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► To cite this version:

Nadège Rochat, Denis Hauw, Ludovic Seifert. Enactments and the design of trail running equipment: An example of carrying systems. *Applied Ergonomics*, 2019, 80, pp.238-247. 10.1016/j.apergo.2018.07.002 . hal-02364401

HAL Id: hal-02364401

<https://hal.science/hal-02364401>

Submitted on 25 Oct 2021

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Enactments and the design of trail running equipment: An example of carrying systems

Nadège Rochat

Institute of Sport Sciences of the University of Lausanne (ISSUL), Switzerland

Centre d'Etude des Transformations des Activités Physiques et Sportives (CETAPS) – EA

3832, University of Rouen, Faculty of Sports Sciences, Mont Saint Aignan, France

Raidlight-Vertical SAS, Saint-Pierre-de-Chartreuse, France

Denis Hauw

Institute of Sport Sciences of the University of Lausanne (ISSUL), Switzerland

Ludovic Seifert

Centre d'Etude des Transformations des Activités Physiques et Sportives (CETAPS) – EA

3832, University of Rouen, Faculty of Sports Sciences, Mont Saint Aignan, France

Corresponding author:

Nadège Rochat

Institute of Sport Sciences

Géopolis Building

CH-1015 Lausanne

Switzerland

Email: nadege.rochat@unil.ch

Tel: +41 (0)21 692 38 07

Fax: +41 (0)21 692 32 93

Grant from ANRT under a CIFRE agreement (Industrial Convention of Learning by Research) with Raidlight and Swiss universities.

Abstract

Sports equipment brands have increasingly turned to experience-centered design, meaning the integration of users' activity into the design process. From an enactive perspective, this research investigated two entries of collecting and analyzing interactions between trail runners and their equipment. The paper articulates two studies. Study 1 analyzed traces of enactments on online forums and showed that trail runners reported the issues they enacted while running and reflexively posted the traces of their activity by highlighting the flaws in their carrying systems. Study 2 presents a field test protocol for assessing different carrying systems. The results showed four typical sequences of enactment that characterized the runners' activity. The outcomes of these two studies of runners' enactments while using equipment suggest a method that designers can appropriate to analyze experiential data, which can then be integrated into the conception process.

Keywords: Enaction, trail-running, design

1. Introduction

Over the last 40 years, trail running has gained in popularity among recreational runners (Hoffman, Ong, & Wang, 2010; Cejka et al., 2014). This outdoor endurance activity consists of self-sufficient running along hiking trails: runners must be autonomous in terms of food, hydration and safety equipment (e.g., waterproof jacket and pants, whistle, water bottle, survival blanket and mobile phone) between two supply stations. Trail race competitors must therefore carry a compulsory kit of minimum equipment (e.g., UTMB, 2015), including a key element: the carrying and hydration system. As Hillairet, Richard and Bouchet (2009) observed, the research and development (R&D) departments of outdoor sports equipment companies need innovative ideas in order to remain competitive and ensure brand expansion on the sports market. Not surprisingly, equipment designers for specialized brands have developed a wide range of trail running products. Yet an important question concerns their impact on trail runners' experience because the runner-equipment interaction (i) is likely to determine the commercial success of a given product and (ii) may well have an impact on performance, especially in competition (Ayachi, Dorey, & Guastavino, 2015).

Historically, sports equipment designers have given more importance to the engineering processes and less to human movement science (Shan, 2008). Also, Darses and Wolff (2006) pointed out that, although designers follow ergonomics guidelines, they tend to refer to their own experience, knowledge and representations to predict users' behaviors. These authors showed that users are considered either as being part of basic design principles or are elements of an imagined scenario. This imagined scenario plays a decisive role in designers' choices during the conception phase. However, a new trend is emerging in which users are perceived as legitimate stakeholders in the design process of co-creation (Prahalad & Ramaswamy, 2004b; Ramaswamy, 2008). As Prahalad and Ramaswamy (2004b) noted, the traditional conception of the creation process kept users out of the design phase. But the

authors rightly pointed out that today's users are connected through customer-to-customer communications on the Internet and their knowledge no longer relies on communications from the company. Therefore, actively bringing them into the design process through a co-creation program is crucial for companies for three reasons: to ensure a steady flow of new offers on the market; to ensure the development of usable, efficient and adaptable products (Ayachi et al., 2015); and to enhance marketing strategies by maintaining personalized interactions between the company and its customers (Payne, Storbacka, & Frow, 2008; Prahalad & Ramaswamy, 2004a; Rowley, Kupiec-Teahan, & Leeming, 2007). Therefore, the challenge for equipment designers is to appropriate users' activity as a tool to enhance their knowledge about customer needs and expectations, with a bottom-up approach to design.

The Raidlight company, which specializes in trail running equipment, adopted this perspective and developed an R&D program to bring the trail running community (many of which are its customers) into the design process. The brand takes into account the community's ideas, viewpoints, experience and feedback in the creation of new products or the improvement of existing products through a dedicated online community forum. In addition to this initial source of information, more detailed data is collected in real situations through the concept of the trail station network (i.e., the Station de Trail® concept), which allows users to test equipment during training sessions along marked routes of varying difficulty. Yet collecting information from these dense sources and then integrating it into a general design process is quite complex, especially given the company's empirical approach to the experiential data. The purpose of this study was therefore to show how the data collected on users' experiences (i.e., user feedback on the forums) and/or constructed (via field test protocols on a trail station route) could be retrieved and analyzed for the design process. Specifically, we considered user experience as a tool for equipment design (Partala & Saari, 2015; Pucillo & Cascini, 2014; Wright & McCarthy, 2010) and constructed a two-

phased experience-centered design with the Raidlight brand that can serve as a valuable and replicable model for R&D in the field of sports equipment use.

Analyzing users' activity is a decisive step in the design process. As shown in the analysis of work activity in design processes (Béguin, 2007), design choices are reinvested in the final product. Yet these choices are based on empirical models of activity in the aim of anticipating the activity, even though, according to activity theory, an empirical approach is problematic because it is disconnected from the actual activity that is inextricably occurring in situation (Suchman, 2006). Activity-oriented perspectives (Daniellou & Rabardel, 2005) take into account a singular characteristic of activity, which is that intra-individual diversity is very high and the same task does not necessarily evoke the same activity and, consequently, not the same experience. The user experience approach, which considers experience to be a core concept, has therefore become an important avenue for studying interactive technology systems (Partala & Saari, 2015) and for using statistical tools in the sports sciences. It would also seem to have a place at the beginning of the design process (Gesbert, Carrel, Philippe, & Hauw, 2016). Moreover, according to Haué (2004), designers should take into account users' actual situations to obtain a valuable design model. Indeed, innovation opportunities reside in users' experiences: that is, no longer in R&D laboratories but in the actual context of use (Kristensson, Matthing, & Johansson, 2008).

