



# Cultural cognition and technology: Mechanical actions speak louder than bodily actions. Comment on "Blind alleys and fruitful pathways in the comparative study of cultural cognition" by Andrew Whiten

François Osiurak, Nicolas Claidière, Giovanni Federico

## ► To cite this version:

François Osiurak, Nicolas Claidière, Giovanni Federico. Cultural cognition and technology: Mechanical actions speak louder than bodily actions. Comment on "Blind alleys and fruitful pathways in the comparative study of cultural cognition" by Andrew Whiten. *Physics of Life Reviews*, 2023, 44, pp.141-144. 10.1016/j.plrev.2022.12.013 . hal-04002214

**HAL Id: hal-04002214**

**<https://hal.science/hal-04002214>**

Submitted on 23 Feb 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**Cultural cognition and technology: Mechanical actions speak louder than  
bodily actions. Comment on “Blind alleys and fruitful pathways in the  
comparative study of cultural cognition” by Andrew Whiten**

François Osiurak<sup>1,2\*</sup>, Nicolas Claidière<sup>3</sup>, & Giovanni Federico<sup>4</sup>

<sup>1</sup>Laboratoire d’Étude des Mécanismes Cognitifs, Université de Lyon, 5 avenue Pierre Mendès  
France, 69676 Bron Cedex, France

<sup>2</sup>Institut Universitaire de France, 1 rue Descartes, 75231 Paris Cedex 5, France

<sup>3</sup>Aix-Marseille Univ, CNRS, LPC, 3 Place Victor Hugo, 13331 Marseille, France

<sup>4</sup>IRCCS Synlab SDN S.p.A., Via Emanuele Gianturco 113, 80143, Naples, Italy

\*Corresponding author (F. Osiurak)

Email: [francois.osiurak@univ-lyon2.fr](mailto:francois.osiurak@univ-lyon2.fr)

Laboratory website: <https://emc.univ-lyon2.fr/fr/equipes/cognition-outils-systemes/francois-osiurak/>

Twitter: <https://twitter.com/osiurakf>

**Keywords:** Cultural evolution; Imitation; Social learning; Technical reasoning; Tool use.

## **Main text**

The distinction between imitation and emulation has gained popularity and attracted much interest and enthusiasm since its introduction by Tomasello and his colleagues three decades ago [1–3]. Imitation describes social learning in which the observer reproduces both the model’s actions (i.e., the means) and the result (i.e., the end). By contrast, emulation occurs when the observer reproduces only the result. As stressed by Whiten [4] (see also, e.g., [5]), the tricky question is, what do “model’s actions” mean, particularly in the case of instrumental activities such as tool use? The first possibility is to consider that model’s actions refer to the mechanical actions performed by the model (i.e., the interaction between the tool and other objects). The second is to consider that model’s actions refer to the motor actions performed by the model (hereafter called *bodily action* to follow Whiten’s [4] terminology). In line with Byrne and Russon’s [6] concept of ‘program level imitation’, Whiten [4] argues that the *bodily-action* level is not really relevant – if not misleading – for studying the transmission of technical behavior between individuals and suggests to reorient the focus towards the *mechanical-action* level (for a similar view, see [7–10]). Interestingly, the same debate between *bodily-action*-centered versus *mechanical-action*-centered explanations has also occurred in the cognitive science literature to describe the cognitive processes at work when humans use tools (for reviews, see [11,12]). Recent evidence suggests the existence of a *mechanical-to-motor* cascade mechanism, which gives priority to mechanical actions over bodily actions. Said differently and to paraphrase Bernstein [13], a pioneer in the study of motor control, one must concentrate on the ‘what’ of the action (i.e., the mechanical action), the ‘hows’ (i.e., bodily actions) come later by themselves. Here we briefly present the work that supports this perspective before discussing how this finds echo in Whiten’s [4] perspective.

