

Crowdsourcing Synchronous Spectator Support: (go on, go on, you're the best)ⁿ⁻¹

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ABSTRACT

Many studies have shown that crowd-support, such as cheering during sport events, can have a positive impact on athletes' performance. However, up until recently this support was only possible if the supporters and the athletes were geographically co-located. Can cheering be done remotely and would this be effective? In this paper we investigate the effect and possibilities of live remote cheering on co-located athletes and online supporting crowds that have a weak social tie and no social tie with the athlete. We recruit 140 online spectators and 5 athletes for an ad-hoc 5km road race. Results indicate that crowds socially closer to the athletes are significantly more engaged in the support. The athletes were excited by live remote cheering from friendsourced spectators and cheering from unknown crowdsourced participants indicating that remote friends and outsourced spectators could be an important source of support.

Author Keywords

Crowdsourcing; Friendsourcing; Spectator Support; Social Networks; Sports; Spectators; Broadcast; Cheering; Human Behavior.

ACM Classification Keywords

H.5.m. [Information interfaces and presentation]: Miscellaneous; H.5.3 [Group and organizational interfaces]: Synchronous interaction; J.4 [Social and behavioral science]: Psychology

INTRODUCTION

The Facebook 'Like' button was a revolutionary tool in digitizing a tiny yet significant piece of human communication within social networks. Receiving 'Likes' can have a positive effect on the emotions of the social

network user receiving them and in the context of behavior change, this is often used as a source of motivation for people trying to attain new goals [18]. However while this type of support is very applicable in scenarios of behavior change that have longitudinal measures [24, 27], such as in motivating persons who are trying to become more physically fit [9] or cease smoking [25], it might not be as practical for situations where motivation is needed in real-time and in sync with the activity that is being conducted such as cheering athletes during a race. Current social networks were primarily designed for asynchronous communication. While this has many advantages, for instance, the message receivers do not need to be online to receive the messages, it may be inapt for situations where support from one's network needs to be in sync with its demand. Currently, athletes who share information about their events through online social networks, often receive encouraging 'Likes' and posts in support. However, athletes typically see these posts only when the activity is completed. Consequently, any motivation created through the perceived social value of accumulating 'Likes', does not translate into support during the activity and has no influence on the outcome.

To start exploring synchronous social network support we use sports. Sports was chosen because many studies have already showed that cheering co-located spectators (e.g. on a race course) can have a direct impact on the performance of the athletes [8, 14]; but can this be done remotely? This could have a huge impact yet there has been negligible HCI or CSCW work that explores ways of digitizing synchronous crowd support in this context. Possible benefits may include 1) allowing fans that don't afford to be physically present at the event's location to support the athlete, 2) allowing non-famous athletes to recruit support from their personal social networks or 3) potentially harnessing the support from globally crowdsourced participants through platforms like Amazon Mechanical Turk. Is this support possible and does the nature of the online crowd matter? Put in another way, are athletes more motivated by friends or is the support of strangers just as effective, if any?

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We implement a system where long distance runners broadcast location and heart rate data to online spectators. The spectators can then cheer the athletes by pressing a 'Cheer' button. This sends an immediate alert to the selected athletes thus making the athletes aware that a crowd is following their activity. In the study we use a crowd made up of two groups. 1) Friendsourced volunteers. Based on Bernstein et al.'s proposition, we express friendsourcing as "collecting resources from a socially-connected group of individuals" [6]. 2) A paid crowd that was recruited through Crowdfunder; a crowdsourcing platform. We then analyzed the effects on both spectator groups and the athletes (being cheered on).

The data showed that friendsourced participants were more engaged with the system than outsourced spectators. We found that the athletes showed mild excitement when receiving real-time haptic and audible cheers but were particularly excited by knowing the number of cheers submitted and the number of people following the activity (logged in and not necessarily cheering) during the event.

RELATED WORK

Up until a few years ago an athlete's performance was often broadcast only if the athlete was famous enough to merit television broadcast. In recent years as social networks became increasingly ubiquitous it became possible for almost any athlete with Internet access, to broadcast their participation in sport events. Freely available mobile applications like Runkeeper, Runtastic and Azumio allow users to share locative and physiological data, with selected friends or even publicly. These commercial implementations were preceded by a number of studies within academia that studied the effect on the athletes and spectators when sharing real-time data during sport events [17, 19, 23]. Sport applications such as Runtastic more recently implemented feedback features by which athletes can not only share live data but also receive live cheers from friends during the activity. After the event, the athletes can then look into who sent them cheers over a web interface. These commercial applications however do not provide much scientific insight on the social network effect of sharing live data and the impact that real-time spectator-support may have on athletes, if any.