There are two entries for collecting user experience to develop tools for an experience-centered design program: (i) evidence from online forums, in which runners spontaneously share their experience feedback (Balkhi, Reid, McNamara, & Geffken, 2014; Becker, Harris, McLaughlin, & Nielsen, 2003; Palosse-Cantaloube et al., 2014), and (ii) analysis of runners' activity while using the products (Béguin, 2007; Daniellou & Rabardel, 2005; Haué, 2004) during field tests. These two entries of experience-centered design and user experience find their roots in enactive cognitive science: Orlikowski (2000) stated that when interacting with

a technology, users enact structures that reflect the emergent and situated characteristics of technology use. She considered technology use as a process of enactment that provides insight into the notion of appropriation. Therefore, rather than analyzing technology use as an appropriation process, she used the notion of “enactment” to highlight its emergent characteristic in her analyses of users’ interactions with technology. By doing so, she was able to identify the typical ranges of activity associated with using technology. Similarly, Hussenot (2008) drew on Orlikowski’s model of enactment and defined appropriation as the typical structure of enactments that are not controlled by designers. Hassenzahl and Tractinsky (2006) defined user experience in the human-computer interaction as a combination of the user’s state and the characteristics of the designed system, with this combination being dependent on the environment in which the interaction occurs. The enactive approach suggests that this structure should be considered in relation to four other core ideas: autonomy, sense-making, emergence and embodiment (McGann, De Jaegher, & Di Paolo, 2013; Stewart, Gapenne, & Paolo, 2010; Varela, Thompson, & Rosch, 1991). An autonomous agent’s activity emerges from asymmetrical couplings with the environment, and intelligible experience comes from a sense-making process. From this perspective, users make emerge—or they enact—the worlds in which they are acting in relation to the environment. Notably, technological equipment is part of these worlds. Thus, drawing from this enactive framework, we argue that the significant elements of equipment that emerge at the level of the user’s experience reflect the structure of his/her enactments.

In sum, the Raidlight brand has access to two entries for analyzing user experience. The first is runners’ feedback, which can be considered as traces of enactment and activity in the sense that runners report the salient elements they enacted while running and using equipment in situation. The second entry is runners’ enactment and immediate experience during field tests on marked trail routes. These two types of data are composed of similar

enactment processes with different degrees of precision and granularity, and both can be integrated into the design process. We conducted a detailed analysis of these two data sources in two studies: In study 1, we analyzed the forum discussions on the Raidlight website and in study 2, we analyzed the results of a field test protocol. The aims of these studies were to (i) identify the traces of typical, salient issues enacted by runners when using carrying systems (study 1), (ii) identify the typical sequences of enactment that emerged at the level of runners' experience while running with a carrying system during an field test (study 2), (iii) identify the typical issues associated with different configurations of the carrying system by articulating the results of studies 1 and 2, and (iv) qualitatively document the contents of these runner-carrying system enactments. We expected that, among the singularities of runners' enactments, we would be able to identify common themes emerging from real equipment use in situation.

2. Study 1: Analysis of traces of enactment from forum messages

Social networks, especially forums for experience sharing, have been explored by researchers as an innovative tool for analyzing narratives (e.g., Pfahl, 2015). Studies have shown that social media are spaces for expression (Bortree, 2005) and therefore provide an observatory for analyzing shared issues, since users tend to gravitate to communities that share their interests (Dawson, 2006). Indeed, Simpson, Young, and Jensen (2014) observed a tendency toward community building in trail running, and we assumed that this sense of community would extend to forums (Rochat, Hauw, Gür, & Seifert, 2018). In addition, brands today are actively involved in managing customer communities on the Internet (Rowley et al., 2007). The discussion themes on forums were therefore expected to offer valuable observations of trail runner's experiences (Bargh, McKenna, & Fitzsimons, 2002; Yarwood-Ross & Haigh, 2014). The data extracted from these online spaces were thus considered

primary data to be completed with further analysis (Dorey & Guastavino, 2011; Jones & Alony, 2008). It seemed reasonable to consider these contents as traces of enactment, since the narratives reflect an interactive sense-making process between a teller and a reader (Popova, 2014).

Previous studies on trail running have used narratives on blog posts to collect runners' enactments at the level of their experience during races. We carefully examined these contents and found that they were similar to those collected during self-confrontation interviews conducted to access significant elements enacted during a trail running race (Rochat, Hauw, Antonini Philippe, Crettaz von Roten, & Seifert, 2017). On this basis, we restored the stories of runners' activity via their spontaneous narratives about their races posted on personal blogs: we assumed that the feedback posted on the Raidlight forums would provide us with valuable narratives of personal experience that describe runners' enactments (Bargh, McKenna, & Fitzsimons, 2002; Jones & Alony, 2008). Interestingly, Dorey & Guastavino (2011) examined how the notion of comfort in cycling is discussed in print and online sources, including forums. They found that negative opinions were more often conveyed on online forums, with users tending to express what they perceived as negative in greater detail than what they perceived as positive. In light of these findings, analyzing forum content may be like critical incident analysis (Bastien & Scapin 2004). If this is so, we might expect that runners, when posting negative experiences, highlight the flaws, issues and critical points about equipment, all of which could be valuable sources of information for designers looking for solutions to improve their products.

Study 1 assessed the place attributed to carrying systems while runners enacted their activity using the systems. To do so, we analyzed forum messages on the Raidlight community forum in the "equipment and products" category. Eight subcategories of equipment constitute the hierarchy of the forum (i.e., shoes, poles, carrying and hydration

systems, GPS watches, clothes, headlamps, compulsory race equipment, and others).

2.1 Data analysis

First, we counted the meaningful threads in each subcategory to identify the most discussed themes. We collected messages between October 2014 and December 2015. Second, 53 messages in the most discussed subcategory were coded, following the three steps of inductive content analysis (Biddle et al., 2001): (i) identify the salient statements of each message as raw data themes, (ii) group raw data themes into first-order themes, and (iii) group first-order themes into general issues.

2.2 Results

2.2.1 Quantitative indicators of the forum messages

Table 1: Repartition of the forum messages in relation to their subcategories

Race compulsory equipment	Headlamps	Poles	Clothes	Other	Shoes	GPS watches and software	Carrying and hydration systems
396	1,930	1,045	3,422	4,766	5,560	6,011	6,634

As shown in Table 1, the theme that was most discussed was “carrying and hydration systems.” This theme encompasses different models of backpacks and waist packs for carrying water bottles or bladders.