Most of our understanding of human tool-use behavior in the cognitive science literature comes from research on brain-damaged patients with tool-use disorders, also called *apraxia* of

42 tool use [14]. These patients show difficulties in selecting the familiar tools and in performing  
43 the mechanical actions appropriate for a given activity. These difficulties are not due to  
44 sensorimotor deficits (e.g., hemiplegia, hemiparesis) or, said simply, to a kind of clumsiness  
45 [15,16]. Since the last century, these disorders have been interpreted as reflecting the loss of  
46 tool-use motor programs [17–20], which contain information about the bodily actions  
47 associated with the use of familiar tools (e.g., broad oscillation of the elbow and a power grip  
48 for a hammer). As apraxia of tool use is common after damage to the left inferior parietal lobe,  
49 it has been hypothesized that tool-use motor programs are stored within this brain region. Yet,  
50 as Whiten [4] argued, “... in acquiring much of our ‘cultural know-how’, such as widespread  
51 technologies like cooking, weaving, basket-making, pottery and weapon-making, any bodily  
52 imitative element is typically intimately meshed with copying resulting movements of objects,  
53 including the actions of tools on other objects” (p. 227). The same is true here. Why would  
54 these patients’ difficulties necessarily reflect a deficit at the “bodily-action” level and not at the  
55 “mechanical-action” level? Answering this question necessitated an epistemological shift.

56       This shift was initiated by a series of studies, particularly Goldenberg and colleagues’  
57 ones, in which left- and right-brain-damaged patients were asked to select, use and even  
58 sometimes make novel tools to solve mechanical problems [21–24]. These studies found a  
59 strong behavioral link between performance in these novel tool-use tasks and performance in  
60 the classical familiar tool-use tasks commonly used to characterize tool-use disorders. Brain-  
61 lesion studies also revealed that a same cerebral network involving the area PF within the left  
62 inferior parietal lobe was critical for both novel and familiar tool use (e.g., [22,25]; for review,  
63 see [26]), thus implying that the same cognitive processes were at work in both tasks. As  
64 claimed by Goldenberg and Spatt [22], “[w]e found that parietal lesions interfered even more  
65 with Novel than with Common Tools and, among the subscores of Novel Tools, even stronger  
66 with their selection than their actual use. These results support the conclusion that the parietal

67 lobe contribution to tool use concerns general principles of tool use rather than knowledge of  
68 the prototypical use of common tools and objects, and the comprehension of mechanical  
69 interactions of the tool with other tools, recipients or materials rather than the selection of grip  
70 formation and manual movements” (p. 1653). The role of the left area PF in the understanding  
71 of mechanical actions and, more generally, of physical principles was confirmed by  
72 neuroimaging studies, which demonstrated that this brain region is preferentially activated  
73 when healthy participants (1) focus on mechanical actions and not on bodily actions in tool-use  
74 tasks [27], (2) observe others performing tool-use actions but not non-tool-use actions (e.g.,  
75 grasping an object) [28], and (3) reason about physical events (e.g., a tower that falls) [29]. The  
76 cortical thickness of the left area PF also predicts performance in psychotechnical tests [30]. To  
77 sum up, the left area PF plays a key role in a more general cerebral network dedicated to the  
78 understanding of our physical world and of the techniques we, humans, have developed over  
79 time. Contrary to the tool-use motor programs hypothesis, this perspective stresses that we do  
80 not use tools because we are able to manipulate them, but because we understand the underlying  
81 physical principles. The selection of the appropriate bodily actions to use tools “comes only  
82 later by themselves”. Evidence for this mechanical-to-motor cascade mechanism has been  
83 provided recently by a series of eye-tracking studies, which have shown that healthy  
84 participants tend to fixate first the functional part of a tool (e.g., the head of a hammer) and then  
85 the manipulative part (e.g., the handle of a hammer) when a pair of tools are presented on a  
86 screen ([31]; see also [32]). Also consistent with this cascade mechanism, this pattern is  
87 observed only when the mechanical action between the two objects is easy to infer mechanically  
88 (e.g., salami–steel knife). However, when the mechanical action between the tool and the object  
89 is not easy to infer mechanically (e.g., alarm clock–bottle opener), participants spend more time  
90 looking at the functional part of the tool and almost no time at the manipulative part, suggesting  
91 that the cascade mechanism does not take place [31,33,34].