Curmi et al. explored work in the area of real-time spectator support in 2012 through the HeartLink project [11]. In this work athletes shared heart rate data online and friends encouraged the athletes remotely. The HeartLink project consisted of two pilot studies and focused on the design and implementation of such systems. The study presented here follows the recommendations for future work that was suggested in this work namely: A) A need to validate results with a larger population. Thus spectator population was increased from 9 to 140. B) Test a new fully independent system (BioShare) and observe whether HeartLink's outcomes were influenced by issues raised from relying on distributed 3rd party systems. C) More

importantly, compare and contrast the engagement of friends vs. unknown crowds by having different groups under observation concurrently. Additionally, we observe whether spectators are influenced by the social connectedness between the person cheering and the participant receiving the cheers. We also explore the effect on the athletes from being remotely cheered and whether the nature of the online cheering crowd matters - are athletes more motivated when supported by known crowds in contrast to unknown crowds?

Supporting crowds that are made up of unknown spectators are typical in sport events. On the other hand, the use of crowdsourced participants for user support is also not new and in recent years, through online crowdsourcing platforms, many innovative applications were developed such as summarizing academic papers [5] or deciphering blurred text [21]. But can crowd support and crowdsourcing be combined effectively in a real-time context?

Real-time Factor

The real-time context is particularly challenging in crowdsourcing. Most crowdsourcing platforms are not designed for recruiting workers as a just-in-time workforce. Typical crowdsourced jobs, such as online surveys, are posted on crowdsourcing platforms and workers would complete the tasks when they please. In the cheering case however, the support has to happen at a specific time and workers have to 'sync' with the event rather than vice versa. Related work is found in studies on crowd-powered interfaces with highly innovative techniques for crowdsourcing just-in-time work such as VizWiz - a system for crowdsourcing near real-time support for vision impaired [7], Lasecki et al.'s ingenious work for captioning live speech [20] and Bernstein et al.'s work on queuing workers using multiple queuing models [4]. However, with the exception of Morris et al.'s work on 'Crowdsourcing Collective Emotional Intelligence' [22], there is very little knowledge on crowdsourcing spectator support.

STUDY DESIGN

In the initial stages of the study that is presented in this paper, two design approaches for digitizing cheering during sport event were considered. The first was that of studying current cheering practices ethnographically and then finding ways to replicate as best as we can the cheering process digitally. The second was that of identifying radically new ways by focusing on the core objective (i.e. motivating the athletes) and designing new systems around this. While both approaches are pertinent, the second approach was adopted. In the first approach it is more likely to omit possible radical new ways of reaching equal or better outcomes for supporting the athletes. Through emerging digital tools, new approaches to cheering might now be possible but are not present in the 'traditional' co-located cheering processes. Consequently design started with a bottom up approach and a series of tests with different prototype configurations.

The preliminary tests were conducted during a range of events that included running, mountain running and cycling, and were intended to 1) test the data broadcasting system, 2) explore the study dynamics within simpler scenarios than those described in this paper and 3) gather insights on the user experience of both the athlete and the spectators. The insights gained from these pretests were then used to develop the research questions and the design of the exploratory deployment here described.

For this study we organized an ad-hoc 5 km race with co-located athletes and an online crowd of spectators. The race selection was based such that there will be enough time for the spectators to log in and understand the interface while at the same time make sure the race was not too long, so as not to increase the complexity of managing the online crowd. Additionally, the selection of the race course ensured that the event would have mobile network coverage on a selected service provider for at least 70% of the course.

Data sharing infrastructure

The data broadcast system was implemented using BioShare [10]. BioShare is an open source application that was designed for broadcasting data during day-to-day activities through a smartphone app and a web portal for visualizing the broadcasted data in real-time. The mobile application runs on Android devices and allows users to collect data through Bluetooth-connected sensors. This data is then shared with an online crowd that can interact with the data-sharing users through multiple modalities.

BioShare was specifically designed for researchers and as such, it also logs user interaction for post event analysis. The system was configured as illustrated in Figure 1. We re-configured the default settings in BioShare such that data is broadcast to those who log through a login process that will be described in the next sections.

In the pre-event tests we found that during synchronous studies that involve online crowds, a communication channel between the researchers and the crowd is essential. The real-time factor makes this work challenging particularly because it is difficult to predict all possible failure modes in such live activities at design stage. Additionally, unlike an in-the-lab study, the researchers have very limited feedback on what is happening within the distributed crowd (and no feedback from facial expressions and body language that may help in adjusting the study accordingly). In this light, a feature that allowed the researchers to broadcast messages on the spectators' interface was also implemented. This was used to inform the spectators of any technical issues that might occur during the live event.

Athlete Participants

We recruited 5 athletes from a university running club who 1) were happy to participate in the study, 2) train regularly for competitive running and 3) had a detailed log of performance records in 5k races. In return of participating, a

