Understanding the Shared Experiences of Runners and Spectators in Long-Distance Running Events

Tao Bi **Nadia Bianchi-Berthouze** **Aneesha Singh** **Enrico Costanza**
UCL Interaction Centre, University College London, London, United Kingdom
{t.bi, nadia.berthouze, aneesha.singh, e.costanza}@ucl.ac.uk

ABSTRACT

Increasingly popular, long-distance running events (LDRE) attract not just runners but an exponentially increasing number of spectators. Due to the long duration and broad geographic spread of such events, interactions between them are limited to brief moments when runners (R) pass by their supporting spectators (S). Current technology is limited in its potential for supporting interactions and mainly measures and displays basic running information to spectators who passively consume it. In this paper, we conducted qualitative studies for an in-depth understanding of the R&S' shared experience during LDRE and how technology can enrich this experience. We propose a two-layer DyPECS framework, highlighting the rich dynamics of the R&S multi-faceted running journey and of their micro-encounters. DyPECS is enriched by the findings from our in depth qualitative studies. We finally present design implications for the multi-facet co-experience of R&S during LDRE.

CCS CONCEPTS

• Human-centered computing → **Empirical studies in HCI;**

KEYWORDS

Long-distance running; runner-spectator connection; shared experience; runner experience; spectator experience;

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1 INTRODUCTION

An increased awareness of the importance of physical activity has contributed to a boom in the organisation of and participation in long-distance running events (LDRE). For example, an estimated 807,000 running events are held in the UK every year [1]; more than 30,000 running events in 2016 were organized in the US [2]. Correspondingly, runner participation in marathon events has globally increased by 13% from 2009 to 2014, with increases of 10% in Europe, 14% in the US, and 92% in Asia [3]. Large numbers of spectators also participate in these events to support runners. Almost 20 times more spectators (800,000) than runners (41,469) participated in the 2018 London marathon [4]. Thus LDRE are social spaces for sharing experiences between runners and spectators [5].

In this paper, we focus on how technology could help increase the connection and co-experience between amateur or beginner runners and spectators (R&S) during LDRE. The spectators we focus on are runners' friends or family members. Due to the geographical distribution of the route, the large number of participants, and the long temporality of such running events [6], R&S might see each other only for a few minutes at a time, and only around two-four times during the event, when the runner passes the spectator [7]. This leads to spectators spending the majority of the event passively waiting for limited interactions with the runner. To enrich interactions between R&S and develop an in depth understanding of what information, beyond performance, should be shared and co-experienced during LDRE, we conducted a set of qualitative studies reported in this paper.

We make three contributions to HCI: First, we propose a framework to highlight the dynamic complexity of the journey from both R&S perspectives at physical, psychological, cognitive and social components (called 4-C hereafter). We enrich the framework with an in depth understanding of the 4-C of experience for R&S including how they change during the LDRE and affect the type and way support should be provided to the runner, and when sharing is appropriate. Second, we systematically investigate R&S interactions as a complex social phenomenon beyond simple cheering, from a macro level (i.e. the overall LDRE journey of R&S) and a micro level (i.e. brief physical encounters of R&S during LDRE). Finally, we contribute to the literature on the spectator's team-identity by identifying the processes that lead spectators to build and strengthen their runner-identity, a phenomenon necessary to fully engage in and feel satisfied from participating in LDRE. We

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conclude with insights and directions on designing for LDRE to maximize active sharing of R&S experiences.

2 BACKGROUND AND RELATED WORK

LDRE are organized endurance running over distance events such as ten kilometers (average finishing time (aft): ~1h), half marathons (~21km, aft: ~2h), full marathons (~42km, aft: ~4.5h), or triathlons of different lengths (aft: ~3h-13h) [8]. In this section, we explore R&S' experiences from sports psychology literature, social science and HCI perspectives to understand how current LDRE technologies support such experiences and their sharing between R&S.

2.1 Runner experience

Runners are motivated both intrinsically and extrinsically to participate in LDRE. Runners' extrinsic motivations include social influence, rewards and honour [9]; the atmosphere and audience help runners cope with the physical and emotional demands of the LDRE [10]. Intrinsic motivations of runners include enjoyment of running and sense of wellbeing. In addition to the social aspects and motivations, studies on elite athlete runners show that the running experience is also characterized by emotional, physiological and cognitive components as detailed below:

Emotional component: LDRE are associated with complex emotional experiences. Sports psychology studies [11-16] show that elite runners are anxious before events and exhilarated after successfully completing them. However, they have also identified the effect of emotional traits on performances and complex relationships between them [16] that depend on arousal levels [14].

Physical component: Sports psychology research has focused on elite runners' physiological experience of fatigue and exertion [17-22]. Studies on treadmills have shown a correlation between self-reported perceived exertion and physiological measurements (e.g., heart rate[21], ventilator minute volume[23], and accumulation of metabolites [24]). Runners' perceived exertion can also be affected by physical and physiological measurements provided by wearable sensors [25], highlighting further the malleability of such perceptions. Social phenomenological approaches have conversely focused on how runners express the experience, highlighting that the sensations of running are not only about fatigue, pain or exertion but also reciprocal haptic sensations between feet and ground, or of the skin touched by heat, wet and air, the auditory sensations of breathing and footfall on different surfaces, and olfactory sensations of sweat [26-33].

