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1                   **Exploring the interplay between humans and sports equipment in the quest for**  
2   **performance**

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6   **Abstract**

7   The processes of appropriation of tools, machines, and other kinds of equipment by human  
8   beings are often linked to the notions of transparency and incorporation. Sport situations  
9   provide appropriate conditions for exploring the interplay between humans and material  
10   equipment when users are engaged in a quest for performance. In the present opinion, we  
11   discuss the notions of transparency of sports equipment used by athletes, showing that the  
12   association between appropriation and transparency is not straightforward. Furthermore, we  
13   highlight distinctions between types of sports equipment based on the latter’s behavior in  
14   relation to the athlete’s activity. This leads us to suggest three directions of research that should  
15   develop a better understanding of the interplay between humans and sports equipment in  
16   particular, and more generally the interplay between humans engaged in a quest for  
17   performance and their material artefacts.

18   **Keywords**

19   Appropriation, Incorporation, Phenomenology, Sports Equipment, Perception, Expertise,  
20   Sensorimotor Empathy

21  
22                   In a study exploring human perceptions of sports equipment under playing conditions,  
23   Roberts et al. (2001) interviewed professional golfers about their perceptions of using different  
24   golf clubs. One of them expressed himself thus: “You want the whole thing balanced together  
25   so that when you hit it, it feels it’s all part of you. You want the club to feel part of yourself  
26   really” (quoted by Roberts et al., 2001, p. 493). This excerpt illustrates a classic

1 phenomenological view on tool appropriation as becoming “transparent” in action, implying  
2 that it becomes integrated into one’s own body. Another illustration of this transparency is  
3 Merleau Ponty’s frequently cited example of the blind person’s cane: “the stick is no longer an  
4 object perceived by the blind man, but an instrument with which he perceives” (Merleau-Ponty,  
5 2002, p. 175). Likewise, Gapenne and Declerck (2009) stated that “the transparency of an  
6 instrument (i.e., its disappearance from the user’s focal field of attention) is manifestly an  
7 indication of its appropriation” (p. 367). In line with these perspectives, human-equipment  
8 systems can be considered as soft-assembled perceptual systems (Favela, 2019) in which the  
9 equipment is incorporated in the extended human body. Interestingly, while there is currently  
10 an interest for research on embodied relationships between humans and a variety of  
11 technological artefacts (Black, 2014), few studies have explored human perception of material  
12 equipment when the actors are engaged in a quest for performance. Studying athletes’ activity  
13 is known to contribute to the understanding of human adaptive behavior (Davids et al., 2006).  
14 In most sports, athletes make use of all kinds of equipment in their quest for performance, with  
15 examples being backpacks, golf clubs, tennis rackets, ice tools, sailboards, or boats. Despite the  
16 diversity of the intrinsic characteristics of these equipments, it might be expected that they  
17 integrally or partly become transparent to the athletes as they reach expertise, just as an author’s  
18 computer mouse is transparent to them when they use it to navigate on the screen while working  
19 on this paper, or a car becomes transparent to an experienced driver during their daily commute  
20 to work.

21         However, some research on sports equipment has shown that expert athletes are highly  
22 aware of their equipment during their ongoing performing action. For example, professional  
23 golfers feel whether or not they have control on the club head throughout the shot (Roberts et  
24 al., 2001). Adé et al. (2017) showed that expert ice climbers obtain information on the quality  
25 of the ice by feeling the vibrations of the shaft of their ice axes. Interestingly, even when the

1 equipment is designed to be transparent in the athlete's activity, the disappearance from the  
2 athlete's field of experience is not guaranteed as it is highly dependent on the context of  
3 performance. For example, Rochat et al. (2019) found that the perception of backpacks by trail  
4 runners was more significant in the less technical trails. Similarly, Poizat et al. (2010)  
5 determined that using a Measuring Active Drag system (MAD system) contributed to the  
6 emergence of uncomfortable sensations in elite swimmers' experience when swimming at low  
7 and maximum speeds. These few cases in point also highlight distinctions of the status of sports  
8 equipment in the athlete's experience. The golfing example demonstrates an awareness of the  
9 club head movement that indicates a quality of control over the equipment for reaching an  
10 expected performance (Roberts et al., 2001). The instance of the ice axe brings to the fore the  
11 awareness of the ice axe shaft acting as a tool that reveals information about the ice's properties  
12 (Adé et al., 2017). The examples of the backpack and the MAD system show that an awareness  
13 of these pieces of equipment is experienced by athletes as a disturbance in the course of their  
14 activities (Poizat et al., 2010; Rochat et al., 2019).