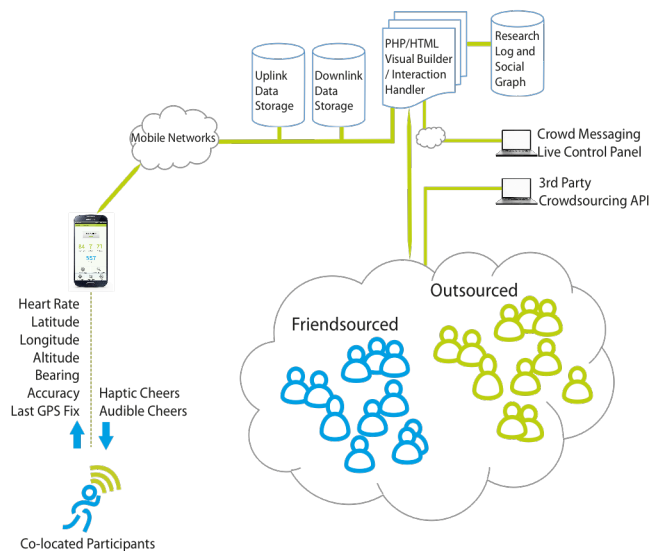


Figure 1: The system infrastructure.

donation was given to the running club. The researchers did not know the athletes prior to this work and met them for the first time just before the race. None of the participants had used smart phones or any other device to track their performance during previous races so the participants had little predefined expectations of the technology or the user experience of carrying extra devices during the event.

Before starting the race the athletes were each given a Nexus 5 phone that was preconfigured with the customized BioShare application, an armband, a mobile data connection and a Polar WearLink heart rate chest strap that was connected to the phones via Bluetooth. The heart rate data type was used as it is a physiological parameter that is easy to measure in unobtrusive ways and because heart-rate measuring sensors are becoming very popular in emerging smartphones and wearable devices. Additionally the heart rate can indicate the fitness levels of individuals and the effort exerted during an activity. To ensure consistency, the phones were preconfigured and positioned by the researchers. The armbands were color-coded and this coding was used for identification of the participants on location.

Crowd Participants

In parallel with recruiting the athletes, 140 online spectators were recruited for the live event. 76 of these participants were recruited from CrowdFlower - an online crowdsourcing platform with a global distribution of active workers. Unlike Amazon Mechanical Turk, CrowdFlower supports European requestors at the time of writing. Crowdsourcing through an independent platform minimized the probability of having participants within this group that are socially connected with the athletes. These spectators were first introduced to the interface. They were then asked to follow the running athletes online for as long as they

wish to and support them in the best way they could. At the end, they were presented with an 8-question survey.

A second group of spectators (n=64) were recruited through social networks at the athletes' university. Communication requesting participants to support the athletes was sent to the athlete's running club Facebook group and their departments' mailing lists. In this paper we refer to this group as 'Friendsourced'.

Procedure

During the event each of the devices carried by the participants collected and broadcasted live data as shown in Figure 2. Online spectators could visualize the live data through any Internet connected web browser after logging in through a Facebook app. The participants were also given the option to log in anonymously.

Following this, spectators were presented with live data visuals from each athlete consisting of heart rate, average heart rate during the event, a line chart with the heart rate, event duration in minutes, percentage of the task completed, meters covered, speed, pace and a chart with the running course overlaid on a map. All the data was dynamically updated every 2 seconds, on average, thus giving a "real-time" feel.

Spectators in both groups could change the athlete that was being followed at any time. This was done to observe how the crowd reacts to different athletes' performance. Just before the race the athletes were assigned as Participant 1 to 5 and this naming was used in the spectators' interface. Thus during the live event, none of the spectators knew who is, say, 'Participant 1'. However, the friendsourced crowd knew that the athletes were from their same department or running club. This approach was adopted to limit the range of tie strength within the group and ethical data sharing issues. In this study we consider these actors as having weak ties [16] with the athletes. The participants who were outsourced through the global crowdsourcing platform were considered as having no ties.

Interaction modality

Spectators could 'Cheer' the selected athlete by clicking a Cheer button. This button sent a small vibration to the device carried by the selected athlete. If the cheering spectator logged in through the Facebook application, then the athlete also heard the name of the person who cheered through the device's speaker and a speech synthesizer; otherwise the athlete heard 'Guest'. The interface presented also allowed all the spectators to post comments through a Facebook frame. By default the posts submitted by the spectators did not go on their personal Facebook profile but were only visible on the spectators' interface. To ensure that the data is not contaminated with crosstalk between the groups, each spectator only saw comments that were posted by those in the same group and following the same athlete.

The data broadcasting app (Figure 3) was designed in such a way that the users do not need to interact with it through

