The Origins of Stone Tool Reduction and the Transition to Knapping
An Experimental Approach

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Introduction

- The earliest Oldowan artifacts were made by skilled toolmakers who had a clear understanding of the fracturing mechanics of different toolstone materials (1-6).
- A gradualist approach requires intermediate tool reduction stages prior to 2.6 Ma (1, 7).
- Three lithic reduction techniques that are within the behavioral repertoire of *Pan* include direct and indirect projectile percussion and bipolar flaking techniques (e.g. 8-10; Fig. 1).
- This paper explores the feasibility of alternative reduction techniques for producing sharp flakes and the reasons why hominins may have transitioned to knapping.

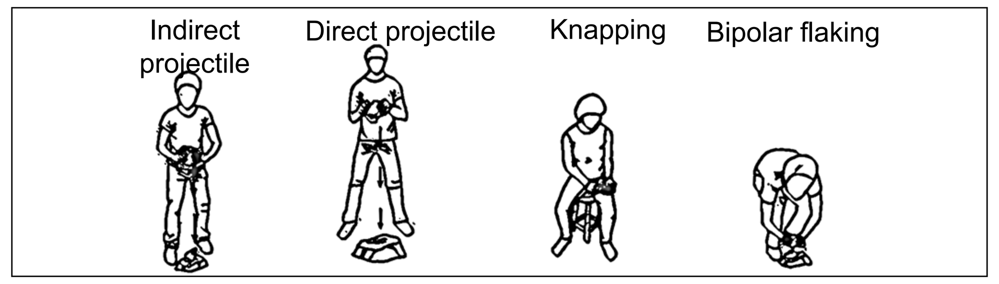

Figure 1. Lithic reduction techniques

Methods

- One male and one female reduced ten cores in each condition.
- The productivity, expediency, and efficiency of each method were determined through a series of measurements from the stone tool debris and video recordings (Table 1).
- A combination of ANOVA and Kruskal-Wallis tests were used to detect significant differences between the conditions.

Table 1. List of measurements recorded for each category.

Productivity	Expediency	Efficiency
Total number of usable flakes per core	Number of flakes produced per second	% core mass into usable flakes % core mass into non-usable elements % core mass into unexploited core
Usable flakes/core mass	Total time duration to exploit the core/core mass	Number of strikes per minute
Maximum cutting edge length		Number of strikes/core mass
Cutting edge length/flake mass		Number of lithic elements produced per strike
Flake size/flake mass		Number of usable flakes produced per strike

Results

Productivity

- The knapping condition produced significantly more usable flakes per gram than the direct projectile ($p = 0.019$) and indirect projectile ($p = 0.044$) conditions.
- Knapping also produced flakes with significantly longer cutting edges than bipolar flaking ($p = 0.005$) and indirect projectile percussion ($p = 0.001$); however, when flake mass was taken into account, there were no significant differences between the conditions (Fig. 2).

Expediency

- Bipolar flaking consistently and significantly reduced a core in the shortest amount of time of all the conditions ($p = 0.016$; Fig. 3).
- While indirect projectile percussion produced the largest number of flakes per second, no significant difference exists between the conditions ($p = 0.139$).

Efficiency

- The efficiency of raw material use was similar for each reduction technique in terms of the proportion of usable flakes vs. non-usable material and the percentage of core exploited.
- Novice knapping consistently performed poorly across all other measures of efficiency.
- Knapping required significantly more strikes per gram ($p < 0.001$) and per minute ($p < 0.05$) than any of the other conditions (Fig. 4).
- The indirect projectile condition produced an average of 1.2 usable flakes per strike, while novice knapping only produced 0.38 usable flakes per strike ($p < 0.001$; Fig. 5).