Taken together, these findings support the same conclusions as the one drawn by Whiten [4] with respect to cultural phenomena: How technological know-how is transmitted between individuals and how individuals use this know-how to use tools seem to be first and foremost driven by mechanical-action-centered cognitive processes. This conclusion does not imply that this is true in domains other than the technological one (e.g., communicative gestures, dance), for which bodily-action-centered cognitive processes could play a primary role (for a similar view, see [4,7,8,10]; see also [4]). This is also in accordance to the idea that witnessing a model acting can lead to social learning, which is true not only for humans [35] but also for nonhuman species such as chimpanzees [36]. Simply, moving the focus to the mechanical-action level inevitably incites us to envisage that non-social cognitive processes (e.g., causal understanding; see [37,38]) have a greater role to play in cultural phenomena than commonly thought [4,9,10,39–43]. This in turn raises new questions such as, why do some species extract more information from observing conspecifics' technical behavior than others? What are the cognitive processes that allow an individual to assimilate novel improvements to its repertoire [44,45]? These new avenues can lead us, as suggested by Whiten [4], to explore new fruitful pathways not only in the comparative study of cultural cognition, but also more generally in cognitive sciences.

## Acknowledgments

This work was supported by grants from the French National Research Agency (ANR; Project TECHNITION: ANR-21-CE28-0023-01; FO and NC) and the Région Auvergne-Rhône-Alpes (NUMERICOG-2017-900-EA 3082 EMC-R-2075; FO).

## References

- [1] Tomasello M, Davis-Dasilva M, Camak L, Bard K. Observational learning of tool-use by young chimpanzees. *Human Evolution* 1987;2:175–83. <https://doi.org/10.1007/BF02436405>.
- [2] Tomasello M. Cultural transmission in the tool use and communicatory signaling of chimpanzees? In: Parker ST, Gibson KR, editors. “Language” and intelligence in monkeys and apes. 1st ed., Cambridge University Press; 1990, p. 274–311. <https://doi.org/10.1017/CBO9780511665486.012>.

- 119 [3] Nagell K, Olguin RS, Tomasello M. Processes of social learning in the tool use of chimpanzees (*Pan*  
120 troglodytes) and human children (*Homo sapiens*). *Journal of Comparative Psychology* 1993;107:174–86.  
121 <https://doi.org/10.1037/0735-7036.107.2.174>.
- 122 [4] Whiten A. Blind alleys and fruitful pathways in the comparative study of cultural cognition. *Physics of Life*  
123 *Reviews* 2022;43:211–38. <https://doi.org/10.1016/j.plrev.2022.10.003>.
- 124 [5] Whiten A, Ham R. On the nature and evolution of imitation in the animal kingdom. *Advances in the study*  
125 *of behavior*, 1992, p. 239–83.
- 126 [6] Byrne RW, Russon AE. *Learning by imitation : A hierarchical approach* 1998:667–721.
- 127 [7] Heyes C. Imitation and culture: What gives? *Mind & Language* 2021:mila.12388.  
128 <https://doi.org/10.1111/mila.12388>.
- 129 [8] Heyes C. Imitation. *Current Biology* 2021;31:R228–32. <https://doi.org/10.1016/j.cub.2020.11.071>.
- 130 [9] Osiurak F, Reynaud E. The elephant in the room: What matters cognitively in cumulative technological  
131 culture. *Behavioral and Brain Sciences* 2020;43:e156. <https://doi.org/10.1017/S0140525X19003236>.
- 132 [10] Osiurak F, Claidière N, Federico G. Bringing cumulative technological culture beyond copying versus  
133 reasoning. *Trends in Cognitive Sciences* 2022:S1364661322002455.  
134 <https://doi.org/10.1016/j.tics.2022.09.024>.
- 135 [11] Osiurak F, Badets A. Tool use and affordance: Manipulation-based versus reasoning-based approaches.  
136 *Psychological Review* 2016;123:534–68. <https://doi.org/10.1037/rev0000027>.
- 137 [12] Buxbaum LJ. Learning, remembering, and predicting how to use tools: Distributed neurocognitive  
138 mechanisms: Comment on Osiurak and Badets (2016). *Psychological Review* 2017;124:346–60.  
139 <https://doi.org/10.1037/rev0000051>.
- 140 [13] Bernstein NA. *Dexterity and its development*. Erlbaum. Marwah: 1996.
- 141 [14] Osiurak F, Rossetti Y. Definition: Limb apraxia. *Cortex* 2017;93:228.  
142 <https://doi.org/10.1016/j.cortex.2017.03.010>.
- 143 [15] De Renzi E. Apraxia. In: Boller, F., Grafman J, editor. *Handbook of neuropsychology*, Amsterdam: 1989,  
144 p. 245–63.
- 145 [16] Goldenberg G. *Apraxia: The cognitive side of motor control*. New York: Oxford University Press; 2013.
- 146 [17] Heilman KM, Rothi LJ, Valenstein E. Two forms of ideomotor apraxia. *Neurology* 1982;32:342–6.
- 147 [18] Rothi LJG, Ochipa C, Heilman KM. A cognitive neuropsychological model of limb praxis. *Cognitive*  
148 *Neuropsychology* 1991;8:443–58. <https://doi.org/10.1080/02643299108253382>.
- 149 [19] Buxbaum LJ. Ideomotor apraxia: A call to action. *Neurocase* 2001;7:445–58.  
150 <https://doi.org/10.1093/neucas/7.6.445>.
- 151 [20] Van Elk M, van Schie H, Bekkering H. Action semantics: A unifying conceptual framework for the  
152 selective use of multimodal and modality-specific object knowledge. *Physics of Life Reviews*  
153 2014;11:220–50. <https://doi.org/10.1016/j.plrev.2013.11.005>.
- 154 [21] Goldenberg G, Hagmann S. Tool use and mechanical problem solving in apraxia. *Neuropsychologia*  
155 1998;36:581–9. [https://doi.org/10.1016/S0028-3932\(97\)00165-6](https://doi.org/10.1016/S0028-3932(97)00165-6).
- 156 [22] Goldenberg G, Spatt J. The neural basis of tool use. *Brain* 2009;132:1645–55.  
157 <https://doi.org/10.1093/brain/awp080>.
- 158 [23] Osiurak F, Jarry C, Allain P, Aubin G, Etcharry-Bouyx F, Richard I, et al. Unusual use of objects after  
159 unilateral brain damage. The technical reasoning model. *Cortex* 2009;45:769–83.  
160 <https://doi.org/10.1016/j.cortex.2008.06.013>.