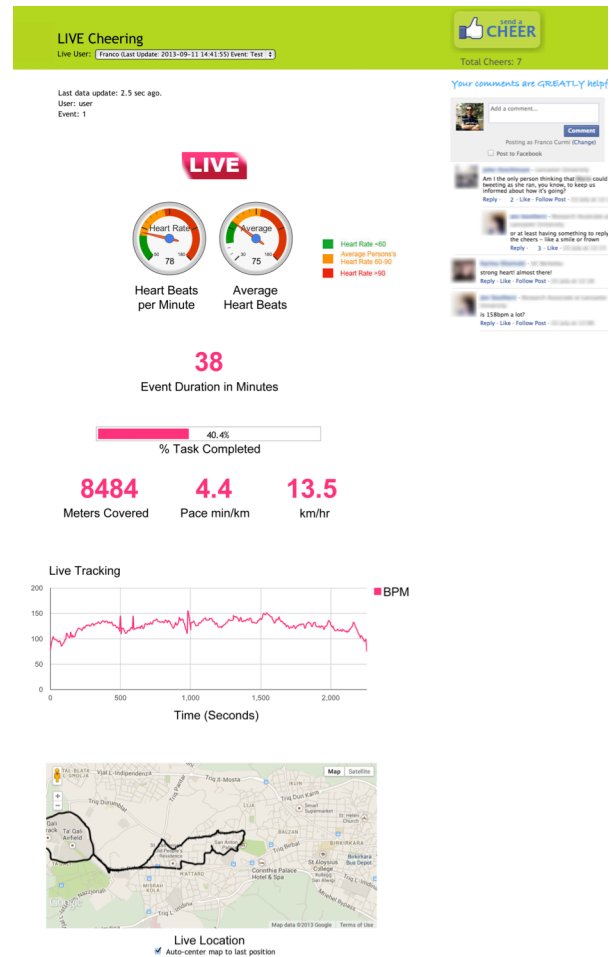


Figure 2: Sample spectator interface.

touch during the activity. Before starting the event, the athletes were briefed on how the system works and what the haptic and audible feedback represents. The pre-event tests showed that the sound level is a key part of the user experience and a too low volume makes understanding difficult while a too high volume, particularly in public areas, makes the system awkward. For health and safety reasons the design intentionally avoided any use of headphones to hear the audible feedback so sound was generated through the device's speaker. At an ambient noise of 70db, the loudness of the devices was set to produce 76db at 30cm for 6db above ambient. 30cm was calculated as the average distance between the sound output of the device inside the armband and the nearest participant's ear. The ambient noise was calculated in pre-event trials using a Phonic audio analyzer PAA3.

Data collection

During the race data was intermittent for 40% of the race due to lack of mobile reception coverage and interference on the Bluetooth communication channels. Any intermittent data was identical for all conditions. The broadcast was time stamped and logged together with the interaction that

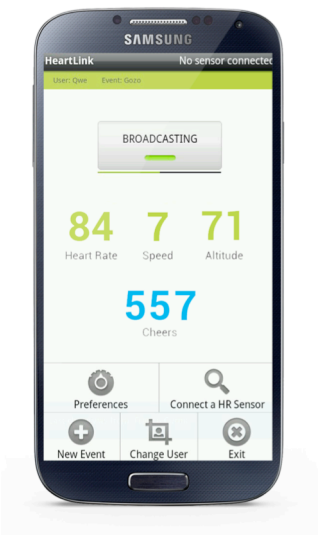


Figure 3: Customized BioShare research application running on athlete's devices.

spectators had with their interface including the cheers submitted, the comments posted and the duration of each participant following the data.

Additionally, when a spectator changed the athlete that was being followed, a modal form containing four questions was presented after 5 seconds. The 5 seconds delay was set to filter out any quick changes in athlete selection. This form collected information on the social network ties among participants, the spectator's age and allowed the spectators to leave comments. Qualitative data was collected from the athletes immediately after the race through a focus group. We felt that a focus group would generate more ideas through cross-pollination among the group in contrast to one-to-one interviews. This post-event focus group was made up of the 5 participating athletes, 3 co-located spectators (2 of these were also members of the

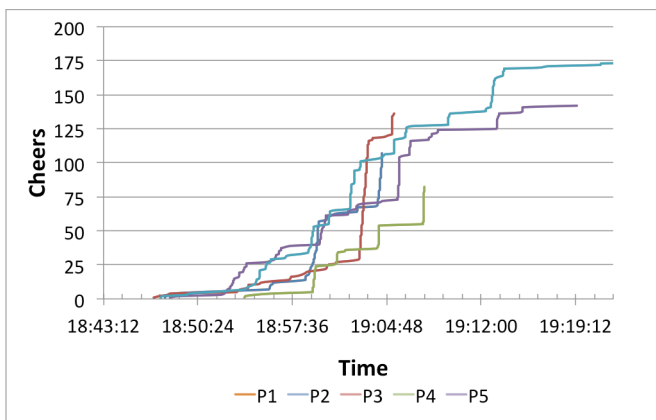


Figure 4: Cumulative live cheers submitted to the athletes.

running club but were injured on the day) and 1 interviewer. In the next section we present insights collected from the study, focusing particularly on the athletes' reactions to the spectator support and the spectators' interaction with the system in terms of the cheers submitted, posts submitted and spectator duration.

FINDINGS

Cheers submitted and crowd duration

The athletes (A) received a total of 727 cheers (A1: 118, A2: 150, A3: 155, A4: 85, A5: 219). Figure 4 represents the distribution of the cheers submitted for each participant. This data shows similar results to previous work [11] where spectators devised strategies to maximize the effectiveness of their cheers. This included holding back from submitting cheers at the beginning to then use the cheers when they feel the athletes need them most. Post event analysis showed that this repetitively resulted in an s-curve cumulative cheering distribution both for individual athletes as well as in aggregate. We note that the spectators had no limit on the number of cheers submitted. Only cheers that were submitted from five minutes before the start of the activity and up to five minutes after the completion of the activity for individual participants are represented in Figure 4. The aggregate number of cheers represented is 645.