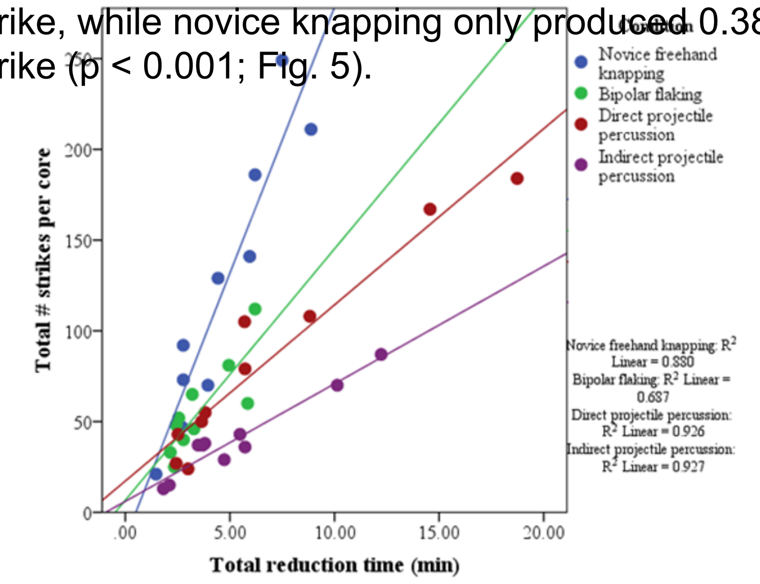

Figure 4. The relationship between the amount of time and the number of strikes required to reduce a core for each lithic reduction condition. Best fit lines reveal novice freehand knapping's inefficient use of energy in comparison to the other techniques.

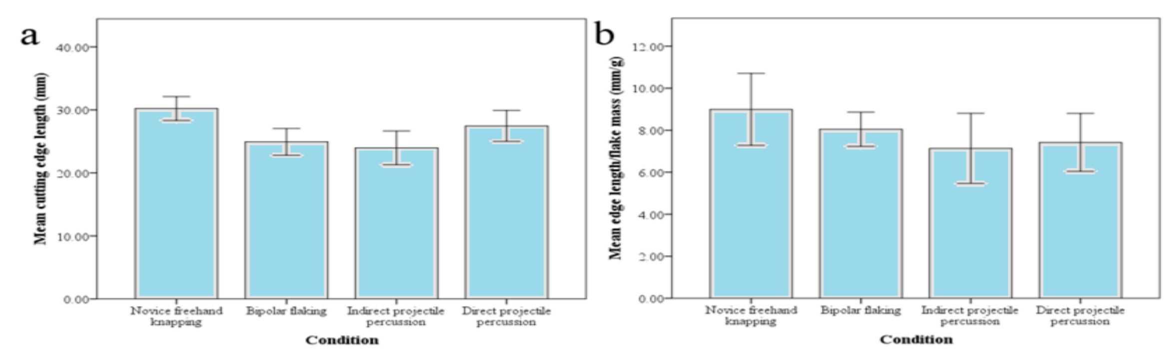

Figure 2. Comparison of the productivity of the lithic reduction conditions in terms of (a) the mean maximum flake cutting edge length and (b) the mean maximum cutting edge length per flake mass. Error bars represent 95% confidence intervals.

