Noname manuscript No.
(will be inserted by the editor)

Testing the motor and cognitive foundations of Paleolithic social transmission

Justin Pargeter 1, 2 · Megan Beney Kilgore 3 · Cheng Liu 3 · Dietrich Stout 3 ·

Received: date / Accepted: date

Abstract Stone tools provide key evidence of human cognitive evolution but remain difficult to interpret. Toolmaking skill-learning in particular has been understudied even though: 1) the most salient cognitive demands of toolmaking should occur during learning, and 2) variation in learning aptitude would have provided the raw material for any past selection acting on tool making ability. However, we actually know very little about the cognitive prerequisites of learning under different information transmission conditions that may have prevailed during the Paleolithic. This paper presents results from a pilot experimental study to trial new experimental methods for studying the effect of learning conditions and individual differences on Oldowan flake-tool making skill acquisition. We trained 23 participants for 2 hours to make stone flakes under two different instructional conditions (observation only vs. direct active teaching) employing appropriate raw materials, practice time, and real human interaction. Participant performance was evaluated through analysis of the

Grants or other notes about the article that should go on the front page should be placed here. General acknowledgments should be placed at the end of the article.

Justin Pargeter 1, 2
1. Department of Anthropology, New York University, New York, NY, USA; 2. Palaeo-Research Institute, University of Johannesburg, Auckland Park, South Africa
E-mail: justin.pargeter@nyu.edu

Megan Beney Kilgore 3
3. Department of Anthropology, Emory University, Atlanta, GA, USA
E-mail: megan.elizabeth.beney@emory.edu

Cheng Liu 3
3. Department of Anthropology, Emory University, Atlanta, GA, USA
E-mail: raylc1996@outlook.com

Dietrich Stout 3
3. Department of Anthropology, Emory University, Atlanta, GA, USA
E-mail: dwstout@emory.edu

stone artifacts produced. Performance was compared both across experimental groups and with respect to individual participant differences in grip strength, motor accuracy, and cognitive function measured for the study. Our results show aptitude to be associated with fluid intelligence in a verbally instructed group and with a tendency to use social information in an observation-only group. These results have implications for debates surrounding the cumulative nature of human culture, the relative contributions of knowledge and know-how for stone tool making, and the role of evolved psychological mechanisms in "high fidelity" transmission of information, particularly through imitation and teaching.

Keywords Oldowan · Stone toolmaking · Social learning · Individual variation · Cognitive aptitudes · Motor skills ·

1 Introduction

Stone tools have long been seen as a key source of evidence for understanding human behavioral and cognitive evolution (Darwin 1871; Oakley 1949; Washburn 1960). Pathbreaking attempts to infer specific cognitive capacities from this evidence largely focused on the basic requirements of tool production (Isaac 1976; Wynn 1979; Gowlett 1984; Wynn and Coolidge 2004). More recently, increasing attention has been directed to the processes and demands of stone tool making skill acquisition (Roux, Bril, and Dietrich 1995; Stout 2002; Stout et al. 2005; Geribàs, Mosquera, and Vergès 2010; Nonaka, Bril, and Rein 2010; Stout et al. 2011; Putt, Woods, and Franciscus 2014; Hecht et al. 2015; Duke and Pargeter 2015; Morgan et al. 2015; Stout and Khreisheh 2015; Lombao, Guardiola, and Mosquera 2017; Putt et al. 2017; Cataldo, Migliano, and Vinicius 2018; Putt, Wijeakumar, and Spencer 2019; Pargeter and Shea 2019; Pargeter et al. 2020). This is motivated by the expectation that the most salient cognitive demands of tool making should occur during learning rather than routine expert performance (Stout and Khreisheh 2015) and by interest in the relevance of different social learning mechanisms such as imitation (Rein, Nonaka, and Bril 2014; Stout et al. 2019), emulation (Tehrani and Riede 2008; Wilkins 2018), and language (Ohnuma, Aoki, and Akazawa 1997; Putt, Woods, and Franciscus 2014; Morgan et al. 2015; Lombao, Guardiola, and Mosquera 2017; Putt et al. 2017; Cataldo, Migliano, and Vinicius 2018) to the reproduction of Paleolithic technologies.

