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SenseShare: Investigating Biosignal Sharing

Introduction and Related Work

Many of the smart devices we carry with us today are able to sense a variety of signals generated by our bodies. The sensors that record these signals are marketed to a wide consumer audience as either standalone products or embedded into technologies that serve multiple purposes. Most smartphones and wearable devices contain at least an accelerometer that measures motion, which applications can use and typically display in number of steps. Also common are devices worn on the wrist like the Apple Watch and Samsung Gear containing embedded heart rate sensors. Other signals like skin temperature and galvanic skin response can be captured by sensors in a smaller selection of products like the Basis Peak and Empatica E4. Galvanic skin response (GSR) is a measure of the electrical conductivity of the skin, which increases with moisture, a response triggered by the sympathetic nervous system and indicative of an empathetic or aroused response to some stimuli. More exotic still, though more rare in common use, are consumer grade devices that measure brain activity including the Neurosky Mindwave and the Emotiv EPOC. These signals have been primarily used for self-tracking purposes, most typically in pursuit of improving fitness, sleep habits, and areas of mental health like detecting stress patterns.

A meet up group who self-identify as the Quantified Self [1] use data from these and other devices in narrative show and tell sessions, describing to fellow

members their self-tracking projects and findings they've come across in their own data. While a full discussion of this group's activities are outside of the scope of this work, the concept of narrating and sharing sensed data with others is a notable departure from the individual-only or individual-manufacturer realm in which the majority of consumer-scale biosensing occurs.

Sharing sensed data with others could be one way to address the fear that technology is isolating us from one another, leading to loneliness and a loss of connection. Authors such as Sherry Turkle [2] have written extensively about their concerns regarding this trend, including technology's "assault on empathy". On the whole, humans have a basic desire to feel close to others, but with much of our communication increasingly occurring in non face-to-face interactions, the difficult in establishing closeness is exacerbated with the reduction of available cues and communication channels. [3] Nonetheless, it has also been observed that people use computer-mediated communication tools to share in online environments for personal benefit [4], emotional disclosure [5], and CMC may facilitate more direct communication than face-to-face. [6] Working in a similar vein of group therapy techniques, this self-disclosure is likely key to trust and relationship building online and increased intimacy may further augment this process [7]. Sharing on social networks in particular has been studied fairly extensively. Posting about feelings and emotions on Facebook has been shown to elicit increased responses compared to non-emotional posts and in particular encourage social support. [8] However, broadcasting to a large audience has been shown to be detrimental to social tie strength when compared with directed communication. [9] In one-to-one

communication, cues indicative of emotion embedded in text like emoticons facilitate affinity in relationship development in less time than without cues. [10]

Sharing of biosignals specifically is an underdeveloped research area, though there are several related works to this topic. Jannsen et al. [11] showed that the sharing of heart rate functions as a cue of intimacy, and the authors suggest this in turn could help maintain close connections. Compared with conscious nonverbal cues however, biosignals like heart rate are much less under our control and Jannssen et al. suggest that users have full control over the display of their biosignals to others. A study by Slovák et al. [12] examined the interpretation of heart rate in laboratory and home deployment settings. Users were curious about their heart rates and tested the signal by doing various activities including "watching emotionally intense movies, playing darts, computer games, and physical activity." Participants acknowledged the need for context to guide interpretation of the heart rates of others, as well as control over the display of their own signals. Another theme among participants was seeing heart rate as a direct connection to another person and that it would be useful when apart from a partner when the availability of other cues is low. Furthermore, two initial studies experimented with sharing breathing movements between participants via wearable devices [13] and a moving picture frame [14] and demonstrated promise given users' reported feelings of physical and sentimental connectedness and supported emotional communication.

The problem space and related work discussed above are highly intriguing and set the stage for a bountiful area of future research. The small exploratory study

I have conducted and will discuss here stems from the combination of a need for increased connection in limited cues CMC environments, evidence that emotional cues can provide this connection, and research suggesting biosignals like heart rate can function as such a cue with proper context. The sparseness and contention in literature regarding the sharing of biosignals and the mixed effects of sharing with networks led me to an inductive research model of exposure to an interactive design prototype and example use case paired with generative semi-structured interviews.

Theoretical Background

A variety of concepts from CMC theories are relevant to this work. As in any system in which people interact with one another, Erving Goffman's theories surrounding self-presentation resonate strongly [15]. Goffman's description centers around the existence of both a front and back stage, the former on which we are always performing for some audience, and the latter the place where we relax intro our true selves. In the front stage we continually move between playing different roles based on our audience. Biosignals have an interesting intersection with this idea, as they are generally produced automatically and out of our control and so cannot be readily integrated into our desired performance. In some ways there is an opportunity here to bring our back stage selves into the front stage, though without a high degree of agency over this new representation, it is unlikely people will feel comfortable with this breech of their curated selves.

