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► 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

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

4 François Osiurak^{1,2*}, Nicolas Claidière³, & Giovanni Federico⁴

5 ¹Laboratoire d'Étude des Mécanismes Cognitifs, Université de Lyon, 5 avenue Pierre Mendès
6 France, 69676 Bron Cedex, France

7 ²Institut Universitaire de France, 1 rue Descartes, 75231 Paris Cedex 5, France

8 ³Aix-Marseille Univ, CNRS, LPC, 3 Place Victor Hugo, 13331 Marseille, France

9 ⁴IRCCS Synlab SDN S.p.A., Via Emanuele Gianturco 113, 80143, Naples, Italy

10 *Corresponding author (F. Osiurak)

11 Email: francois.osiurak@univ-lyon2.fr

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

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

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

16

17 **Main text**

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

40 Most of our understanding of human tool-use behavior in the cognitive science literature
41 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].

92 Taken together, these findings support the same conclusions as the one drawn by Whiten
93 [4] with respect to cultural phenomena: How technological know-how is transmitted between
94 individuals and how individuals use this know-how to use tools seem to be first and foremost
95 driven by mechanical-action-centered cognitive processes. This conclusion does not imply that
96 this is true in domains other than the technological one (e.g., communicative gestures, dance),
97 for which bodily-action-centered cognitive processes could play a primary role (for a similar
98 view, see [4,7,8,10]; see also [4]). This is also in accordance to the idea that witnessing a model
99 acting can lead to social learning, which is true not only for humans [35] but also for nonhuman
100 species such as chimpanzees [36]. Simply, moving the focus to the mechanical-action level
101 inevitably incites us to envisage that non-social cognitive processes (e.g., causal understanding;
102 see [37,38]) have a greater role to play in cultural phenomena than commonly thought
103 [4,9,10,39–43]. This in turn raises new questions such as, why do some species extract more
104 information from observing conspecifics’ technical behavior than others? What are the
105 cognitive processes that allow an individual to assimilate novel improvements to its repertoire
106 [44,45]? These new avenues can lead us, as suggested by Whiten [4], to explore new fruitful
107 pathways not only in the comparative study of cultural cognition, but also more generally in
108 cognitive sciences.

109 **Acknowledgments**

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

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