Figure 5 shows the time spent online by distribution density for each spectator group. Participants who were friendsourced spent significantly more time on the site (mean 14min. 24sec.; SD 21min. 45sec.) than paid outsourced spectators (mean 7min. 26sec.; SD 8min 48sec). They were also more diverse in engagement than the outsourced spectators.

Post-event focus group with athletes

The insights gained from the post-event focus group complemented this data and contributed to contrast 1) the type of support that was provided (e.g. cheering modalities and motivators wrapping the live cheers), 2) the source of support (e.g. the contrast between the support from friendsourced and outsourced crowds on the participants), and 3) directions for future work in system design. These will be discussed next.

1. Type of support provided

We found that the participants were excited when they received live cheers during the race however other motivational factors that were not intentionally designed emerged during these interviews. Namely, the total number of cheers that each athlete receives and the number of spectators that are currently following their performance live on the portal (even though they might not necessarily cheer) could be a source of motivation. Whenever an athlete (A) arrived at the finish line, the interviewer (I) collected the devices and sensors. The interviewer then informed the arriving athlete the total number of cheers that the athlete received up until then and this resulted in high excitement from the athletes receiving the information. During the race,

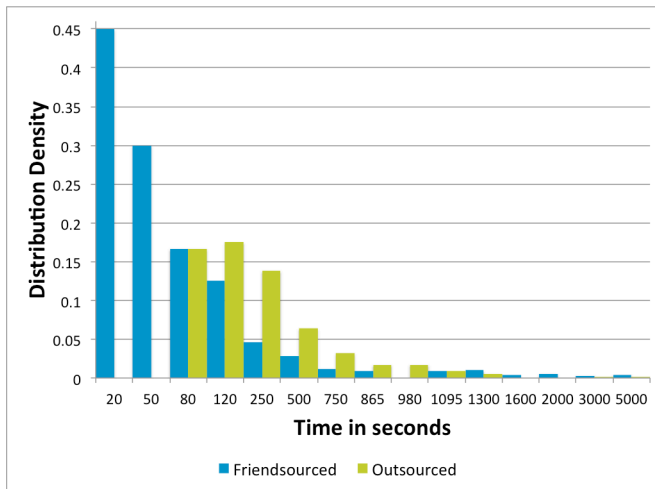


Figure 5: Friendsourced and outsourced crowd duration.

the athletes were only receiving aggregate cheers at a minimum of one vibration every 10 seconds (if cheers were sent within those 10 seconds) but they were not aware of the actual total number of cheers up until that point.

I: yours is 137 cheers.

A2: 137 cheers? all for one persons! 137?

[excitement/laughing] quite a lot.

[A2 some time later; asking A1] Is that the most cheers?

A1 what's the cheer count you've got?...

[later] Co-located spectator 1: how much have you got?

A2: a 137 cheers apparently

Non participating athlete: you're a popular man.

A2: 137? that can't be right; a 137 in all? in total?

I: no no, just for you

A2: just for me? What!

Race Organizer [teasingly]: oh we're getting insane there.

I don't know who said I don't want my arm to be cheered (before the race).

Not only receiving the cheers during the race excited the athletes but even simply getting to know the total number of cheers that were submitted. This, become a matter of competitive comparison more than the race timings themselves. All the participants agreed that the 10 seconds interval was fine otherwise "it might become a bit annoying." [A5]

Asked about the sound level of the devices, during the race the participants felt it was "all right actually, I could hear the names and that was an all right noise, you don't want it really loud. If there were a lot of people on the way then you might need it a bit louder." [A2] Three of the participants commented that they did not feel the vibrations. We found that the typical smartphone vibration is not a reliable communication modality when strapped on the arm in a running context. The strength of the haptic feedback was weak particularly since the armbands suppressed the vibrations. The audible feedback, calibrated as listed earlier, proofed to be more reliable in this context.

2. Source of the provided support

The athletes were asked a series of questions that were intended to identify whether the support from people they know was found more relevant than the support that was received from unknown crowds. Three of the athletes agree that both are relevant:

A3: ...it's already nice to know people you know [are there]. A lot of numbers, is like when we go to big races and there are loads of crowds cheering you, and you don't know anyone... we always find this better - that is - with the volume of people there, cheering you on.

R5 partly agrees stating that sometimes it is "better to have people you don't know cheering... you don't want your mum dominating". The athletes were not bothered when they heard other athletes being cheered claiming that "it is how it works in real-life, you hear all cheers around you" A4.

3. Considerations for future designs

We observe that the athletes' suggestions for future design were particularly focused around new cheering modalities and means of aggregating the collective support. A3 suggests having features that allow the spectators to "record their name" as this is expected to communicate emotions better than a text to speech synthesizer. In this case, the athletes are likely to recognize the voices even if names are not narrated. A2 agrees: "I don't think there is much more you could feel, because anything longer than that could be annoying. ... we though of if people online could record something, say it would come up with their voice, say 'go on go on, you're the best' [clapping - excited] and it is in their voice." Similar remarks were made by A4 and A5. When we aggregate the suggestions that emerged from the athletes we observe that, unknowingly and indirectly, the athletes were encouraging more synchronous social interaction within the system and from the crowd.