In tandem with self-presentation, work involving social cues and signals are also relevant to CMC environments. As Judith Donath discusses [16], signaling theory describes cues as anything indicating a hidden state or intention and signals

as cues that are meant to serve as communication. Furthermore, Donath discusses why certain signals are reliable and others are not and what keeps signals reliable. A biosignal like heart rate or GSR is extremely difficult to fake, lending the signal reliability and when used for communication, reliability to the message being communicated as well. These signals are unintentional however, and as Donath describes unintentional cues can provide information detrimental to the one revealing them. In his work on cues [17] and social information processing theory, Joseph Walther describes several ways in which the senders and receivers of cues understand and communicate with one another. Walther describes five approaches: cues filtered out, cues to choose by, cues filtered in, cues about us, and cues bent and twisted. With these approaches, Walther complicates the simplified idea that greater bandwidth a system affords, the greater the social presence of the communicators, suggesting that CMC receivers read in additional context, attribute group characteristics, and engage in hyperpersonal behavior that can result in exaggerated positive or negative perceptions.

Media richness theory is a concept that all of the above work draws from and is worthy of mention here as well. The notion of richness in media is that richer media have more channels to communicate more cues, and the leaner the media the fewer channels exist. Biosignals again uniquely interact with this theory, while the signal itself remains lean and gains some of the benefits therein like flexibility and control, it also adds a dimension of richness not even present in face to face communication allowing the conveyance of a degree of complexity. These theoretical frameworks appear in various ways throughout this project, providing

useful lenses to see results through and draw additional hypotheses and conclusions from.

Methods

Design Prototype

With the idea of sharing biosignals in mind, I set out to create an initial low fidelity prototype of the technology to use in discussions with interviewees as a prompt and example from which to generate ideas and discussion. The prototype was drawn by hand, and then made interactive using the app Marvel. The screens of the prototype, tentatively named SenseShare, are shown in Figure 1 below.

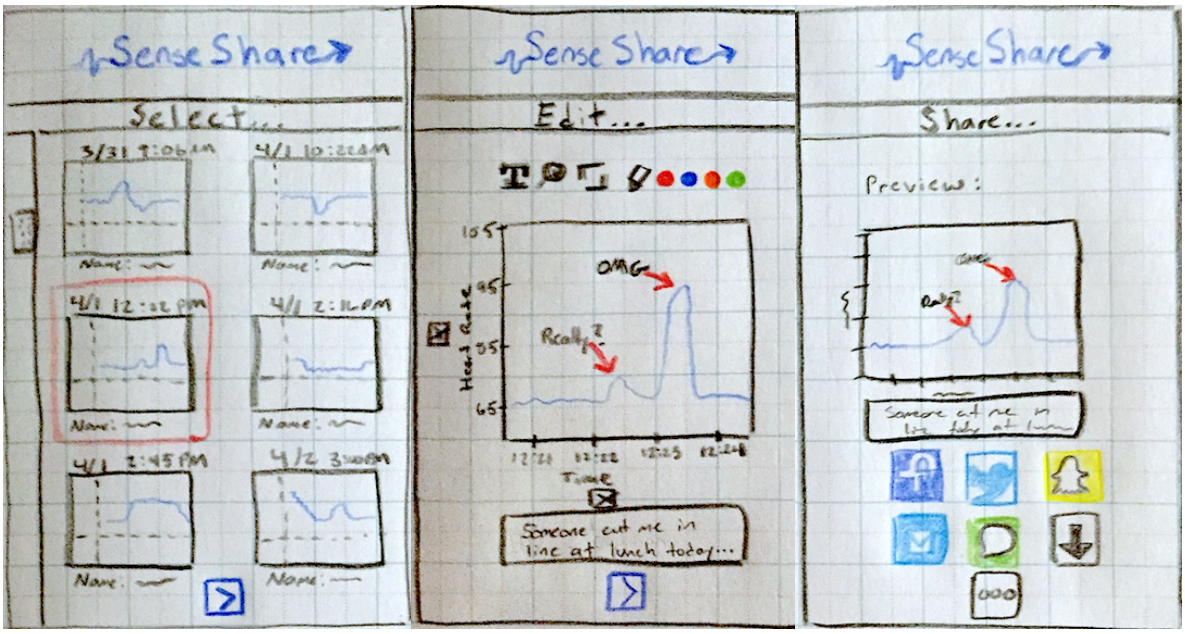

Figure 1: SenseShare low fidelity screens shown to participants in an interactive app format.