- [24] Jarry C, Osiurak F, Delafuys D, Chauviré V, Etcharry-Bouyx F, Le Gall D. Apraxia of tool use: More evidence for the technical reasoning hypothesis. *Cortex* 2013;49:2322–33. <https://doi.org/10.1016/j.cortex.2013.02.011>.
- [25] Salazar-López E, Schwaiger BJ, Hermsdörfer J. Lesion correlates of impairments in actual tool use following unilateral brain damage. *Neuropsychologia* 2016;84:167–80. <https://doi.org/10.1016/j.neuropsychologia.2016.02.007>.
- [26] Osiurak F, Reynaud E, Baumard J, Rossetti Y, Bartolo A, Lesourd M. Pantomime of tool use: looking beyond apraxia. *Brain Communications* 2021;fcab263. <https://doi.org/10.1093/braincomms/fcab263>.
- [27] Reynaud E, Lesourd M, Navarro J, Osiurak F. On the neurocognitive origins of human tool use: A critical review of neuroimaging data. *Neuroscience and Biobehavioral Reviews* 2016;64:421–37. <https://doi.org/10.1016/j.neubiorev.2016.03.009>.
- [28] Reynaud E, Navarro J, Lesourd M, Osiurak F. To watch is to work: A review of neuroimaging data on tool use observation network. *Neuropsychology Review* 2019;29:484–97. <https://doi.org/10.1007/s11065-019-09418-3>.
- [29] Fischer J, Mikhael JG, Tenenbaum JB, Kanwisher N. Functional neuroanatomy of intuitive physical inference. *Proc Natl Acad Sci USA* 2016;113:E5072–81. <https://doi.org/10.1073/pnas.1610344113>.
- [30] Federico G, Reynaud E, Navarro J, Lesourd M, Gaujoux V, Lamberton F, et al. The cortical thickness of the area PF of the left inferior parietal cortex mediates technical-reasoning skills in press.
- [31] Federico G, Brandimonte MA. Tool and object affordances: An ecological eye-tracking study. *Brain and Cognition* 2019;135:103582. <https://doi.org/10.1016/j.bandc.2019.103582>.
- [32] Tamaki Y, Nobusako S, Takamura Y, Miyawaki Y, Terada M, Morioka S. Effects of Tool Novelty and Action Demands on Gaze Searching During Tool Observation. *Front Psychol* 2020;11:587270. <https://doi.org/10.3389/fpsyg.2020.587270>.
- [33] Federico G, Brandimonte MA. Looking to recognise: the pre-eminence of semantic over sensorimotor processing in human tool use. *Sci Rep* 2020;10:6157. <https://doi.org/10.1038/s41598-020-63045-0>.
- [34] Federico G, Osiurak F, Brandimonte MA. Hazardous tools: the emergence of reasoning in human tool use. *Psychological Research* 2021;85:3108–18. <https://doi.org/10.1007/s00426-020-01466-2>.
- [35] Flynn E, Whiten A. Dissecting children’s observational learning of complex actions through selective video displays. *Journal of Experimental Child Psychology* 2013;116:247–63. <https://doi.org/10.1016/j.jecp.2013.06.001>.
- [36] Hopper LM, Spiteri A, Lambeth SP, Schapiro SJ, Horner V, Whiten A. Experimental studies of traditions and underlying transmission processes in chimpanzees. *Animal Behaviour* 2007;73:1021–32. <https://doi.org/10.1016/j.anbehav.2006.07.016>.
- [37] Osiurak F, Lasserre S, Arbanti J, Brogniart J, Bluet A, Navarro J, et al. Technical reasoning is important for cumulative technological culture. *Nature Human Behaviour* 2021;5:1643–51. <https://doi.org/10.1038/s41562-021-01159-9>.
- [38] Osiurak F, Claidiere N, Bluet A, Brogniart J, Lasserre S, Bonhoure T, et al. Technical reasoning bolsters cumulative technological culture through convergent transformations. *Science Advances* 2022.
- [39] Singh M, Acerbi A, Caldwell CA, Danchin É, Isabel G, Molleman L, et al. Beyond social learning. *Phil Trans R Soc B* 2021;376:rstb.2020.0050, 20200050. <https://doi.org/10.1098/rstb.2020.0050>.
- [40] Brand CO, Mesoudi A, Smaldino PE. Analogy as a Catalyst for Cumulative Cultural Evolution. *Trends in Cognitive Sciences* 2021;25:450–61. <https://doi.org/10.1016/j.tics.2021.03.002>.
- [41] Perry S, Carter A, Smolla M, Akçay E, Nöbel S, Foster JG, et al. Not by transmission alone: the role of invention in cultural evolution. *Phil Trans R Soc B* 2021;376:20200049. <https://doi.org/10.1098/rstb.2020.0049>.