Cognitive component: Two common cognitive strategies to cope with LDRE in athletes have been identified: association and dissociation [5, 16, 34-36]. Associative strategies indicate that runners associate attention to the internal state of the sensed body, reading and processing sensory information from different body parts such as feet, calves, and respiration to modulate their pace accordingly [37]. Elite runners using associative strategies consume less oxygen than amateur distance runners as they may be more capable of responding to their body needs [18]. Dissociative strategy refers to runners focusing on external events, other than the run, to reduce boredom, monotony, and pain during LDRE. Examples of dissociative strategies employed by experienced runners include reconstructing images of past events and complex mathematical exercise [35].

Such studies demonstrate the need to design technologies that capture and support the runner's experience based on an understanding of these experiential components. They also show that such components cannot be looked at in isolation as they interact to form the running experience. Hereafter, we call these components **4-C** to including the social component too. As long-distance runners run for hours, it can be expected that these 4-C and derived needs change during this period [16, 18]. Understanding these changes is important to inform technology design, an aspect still missing from the literature. In addition, such an understanding needs to take into account a wider type of runner rather than just elite athletes, as differences appear to exist but are rarely investigated. Amateur and beginner runners have limited training and expertise with differing levels of coping capabilities and hence emotional needs. Thus, for this population, social aspects may be as important as performance, calling for a better understanding of how these three components may interact with the social one.

2.2 Spectator experience & technology

Most sports literature on spectators has focused on how spectators engage with other spectators [38] and spend free time (e.g., how they build digital memories of the event [39]). This is even more in the case of geographically spread events (eg., LDRE [7], car-races [40]) where spectators may, for long period of time, not see their supported athlete. For example, mGroup allows the creation and sharing of lived multimedia experiences through sharing messages and pictures within spectator groups [41]; BannerBattle visualizes spectators' activities on a display to enhance the experience of competing between two groups of spectators [40]. RunSpotRun allows spectators to crowdsource corpuses of LDRE to share among spectators [42].

Still, this literature acknowledges spectatorship (with respect to the athlete/team) as an active process, independently of the type of sport. In geographically colocated events (e.g., soccer, baseball), supporter groups actively support the team and compete against other supporter groups (e.g., [40]). In

geographically spread events, spectators actively plan routes, navigate to particular spots to see event highlights, and interact and chat with other spectators [40-44]. To support athletes, they cheer and track athletes/teams' performance. However, despite recognizing the active role of the spectators, the identified activities are not investigated in depth and hence fall short in informing design.

2.3 Technology for runners and spectators sharing

There is increasing interest in designing for sports and events such as LDRE. While very large LDRE like the Boston Marathon or the Olympic Marathon are broadcast live [45-47], commercial technologies are starting to improve the personal experience of LDRE [48] for both R&S. The 2018 London Marathon mobile app tracked runners' progress every five kilometers, enabling spectators to reach viewing points on time to watch their supported runners[49]. Current technology (e.g. MYLAPS) enables remote spectators (from their home) to remotely track runners, by providing live position and leaderboard updates, or sharing this information online through social media [50]. However useful, this information is still limited to location and basic performance statistics treating the supporter as a passive consumer.

Researchers are pushing the boundaries of tracking more advanced running information (e.g., foot strike [51-53], gesture [22, 54-58] and rhythmic breathing[59]). Studies have targeted social aspects of running together (between runners) using a computer-controllable flying Quadrotor as running companion [60], simulating the virtual team running experience [61], and displaying group running information on shared LED screens for team running [62]. But these studies ignore emotional and cognitive needs as highlighted for elite athletes in the sports literature.

Some prototypes communicate running experiences to interested spectators wherein the main approach is to share runners' performances and physiological signals. For example, TickTockRun displays a runner's daily training information (i.e. location, speed, route) at home to share running experiences with the runner's family [63]; SMASH, a handle-shape device, enables spectators to synchronously feel the runner's heartbeat through haptic sensations in their palms for a sense of closeness [64]; RunWithMe uses 360° video to stream a runner's view to online spectators [65].

Some studies have attempted to support runner-spectator interaction in real time during LDRE. For example, HeartLink allows a runner to broadcast heart rate data and enables online spectators to send cheering vibrations to support runners [66]. The RUFUS system allows a runner to actively request or stop cheering signals from spectators [7] as runners might want to limit external interruptions during a competitive race. Such interactive tools can give runners the sense of being followed and motivate them and make spectators feel engaged; however, spectators expressed eagerness for a stronger sense of connectedness [7, 66]. They were not satisfied with simple virtual "cheers" but wanted to access more runners' experience and have real interactions like onsite spectators [66]. However, being mainly technology-driven, these studies did not further investigate what spectators wanted in terms of real interactions or more information. Thus, this literature continues to use simple concepts of sharing performance data and R&S interactions.

In response to this gap in the literature, our study aims to build a deeper understanding of amateur/beginner R&S' experiences, their needs and changes over the journey to better inform the design of LDRE sharing technology.