2.2.2 Discussion contents of the “carrying and hydration systems” forum

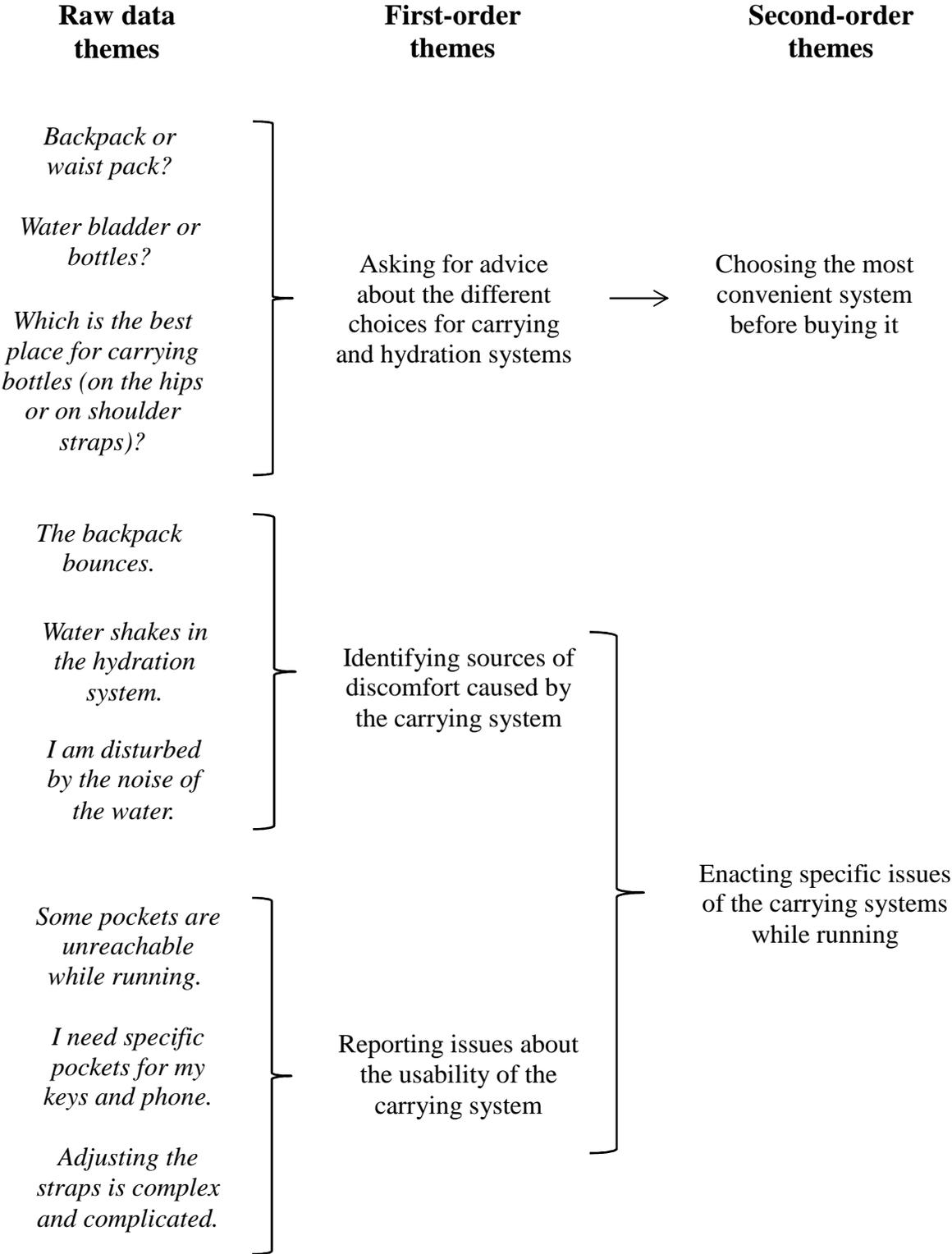
In-depth analysis of the forum messages revealed two meaningful themes: “choosing the most convenient system before buying it,” which was composed of one first-order theme

and three raw data themes, and “enacting specific issues of the carrying systems while running,” which was composed of two first-order themes and six raw data themes (Figure 1).

Choosing the most convenient system before buying it. This theme referred to finding the best compromise between the backpack liters and the distance to cover (assuming that the longer the race is, the bigger the backpack should be). Runners asked about other runners’ experiences and sought advice about choosing a convenient and efficient carrying system. It concerned both a general level (i.e., backpack or waist pack) and a more specific level about the location of the system load (i.e., on the hips or the shoulder straps).

Enacting specific issues of the carrying systems while running. The second theme referred to the problems runners encountered while running with the carrying systems. The runners reported discomfort because of the noise and bouncing of the system. They also reported issues of usability, difficulties adjusting it, and difficult access to the pockets, which made the carrying system disturbing and incompatible with running. These issues prompted a negative assessment of the carrying system.

Figure 1: Overview of raw data themes, first-order themes and second-order themes; first-order themes and raw data themes identified from the forum discussion messages



2.3 Discussion

The results indicated common themes emerging from the users' experiences with carrying systems that had generated discussion. There are generalized levels in these themes, with problem selection emerging from their experience. The runners had a technical and functional approach to the carrying systems, emphasizing global issues like comfort and usability. They also reported on more specific issues, like noise. This illustrates the principle of asymmetry (Froese & Di Paolo, 2011; McGann et al., 2013; Stewart et al., 2010; Varela et al., 1991), revealing the specific and meaningful worlds they enacted with the carrying systems. The runners had questions about the concerns that emerged from their enactment relative to the carrying system.

These results thus unveiled some of the practical issues reported by the users, and designers should start from these concrete issues as they enter the design process. Questions that they might ask are: What characteristics of the carrying system will ensure that it is sufficiently convenient to justify purchase? What are the salient features of the carrying system that will be problematical for users? If designers root product innovation and enhancement in user experience, they will be able to anticipate potential issues that their product might generate when runners' enact their activity using the equipment.