15         Furthermore, the studies of Terrien et al. (2020, 2022, 2023, in press) in sailing have  
16 shown that the behavior of sports equipment affects the interplay between athletes and their  
17 equipment. Indeed, some sports equipment exhibits behaviors that are not directly controlled  
18 by the athletes. For instance, the movements of hydrofoil sailing watercrafts (e.g., in  
19 windsurfing, kitesurfing, double-handed sport catamaran) are partly produced by forces created  
20 through a craft's coupling with the environment (e.g., aerodynamic forces in the sail and  
21 hydrodynamic forces in the foil). This contrasts with the movements of a backpack, which stop  
22 if the runner stops moving, or the movement of a golf club, which directly depends on the forces  
23 applied by the golfer. The studies of Terrien et al. (2020, 2022, 2023, in press) were conducted  
24 within the course-of-experience framework (Poizat et al., 2022; Terrien et al., 2023; Theureau,  
25 2006) with elite sailors. The aim of this research was primarily to study the interplay between

1 humans, sports equipment and the environment by analyzing sailors' intentions, expectations,  
2 knowledge, perceptions and actions, in relation to the equipment's movements. The results of  
3 these studies contain several elements that contribute to the understanding of the interplay  
4 between humans and sports equipment. For instance, the studies of Terrien et al. (in press) and  
5 Terrien et al. (2023) in Formula Kite and windsurfing reveal that the sailors are highly sensitive  
6 to the transmission of power between sail, body and board. These studies suggest that the riders'  
7 assessment of performance partly depends on these perceptions of balance. As a case in point,  
8 in Formula Kite (Terrien et al., in press), when everything is going well, riders perceive the pull  
9 of the kite in the direction they want to go. This sensitivity to transmission balance was also  
10 identified in windsurfing, where riders express the sensation of feeling the sail "sucking  
11 forward" that they associate with episodes of optimal performance (Terrien et al., 2023). While  
12 it could be expected that optimal performance is perceived when the equipment becomes  
13 transparent, while poor performance would be associated with opacity of the equipment, the  
14 above examples demonstrate that fine perceptions of the equipment remain, even during  
15 optimal episodes of performance. Moreover, these permanent perceptions of the equipment  
16 appear to provide relevant information to the sailor in self-assessing their performance. The  
17 studies on double-handed foiling catamarans (Terrien et al., 2020, 2022) suggest that from each  
18 sailor's perspective the boat can be considered as a partner that sometimes responds to the  
19 sailor's action, but at other times needs them to accompany it in its movements. That is, reaching  
20 optimal performance on double-handed foiling catamarans involves both controlling the boat  
21 and accepting to be controlled by its movements. Indeed, solving this paradox presupposes that  
22 the sailor develops and maintains a fine sensitivity to the boat's movements; this would not be  
23 compatible with the idea of a boat becoming transparent to expert sailors.

24         At elite level, there is no doubt that the recurrent use of sports equipment by athletes  
25 leads to an advanced process of appropriation that includes integration of the sports equipment

1 in the athletes' own bodies (i.e., incorporation). While incorporation is usually assimilated to  
2 disappearance from the field of experience, the elements presented in the present opinion paper  
3 suggest that the relation between expertise, appropriation and transparency of sports equipment  
4 is not obvious. We suggest three directions of research to develop a better understanding of the  
5 interplay between humans and sports equipment in the quest for performance. The first is to  
6 interrogate the notion of transparency in relation to the situation, as did Rochat et al. (2019).  
7 For example, the situation of optimal performance may be accompanied by higher sensitivity  
8 to sports equipment than the sensitivity we have to our usual equipment in daily routines. This  
9 would be in line with the research focused on bodily awareness of athletes absorbed in a quest  
10 for performance activity, rebutting the association between expert skills and automaticity of  
11 movement execution (Gallagher, 2020; Montero, 2010). Secondly, we suggest that the process  
12 of appropriation of sports equipment that has behavior of its own, such as in sailing sports, may  
13 include the development of sensorimotor empathy (Chemero, 2016; Leblanc et al., 2022)  
14 together with a certain degree of incorporation. Indeed, the research we have presented in  
15 sailing has shown that sailors need to "understand" their craft's movements and possibilities of  
16 movement through their own bodies. Thirdly, we suggest developing the reflection of Terrien  
17 et al. (2022) on the distinctions between classes of sports equipment, by considering their degree  
18 of autonomous behavior and the implication of this on appropriation processes.

19 In conclusion, in the present opinion paper we have used examples from sports for  
20 apprehending the interplay between humans and material artefacts, in performance-seeking  
21 activities. Along the way, we pointed out issues that are subject of intense debate in 4E  
22 cognition approaches such as the phenomenal characterization of transparency and the non-  
23 consensual relationship between transparency and incorporation of artefacts (Facchin, 2022;  
24 Gallagher, 2023). Considering all this, we encourage further empirical research on the interplay

1 between humans and material artefacts in order to gain improved understanding of the processes  
2 of embodied appropriation of tools and machines.

3

#### 4 **Authors' bios**

5 Eric Terrien is a postdoctoral researcher at Nantes Université, member of the Movement,  
6 Interaction, Performance laboratory (MIP, EA 4334) and a former professional athlete. His  
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8 situations from an enactive perspective. His current research consists of analyzing elite athletes'  
9 individual and collective activity in Olympic sailing.

10 Benoît Huet is associate professor at Nantes Université and member of the Movement,  
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12 on individual and collective cognition in sports and physical education situations, and the  
13 exploration of the sensorimotor dimensions of human experience from an enactive perspective.

14 Jacques Saury is professor emeritus at Nantes Université and member of the Movement,  
15 Interaction, Performance laboratory (MIP, EA 4334). His research interests are focused on  
16 individual and collective cognition and human performance in sports and in physical education  
17 situations from an enactive perspective. His recent research has more particularly explored the  
18 experiences of elite athletes aiming to optimize their performance in interaction with their sports  
19 equipment, particularly in Olympic sailing and rowing. These research involves methodologies  
20 for analyzing activity in real-life situations, including first-person and third-person methods for  
21 activity analysis.

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