3 METHODS

Based on the literature, four qualitative studies were designed to build an in depth understanding of the experience and corresponding needs for interaction of R&S during LDRE. Our studies were approved by the UCL Ethics Committee (UCLIC/1516/003), and they are described here:

Analysis of online blogs of marathon runners: to gain an understanding of running experience during LDRE. We used Google search with three key words: "marathon", "experience", and "blog". From the results, we filtered ten blogs (6 female, 4 male) based on content (event running not training) and length (more than 2 pages). Selected blogs are mainly about the marathon experience of amateur runners. For privacy, we do not list the blog URLs. We did not find any spectator blogs documenting their experience.

Analysis of reviews of marathon events' apps: to understand spectators' appreciation of current LDRE technology. Ten apps of the main marathons from the Apple App Store (e.g. 2017 London Marathon, 2017 Chicago Marathon. etc.) were selected as expected to be the most advanced ones available. We collected 89 publicly available reviews of these apps.

Semi-structured interviews: to gain a rich understanding of R&S' experiences. Twelve participants (4 female, 8 males; age 20-45), including five spectators and seven amateur/ beginner runners were interviewed. Runners were recruited by advertising at LDRE, social networks, UCL university club. Spectators were recruited through runners' recommendations. Interviews were either face-to-face (7) in a university room or via skype (5): ten participants had participated in a full marathon and two in a 10KM running event. Two pairs of R&S were interviewed together, all others individually. We obtained informed consent for all interviews. All interviews were audiotaped. Participants

received an £8 amazon voucher. A week before the interview, each participant was asked to email a map of a recent or memorable marathon they participated in either as a runner or spectator. The map's printout was used during the interview as a probe to elicit the experience details [67]. Participants were asked to describe the race on the map and runners to describe experiences and memories of running and of their spectators, how they felt physically and mentally, etc. Spectators were asked about experiences and memories of the run, of the runner's actions, and information desired. Finally, participants reflected on the annotated map.

Observations: to gain an understanding of the physical encounters and of the spectators' behavior. Two marathons were observed, involving contextual interactions and informal conversations with 20 spectators and 2 runners: (i) Hever Castle Marathon (9th July 2017) (ii) Virgin London Marathon (22nd April 2018). The first author recorded spectators' facial expression, behaviors, group conversations through field notes and pictures/ videos (with permission).

All data were transcribed and analyzed following thematic analysis according to the Braun and Clarke's six steps [68]. Themes were discussed with other authors before finalizing and writing up. Identified themes are described in the findings section; quotes are identified as follows: bloggers=B#, app-reviews=R#, and interviewees=Ps# (spectators) or Pr# (runners).

Findings are organized into two parts. Part 1 presents a framework describing the overview understanding of R&S' experiences and interactions during LDRE mainly based on observations and blogs analyses, complemented by interviews and literature. Part 2 presents the in-depth understanding of those experiences and sharing based on a synthesis of findings from all qualitative studies conducted.

4 PART 1: LDRE EXPERIENTIAL STRUCTURE

We identified an initial structure of the complex experience of a marathon from both R&S' perspectives based on the data from our blogs and observations, and the literature review above. Here, we present the DyPECS (Dynamic Physical, Emotional, Cognitive, Social journey) framework to capture this initial structure, highlighting components and phases of R&S' experiences and interactions. DyPECS (Figure 1) consists of an outer layer (OL) and an inner layer (IL). The OL of the DyPECS framework represents the R&S' phases of the journey and respective 4-C (and interaction among them). The IL captures the dynamics of the R&S' physical micro-encounters during LDRE and highlights the complex dynamic nature of support and interaction between the two stakeholders. It also helps to distance ourselves from a simple view of delivering cheering currently used in LDRE technology. These layers are described below:

OL Runner's thread: A marathon is an incredibly challenging long-distance run lasting for 42.2KM. We used the blogs' analysis to build a rich picture of the first-person perspective of running a marathon: we found a common structure among the blogs used to report the running experience based on sequential stages of km-based milestones: 0-5KM (phase 1), 5-10KM (phase 2) 10-20KM (phase 3), half way (phase 4), 30- 40KM (phase 5), and the last 2KM or finish line (phase 6). We use this incremental distance structure to represent the OL runner thread (Figure 1). However, we name each section in a more neutral way, i.e. phases 1-6 (Figure 1), to make the framework less constrained by specific distances run, instead capturing the main differences among those sections in terms of changes in 4-C (and their interactions) as the journey progresses. In addition, this naming takes into account that in reality these phases (ie. 4-C changes) may occur in a different order (or may not occur) as they depend on the specific runner's capabilities and