The forum analyses were a starting point for identifying the practical issues that make up the holistic experience of sports equipment use (Dorey & Guastavino, 2011). On the basis of these results, we formulated the following hypotheses about the methodology and outcomes of the field test protocol: (i) the location of the liquid container (on the shoulder straps vs on the hips) would play a significant role in the evaluation of a carrying system, (ii) the noise of the liquid moving around in the container would be a source of discomfort, (iii)

backpack bouncing would be associated with oscillations in the liquid container, and (iv) strap adjustments would not be efficient enough to reduce backpack bouncing. The first level of enactments retrieved on the forum was thus articulated with a deeper analysis of the unfolding experience during a field test protocol. In this way, we were able to test these hypotheses by restoring a **naturalistic** context of use (Bastien & Scapin, 2004).

3. Study 2: Analysis of runners' experience during a field test protocol

The articulation of an experience-centered design program with the analyses of trail runner's enactments while using equipment seemed an important next step, as designers are increasingly interested in how equipment is used in situation. Previous studies have used field test protocols to generate data for designers seeking to create safer cricket equipment (Velani, Wilson, Halkon, & Harland, 2012) or prevent injuries through improved climbing shoe design and better adapted sizing charts (van der Putten & Snijders, 2001). The authors were able to make recommendations to enhance the design of sports equipment that would fit user activity more closely.

On the basis of the study 1 results, we examined runners' activity while running with various carrying system models to determine how the issues identified in the forum discussions would actually emerge in a situated context. A field test protocol was used to identify the characteristics and asymmetrical interactions (i.e., enactments) between runners and equipment in relation to the situational particularities of a trail running race. By restoring the race settings during a field test, as can be done at a trail station, we sought to characterize the typical situations in which these issues would emerge and identify which carrying systems were associated. We assumed that specific issues might emerge in specific situations, depending on the system. In other words, the aim was to identify the succession of enactments

between runners' actions and the situation of running with different configurations of carrying systems.

One way to study these enactments is to work within the methodological framework of course-of-action theory (Theureau, 2015). The principle is to rebuild the succession of trail runners' enactments at the level of pre-reflective consciousness by describing the story of their experience (i.e., what they perceived, felt and did within the unfolding protocol). In the domain of informatics and rooted in the enactive approach to human activity, Theureau and Jeffroy (1994) provided a theoretical and methodological framework based on the course of action, which they defined as follows:

The activity of a given actor engaged in a given physical and social environment belonging to a given culture, where the activity is meaningful for the actor, that is, he can show it, tell it, and comment upon it to an observer-listener at any instant during its unfolding. (p. 19)

Applied to design and ergonomics, this framework has been used to identify perturbations in user experiences. It has also been frequently used in sports for performance analysis (e.g., Briki, den Hartigh, Hauw, & Gernigon, 2012; Mohamed, Favrod, Philippe, & Hauw, 2015), doping (e.g., Hauw & Bilard, 2012; Hauw & Mohamed, 2015), and trail running (Antonini Philippe, Rochat, Vauthier, & Hauw, 2016; Hauw et al., 2017). Perturbations form an asymmetrical interaction between the agent and the environment that forms the agent's own world. In the light of these works, we assumed that a carrying system might be a source of perturbation enacted in trail runners' experience. Recent studies in sports science have indeed shown that tool use and instrumented activity have an impact on athletes' courses of action (Adé, Poizat, Gal-Petitfaux, Toussaint, & Seifert, 2009; Pouponneau, 2015). Also, several studies have explored athletes' activity in different sports (e.g., trampoline, skydiving, orienteering, tables tennis, etc.) by analyzing the athletes' salient statements,

yielding typical sequences that then provided general models (Hauw & Durand, 2004; Mohamed et al., 2015; Mottet & Saury, 2013; Sève, Saury, Theureau, & Durand, 2002). In the present two-step study, which articulates an analysis of forum discussions and an experimental protocol, we report the practical outcomes of a field test protocol and present the collection of experience data from runners using different models of carrying systems. On the basis of the raw data themes from study 1, we expected the results to provide insights into the issues enacted by runners while interacting with a carrying system in situation, especially regarding (i) the impact of the location of the liquid container (on the shoulder straps vs on the hips) on their evaluations; (ii) backpack bouncing, liquid container bouncing and noise of the liquid sloshing as sources of discomfort; and (iii) the way runners deal with the straps to find the most convenient adjustment for their unfolding activity. We assumed that these results would guide designers to the most significant elements of the carrying systems that need to be dealt with during the design process.

3.1 Materials and Method

3.1.1 Participants

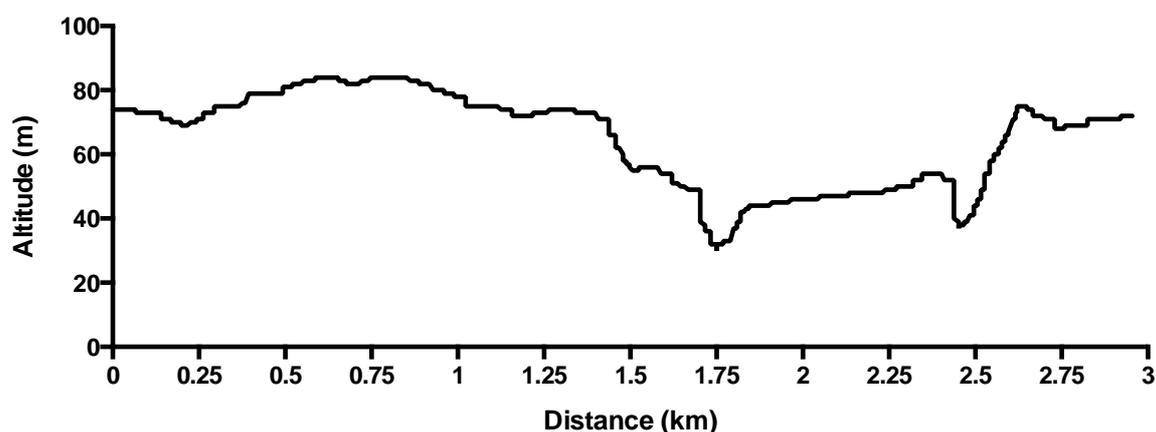
Nine non-professional trail runners volunteered to participate in the study. They had a mean age of 37.8 years old ($SD=7$). They usually ran a mean of 51.1 km per week ($SD=21.03$) and had been trail running for 2 to 15 years. The information document describing the protocol and a consent form were sent by email and signed by the participants.

We asked them to provide information about their usual carrying and hydration systems; two of them used a backpack with a water bladder (R1, R8), three used a backpack with rigid bottles on the shoulder straps (R2, R3, R4), three used a waist pack with rigid bottles (R5, R6, R9), and one used a backpack with soft bottles of the shoulders straps (R7).