The modality of aggregating and communicating the support seems key for motivating the athletes. During the event the athletes received a haptic and audible cheer at most every 10 seconds if there were any cheers submitted in the previous 10 seconds – irrespective of the number of cheers submitted. The athletes, as quoted in previous sections, positively commented on this as a way of limiting the number of 'alerts'. However, this approach tells the athletes nothing about the number of spectators that are actually cheering. Non-participating athlete A7 suggested varying the sound level of the cheers based on the size of the cheering crowd, "...say, every 10 seconds if there are more cheers than the previous [10 seconds] you get a louder noise." This approach would be congruent to the s-curve cheering distribution presented earlier.

A major issue for all the participants except for one was the device form factor, claiming that they would not carry the device during competitive races due to the size and weight that they would have to carry. A3 states "it has to be a less

clunky device for me. I could never run with something as big as that on my arm. I know that you can't at the moment but if you could put it into your Garmin [watch]...". A4 suggest that a device on the waist would be less annoying than on the arm. Similarly A3 comments: *...people that are racing wouldn't do it; they want as little weight as possible... I really don't like it [carrying that device]*. The only athlete who did not mind carrying the device had significantly bigger arms than the other athletes. This suggests that if such technology is designed for mass diffusion, then the size and weight of the device are critical design factors and that the current smartphone form factor is still not small enough for using it during competitive races.

From a spectator-support perspective, all the (competitive) athletes agreed that cheering would be more effective for non-competitive athletes such as the occasional amateur marathon runners *"because they are struggling to finish the race unlike people who train regularly"* and *"knowing that people are supporting you at that moment in time could be a source of encouragement"*.

Facebook comments

Figure 6 shows the distribution of posts send by the spectators during the event. Posts can be grouped into those that were directed to the athletes and those directed to the community on the site. The latter were instigated either because of intermittent data or because one or more spectators wanted clarifications on the system itself. The spectators posted a total of 60 comments. 28 comments were posted in the landing page and 32 were posted in the athlete's respective visualizations.

The athletes' demands for increase in social interaction that were exhibited during the focus group were also reflected in the comments posted by the crowd. For example, as athletes proposed that future implementations should allow spectators to send them live or recorded voice messages, many of the spectators were already posting text formatted as if the athlete would hear them, even though the

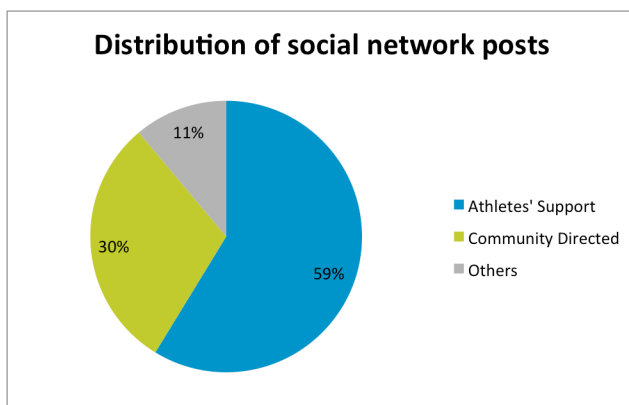


Figure 6: Distribution of social network posts submitted by the spectators.

spectators knew that the text messages will not be received by the athletes up until after the race. Posts like "Keep going (you aren't running as fast as you can)!" and "ALMOST THERE!" were typical. We observe that these are quite distinctive from the classical social network posts where athlete's friends often congratulate the athlete upon successfully completing an event - thus using the past tense rather than the present.

DISCUSSION AND LESSONS LEARNT

These results have both academic and commercial implications. The design of real-time systems for supporting athletes from remote crowds received negligible attention up until now as little research was done around real-time interaction between co-located and distributed crowds in sport events. We expect that similar studies that involve complex real-time structures will increase in the near future. With the rapidly advancing social networking and communication technologies, the implementation of such systems is becoming more feasible. These results also indicate that real-time spectator support could have high impact for many stakeholders that are directly and indirectly involved in the cheering process. Athletes feel more supported and the cheering process can increase spectator engagement. This process could be very attractive for indirect stakeholders such as marketing strategists who seek tools that facilitate social network diffusion through innovative sports-based communication channels. Additionally, having spectator support that is received 'just-in-time' when it is needed, is expected to augment the social support models that are used on existing social networks. Next we summarize the key lessons learnt around the effect of synchronous spectator support on the athletes, the spectators, and the limitations in the tested design.