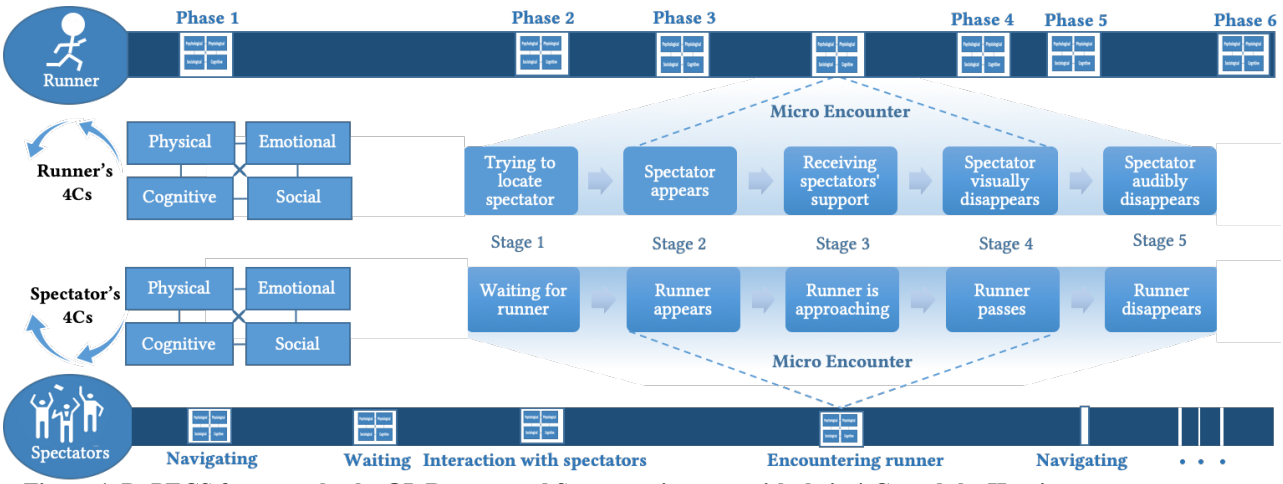

Figure 1. DyPECS framework: the OL Runner and Spectator journey with their 4-Cs and the IL micro-encounter stages

4-C state of the day. The aim is to aid a systematic analysis of LDRE rather than capture every aspect of it.

This identified phase-based structure also inspired the use of a marathon circuit map as an interview probe (described in the Methods section) to elicit participants' experiences. Figure 2 (left) shows Pr12's marathon map annotated during the interview. The annotations demonstrate the richness of noteworthy events during the marathon. From the runner's annotated map (Figure 2 – left), we can see examples of the 4-C experiences with emotions (e.g. in red: joy, fear, doubt, pride.), physical sensations (e.g. in blue: heat, pain), cognitive strategies (e.g. in brown: adjustment of plan), and social interactions with spectators (e.g., in green).

OL Spectator thread: The spectator's thread of DyPECS emerged mainly from the observations study confirming the phases identified in the literature on active spectator experience during other types of long-distance sports events [41, 69]. Spectators plan how to move from one spot to another, wait for their runner to appear, support (emotional and physical) the runner as s/he passes and then plan (cognitive and emotional) and move to another spot (physical). During idle moments, they interact with other spectators or enjoy the atmosphere. As such, the **4-C** emerge also for the spectators: Ps11's annotated map from the interviews (figure 2 – right) provides examples of multi-faceted spectatorship experiences: emotions (in red), physical effort (in blue), cognitive planning (in brown) and social interactions (in green).

IL Runner-spectator micro-encounters: The inner layer (IL) of the DyPECS aims to capture the structure of the R&S' physical micro-encounters. 5 consecutive stages emerged, based on first author's observation notes of marathons:

Stage 1 – Looking for each other: Spectators are "waiting for the runner" to appear and runners are "trying to locate their spectator" in the crowd as the excitement builds up.

Stage 2 – Connecting: Spectators connect with runners by shouting or waving to attract their runner's attention but the physical state of the runners may limit the external information they are able to process. The crowd density (especially at the end) may also hamper the connection.

Stage 3 – Passing by: The connection is established. As the "runner is approaching", the excitement increases. They actively seek interaction (e.g. talking, clapping or hugging).

Stage 4 – Separation: The "runner has passed by". The spectators still see the runner from behind and keep cheering to provide motivation. For runners, the "spectator has visually disappeared" from sight.

Stage 5 – Disappearing: The "runner disappears" from spectators' sight and the "spectator audibly disappears" in the runner's mind. Spectators keep cheering until they do not see the runner anymore and the excitement drops.

We will use the DyPECS structure in part 2 to further build a deeper understanding of the R&S' 4-C and their needs to share. We use "DyPECS: OL-R:P#" to refer to the OL runner-thread phases; "DyPECS: OL-S:P#" to the OL spectator-thread phases; "DyPECS: IL" and "DyPECS:IL-S#" to refer to the internal layer (IL) micro-encounter stages.

5 PART 2: RUNNER-SPECTATOR EXPERIENCE

Six themes characterizing the R&S' experience emerged from our studies and are described below.

5.1 Physiological beauty and pain

Similarly to findings from the social phenomenology literature for athletes [27-29], but absent from the HCI literature, our runners described the beauty of running.

Physiological beauty: Runners describe experiencing many enjoyable physiological sensations during LDRE. Examples from blogs and interviews include: auditory sensations, such as of their own panting, haptic sensations of wind crossing their face as they run, thermal sensations of warm chest, burning lungs, and dry throat when running on the top of a

Figure 2. Runner's Experience Map (left), Spectator's Experience Map (right)

hill. Pr2 said: "*When this (burning) sense lightens, you start to enjoy the mixture of heat and cool and fresh air. It's like the chemical mixture of adrenaline and endorphins*." Runners enjoyed these sensations especially in the second and third phases of the marathon when starting to perceive the effort of running (DyPECS: OL-R:P2-3) but it is still manageable. They wanted to share the beauty of the run with spectators.

