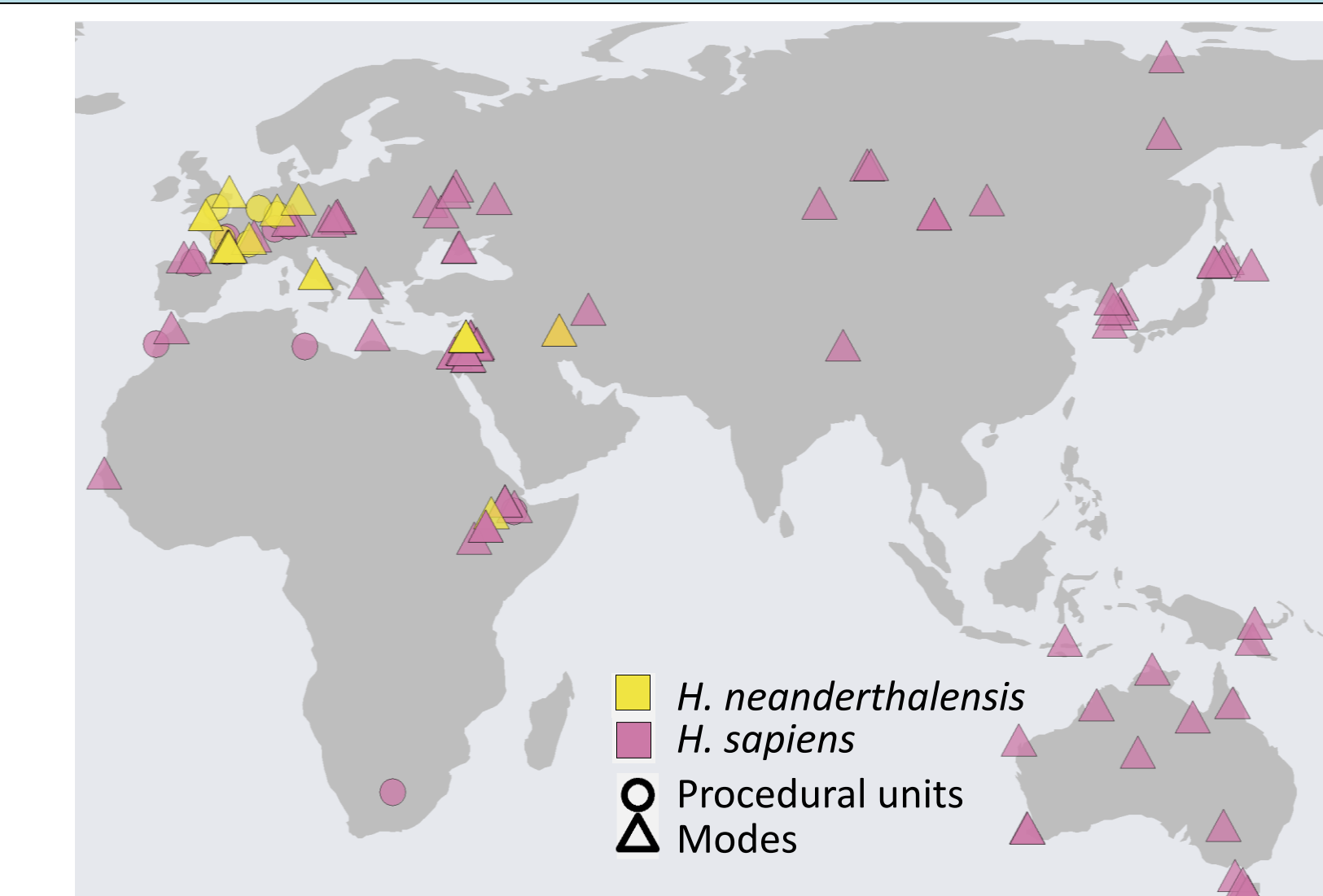
- Technologies above baselines postdate 2 million years ago.
- Similar pattern in both procedural units and technological modes
- Later hominins still relied on relatively simple, easy to learn (but effective) technologies.
- Hominins continue to explore more complex and extensive technological repertoires into the Holocene.

**Figure 3.** Procedural units (top) and technological modes (bottom) per assemblage over time compared to baselines.



## Result 2: Mixed evidence for differences in complexity between Neanderthals and Homo sapiens

- Compared assemblages associated with *H. neanderthalensis*/*H. heidelbergensis* and *H. sapiens*.
- Among procedural units (11 for *H. sapiens*, 6 for *H. neanderthalensis* / *H. heidelbergensis*), there is no statistically significant difference (Kolmogorov Smirnov test, P.value = 0.44)
- H. sapiens* assemblages (N = 104) tend to have slightly more technological modes than *H. neanderthalensis* / *H. heidelbergensis* (N = 18) (Kolmogorov Smirnov Test p-value < .00).



**Figure 4.** Map of assemblages associated with *H. neanderthalensis* / *H. heidelbergensis* and *H. sapiens* (top). Number of procedural units (middle) and technological modes (bottom) across archaeological assemblages divided by species. The solid vertical lines represent means.

## Summary and discussion

- Hominins likely were relying on technologies that would have required cumulative culture by ~1.8 mya.
- No differences in the number of procedural units involved in making Neanderthal and Modern human technologies. However, modern humans did have more kinds of tools and cores.
- Neanderthals and Modern Humans likely had similar shared capacity for cumulative culture.
- Overall results are consistent with the early evolution of cumulative culture in the Hominin lineage, and not consistent with cumulative culture being unique to modern humans.

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