3.1.2 Procedure

The aim of this protocol was to restore a situation of use in a **naturalistic** context. We therefore selected a trail running route and the runners were asked to run the same 3-kilometer loop five times at a regular pace. The route was marked and featured several terrain conditions typical of trail running, such as forest trails, asphalt road portions, a technical descent and a steep ascent (Figure 2). At the end of the protocol, each runner had run 15 kilometers and in total we obtained 45 trials.

Figure 2: The route profile of the 3-kilometer loop



The runners changed equipment at the end of each trial. On the basis on the study 1 results, we selected the most often discussed models of the Raidlight carrying systems. Five carrying conditions using the system models were applied (Figure 3): (i) a backpack with two front bottles (2x600ml) on the shoulder straps, (ii) the same system with half-filled bottles (2x300ml), (iii) the same system with half-filled soft bottles (2x300ml), (iv) a backpack with a water bladder in the dorsal pocket (1.2l), and (v) an waist pack with the bottle (2x600ml) on the hip. To avoid the order effect, each runner experienced all the conditions in a different order.

Figure 3: Illustration of the carrying system configurations used for the field test protocol

3.1.3 Data collection

Immediately after the running trials, a self-confrontation interview was held with each runner, following an interview guide similar to that used in previous sports research (Hauw & Durand, 2004, 2007; Mohamed et al., 2015). Runners were confronted with the traces of past activity (i.e., pictures and maps of the route, and pictures of them during the transitions between each trial). The confrontation with these traces aimed at collecting their experience at the moment their activity was unfolding (Theureau, 2010): the runners were asked to describe and comment on their own activity by expressing what they were doing, thinking, and perceiving at every instant. Particular attention was given to their interactions with the carrying systems, without excluding other dimensions of their activity in order to gather all the significant elements that marked their experience. In order to help them to express their experience, the researchers asked questions about their sensations (e.g., What do you feel here?), concerns (e.g., What are you concerned about?), involvements (e.g., What are you trying to do? What are you thinking about?), representaments (e.g., What is drawing your attention? What are you seeing? What are you feeling?), and interpretations (e.g., What do you think of that?). The interview guide was designed to obtain descriptions of actions and events as the runners experienced them. Requests for interpretations and generalizations were avoided (Theureau, 2010). All self-confrontation interviews were video recorded and transcribed for further analysis. Each was anonymized using the letter R for runner and a number. Last, using a 5-item scale, runners were asked to rank the trials based on their preference for the experience with each carrying system; 1 point meant that it was the most

preferred situation and 5 points meant that it was the least preferred situation. Thus, the fewer points attributed to a situation, the better the runners assessed it.

3.1.4 Data analysis

The data were processed in three steps: (i) labeling the elementary units of meaning (EUM) and their underlying components, (ii) identifying the sequential relationships between EUMs, and (iii) identifying typical themes from the comparison of all runner's courses of action (Hauw, Berthelot, & Durand, 2003).

Identifying EUMs and their components

When describing their experience, runners spontaneously broke it down into units of meaning. This allowed us to label these salient statements by using an action verb followed by a direct object or another complement. Moreover, the components associated with each EUM were also identified: the involvement (i.e., the runners' concerns) and the representamen (i.e., "What is he/she concerned about in this situation?").

The elementary units of meaning (EUMs) were labeled based on the coding of the self-confrontation interviews. The actions were described using an action verb followed by a direct object, an adverb, or another complement (e.g., runs carefully on technical terrain). This coding also helped to identify the underlying constituents of each EUM, which were identified using a set of more specific questions: What is the runner concerned about in this situation (involvement)? What element of the situation is he/she considering, and what is he/she recalling, perceiving, or interpreting (representamen)?

Grouping EUMs into sequences

Sequences were identified and labeled on the basis of relationships between the EUMs

and their components. Each sequence was made up of EUMs that formed a coherent chain around a meaningful theme for the runner. Sequences are groups of elementary units that all refer to the same actors' concerns and are linked to each other (e.g., Sève, Saury, & Durand, 2006); the outcome of an EUM coherently determines the following one. Sequences were identified and labeled by synthesizing the contents of the EUMS that composed it. These sequences were labeled by using a verb that reflected the runners' main concerns in the situation and a direct object.

Identifying typical themes

In order to characterize the components of runners' experience during this protocol, we examined the contents of the first-order sequences to identify common similarities: when sequences contained a common theme and were identified in the nine codings, they were considered to be a typical sequence. These typical sequences portrayed typical runners' enactments in the situation of running with a carrying system. Furthermore, all the runners' representaments in relation to the carrying systems were identified for each typical sequence in order to highlight the salient issues of each carrying system condition.

3.1.5 Ensuring trustworthiness of the data and analysis reliability

Several measures were taken to ensure the trustworthiness of the data and analysis. First, the researchers were experienced in conducting qualitative research, particularly in the course-of-experience approach. Second, two of these experienced researchers in sports science and psychology collected the data and were supervised by a third researcher experienced in course-of-action methodology. A session for practical training in this type of data collection and coding process was held. Third, the data were coded independently by the three researchers, including the one experienced in course-of-action methodology. An

agreement rate of 90% was obtained between the coders and a joint coding session was held to obtain consensus for the 10% of disagreement.

3.2 Results

3.2.1 Assessment scales

The runners were asked to rank the five loops according to their preferences. One point meant that it was the most preferred situation and 5 points meant that it was the least preferred situation. Thus, the fewer points a situation earned, the better the assessment was.

Table 2: Results of the assessment scales

Waist pack Rigid bottles	Backpack Soft bottles	Backpack Water bladder	Backpack Half- filled bottles	Backpack Rigid bottles
13	19	32	33	38

Table 2 shows that the waist pack and the backpack with soft bottles were the preferred situations, whereas the backpacks with rigid front bottles and the water bladder were the least preferred. This ranking showed a clear difference between the two first situations (waist pack and backpack with soft bottles) and the others (backpack with water bladder, half-filled bottles and rigid bottles).

3.2.2 Analysis of the courses of action

Four typical sequences of enactments were identified: (i) exploring and adjusting the carrying system, (ii) reducing permanent perturbations caused by the carrying system while running, (iii) dealing with environmental constraints, and (iv) analyzing enactments with the carrying system. Moreover, the typical disturbing elements of each carrying system condition (i.e., typical representaments) were identified for each typical sequence.

Exploring and adjusting the carrying system

Typical involvements were identified and refer to the concerns of exploring and asking questions about the carrying systems and the activity of taking possession of them. This typical sequence refers to first-order sequences of:

(i) Placing the carrying system on the back comfortably: these sequences refer to specific actions to adjust it, such as tightening the straps or placing the bottles in the right place.