Physiological chemistry: Differently from literature, runners also enjoyed discussing the chemistry of running. The complexity of the processes and the pride of being able to exploit those processes made such processes attractive to them. "*The marathon is a fiendish distance. Your main source of energy for running is glucose. When this source runs out your body turns more to fat burning to keep your legs moving. The transition can be uncomfortable. It's like being hungover. It's a real feeling in response to the real change in your body but they won't last long. However, it can poison the mind, and then the wall can hurt you for much longer*" (B2). Most runners (especially beginners) "*hit the wall*" in the later phases of the run (DyPECS: OL-R:P4-5), i.e. they run out of energy and start to lose the physical capability of moving if they have not learned to transition between resources. The intense physiological consumption may also be caused by runners pushing harder for a better finishing time than they achieved during training. Pr2 said "*If it's not racing, you can do it in a slow time. But you just keep pushing [...]trying to do this as proper race.*"

5.2 Runners' cognitive strategies

As described in the background, associative and dissociative strategies also emerged in our studies. These could be planned or unplanned throughout the journey (OL-R:P1-6). We report them here briefly, even if not novel per se, as they interact with other components (see next themes). In addition, some examples are also interesting as different from the elite athletes' who are much more focused on performances (math computation, motor imaging).

Dissociations: Pr6 described his strategy to maintain motivation for running, through purposeful dissociation: "*There is a trick that you associate a person or something to each of the last few miles. And in my case, at mile 25, I was thinking about a promise to someone. When it was really hard in the last two miles I was thinking about my little niece.*" Runners could also be dissociated without an active plan, for example because of the live event atmosphere, which could reduce the sense of boredom and tiredness. Pr5 described: "*Every several hundred meters, there were some music bands, music, drums playing […] it helps you …".*

Associations: Runners passively switched to the associative state because of emerging pain (e.g. OL-R:4-6Phase). Pr6 explained, "*I start to feel a little pain on my hip and I realized I started to run a bit differently[...]. I started to operate my strategies. As soon as I focused on the run, my hip got better."* The ability to change strategy and to better manage your body, emerged as an important, even critical, skill and was seen in more experienced runners.

5.3 Runner's Emotions and 4-C interactions

Whilst the sports literature has mainly investigated emotions felt before and after a run, our results show that runners experienced a full dynamic emotional journey with these emotions interacting with the other components and behaviour:

An emotional journey: In the beginning of the race (DyPECS: OL-R:P1-2), many runners felt excited by the event atmosphere and support from friends and family. They were relaxed, confident, and enthusiastic. B1 shared: *"I started to overtake some of the runners".* By the end (DyPECS: OL-Runner-phase 5 or 6), the pain and hardship overcome to complete a race provided a sense of pride. B2 said, "*You'll feel like crap. But it's worth to be proud of yourself.*" Social aspects of the LDRE contributed to the emotional experience. When passing known spectators (DyPECS: IL), runners felt excited and showed they were doing well. Pr3 adjusted his running performance, *"That was such a really lovely surprise. I looked at them, waved at them and started to run faster and feel more active."* Besides being motivated by their supporters, runners were delighted by things they saw: people in fancy dress, amazing scenery, and high-fiving with children. Pr6 felt inspired on seeing a disabled participant, *"The wife was on the wheelchair and the husband was pushing her. This was really difficult".*

Emotional, physical and social interactions: Our results also shed further light on the interaction between physical and emotional factors reported in the literature [18], especially during the more demanding phases (DyPECS: OL-R:P4-5) when resources are ending and the finishing line is still far. Negative feelings emerged such as exhaustion, desperation, self-doubt and lack of confidence. This often happened when runners were hitting the wall. B2 said, *"You start off a downward emotional spiral where you start to doubt yourself, question the point of what you are doing and start to find excuses for why you didn't finish."* When emotionally vulnerable, many runners wanted to communicate their difficulties and were eager for understanding and support. Pr4 said, *"My legs were extremely heavy. I couldn't run anymore. I want a person who can talk with me, who can understand my terrible situation."* Some runners wanted encouragement even when they did not articulate the need. Pr3 said, *"If there's some technology [without runner asking], [supporter] can shout messages out for an app to say 'Keep going' to motivate you when you are in pain."*

Support is not always good: Differently from the literature [70, 71], social support did not emerge as a simple process. In contrast to runners who wanted encouragement at difficult moments, some runners in our studies felt annoyed and misunderstood by the crowd or even their friends cheering. Pr1 explained: *"There were always some people who shouted "keep going, keep going". They didn't know my real condition that I was in pain. [...] I felt very annoyed..."* Cheering by spectators encouraging them to run faster irritated runners who needed to carefully adjust their pace (associative strategies) according to their physical state and pain. Pr2's friend was running with him and over-cheering when he was struggling: *"He (Pr2's friend) tried to be cheerful as I'm falling over. He's like 'Come on! We can (do it)!' He was dragging me along. But I said 'No, it's not going to work. I don't want to!' I shouted at my friend. I was feeling angry.*" In some instances of extreme struggle, runners might lack mental resources to interact with spectators (and need to shift to associative strategies) and their support was no longer enjoyable or easy to process. Pr6 said, ". *I'm tired. [...] It was all about [...] going deeper into my little corner in my own mind. I was no longer enjoying the spectator crowd as much. I actually moved away from the people so that I didn't have to deal with that."* In extreme cases, runners could hurt themselves in trying to meet spectators' expectations. Pr1 said: "A *runner was trying to high five with the kids ... in the crowd. And after that, he seemed more motivated and trying to speed up, but suddenly he cramped and fell over*". Spectators' improper cheering was due to not being fully cognizant of the runner's (Emotional X Cognitive) situation. Pr2 said of his friend, *"... he knows a lot about running, the wall stuff, he couldn't feel this because he hasn't done the whole running."*