The first screen displays a collection of saved snapshots of signals captured throughout the day, assuming the user had been wearing a device that allowed them to do so and provide a name for the snapshot at the time of saving, which is shown beneath each signal in the gallery. The date and time stamp are also shown above

each. On this screen the user selects a signal and taps the blue arrow to advance. The second screen displays the signal snapshot selected in the previous screen and provides a host of tools the user can use to edit, annotate, and caption the snapshot. The tools include a pencil to draw with multiple color options, a zoom function, a cropping feature, and an ability to hide the axes, as well as a place to add text for a caption. When the user is finished editing they press the blue arrow to advance. On the final screen the user is shown a preview of their edited snapshot and prompted to choose a way to share it. Possible options include Facebook, Twitter, Snapchat, e-mail, text message, and finally to download and save the snapshot on their device.

Exploratory Testing

The goals of this project are inductive and I did not attempt to build out a fully functional prototype for sharing biosignals. However, to get a fuller idea of a sample use case and have more concretized material to use as a probe in interviews I recorded, annotated, and shared my own biosignals. For this exploratory exercise I used an Empatica E4 wristband to record my heart rate and GSR while sitting at a desk watching two episodes of the HBO television series *Game of Thrones* and shared annotated versions of this data with my friend network on Facebook.

The Empatica E4 simultaneously records heart rate and GSR as well as other signals and both live streams this data to a Bluetooth-connected smartphone as well as uploads it to the Empatica website for later download. The data are made available for download in the format of comma-separated variable files (CSVs), one for each type of recorded signal (heart rate, GSR, etc.). The Empatica E4 has the additional functionality of a single button on the band that when pressed saves a

time stamp for each press, which I could see as a useful function for future "in the wild" prototype designs, but I did not make use of it in this example. To my knowledge, the Empatica E4 does not produce a measure of signal quality, which could be a limitation in interpretation of the recorded data.

I used this device to record my biosignals during two one-hour episodes of the television show *Game of Thrones* on a laptop. While watching each episode, I took a screenshot if I felt I was emotionally reacting to action or dialogue in a scene. The two episodes I chose to record signals for were the finale episode of season one and the season premiere of season six, which as of writing is ongoing. The first of these I chose because it contains well-known events to watchers of the show (and likely even non-watchers) and was old enough that I felt comfortable posting detailed descriptions of events in the episode without spoiling the plot for others. The second I chose as it was more relevant to the present day and I could take advantage of the excitement surrounding the season premier. For the season one premier, I took the CSV data for my GSR and plotted it in a time series using the software Tableau. In addition, I labeled the time points on the graph where I took screenshots with a short description of the event occurring at that moment; I then took the resulting graph and added some of these screenshots in Adobe Illustrator and shared the final product as a timeline post on my Facebook page. The final posted version is shown in Figure 2 below.