(ii) Manually and visually exploring the carrying system to make predictions about its behavior while running: “My first reaction was to tighten the straps, because I felt they were too large for me. Actually, I’m always doing this when I run, I always tighten my backpack a lot. So here I thought, oh no, it’s going to move around a lot” (R2). Moreover, the runners pointed out potential issues with specific parts of the system; they thus had expectations about its disturbance on their activity: “I was wondering if the waist pack would twist or not: would the bottles on the hips make the waist pack bounce?” (R7).

(iii) Exploring the system when starting to run. This refers to a sequence of inquiry at a cognitive level: “I start running and I’m observing to check if there are vertical oscillations, I’m trying to pay attention to it, to see if I detect something” (R7). It also refers to actions, such as trying to tighten the straps again to see if the carrying system is more comfortable.

In sum, this typical sequence refers to an inquiry that started when the runner put on the carrying system and continued while he ran and tried to see if the issues identified when standing still would be confirmed when running: “My first impression at the start was that it’s going to be heavy in the front because I looked at the bottles and expected it to be uncomfortable. And it was when I started running on flat terrain” (R8). In some cases, these expectations came to nothing: “I wanted to fix the bottles in their pockets to prevent them

from bouncing. I didn't know this backpack so I was checking it and then when I started running they didn't bounce" (R4).

This typical sequence occurred at the beginning of each loop, when the runners changed equipment for the following trial. They immediately reported specific representamens associated with the carrying systems (Table 3).

Table 3: Typical representamens associated with the carrying systems in the typical sequence "exploring and adjusting the carrying system"

Backpack + front bottles	Backpack + front half-filled bottles	Backpack + half-filled soft bottles	Backpack + water bladder	Waist pack + bottles
Weight on the shoulder straps	Bottles in front	Bottle tubes	Weight on the back	Lightness, Pectoral strap is low

Reducing permanent perturbations caused by the carrying system while running

In contrast to the previous sequence, this typical sequence of enactments refers to the adaptations made after a certain amount of time running with the carrying system. Specific representamens emerged and lasted (see Table 4) to the point where the runners attempted to adapt by interacting with the carrying system in new ways. The actions of this sequence were observable and aimed at reducing the disturbances caused by the carrying system while running. Runners attempted to reduce them by either adapting their own activity (e.g., posture) or manipulating the system itself:

(i) Adapting trunk posture in response to the sensation of the weight of the front bottles and/or the water bladder: "Because of the weight on the front straps, I struggled a bit more to keep my posture straight" (R6).

(ii) Changing the position of the arms while running: “My elbow and forearm were always touching the bottles on the hips. So I changed the position of my arms” (R6). However, only R4 and R6 reported this issue.

(iii) Tightening the straps while running to reduce bouncing. In all cases, this kind of action did not completely prevent the carrying system from bouncing.

(iv) Loosening the straps to reduce compression: The outcome of this action was sometimes problematic because some reported that bouncing increased when they loosened the straps. So the outcome of this action led to another issue.

(v) Fixing the water bladder tube.

Table 4: Typical representamens associated with the carrying systems in the typical sequence “reducing permanent perturbations caused by the carrying system while running”

Backpack + front bottles	Backpack + front half-filled bottles	Backpack + half-filled soft bottles	Backpack + water bladder	Waist pack + bottles
Weight, oppression, friction, bouncing	Noise of the water shaking inside, bouncing	Tubes are close to the face	Weight on the back Tube always moving, bouncing	Forearm and elbow touching the bottles

Dealing with environmental constraints

This typical sequence of enactments refers to runner’s adaptations to the environmental constraints of the terrain, such as the steepness of some descents/ascents, technical segments and physical sensations like muscle pain. The actions to deal with these constraints were:

(i) Running carefully in technical segments: “In the technical parts, I’m very careful with my stride, because I’ve had a lot of problems with my ankles, so there, I’m not thinking

about the backpack at all” (R8). The runners considered a part to be “technical” when it was a steep descent with many roots and stones on the ground.

(ii) Looking carefully at the ground: “In this descent, I don’t want to stumble over a stone or root, so I reduce how far ahead I’m looking, and with these bottles I was disturbed... there’s interference, you don’t see the ground as you usually see it” (R8).

(iii) Slowing down or even walking in steep ascents: the runners knew that they had to make a steep ascent five times at a regular pace, and all reported their concern about saving their energy, especially when they felt muscle pain (e.g., “My legs started cramping”).

These actions emerged from their concerns about not getting hurt and ensuring that they had enough energy to complete the five trials. These concerns were greater than the concerns about the carrying system: “Here, I was so focused on the path that I wasn’t even thinking about the backpack” (R2). Consequently, few representamens related to the carrying systems were reported (see Table 5).

Table 5: Typical representamens associated with the carrying systems in the typical sequence “dealing with environmental constraints”

Backpack + front bottles	Backpack + front half-filled bottles	Backpack with half-filled soft bottles	Backpack + water bladder	Waist pack + bottles
Bottles in the vision field	-	-	Weight, Bouncing	-

Analyzing enactments with the carrying system

At a cognitive level, the runners engaged in reflexive activity after identifying the system’s salient issues and had expectations about its dimensions:

(i) When running on flat and easy segments, thinking about the effect of the carrying system during prolonged effort: “I wouldn’t be able to run a 100-km race with that kind of device, it’s too disturbing” (R2).

(ii) Identifying precisely in which part or kind of terrain the carrying system might become disturbing:

“Researcher: So here after this steep ascent, you keep running on the flat part.

Runner: Yes, and I felt the bottles again, I felt them bouncing. When I became aware of it, I was always running on asphalt road” (R5).

(iii) In the same vein, identifying precisely during which activity the carrying system might become disturbing: “You don’t really need to run the entire loop; after 300 meters, you know if the backpack suits you or not... On technical parts I run slower, so all its flaws seem less important: bouncing, weight, etc., are not disturbing when you run slowly” (R4).

(iv) Assessing the effect of habit: “The more I ran, the less I focused on the bottles. I felt them bouncing less. I got used of it” (R6).

(v) Once identified, the sensations caused by the carrying system led to reflexivity about how it impacts overall running activity: “The equipment has a small influence on the way you run because you don’t feel the same sensations as usual. There is the logistical aspect and a different weight distribution” (R5).