5.4 Spectators' emotional & cognitive journey

Spectators identified themselves as runners' supporters. They wanted to know when the runner was having difficulties or feeling stressed, and the best time to encourage them mentally (cheering) and physically (providing energy supplements). Differently from the literature, our supporters were aware that support was not simply about motivating the runner. They knew that running was a complex multi-faceted experience and to really support their runners (i.e., fulfill their role of supporter), they also needed to understand their runner's cognitive needs. Ps7 said, "*If she lacks water, I can prepare it. It would be nice to know when she […]is tired or if she has doubts. It would be nice to encourage her …*".

The tension of planning for the best meeting spot: The spectators' journey clearly emerged since planning for the first spot to see the runner (DyPECS: IL-stage 1). Spots are often pre-planned with runners but also decided on the moment by using tracking apps and rough estimates of the runner's speed. App review data shows spectators like the app tracking function for this. R26 commented, *"Being able to track runners and see the leader board is brilliant..."*. As they wait for the runner (DyPECS: IL-stage 2), Ps7 said, *"We have the app that can get measurement of her location every five miles. I kept looking at the runners [...], see if I could spot her. [...]I felt quite tense, quite nervous, thinking 'she's going to come through...'"*. At the same time, planning was colored by nervousness also due to the lack of precision of the tracking device. Ps11 said, "*It was difficult to tell what the exact time she would come."* This was also confirmed by app reviews where most complaints were about this lack of tracking accuracy. R36 commented, "*The live tracking said he had finished the race when he hadn't, which meant I missed cheering him on. Spoiled my day."* For some, unpredictability itself was a part of the event. Ps8 enjoyed the nervousness: *"... after the marathon, I feel I enjoyed this feeling because it was an element of the experience ..."*

Runner passing moment: The runner passing by (DyPECS: IL-stage 3) is a brief and only moment where R&S can interact. Attracting the runner's attention was considered a pleasure. Ps10 said, *"I'm excited and firstly trying to get her attention to see me. I waved to her straight away"*. Observational data of spectators' facial and verbal expressions showed that spectators were emotionally aroused even after the runner had just passed (DyPECS IL: runner passed). Spectators tried to extend the connection with runners. Ps7 said: *"I still kept shouting her name and trying to give her some boost as much as I could. Even though I [knew]she might not hear that."* As the runner disappeared (DyPECS IL-stage 5), spectators chatted and exchanged their experiences, covering topics including runners' face, gestures, and movements. Ps11 described, *"I was quite happy because she looks comfortable. She looks like she is doing well."*

Missing the Runner: However, there were situations when spectators were disappointed by missing the runner (lack of DyPECS: IL-stage 3). Ps10 missed the runner because "*there are so many spectators, it is very difficult to get a good view. I know she was coming but I couldn't get into the people to see her. So, we missed*". R67 missed the runner because the moment is too brief, "*I watched the coloured line of my friend on the app get closer, with my camera poised to take her photo … and then to my surprise, she passed me. I missed the chance*." Spectators were also upset when they were not recognized by the runner as the runner was focusing on running or did not manage to locate the spectator. Ps7 described, *"I did shout to her, and I waved my hands. But I don't think she saw me cos she had headphones in. She was too focused on the run [...] I was a little bit disappointed."*

5.5 Spectator's runner-identity (SRI) process

Similar to the literature on team-identity [72, 73], our findings show that spectators experienced a kind of team-identity or more precisely a SRI. They described themselves as mentally running with their runners with the shared goal of finishing the race. For example, Ps8 said, "*You stay here for a long time, you mentally run with them, you know how much work they put it in to prepare for it*".

Our literature review showed that building an identity with the group of supporters and the team they support is critical to fully enjoy the event [74, 75] including LDRE [7]. Our findings add to this literature by describing the process of building the SRI. In professional sports literature, the process of building a team identity is based on long term exposure to the professional sports team and the supporter group, enhanced by purposely created media representations of the team and sold merchandise [72]. Our results show a different process of building SRI with friend/family runners, starting with the training period and continuing during LDRE. We summarise below the identified elements and the process:

Knowing the runners' goal: Our participants talked about knowing the physical and emotional effort put into the training by their runners: *"I really feel very emotional cos she has been working hard, running and training a lot. She said she want to finish within two hours. I was so emotional she has really done it. For me, it's important to see her (at the finishing line), the way she looks when she's gone through, ...she just achieved that ...*" (Ps7); *"Great to see him after the finishing line with the medal, that's the highlight [...] it's the months and months work,"* (Ps10).