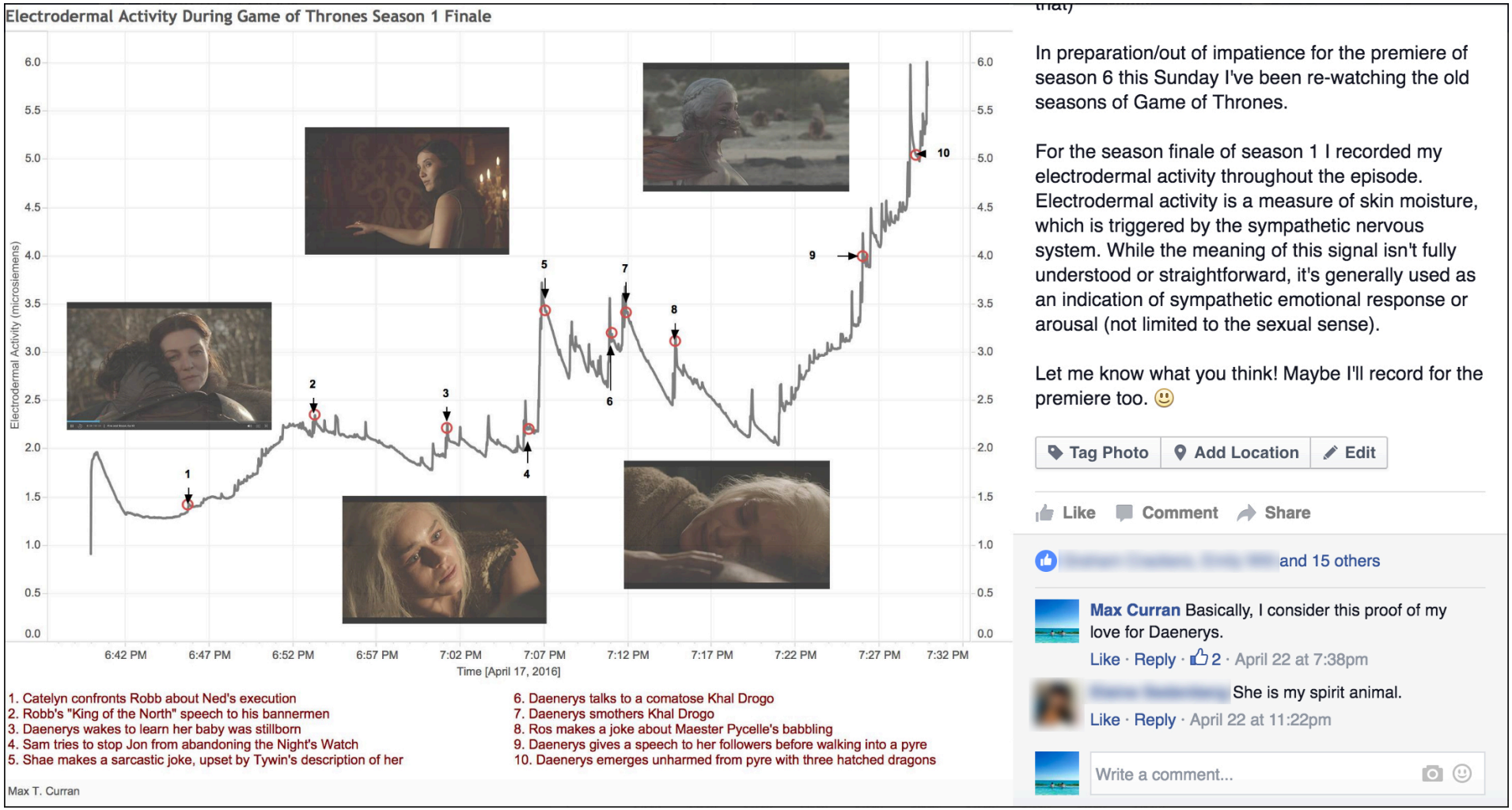

Figure 2: Annotated GSR for season 1 *Game of Thrones* finale posted on Facebook.

Included in the description of the post were a spoiler warning and a short description of GSR. As of writing, this post received 17 “likes” and one comment. The comment read “She is my spirit animal” in reference to one of the characters included in the annotations who was heavily featured in the episode and especially evocative of my GSR. I also later commented on the post myself, writing “Basically, I consider this proof of my love for Daenerys.”, which received an additional two likes. This post was apparently well received given the number of “likes” it garnered, but it did not spark as much conversation as I’d hoped, even with my additional comment. One reason is that perhaps GSR as a concept is too ambiguous or difficult to understand from just a short description, another might be that I added all of the context myself so there wasn’t much room left for interpretation or discussion.

For the season six premiere episode, I recorded my biosignals using the same device and plotted both my heart rate and my GSR in Tableau. I took screenshots again throughout for my own reference, but did not include these or any annotations on the graph I shared on Facebook. I chose to do this intentionally to see if less explicit annotated context could spark more discussion among those who viewed my post. The final posted version is shown in Figure 3 below.