Table 6: Typical representamens associated with the carrying systems in the typical sequence “analyzing enactments with the carrying system”

Backpack + front bottles	Backpack + front half-filled bottles	Backpack + half-filled soft bottles	Backpack + water bladder	Waist pack + bottles
Weight, oppression, friction, bouncing	Noise of the water shaking inside, bouncing	Tubes are close to the face	Weight on the back Tube always moving, bouncing	Forearm and elbow touching the bottles

3.3 Discussion

The aim of this study was to identify the salient elements that describe the impact of running with a carrying system on trail runners' experience. Our results show that during this protocol, runners went through four typical sequences of enactment associated with the carrying system (i.e., (i) exploring and adjusting the carrying system, (ii) reducing the permanent perturbations caused by the carrying system while running, (iii) dealing with environmental constraints, and (iv) analyzing enactment with the carrying system). These results suggest that the runners integrated the carrying system at different levels of their activity. Integration began at the moment they put it on and continued throughout the activity of running as it related to the specificities of the trail environment, with the emergence of reflexive activity regarding how they were interacting with the system. The two first sequences consisted of progressive adaptation: after identifying the potential issues while putting on and adjusting the carrying system, the runners enacted perturbations caused by the system while running and tried to reduce them. When the terrain required specific and increased attention, they had to deal with other perturbations that were not directly related to the system. At a general level, our results reflected three of the so-called *four E* approach to human activity and cognition: Extended, Embedded, Embodied and Enacted (e.g., Vörös, Froese, & Riegler, 2016). Hence, the identified experiences reflected a specific development of the enactment of the carrying system in the runners' activity. The enactment process started at a general level with inquiries about its functionalities in relation to previous experiences. The involvement was mainly focused on comfort in a static position and they had expectations about future behavioral interactions. At the same time, an initial experience, a general feeling, emerged that portrayed the frame of the enactment. The enactment process then continued as they ran. The situation induced perturbations that dynamically shaped the enactments. The runners enriched their experience by collecting embodied and embedded experiences linked to specific race situations. The enactments intensified and distinctions

between the carrying systems were able to emerge. Finally, at the end of our field test protocol, a precise experience emerged that embedded all these micro-experiences into an integrative cognitive, embodied and embedded enactment process of the carrying systems. These results are coherent with others obtained in sports situations, notably one in which the enactment of safety was grounded in step-by-step and cumulative enactments (Mohamed et al., 2015) and another that demonstrated the progressive enactment of ultra-trail race withdrawals (Antonini Philippe et al., 2016).

The rankings of the carrying systems showed that the runners thought some devices were more efficient than others, suggesting that the carrying systems were not enacted the same way, depending on their characteristics and the environment. These differences highlighted the qualities and flaws of each model that were enacted in specific situations. Taken separately, each carrying system could be characterized by a unique emergence of the representamens that were enacted. Representamens of the backpack with the rigid bottles indicated that the weight on the shoulder straps made feelings of oppression and bouncing emerge while running: In technical parts, the presence of the bottles in a runner's visual field was a source of discomfort. Similarly, the backpack with the water bladder was uncomfortable mainly because of the sensation of oscillating weight when running. The other situations of the carrying systems were more transparent in the sense that few representamens were reported. In line with Partala and Saari (2015) on user experiences and emotions, we hypothesized that the runners would prefer a carrying system with few flaws drawing their attention and would thus rate it the most positively.

These dynamics of the enactments of representamens thus provided the grounds for the runners' assessments and rankings. Through this kind of analysis, we were able to situate the properties of each carrying system and its behavior in situation from the runners' feedback, suggests the enhancements that can be made to ensure better adaptation and reliable

marketing arguments. The runners reported that a carrying system was comfortable when they did not feel it and ran as if they were wearing nothing (e.g., “I almost didn’t feel it”). Indeed, they reported few representaments associated with the waist pack and the backpack with the soft half-filled bottles. Therefore, the absence (or the non-enactment) of disturbing elements (e.g., weight, bounce, noise) had a positive impact on their experience. Equipment designers should attempt to make enhancements that render the carrying system as transparent as possible, as this generates positive experiences for users (Hassenzahl & Tractinsky, 2006).

Taken together, our results suggest that the runners’ interactions with the carrying systems relied on both actual and cognitive dimensions. There were observable actions (e.g., adjusting the straps) and cognitive sense-making processes that were accessible only through self-confrontation interviews. These different levels of activity highlight how the interactions with the carrying systems occurred in trail running activity. In spite of the singularity of each runner’s experience, we were able to identify common sequences of activity. These results also suggest that all dimensions of activity should be taken into account since the significance of the carrying system emerged in a situated process (e.g., the typical sequence of “dealing with environmental constraints”). In specific situations, the carrying systems, even when uncomfortable, became less significant or even absent in the runners’ activity. Conversely, when the situation appeared less constraining (e.g., running on a flat asphalt road), the carrying issues emerged again as significant concerns. The first minutes after departure seemed determinant for backpack evaluation, as many representaments were reported. In contrast, on technical parts, the runners were concerned with other dimensions of their activity (not getting hurt, not falling, etc.), but they were also constrained to slow down and thus we can assume that the carrying systems bounced less. It is likely that the faster they ran, the more disturbing the systems became. We also hypothesized that distributing the weight according to its location (shoulder straps or waist) would play a significant role in their

perceptions: weight on the front straps appeared to be more disturbing, probably for mechanical reasons, an obstructed visual field for some, and/or the noise of the water sloshing inside the bottles. Also, when the load was located in a single place (i.e., the 1.2-liter water bladder), the runners had the sensation of additional weight, whereas they did not report this with the waist pack (2x600ml): the weight was similar in both situations but enacted differently. Interestingly, the structure of these interactions that embed the characteristics of the equipment, environment and activity are in line with the findings of Ayachi et al. (2015) in cycling. These authors highlighted that the perception of comfort included the bicycle components (i.e., saddle, frame, handlebar), environmental factors (i.e., characteristics of the road, clothing, weather conditions), and cyclists' behaviors and decisions (positions, adjustment of saddle and handlebar during activity).

Some limitations of this study should be underlined: First, the low number of participants prompted care in making generalizations. Second, the shortness of the trials (3 kilometers per trial) precluded study of the cumulated effects of carrying discomfort, although attention was given in choosing a loop offering a representative diversity of sections and type of trail. Nevertheless, prolonged effort and the sheer length of the route are also typical characteristics of trail running, and we could not restore them for this protocol. Indeed, the typical sequence of "analyzing enactments with the carrying system" showed that the runners built expectations about prolonged use of the carrying system. The shortness of the trials prevented us from observing the cumulated effects of a disturbing carrying system, and it is likely that, knowing the loop was short, the runners somehow accepted the backpack constraint and thus did not significantly adapt their activity. A third limitation is that we did not investigate the usability of the carrying systems, although this is a significant element in trail running activity as shown in study 1 (e.g., filling bottles, drinking while running, looking for equipment stored in the system pockets).