- 206 [42] Vale GL, McGuigan N, Burdett E, Lambeth SP, Lucas A, Rawlings B, et al. Why do chimpanzees have  
207 diverse behavioral repertoires yet lack more complex cultures? Invention and social information use in a  
208 cumulative task. *Evolution and Human Behavior* 2020.  
209 <https://doi.org/10.1016/j.evolhumbehav.2020.11.003>.
- 210 [43] Whiten A, Horner V, Marshall-Pescini S. Cultural Panthropology. *Evolutionary Anthropology* 2003;12:92–  
211 105. <https://doi.org/10.1002/evan.10107>.
- 212 [44] Davis SJ, Schapiro SJ, Lambeth SP, Wood LA, Whiten A. Behavioral conservatism is linked to complexity  
213 of behavior in chimpanzees (*Pan troglodytes*): Implications for cognition and cumulative culture. *Journal*  
214 *of Comparative Psychology* 2019;133:20–35. <https://doi.org/10.1037/com0000123>.
- 215 [45] Davis S, Rawlings B, Clegg JM, Ikejimba D, Watson-Jones RE, Whiten A, et al. Cognitive flexibility  
216 supports the development of cumulative cultural learning in children. *Sci Rep* 2022;12:14073.  
217 <https://doi.org/10.1038/s41598-022-18231-7>.