Athletes' motivation

The motivation instilled in the athletes through live cheering could be explained through theories of expectations management [1] and self-determination theory (SDT) [13]. In the work presented in this paper, the participants had more online supporters than they expected. This difference between their 'expectations' and 'actual' support, created the excitement that was reported earlier. It will be interesting to analyze if the inverse effect would happen should the athletes not receive any cheering when they are expecting to be cheered. We believe that this would have a negative effect on the athletes that translates into a demotivating factor with similar effect to that of receiving jeers rather than cheers [14].

As regards motivation, sport athletes' 'intrinsic motivation' arises from values within the activity itself - for example, they may enjoy running, or satisfy a need to seek attention, or simply feel physiologically better. The motivators that are not intrinsically part of the activity such as receiving medals or as in the case of this study, receiving 'digital cheers', are 'extrinsic motivators'. Based on the motivational synergy model [2], these can fall in one of two

states: ‘synergistic’ (in which case these support the intrinsic motivators thus augmenting the satisfaction and performance improvement from the intrinsic motivators) or ‘non-synergistic’ (in which case they undermine the intrinsic motivation). For example an athlete’s intrinsic motivation for participating in running events may be attention seeking. In this case, the cheering process presented, is expected to increase the athlete’s motivation should this make the athlete aware that an even larger crowd is following the performance. Inversely, the cheering becomes non-synergistic should this distract the athlete from the core intrinsic motivators, say, when the cheering device makes a bothering loud noise in public.

Deci and Ryan provide a more detailed approach to classifying extrinsic motivation over five classifications in the organismic integration theory as a subclass of SDT [26]. In this regard, our observations of the athletes’ reactions brings us to highlight the psychological need of ‘*relatedness*’ where through remote cheering the athletes feel connected to others and build a sense of belonging. Further research that looks into how the cheering process can be designed in ways that make this support synergistic to the athlete’s intrinsic motivators is needed. Such design must take into account individual personalities and traits as different athletes have different motivators individually, which are different across time.

While paying crowds might not pertain to an applied research perspective, in hindsight, the predicted effectiveness went beyond our expectations. Both groups motivated the athletes (including paid participants) particularly because paid participants could freely cheer any athlete, so the athletes were motivated by the fact that the crowd was cheering ‘them’ vs. ‘others’ (rather than whether it was a friend or a paid supporter). It seems that in the proposed model, supporters’ pay did not distract the intrinsic motivation of the athletes [12].

Spectators’ engagement

The results confirm that the spectators’ engagement is influenced by **1) the social tie strength** between the supporter and the athlete. This is not all encompassing and other unaccounted factors may be present. **2) The type of data visualized** is also expected to influence engagement as shown in Figure 4. Additionally, when comparing the event discussed in this paper to the work done in the HeartLink pilot studies [11], through content analysis of the spectators’ posts in the two settings, we observe that the cheering crowd was much more enthusiastic in HeartLink. We believe that this effect was due to the ‘charity’ nature of the HeartLink event; the charity element seems to inject an obligation of making social good and encourage athlete-support. Thus another influencing factor is expected to be **3) the perceived athlete’s motivation to do the activity** as in the theory of mind [3] – this perceived motivation ranges from self-centered (e.g. a competitive event) to altruistic (e.g. supporting the charity run’s cause through the

perceived value of supporting the athlete). In this light, the fact that the race in this study was specifically organized for a research purpose (in contrast to a public event) may have also influenced the intrinsic motivation of both the participating athletes and the spectators. Finally, **4) the spectator’s incentive for recruitment** (e.g. being paid vs. voluntary support) is another influencing factor of spectator engagement that is worth further exploring through crowding theory [15].

In this work we did not account for the effect of paid vs. unpaid crowds. Future work is expected to single out these conditions across groups of equal social ties and pay. To decrease the workers’ time-to-recruitment, we paid twice the value that was suggested by the platform for each worker thus making the task more compelling for the job-seeking workers. The job was posted 15 minutes before starting the event and any data from workers who started the ‘task’ after race completion were removed from the dataset. 0.20\$ were paid to each worker for taking part in the task that was estimated to be fun and lasting few minutes on average. Participants were not instructed on how long they should watch the event for. They could spend just a minute but they were also free to stay online for longer if they wished to do so. Thus, a payment strategy was set such that pay was large enough to trigger an initial engagement from participants but low enough to allow us to observe if the initial paid engagement becomes intrinsic once spectators log in (i.e. would spectators freely stay online beyond what they are paid for by current crowdsourcing norms?). Based on the crowdsourcing platform’s independent post-activity survey, through this approach the assigned task scored high on “contributor satisfaction” (4.3/5 n=41) and “pay” (4.3/5; n=41).

