Towards Mental Balance: A Quantified Self Approach for Communicating Mental State

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Abstract

Today's world focuses on balance, balance of self and group, work and personal time. Mental balance is more than topical, "Did I spend enough time thinking about my proposal?" Cognitive experiences and mental state also play a role in mental balance. Elements of daily life like activity engagement and attention flux also make up mental balance. Personal attentional metrics have primarily relied on subjective evaluation, making it difficult to compare across other activity attention levels. New mobile and wireless Electroencephalographic (EEG) devices can unobtrusively collect objective user-specific task engagement in intra-activity. These new EEG devices provide on-board data collection, wireless communication, long-lasting battery life, and reduced setup time. By subjectively measuring and archiving user engagement (how focused the user was) as well as activity engagement (what the user was focused on) information, new engagement prosthetics can help facilitate review of user's personal values and identifying engagement trends.

Author Keywords

Engagement; Quantified Self; Mobile; Android; Electroencephalography (EEG); Biometrics

Engagement Metrics

Our initial personal engagement index uses a metric defined by Alexander Pope that derives values from EEG powers [9]. This metric is computed by obtaining EEG readings for Alpha, Beta, and Theta brainwaves and applying the following formula:

Engagement Index =

Beta / (Alpha + Theta)

This engagement index is represented by a decimal number between 0 and 1. The scale is notably unique for each person, such that if two people both have values of 0.7 for their engagement index, it does not necessarily mean that they are equally engaged. It should be noted that Pope's metric was derived with a specific activity in mind and may not be scalable to other activities. We are investigating appropriate alternate metrics as well.

Introduction

What do "mentally balanced" and "mental state" really mean? They can (and have) taken on many meanings, often stemming from an emotional or visceral understanding by technology of the users' state. Indeed, Don Norman, in his Emotional Design book, separates the emotional aspects of design from the cognitive ones that he focused on earlier in his career[7]. Meyer describes wellness as composite of life elements consisting of mental state, feelings and social interactions [6].

There are currently limited ways for a user to objectively track their mental performance throughout their day [5]. Engagement is a particularly useful and actionable mental metric. It is also difficult for our minds to track naturally, as we typically only remember general information about how engaged we typically become when performing a particular activity. The lack of specific, accurate, engagement information about individual instances of common, daily activities is a problem worth addressing. New advancements in wireless EEG devices offer a way to objectively measure user engagement while storing the results for later review.

By creating biometric models of when users' cognitive experiences, and by aggregating them in a way that is meaningful to the users, our approach enables users to make informed decisions about their choices for tasks moving forward. Much of the recent work in this area has proposed to automatically adjust aspects of an interface based on possible or perceived interruptors [4]. But this approach ignores the explicit desires of the user: perhaps the user is locked in on a task, or perhaps multiple tasks are all important and the user is willing to take performance (and mental health) degradation. Too often interfaces seek to do things for the user, e.g., to control when interruptions take place by limiting access to information.

Our work focuses on developing tools and use cases to address this. Personal engagement monitoring research acts as part of the growing Quantified Self movement. The idea of this movement is to give the everyday person the ability to log, analyze, and productively apply information about their body. Popular examples of devices that fit into this movement are the Jawbone up, FitBit, and Nike Fuelband. All of these devices are essentially unobtrusive pedometers and life loggers with exceptionally accessible user interfaces. They have allowed the everyday person to statistically analyze their activities, all without any amount of specialized knowledge. However, the trend we have noticed is that most of these devices focus primarily on the physical aspects of the user's life [6].

Engagement & Arousal Monitoring

No two brains are the same, as such EEG derived engagement indices are useful for comparing activities by the same person, but not across people. To describe engagement activity, we can show the user a relative metric rather than an absolute number. We show the change of their current engagement index above or below their baseline index. This high, neutral, low conceptualization of engagement is similar to other papers in the field that visualize engagement and arousal [5].

Engagement information displays should at minimum:

● *Quickly glancing at the application should give a user useful information about their overall engagement trends (based off of categorical organization).*

● *Contextual information, i.e. events on a user's Google calendar, needs to be available in the application*

● *Real time as well as historic data about a user's engagement should be easily accessible.*

Arousal is a supplemental metric to engagement in our research. In simple terms, changes in heart rate can indicate that the user has experienced some excitable event in their daily activities[8]. Engagement and emotion are regulated through a set of complex feedback loops between the brain and the cardiovascular system [8, 10]. Consequently, the inclusion of heart rate measures with Cardiovascular Nervous System indicators will likely provide a more holistic picture of the many cognitive and affective processes that are related to performance-relevant states such as stress.

Why do we need tools like this?

The objective of this work is to design tools that allow the user to reflect over their personal engagement levels throughout a day, week, or month. But data-logging isn't enough[1, 2]. *What will the user do with this data? How will they interact and interpret it?* Initial design requirements are listed to the left.

We have conducted a workshop on biometric engagement design as well as a semester long prototyping project with 3 senior undergraduates to begin investigating these questions. We found that users wanted to know comparative engagement values, not necessarily based around time.

As an example, one of our prototypes focused on providing a categorical view of the engagement data. Our favorite design to support the categorical comparison scenario was what we called a "Bubble UI". An example of this concept can be seen in Figure 1. Users are presented with "bubbles" labeled with their activity (derived from calendar scraping). The size of the bubble correlates to their mean engagement score

during the activity. Users can quickly determine which activities they were most and least focused in. Numerical engagement and timestamp values were available by tapping a bubble for more information.

This work is part of a larger research project focused on helping people achieve temporal understanding of derived engagement through prototyping-toward knowledge that leads to improved wellbeing. Deriving engagement through a combination of unobtrusive objective (biosensed) as well as subjective (calendar scraping, social media scraping) methods addresses two of the dimensions traditionally associated with engagement: user level and activity type.

Conclusion and Future Work

The trend of wearable devices moving towards smaller, faster, and robustness gives us confidence in proceeding with cognitive biometric tracking [1,2]. Current EEG devices offer the reliability of 100+ sensor devices in less than 14, and provide the mobility to be worn in new and exciting scenarios.

In the quantified self research field, a large stable of work is focused on physical wellness. There has been less work developed towards mental wellness and cognitive tracking. To do that we are investigating ways to combine objective and subjective user engagement, activity engagement, and arousal volatility as a means to enable reflection.

As an exploratory tool, we have begun development on an initial multimodal-tracking set-up and user interface focused on reflecting on longitudinal engagement trends, presenting information in categorical spheres. This work is hardware independent by design, focusing

Figure 1. Example UI showing user engagement displayed by activity and mean engagement during activity.

Each bubble represents an activity derived from calendar scraping. Users can filter by time using the view option at the top of the screen. The size of the bubble represents the mean user engagement level during that activity. The color fill of each bubble represents the arousal frequency during the activity.

on data presentation regardless of the devices used to collect it. This allows users to review and compare their engagement trends by time and activity.

Our ongoing work examines how biometric data can be combined with other readily available information about user activity to provide a contextually connected view of the user's behavior. Our efforts at calendar scraping associates user events and deadlines with changes in biometric data. Geographical information from a mobile phone's GPS provides a continuously updated view of user location, highlighting how changes in location correlate with changes in biometric data. Information from online classroom management tools like Sakai and Scholar augment these other data sources with course-related deadlines.

Future work needs to be done to investigate how objective engagement information can be used in practice, and which metrics are appropriate. Tools like the Fitbit and heart rate monitor tracking devices have seen steady adoption and continued use for longitudinal personal informatics review.

Acknowledgements

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