Spectators' Investment (enabling, properly supporting, effort during both training and LDRE): The spectator's investments of time and preparation both during the marathon (DyPECS:OL-S-navigating & waiting) and already started during the months of training contribute to build up the sense of involvement in the marathons (and its preparation) and lead them to appreciate the effort of their runner. Ps11 felt more involved when seeing the runner approaching the finish line by having been part of it for long: *"Great to see her in the finish line. You might be tenser and so much more involved with the experience of finishing and success as you have already emotionally invested months before you hear about it. You've already been a part of it".*

Role recognition by the runner: As for the sport psychology, strengthening of the team-identity is critical to reach fulfillment of the event. Our findings suggest a different type of element critical to the strengthening of the runner-identity: recognition of supporting role. Spectators needed to have their effort and support recognized by runners. *"It would be nice for her to see me there. So, she knew I was there to support her at that point."* (Ps7).

5.6 Difficulty of sharing VS desire to share

While the literature highlights the importance of social support, it downplays the sharing of running experiences to a cheering service that can be switched on/off [7]. Our findings depict instead a rich and complex process. As seen in the previous sub-sections, both R&S are eager to know and share. Runners want to share to receive support but also to reward the spectator. Pr12 explained, *"If your friend is travelling to Berlin because you run a marathon, (share the experience) it's kind of the best way to engage them, thank them for being there..."* We saw before that spectators want to know the runners' needs (4-C) to better support them and to some extent share their own 4-C to have their role recognised. However, sharing is complex and we discuss here a few specific barriers identified specific to sharing.

Too busy and too complex to share: Runners found it hard to share their experience with spectators during an event, even though they wanted to. They found it hard to verbalize their real-time emotions because they were complex states mixed with cognitive elements. Pr2 explained: *"It's easy to talk about things like 'My calf is hurting, or I need water'. What you can't say is the emotional stuff."* Pr2 added, *"I don't know how to make non-runners understand your feelings like the achievement of getting to the top of the hill."* Further, it was challenging to share information while running. Pr5 said, "*It's too much mental energy and you don't really want to have a conversation, you have to focus on the race".* The only chance for runners to talk with their spectators is when they pass them (DyPECS: IL-Micro-encounter). However, this moment is brief as they have to continue running. "*You only got few seconds. What you can say is 'I'm doing okay, or I'm feeling good"* (Pr2). Consciously or unconsciously non-verbal behaviour was a means to overcome this difficulty.

When not to share: Some runners did not share pain with spectators, especially their parents, as they did not want to worry them. Pr2 said *"If I told them [pain] was really bad, they actually would be scared."* What runners want to share is the need for support rather than the pain itself. Pr4 said, *"I don't want to let them know about my pain. But I still wanted to get encouragement from them when I was in pain*."

Sharing experiential maps: Many runners liked the idea of using annotated experience maps (e.g. figure 2) to document the running experience and tell their running stories. Pr2 said, "*it's definitely amazing when you share your own running experience with friends. Cos it has [...] interesting information, you don't have to recall by yourself. It's easy to tell the story."* Pr6 added, *"It would be great if the app can*

present a map like this. It's like a record of my memory. I probably will forget some details few days later." Some runners thought maps were useful to compare experiences (and not just performances) as they aid understanding and memory of previous runs, helping to improve running strategies. Pr12 said: *"If I had such a map, I would look back again to see where I did well or not, to adjust my strategies in next race. Like the emotion or the pain could more directly tell my situation, when compared with basic speed data."*

Similarly, spectators enjoyed reading the runner's experience map and discover more about their experience. The rich information made them feel more involved. *"I must confess I thought I knew everything about your marathon, however reading your map, I've learnt so much more and feel I've been given a close-up view of the dayyou lived, one of torment, euphoria and celebration!" (*Ps11) Spectators expressed dissatisfaction in existing commercial applications and wanted a live experience map during the race to help them better support runners. Ps9 said, "*We can only know the check point time*". Ps11 felt that: *"[using the annotated map] I could give her some motivation if I saw her emotion on this map, especially when she was struggling."*

6 DISCUSSION AND DESIGN IMPLICATIONS

Here, we discuss the design implications of our findings.

6.1 Capturing runners' experience

Our results indicate that sensations, emotions and cognitive states are critical to understand the runners' experience and needs, not just performance measures. Advances in affective computing and sensing technology provide the basis for this new direction in designing LDRE technology. Pain levels can be measured using physiological sensors [76, 77] and activity sensors, in both static and sport situations [78, 79]. Fatigue and muscle tiredness can be captured through EMG and pressure sensors (e.g., in shoes [80]). Skin temperature can be tracked by temperature sensors or even thermal cameras which are becoming smaller and smaller (e.g., attached to headset [81]). Body movement sensors can also detect affective states, that emerged in our studies, such as pride and excitement [78, 82], low confidence and concentration [83]. Physiological sensors can track high arousal, excitement [75], and frustration [76]. In addition, movement sensors might be able to discriminate between periods of associative strategies, possibly characterized by a more controlled body stance to save resources, from dissociative states where the body (and the head in particular) may be less controlled as engaged in exploring the external world [83-85].

New opportunities for LDRE interventions are provided through increasingly used low cost portable EEGs [86] in HCI [87] and the growing body of work on EEG measurements during long distance sport events (e.g., review [88], cycling[89], running[90], running and mood[91]). This work shows the possibilities offered by EEG to discriminate between levels of fatigue and suggests that associative strategies to cope with increased physical demand may result in output in the pre-frontal cortex. Simultaneously, work on pleasurable tactile experience illustrates how EEG measurements of the sensory motor cortex (among other brain areas) can discriminate pleasurable tactile sensations (lack of cortical activity inhibition) from not-pleasurable/neutral tactile sensations (cortical activity inhibition) on the arm [92]. Such measurements could detect pleasurable thermal sensations on the skin caused by reactions of different skin mechanoreceptors.