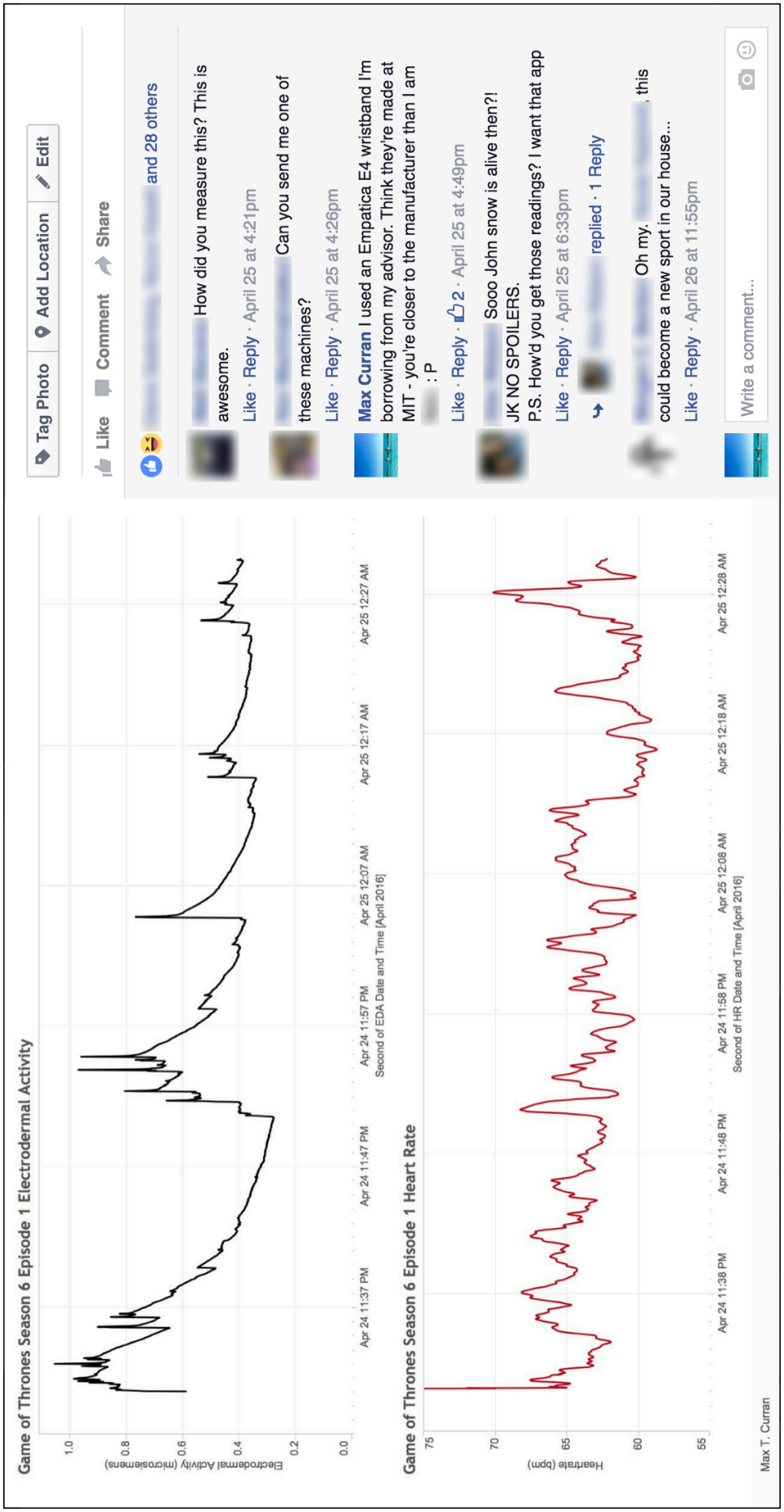

Figure 3: GSR and heart rate for the season 6 *Game of Thrones* premier posted on Facebook.

I posted this graph the day after the episode's premiere. This post has received 30 "likes" and four comments including "How did you measure this? This is awesome.", "Can you send me one of these machines?", and "Oh my, […] this could become a new sport in our house…". The fourth was a reference to an ongoing storyline in the show: "Sooo John Snow is alive then!? JK NO SPOILERS. P.S. How'd you get those readings? I want that app." All of these comments contain excitement about the novelty of the idea, and seem likely that the commenters would want to perform a similar recording themselves. Other than the last comment, there was little discussion about the episode or show itself, a result I was surprised by given I provided no context other than which episode the recording was for and the spikes in the graphs could be interpreted in many ways. Despite the same potential sample, this post did receive a much greater response in number of likes and comments compared with the first however, and this could be due to a variety of reasons as this isn't a well-controlled comparison. First, this graph showed both GSR and heart rate, and given results from my interviews and general impression, heart rate is a much more accessible signal for others to understand (whether correctly or incorrectly) compared with GSR. Second, this post did not contain any context for the signal other than that it was recorded throughout the season six premier and viewers may have found this ambiguity more relatable or evocative as they were able to draw their own conclusions about the changes in the signal. Finally, the airing of this episode was a much more recent event then the previous one, which likely resulted in more attention being paid to it and a fresher shared context for others who watched the premier the night before. Future work should control for

each of these, and other, variables separately to discern the source of increased response toward one compared with the other.

Semi-structured Interviews

I conducted interviews with 6 participants (4 male, 2 female) of 20-30 minutes each with graduate students between the ages of 25 and 30. Participants were recruited by convenience, but were not students in the class for which this project was done to prevent prior exposure to the concept and out of privacy concerns when presenting this work to the class. The interviews had four phases beginning with an initial questionnaire about current sharing habits on a CMC platform the participant used, then a think aloud with the interactive low fidelity prototype, an explicit description of the prototype, and finally a series of questions about the prototype including general impressions, the participant's thoughts on viewing others' signals, sharing their own, and what ideas they had for use cases for this technology. After the questions about the prototype, I also showed participants the two Facebook posts of my own signals while watching *Game of Thrones* and asked about their impressions and thoughts of this example use.

Results & Discussion

Participants' Current Sharing Habits

In the questionnaire about participants' current sharing habits four participants responded about Facebook, one about Facebook Messenger specifically, and about Snapchat.

For "Why do you use this platform? (select all that apply)", five participants marked "maintain relationships with people you've met in person", five marked

"share or spread information (ex. Links, news articles)", three marked "update others on changes in your life", two marked "make new friends or connections", two "learn about others' life changes and updates", and one "Receive reactions from others (ex. Likes, favorites, +1's, comments). One participant also wrote in "learn about others".