Issues, limitations and critical reflection

In conducting this exploratory deployment the authors faced a number of challenges arising from the quite unusual combination of interaction contexts that were involved. Namely, 1) being in-the-wild, 2) having co-located participants in combination with 3) a geographically distributed crowd that was recruited through social networks, 4) an outsourced crowd and 5) all necessitating synchronous interaction. Each of these factors augmented the complexity of running the deployment. The intermittent data broadcast that was due to the lack of mobile reception in parts of the racecourse was equal to all conditions yet it may have impacted some of the results. When an athlete enters a temporary ‘blind spot’, spectators following that athlete seem prompted to switch and follow other athletes. In this light we refrained from reporting results that would have had direct influence from this. For example, it would have been interesting to link the cheering patterns of spectators to the athletes’ positions in the race but further tests are needed. Data indicated that athletes who ran slower received most cheers however this was not due to social network effects but was likely due to broadcasting for a longer timeframe thus giving the spectators more time to

cheer. We do encourage future research to look deeper into this interesting area of human behavior with questions such as: ‘During a challenging task, do crowds support the weakest or the strongest, and how is the distribution effected by the social tie strength between the supporter and the supported?’ Our generalized hypotheses, based on athlete’s feedback in this study, is that while the supported might appreciate support from both strong and no tie, the weak ties might be the most effective.

Future work

In addition to the future work suggested above, experimenting with different cheering modalities is an avenue worth pursuing. This should look at 1) **ways to aggregate and communicate** the support (e.g. using spacialized audio, modulating the audio amplitude based on crowd size or using different haptic feedback positioning). Another important factor is 2) the **type of support** that is communicated (e.g. communicating the number of persons following online, number of cheers, or using a recommender system to compute and present the most motivating comments to the athletes in near real-time).

In hindsight, in future we would modify three key design decisions taken; 1) presenting the data of one participant at a time in the interface, 2) allowing users to switch athletes and 3) presenting anonymized participants:

1) *Presenting collective vs. individual athlete data*: Our observations of the event dynamics indicated that if the spectators were presented with athletes’ aggregate data, like for example a map that represents the location of all the athletes, then the crowd might have taken different cheering strategies. Presenting the spectators with individual athlete’s data was a research driven design decision. From pilot studies we learned that presenting the data of all the athletes in one interface makes it difficult to link spectator comments with the data that prompted those comments. However, presenting multiple athletes in one interface would help spectators follow athletes’ relative performance. This would let us observe the distribution of spectator-support from human crowds across the weakest and the strongest athlete.

2) *Switching athletes*: Additionally, if spectators were locked into selecting one athlete at the start of the event, rather than being allowed to change athletes throughout the event, we envisage that the spectators would have been more captivated in having ‘their’ athlete do better thus increasing engagement through gamification dynamics.

3) *Anonymizing participants*: We believe that there is significant room for improvement in terms of spectator engagement particularly by designing interaction around spectators’ intrinsic motivation to follow such events. The increase in engagement of the friendsourced and outsourced spectators shows that the bond between the spectators and the athlete is a key element of spectators’ engagement. The anonymization of athletes within the spectators’ interface was a design decision taken to minimize ethical concerns

when sharing data, however, if the athletes were presented with their real names, we believe that the spectators would have experienced a more ‘personal’ connection. The decision to anonymise athletes was driven by the researchers not the athletes. Since this work was a first deployment of its kind in a research setting that includes very personal data sharing such as heart rate, we felt that it would be appropriate to use anonymity in this case. This decision was also supported by earlier interviews conducted with experts in this area [10]. Although future deployments of the system will not anonymise athletes for reasons specified earlier, the anonymisation of athletes in this context had research benefits, namely, that the cheering decisions (as perceived by the athletes) were based on athletic performance.

As findings show, a few more years of technological advancements are needed until easier and less obtrusive solutions are widely available. The smartphones’ form factor and the unpredictability of mobile-data communication infrastructures are key issues. The availability and quality of mobile data connections are dependent on the number of users using the system at one time and the (typically) unknown operator’s data vs. voice bandwidth policies at the connected nodes. This nulls the relevance of testing the mobile data connection across the course before events since the actual scenario during the race, particularly if it involves more than a handful of participants, may change drastically during the event. Predictability is critical if such systems are scaled up for larger crowds during popular city marathons. Interestingly, technology has evolved in such a way that aggregating and broadcasting data from large crowds that are distributed across the globe may be easier than aggregating data from co-located in-the-wild participants.

In the longer term, further studies could precisely indicate how humans seek spectator support and socially support others. In specific contexts of human behavior, would we cheer the best or the weakest? Having enough data for a specific scenario, can we build a model that takes into consideration the data presented to spectators, the real-time performance and the social connectedness, to predict cheering patterns? Having such a model, could we influence the cheering patterns and maximize the athletes’ performance - for example by encouraging cheering just when the athletes need them most?

CONCLUSION

The innovativeness of the work presented in this paper is the crowdsourcing of real-time spectator support through friendsourced and outsourced crowds. In this paper we have presented the results and insights gained from the study with 5 co-located athletes and an online crowd of 140 distributed spectators that were recruited from community networks and a crowdsourcing platform. The results showed that the social ties between the spectators and the athletes influence the engagement of spectators. More

importantly, as in co-located cheering, the athletes were excited with both the support received from known crowds as well as support that was received from unknown crowds. This indicates that in spectator support, within the context that is presented in this paper, outsourced spectators could be a valuable source of support. We hope that this first step in crowdsourcing just-in-time support will help other researchers and more importantly stimulate new research in this very promising area.

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