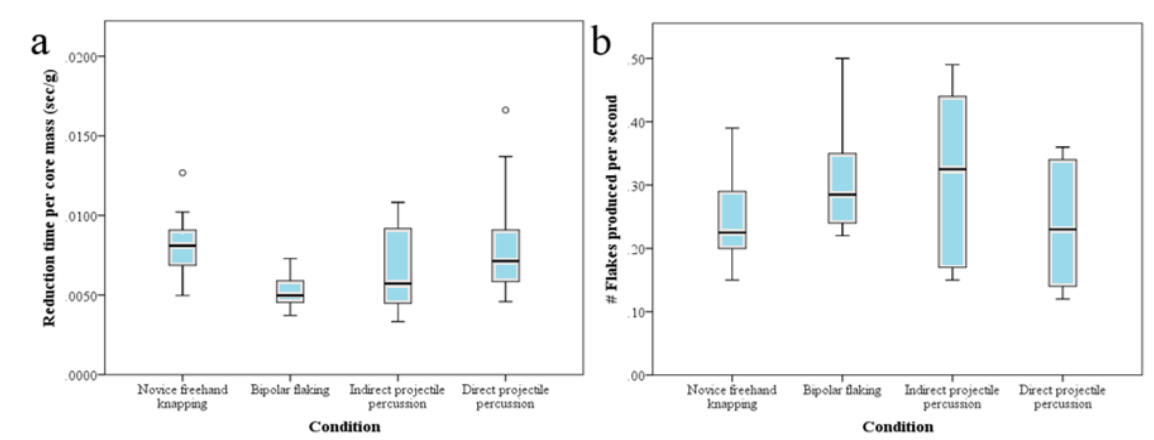

Figure 3. Comparison of the expediency of the lithic reduction conditions in terms of the (a) reduction time per core mass and (b) the mean number of flakes produced per second.

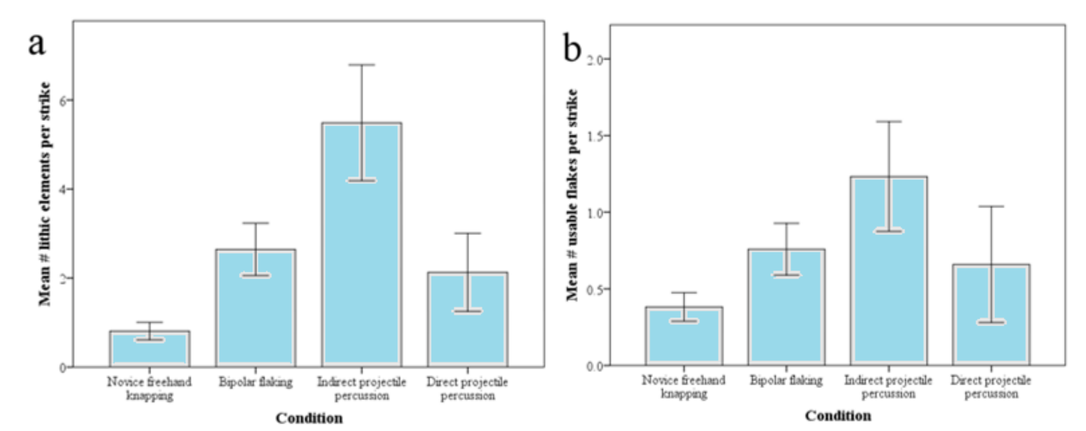

Figure 5. Efficient use of energy measured by (a) the mean number of lithic elements produced per strike and (b) the mean number of usable flakes produced per strike. Error bars represent 95% confidence intervals.

Discussion

- There has been little attention paid to the expedient and efficient nature of projectile percussion methods for flake production in the Early Stone Age.
- Some controversial, archaeological and anatomical evidence exists for projectile and bipolar flaking techniques being used by hominins prior to 2.6 Ma, such as early cut marks (11), derived features of the hand for advanced throwing and clubbing grips (e.g. 12-13), and the expansion of Broca's area in *Homo habilis* and its homologue in throwing chimpanzees (14-16).
- Percussive tasks may have been the most significant technical activities at several Olduvai sites, even surpassing knapping (17).
- Severely battered anvils at Olduvai that do not fit the pattern of bipolar or block-on-block reduction (18) may be better explained by projectile reduction techniques, similar to what was observed in this experiment.
- The increase in productivity, even at the beginning stages of knapping, would have provided enough incentive for hominins to continue the activity and increase their skill with more experience.

Summary and Conclusion

- Bipolar and throwing techniques are effective, alternative lithic reduction methods to knapping that early hominins with a primitive hand structure and little understanding of the mechanics of conchoidal fracture would have been capable of doing to obtain sharp stone flakes.
- Indirect projectile percussion was found to be the most efficient technique relative to the other conditions tested, while bipolar flaking was the most expedient.
- Novice knapping produced the most productive tools for butchery.
- This preliminary experiment provides evidence that the transition to knapping may have been the result of a shifting emphasis to productive toolmaking over expediency or efficiency.

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Further Information

- **Contact:** shelby-putt@uiowa.edu
- **Full article:** Putt, S.S. (2015). The origins of stone tool reduction and the transition to knapping: An experimental approach. *Journal of Archaeological Science: Reports* 4, pp #.

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