In response to the question "Do you use this platform more often for communication with many people, a few, or one at a time? (check all that apply)" four participants responded with "a few people or small groups", and three checked "one-to-one communication".

For the question "What types or groups of people do you use this platform to communicate with primarily? (check all that apply)" four participants checked "work or school colleagues", four checked "close friends", two "family", and one "acquaintances".

To the open response question "On this platform, do you ever post/message for reasons other than just spreading information? For example do you share personal details, experiences, reactions, or thoughts?" participants generally responded with "experiences", or "thoughts", one user wrote "Yes. I usually message my close friends to talk about personal life issues/update each other on our progress."

The final open response question asked "Have you ever used this platform to share information about your activity or exercise? For example, data from a device like FitBit or an app like Nike+?". Most participants did not share this information on the platform they were responding about, but one wrote "No, but I do sometimes

make status updates about my gym progress (squats, deadlifts, etc.)" and another wrote "Yes, I post using Strava." and under why wrote "To brag, motivate others, and share my journey."

This questionnaire was administered to get a general idea of the sharing habits of this group of participants. In general these participants use CMC tools like Facebook to maintain relationships and spread information either one-on-one or with a few people at a time who are typically close friends and/or colleagues. The question about sharing exercise data was included to probe at the closest approximation to biosignal sharing in present practices, and the one participant who wrote about his sharing habits with it had an interesting response in line with the intended use case of SenseShare.

Themes from Interviews

Several key themes regarding participants' impressions of SenseShare including their ideas for using it themselves and their concerns with such a platform.

The first was that participants generally only wanted to share their biosignals with those close to them. This is consistent with the participants' responses to the initial sharing habits questionnaire, as well as previous work around sharing heart rate. [12] Responses that highlight this theme include "Given someone relatively close to me and I have context, not random people, but a shared circle in a group I think it'd be cool to share with them." – P01, "I could imagine myself occasionally sharing it with a very close friend in a private message or with a significant other." – P02, and "There might be other things I might share with more

um… more intimate friends that I wouldn't share on Facebook." – P05. These responses highlight the intimacy and sensitivity participants associated with a biosignal like heart rate. Given this association, it makes sense that participants felt they wanted to share this only with those closest to them, those who, as some pointed out, would understand a shared context.

A second theme that emerged from participants' interview responses was the use of this platform for personal reflection in addition to or instead of sharing with others. P03 said, "If I was asking someone out and I could see how nervous I get. I could see if I get better over time" as well as "I'd be interested to see before a stressful event and compare it with what my levels were afterwards.". P05 similarly saw an opportunity for reflection and learning more about himself, "If I could go back over my day and know when my heart rate rises, that would be really interesting for myself." I foresaw this use case, which is why the prototype included an option to download the annotated snapshot to the user's device. In retrospect, given the little understanding general users have of these signals it makes sense that users may want to use this platform to better understand their body's unique responses to stimuli before deciding to share this reaction with others.

Another intriguing theme was that participants saw biosignals as providing a sense of truth or evidence of an experience. Participant responses around this theme included: "It would be the best thing ever if I told my friends I saw this really hot chick today and then look like my heart went racing when I saw. I would love to be able to do that. It would be so awesome. Show them dude I'm not joking." – P01, "I could see how it can be a way to demonstrate my emotions. Like hey look how

frustrated I really got when someone cut me off, I'm not just playing around." – P03, and "It's like authentication to say like see I did do my pushups and flutter kicks this morning." – P05. One participant compared a biosignal to a photograph in terms of evidence and as material for conversation, "I think it's gonna be more additional proof of information. It's like when you're talking to someone and what helps it further is a photograph." - P01. These responses reflect a biosignal's status as a highly reliable signal in communication, one that is difficult to fake, and point toward their use in situations where a user would want to convey honesty and truthfulness, something lean media currently does not typically provide a channel for.

In a similar vein, the next theme that emerged from interviews was the use of this platform to foster empathy and understanding, as well as potentially competition. P01 said he would share emotions like "Fright, anxiousness, these emotions that everyone faces in a day", and went on to say "If you're sharing the same situation or scenario with someone you can be like I'm so scared right now look at my heart rate and they'd be like no you're not more scared look at me." And that it would serve as "auxiliary and supplementary information to sort of make the experience more real to the other person." P02 stated they would share their signals "To relate experiences and build the relationship by sharing experiences" and provided an example "If it was something we did together and then as a recap like 'Oh I was so excited when we went to that concert together' or maybe share it with my close friend to say I had such a crappy time. I think I might use it as a story telling thing, similar to how I might use a photo." P06 had similar thoughts, "to gain

