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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**

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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.

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