Thus, we see potential for LDRE experience sharing technology to be built on such automatic recognition capabilities. Yet, more foundational work is needed to better understand how running affects expression patterns (behavioral or physiological), and to deal with possible interferences and possible confound (e.g., sweat as discussed in [89]). Separating exertion measures from emotional measures in physiological signals is also a challenge, but methods have been proposed to discriminate physiological signatures [93] and could be further studied in this context. Multi-modal detection of such patterns is also shown to produce more reliable interpretation 4-C meanings [83, 94].

6.2 The annotated runner's map

Both R&S suggested the use of **4-C enriched maps** to better understand the runner's journey, so that spectators could better support the runner, and runners could remember and recount experiences after the event. The technology discussed above could help annotate these maps with multimodal representations of the runner's experience. Ideally, such representations should be designed both for the spectator to experience the event from the runner's perspective, and to aid their decision making (i.e. for where to go and when to cheer).

Our results suggest that the annotation of such maps should be semi-automatic, rather than fully automatic, not only to address the technical limitations of classifiers discussed above (due to the complexity of such detection, e.g. contextual factors) but also because inferring such states may be an enjoyable part of the supporter's role. Indeed, beyond the activities of the supporter highlighted by the literature [7, 41, 43, 70, 72, 95], our results show that supporters engage in making sense of their runners' states by building on their knowledge of their runners and observing

their behavior as they pass. In addition, runners could annotate the maps directly, to indicate how they feel and what they need. Pr6 said "*I wish I asked her to wait for me at this spot as I really need her support now … just before falling."*(Pr6). Runners could contribute to the annotated map to decide what they would like spectators to experience.

6.3 Supporting Spectator's Runner-Identity Process

Spectators are treated as passive consumers of information and to deliver cheering in existing LDRE technology. Our findings open a new space for design: to enhance spectators' engagement [7, 40, 96], satisfaction [74, 97, 98] and wellbeing [99]. This space is conducive to the building of the runner-identity. First, technology design could support spectators in their identity of Runner-Enabler and Supporter both during training and the LDRE. As discussed in sections 6.1 and 6.2, providing a better understanding of the 4-C is critical to building better knowledge of running and its needs and sensing technology could be leveraged for this purpose.

Another important design space, to support the process of building runner-identity (Section 5.5), is role recognition. Spectators were involved since training in for example taking care of children or cooking to provide free time to the runner (enabling), or tracking the runner to prepare food for them on time (supporting) [7]. Technology design could start recognize spectators' involvement since early stages (training) even before the journey in DyPECS. Furthermore, the 4-C effort during LDRE should also be recognized. For example, one of the authors ran 4.5 km to reach 4 viewing spots during her spouse's marathon. These unseen efforts could be tracked using sensors currently designed only for runners and then represented on the spectator's annotated map (complementary to the runner's map) or sent to the runner at run-time for bidirectional sharing of the journey.

6.4 Physical/Virtual micro-stage encounters

Most of the literature has focused on increasing moments of sharing between R&S by simply enabling virtual cheering or readings of tracked information [7, 66, 71]. Our results show the micro-stages of physical interaction between R&S. Our data indicates that these micro-encounters are not just about the moment of seeing each other, but tension is built in advance, and success is appraised afterwards. We refer to the 'success' of the encounters because each actor described their role towards the other and how part of their role is accomplished during these moments.

Detailed analyses of the encounters' micro-stages highlight the opportunities available to enrich the encounters. The use of strategies from the digital media and movie making literature [100] could support the building of tension or surprise before and during the encounters, and their appraisal during and after it. Relevant information of the runner's states (i.e. 4-C) needs to be provided to spectators so they can deliver appropriate support, but also emotional and physical responses of runners to the received support could be used to reward the supporter, helping the runner-identity building process.

Finally, our results about micro physical encounters could inspire the design of virtual/digital encounters of R&S. As physical encounters are limited in LDRE, a similar structure could be used to develop digital encounters: not simply cheering but the emotional building aspect including the possibility of missed opportunity as frustration is also part of the experience. This would provide valuable possibilities for engagement given the increasing numbers of remote spectators following runners internationally from their home through apps.

7 CONCLUSIONS

The growing body of literature investigating the design of technology to connect R&S is still modelled on a limited understanding of the LDRE experience. Our findings led to a new framework, DyPECS, to facilitate a systematic analysis of macro and micro-phases of running from the R&S' perspectives. In particular, (i) we show the dynamic changes (see DyPECS:OL) and complex interactions between physical, emotional, cognitive internal components and social factors (4-C) and how they contribute to the experiences of R&S during LDRE and affect runners' behaviors and needs; (ii) we provide an in-depth understanding of the complexity of sharing and how the 4-C of the runners direct the type of support they need from spectators and when silent support is better; (iii) we identify that spectators' needs should be understood and rewarded (DyPECS:IL) and propose the formation process of spectator's runner-identity (SRI) and how it builds on spectators' engagement during LDRE. Finally, we propose design directions calling for experiential bi-directional sharing rather than one-directional performance-cheering.

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