insight into something we wouldn't know otherwise, and to do it together. There is the comparative part to be able to talk about it" and also hinted at using biosignals as a form of competition, "if we went to see a scary movie together we could see who is more scared." P03 also talked about competition, "I might even get a little competitive, like oh their heart rate looks pretty good…" and more specifically, "the lower your heart rate is, the healthier your heart. I think I might be competitive in that regard." I was excited to see the theme of empathy emerge as it was something I expected and saw as a potential strength of this platform prototype. Combined with the sense of truth conveyed by these signals, sharing biosignals of experiences could help give others' a clearer picture of what happened and how the participant felt, more so than simple text allows or even verbal explanation of the event. The competition aspect adds complexity to the implementation of such a platform given that different users' bodies would react differently to stimuli, especially when only measured on a few dimensions, which could lead to unfair comparisons between users.

An interesting theme that I did not expect was that participants said they would likely add a positive spin to a signal or annotation shared with others, even if the experience were a negative one. P01 said, "I would share it in a fun way, even for those negative experiences." and that this applied more broadly, "Whenever I share, even if it's a negative thing I'm gonna share it in a positive way." P06 stated that this may be a perquisite for sharing at all, "If they were funny in a way I might share them." This insight was unexpected, but given behavior on social networking sites it is understandable as users of these services typically try and present their idealized

self to the world, omitting or glossing over less-than-ideal experiences. I still found these responses intriguing however, given that these same participants said they wanted to share these signals only with those close to them, whom I would think they would also be more comfortable sharing non-positive experiences.

A final key theme that emerged was the importance of the annotations to provide context to the signal. P02 said, “"I think I would mostly be interested in [others'] annotations. If I saw someone's heart rate without an annotation I wouldn't feel comfortable inferring too much about what the signal meant for them. I'd be curious to see their annotations of it and to learn more about their experience." P04 felt the annotations made it interesting, “"When it becomes annotated it adds a personal story to it. I think that would contextualize the information a little more. I've seen run trackers on Facebook and I scroll right by them, but I do see the value in being able to edit it and customize it in a personal way." and “Once it becomes too ambiguous it would be like what am I looking at? I don't really care for this." This was an encouraging finding for the platform as it is built around users adding their own context to take ownership of the signal and have agency and control over the interpretation of the signal.

Participants had many ideas for potential use cases for this platform as well, spanning all types of positive and negative experiences. A common idea was showing nervousness or anxiety as P01 said, “Like if I had a presentation due I’d be like look at my heart rate, I’m so tense right now.” similarly, P03 stated “right before a big presentation, or when the spotlight is on me, my god everything just spikes up.” Two participants, P01 and P06 thought of using this if they were walking home

late at night, P06 responded, “I hate walking anywhere alone at night, I’d be curious as to what my response was because there’s like the surface pretending I’m cool with it but internally I’m constantly nervous.” Participants 05 and 06 mentioned recording their signals while reading, P05 said “It would be interesting like when I read or something, I could share with friends how boring or how exciting it was to read.” P04 talked about recording and sharing their signals when seeing someone they were attracted to, “Like if so-and-so walked into the room and your heart rate went up and you could put like a smiley face and then she walked away and you could put a sad face.” P03 mentioned proving his feelings for his girlfriend, “Maybe when I’m talking to my girlfriend I could show her how excited I am to talk to her or when I get a text from her. Like hey I really am excited!” Two participants, P02 and P03 mentioned the use case of music concerts, P03 suggested, “Maybe if you’re both at a concert and you’re both so hyped that your favorite artist is gonna come out.” Finally, two participants discussed potentially personal or private topics, P01 said, “If someone smokes up and then were like dude I was so high today look at my heartbeat how lot it was. That would be so fun to show people” and P02 mentioned sexual experiences, “What about when I’m just checking my e-mail or doing something sexual. I probably wouldn’t share all of those, obviously, but I’d use it as a self-exploration tool.”

When presented with the example use case and my annotated signals while watching *Game of Thrones* participants had a variety of responses. P02 thought “You seem to have enjoyed the episode” and said she read it as “Oh Max was experiencing this then”. P04 commented on the annotation, “I do like the annotation because I

think it adds that layer of what you expected versus what you actually got, it was interesting when the spikes didn't line up with what you thought was happening." For other participants this sparked use ideas for other video content, P01 described "There's a scene in The Avengers when the Hulk says 'My secret is I'm always angry' – the first time I watched that I was so excited and I couldn't even tell people how excited I was so I could see doing this." and P03 had a similar reaction, "I watch Once Upon a Time, that's something that just gets my emotions raging for some reason – it would be better to have data to back it up, instead of just trying to sound cool like 'oh this part was so emotional'". For P06, this sparked an idea for using this platform when listening to music and potentially aggregating many people's signal responses to the same piece of music, "It made me think of SoundCloud people post music and then people will have reactions at different points in the song and you can see them all."