References

Cataldo, Dana Michelle, Andrea Bamberg Migliano, and Lucio Vinicius. 2018. "Speech, Stone Tool-Making and the Evolution of Language." *PLOS ONE* 13 (1): e0191071. https://doi.org/10.1371/journal.pone.0191071.

Darwin, Charles. 1871. *The Descent of Man, and Selection in Relation to Sex*. 1st ed. London: John Murray.

Duke, Hilary, and Justin Pargeter. 2015. "Weaving Simple Solutions to Complex Problems: An Experimental Study of Skill in Bipolar Cobble-Splitting." *Lithic Technology* 40 (4): 349–65. https://doi.org/10.1179/2051618515Y.0000000016.

Geribàs, Núria, Marina Mosquera, and Josep Maria Vergès. 2010. "What Novice Knappers Have to Learn to Become Expert Stone Toolmakers." *Journal of Archaeological Science* 37 (11): 2857–70. https://doi.org/10.1016/j.jas.2010.06.026.

Gowlett, John A. J. 1984. "Mental Abilities of Early Man: A Look at Some Hard Evidence." *Higher Education Quarterly* 38 (3): 199–220. https://doi.org/10.1111/j.1468-2273.1984.tb01387.x.

Hecht, E. E., D. A. Gutman, N. Khreisheh, S. V. Taylor, J. Kilner, A. A. Faisal, B. A. Bradley, T. Chaminade, and D. Stout. 2015. "Acquisition of Paleolithic Toolmaking Abilities Involves Structural Remodeling to Inferior Frontoparietal Regions." *Brain Structure and Function* 220 (4): 2315–31. https://doi.org/10.1007/s00429-014-0789-6.

Isaac, Glynn L. 1976. "Stages of Cultural Elaboration in the Pleistocene: Possible Archaeological Indicators of the Development of Language Capabilities." *Annals of the New York Academy of Sciences* 280 (1): 275–88. https://doi.org/10.1111/j.1749-6632.1976.tb25494.x.

Lombao, D., M. Guardiola, and M. Mosquera. 2017. "Teaching to Make Stone Tools: New Experimental Evidence Supporting a Technological Hypothesis for the Origins of Language." *Scientific Reports* 7 (1): 1–14. https://doi.org/10.1038/s41598-017-14322-y.

Morgan, T. J. H., N. T. Uomini, L. E. Rendell, L. Chouinard-Thuly, S. E. Street, H. M. Lewis, C. P. Cross, et al. 2015. "Experimental Evidence for the Co-Evolution of Hominin Tool-Making Teaching and Language." *Nature Communications* 6 (1): 6029. https://doi.org/10.1038/ncomms7029.

Nonaka, Tetsushi, Blandine Bril, and Robert Rein. 2010. "How Do Stone Knappers Predict and Control the Outcome of Flaking? Implications for Understanding Early Stone Tool Technology." *Journal of Human Evolution* 59 (2): 155–67. https://doi.org/10.1016/j.jhevol.2010.04.006.

Oakley, Kenneth P. 1949. *Man the Toolmaker*. London: Trustees of the British Museum.

Ohnuma, Katsuhiko, Kenichi Aoki, and And Takeru Akazawa. 1997. "Transmission of Tool-Making Through Verbal and Non-Verbal Commu-Nication: Preliminary Experiments in Levallois Flake Production." *Anthropological Science* 105 (3): 159–68. https://doi.org/10.1537/ase.105.159.

Pargeter, Justin, Nada Khreisheh, John J. Shea, and Dietrich Stout. 2020. "Knowledge Vs. Know-How? Dissecting the Foundations of Stone Knapping Skill." *Journal of Human Evolution* 145 (August): 102807. https://doi.org/10.1016/j.jhevol.2020.102807.

Pargeter, Justin, and John J. Shea. 2019. "Going Big Versus Going Small: Lithic Miniaturization in Hominin Lithic Technology." *Evolutionary An-*

thropology: Issues, News, and Reviews 28 (2): 72–85. https://doi.org/10.1002/evan.21775.