4. General Discussion

We tie together the main findings of studies 1 and 2 by successively discussing each first-order theme identified in the forum and its respective raw data themes and then connecting them with the results of the field test. The first-order theme “Asking for advice about the different choices for carrying and hydration systems” was composed of typical questions about choosing the most convenient system: “Backpack or waist pack?” “Water bladder or bottles?” “What is the best place for carrying the bottles?” These questions seemed to find a response in the field test, which showed that the waist pack with bottles on the hips and/or a backpack with front soft bottles were the preferred systems, suggesting also that the most convenient places for putting the load are the hips or the shoulder straps for lighter loads, rather than in the back as with the water bladder. This confirmed our hypothesis that the location of the liquid container (on the shoulder straps vs on the hips) would play a significant role in the evaluation of the carrying systems, as shown in the typical sequence “analyzing enactments with the carrying system.”

This was confirmed by the second first-order theme about the sources of discomfort, such as the bouncing and noise, that were reported in the forums and the protocol. The runners reported that the carrying systems bounced more when they ran on flat and asphalt segments, which are more “runnable” and give them the opportunity to run faster. Moreover, they were able to point out which part of the carrying systems was bouncing too much, such as the shoulder straps with the rigid bottle or the water bladder bouncing in the back. This confirmed the hypothesis that backpack bouncing would be associated with oscillation of the liquid container, especially when the runners ran fast and were not focused on the difficulties of the terrain, as described in the typical sequence “dealing with environmental constraints,” in which few representaments about the system were reported. Similarly, our hypothesis that

the noise of the sloshing liquid would be a source of discomfort was also confirmed by the protocol.

The third first-order theme, referring to carrying system usability (i.e., accessibility to pockets and ease of strap adjustment), was partly verified in the protocol. The two typical sequences, (i) exploring and adjusting the carrying system and (ii) reducing permanent perturbations caused by the carrying system while running, refer to actions to adjust the backpack by tightening the straps, yet without being able to prevent bouncing completely. Therefore, our hypothesis that the strap adjustments would not be efficient enough to relieve the discomfort of bouncing was confirmed. However, as the protocol did not test usability, we do not know whether a problem of pocket accessibility emerged and we cannot provide a detailed account of backpack usability. The forum analysis nevertheless helped us to formulate hypotheses and research questions to design the field test protocol, which ultimately helped us to examine most of the forum themes in a **naturalistic** context of use.

By using a forum as a starting point for defining the direction of field test protocols, we show that companies can enhance their co-creation process by taking into account the meaningful experiences posted there. From this perspective, extending the communication possibilities via online forums helps companies to extract valuable knowledge about user problems and expectations (Rowley et al., 2007). This is in line with Ramaswamy's (2008) statement that companies should give importance to their customers' experiences via dedicated platforms for brand-customer interactions. According to this author, this positions the companies to develop strategic capital centered on customers through the knowledge and skills extracted from continuous dialog. In addition, company-hosted forums strengthen customer networks and sustainable online communities ensure idea sharing, innovation opportunities and the active involvement of the users in test protocols.

These two studies explored two entries for providing a valuable method to make use

of online forums and field test protocols. The aim was to explore trail runners' enactments with their carrying systems as a way to enhance the design process. Study 1 showed how forums provide a first level of analysis based on the salient traces of the enactments that make up runners' experiences, and study 2 provided a deeper analysis of the structure of the enactments and their temporal organization by linking them to the environment in which the runners were asked to run. The forums enabled us to delimit the problematic themes from the many community discussions and formulate hypotheses about problems that might be encountered during an unfolding situation of use. The test field protocol enabled us to analyze these themes by contextualizing carrying system use and gathering online experience data. This provided more knowledge about the asymmetries of runners' enactments.

From an ergonomics perspective, we explored a way to implement user-centered design in the conception of trail running equipment by testing carrying systems, and we observed that the runners assessed some models negatively. For future product development, we believe that if test protocols are rigorously designed to ensure a representative context of performance and the results are correctly analyzed via self-confrontation interviews and coding, companies will save time and money by commercializing more efficient systems shaped by the runners' experience. This study therefore explored a method that is replicable for designers developing a new product.

The main challenge in equipping trail runners is to meet the criteria for performance by taking into account the asymmetry of couplings between runners and their environment. During trail and ultra-trail races, runners face a number of environmental constraints (e.g., weather, long distances between supply points, extreme physical fatigue, injuries, etc.), and reliable equipment is crucial to ensure their safety and performance in tough situations.

Future studies should investigate the usability of carrying systems in situation (e.g., easy access to pockets, use of the hydration systems). Nevertheless, our protocol provides

practical guidance for equipment designers through an original method based on the analysis of data extracted during in-situation equipment use (Poizat, Haradji, & Seifert, 2011). Moreover, self-confrontation interviews are suitable for studying runners' activity in context because they provide access to activity in real situations of performance without interfering with the activity in progress.

Haué (2004) noted that a weakness of the user-centered approach is that it is difficult to take into account the final needs that a tool must fulfill during the design process. Forums, however, may be useful to predict runner's needs (Dorey & Guastavino, 2011; Rowley et al., 2007). As observed in previous studies, R&D departments are confronted with the dilemma of maintaining stable R&D activity and developing their know-how, often at the expense of research (which is costly), and daring to innovate by exploring unknown devices, which is riskier (Hillairet et al., 2009). Instead of commercializing devices that appear unsuitable during real-use situations, we suggest that brands first replicate our field test protocol using prototypes (Payne et al., 2008). The challenge for designers at this point would then be to adjust the prototype on the basis of the experiential feedback to produce equipment that is optimally suited to the real trail runners' activity.

Further research on human instrumented activity is needed in the sports sciences and, in the case of running, studies should analyze how the use of equipment impacts runners' coordination by coupling analyses of first-person data with third-person data (e.g., Mao, Macias, & Hargens, 2015; Gal-Petitfaux, Adé, Poizat, & Seifert, 2013; Seifert et al., 2013; Seifert et al., 2014; Sève, Nordez, Poizat, & Saury, 2013). Our results, for example, point to backpack bouncing associated with the weight of the carrying system as a problem that merits further analysis: it might be relevant to quantify the actual bouncing and its impact on running coordination and runners' experience; this could be done by quantifying the vertical acceleration data in relation to the runners' center-of-mass accelerations.

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