All in all, these interviews functioned very well as both confirmation that this platform has valid use cases, and for generating many more use case ideas than I could come up with on my own. The themes that emerged from these interviews were insightful and intriguing, and have implications for any future design prototypes around this same concept as will be discussed in future work.

Caveats & Limitations

Participants' reactions and use case ideas for this platform were generally positive, but they also highlighted particular concerns regarding recording and sharing their biosignal information. Understandably, privacy and security were a concern for a few participants, as P06 describes, "Even sharing this conceptual thing

about yourself, if you aren't secure end to end who's receiving it, that disturbs me a bit." Biosignal information is intimate and personal and can be very revealing in certain situations, therefore any platform that makes use of recording biosignals must have security as a priority to ensure that sensitive information is kept private and protected. Another concern that I hold myself is that these signals could be taken as the one and only truth, held above a user's personal accounts of an event. P05 echoed this sentiment while still seeing the value of sharing, "It's like seeing a shadow of a puppet of a horse. We experience things massively filtered through our own and other people's emotions. It's all shadows. We can make guesses but we don't really know. This is another signal, it's not the truth, I think it's very interesting and could prompt a lot of interesting discussions."

A limitation I noticed when carrying out interviews is that it is unclear whether to use a signal with preconceived notions of meaning like heart rate which a few participants associated immediately with exercise, versus a more ambiguous signal like GSR that risks users and receivers not understanding what the signal measures. Participants were also torn on this aspect, P01 felt heart rate was better because it could be readily understood, "Heart rate would be the most fun, and the most interesting to share – something everyone could understand" but P02 thought GSR would be better, "I think GSR is easier to interpret because it's a spike up or down… with heart rate it's variability that matters or something?". Another limitation that must be stated is the potential flaws and inaccuracies in the sensors collecting this data, especially in light of participants perceiving this data as truth. Two examples from my own experience using the Empatica E4 come to mind, the

first I wanted to record my GSR while walking home from school uphill and listening to music, but upon reading the data I realized that physical activity resulting in perspiration quickly maxes out a GSR sensor, rendering it insensitive to emotional or sympathetic responses to stimuli. The second example is from my experience trying to record my signals for another episode of *Game of Thrones*; while watching the episode an insect flew very close to my face and I jumped, resulting in a spike in my GSR and heart rate not related to the original stimuli, as well as a change in sensor position as my wrist moved quickly up toward my face. These limitations are particularly relevant for the use cases described by participants involving motion and physical activity that could affect the capability of the sensors such as sexual activity or going to a concert.

This project itself has its own set of limitations. The sample size is very small, at only six participants, and the sample was drawn from a specific population of graduate students. While the intention of this work was not to gather a sample size large enough for statistical evaluation, interview responses from a small pool of participants are very specific to those individuals and may have low ecological validity in other users and contexts.

Future Work

This work was designed and carried out as inductive research to surface more specific areas of interest to tackle in future experimental work. Given the diversity of responses from interview participants and their own curiosities about their biosignals, one of the first studies I think would be interesting to do with a more functional prototype would be to set up participants with the device and send

them out into the world to use it. Observing what kinds of experiences participants want to record and/or share, and what kinds of signals show these experiences best would be key to further development and exploration of a platform like SenseShare. Like my *Game of Thrones* example, sometimes our bodies exhibit these signals contrary to our expectations, which could prove very useful for participants in their own reflections. More ideas for use cases may surface while participants are out living their lives, one interview participant even texted me after the interview saying that he noticed his heart rate increasing when asking a question in class and wish he had the SenseShare platform to record this change to reflect on.

Another simple yet fruitful area of research around this topic would be an experimental study determining differences in perceived meaning between text descriptions, biosignals, and annotated biosignals. A well-controlled experimental study like this one would shed light on what is gained by adding these new dimensions of media richness, and what sorts of conclusions receivers draw or miss using different communication modalities.

Another experimental study could look at how these signals can serve as the basis or catalyst for conversation about a shared experience or event. For example, if two participants both watched the same video together and discussed it in a control group while in an experimental group the participants also recorded their biosignals and had them available for the discussion, what sorts of insights might be gained by having this additional information about bodily responses to stimuli. Perhaps participants would gain insight into the differences in their signals and awareness of the other person's different response to the same stimulus, or maybe

they would focus on where their signals were similar and use that as a point of discussion.

Any of these experiments and others would be useful for probing how the use of biosignals can interact with existing face to face or computer mediated communication research. While there are significant limitations that must be kept in mind for this sort of technological platform, it could prove to be a much-needed source of intimate connection in a world increasingly dominated by mediated communication.

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