Putt, Shelby S., Sobanawartiny Wijeakumar, Robert G. Franciscus, and John P. Spencer. 2017. "The Functional Brain Networks That Underlie Early Stone Age Tool Manufacture." *Nature Human Behaviour* 1 (6): 1–8. https://doi.org/10.1038/s41562-017-0102.

Putt, Shelby S., Sobanawartiny Wijeakumar, and John P. Spencer. 2019. "Prefrontal Cortex Activation Supports the Emergence of Early Stone Age Toolmaking Skill." *NeuroImage* 199 (October): 57–69. https://doi.org/10.1016/j.neuroimage.2019.05.056.

Putt, Shelby S., Alexander D. Woods, and Robert G. Franciscus. 2014. "The Role of Verbal Interaction During Experimental Bifacial Stone Tool Manufacture." *Lithic Technology* 39 (2): 96–112. https://doi.org/10.1179/0197726114Z.00000000036.

Rein, Robert, Tetsushi Nonaka, and Blandine Bril. 2014. "Movement Pattern Variability in Stone Knapping: Implications for the Development of Percussive Traditions." *PLOS ONE* 9 (11): e113567. https://doi.org/10.1371/journal.pone.0113567.

Roux, Valentine, Blandine Bril, and Gilles Dietrich. 1995. "Skills and Learning Difficulties Involved in Stone Knapping: The Case of Stone-Bead Knapping in Khambhat, India." *World Archaeology* 27 (1): 63–87. https://doi.org/10.1080/00438243.1995.9980293.

Stout, Dietrich. 2002. "Skill and Cognition in Stone Tool Production: An Ethnographic Case Study from Irian Jaya." *Current Anthropology* 43 (5): 693–722. https://doi.org/10.1086/342638.

Stout, Dietrich, and Nada Khreisheh. 2015. "Skill Learning and Human Brain Evolution: An Experimental Approach." *Cambridge Archaeological Journal* 25 (4): 867–75. https://doi.org/10.1017/S0959774315000359.

Stout, Dietrich, Richard Passingham, Christopher Frith, Jan Apel, and Thierry Chaminade. 2011. "Technology, expertise and social cognition in human evolution." *The European Journal of Neuroscience* 33 (7): 1328–38. https://doi.org/10.1111/j.1460-9568.2011.07619.x.

Stout, Dietrich, Jay Quade, Sileshi Semaw, Michael J. Rogers, and Naomi E. Levin. 2005. "Raw Material Selectivity of the Earliest Stone Toolmakers at Gona, Afar, Ethiopia." *Journal of Human Evolution* 48 (4): 365–80. https://doi.org/10.1016/j.jhevol.2004.10.006.

Stout, Dietrich, Michael J. Rogers, Adrian V. Jaeggi, and Sileshi Semaw. 2019. "Archaeology and the Origins of Human Cumulative Culture: A Case Study from the Earliest Oldowan at Gona, Ethiopia." *Current Anthropology* 60 (3): 309–40. https://doi.org/10.1086/703173.

Tehrani, Jamshid J., and Felix Riede. 2008. "Towards an Archaeology of Pedagogy: Learning, Teaching and the Generation of Material Culture Traditions." *World Archaeology* 40 (3): 316–31. https://doi.org/10.1080/00438240802261267.

Washburn, Sherwood L. 1960. "Tools and Human Evolution." *Scientific American* 203 (3): 62–75. https://doi.org/10.1038/scientificamerican0960-62.

Wilkins, Jayne. 2018. "The Point Is the Point: Emulative Social Learning and Weapon Manufacture in the Middle Stone Age of South Africa." In, edited by Michael J. O'Brien, Briggs Buchanan, and Metin I. Eren, 153–74. Cambridge, MA: The MIT Press.

Wynn, Thomas. 1979. "The Intelligence of Later Acheulean Hominids." *Man* 14 (3): 371–91. https://doi.org/10.2307/2801865.

Wynn, Thomas, and Frederick L. Coolidge. 2004. "The expert Neandertal mind." *Journal of Human Evolution* 46 (4): 467–87. https://doi.org/10.1016/j.jhevol.2004.01.005.