Measuring Immersion in Experiences with Biosensors
Preparation for International Joint Conference on Biomedical Engineering Systems and Technologies

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Abstract: When people are engaged in an immersive task or experience, they can become so absorbed in it that they lose track of time and place. Narrative transportation, has similar effects, producing meaningful psychological responses and influencing behavior. Those seeking to create immersive experiences typically rely on inaccurate self-report to measure immersion. We describe research from our group on the neuroscience of immersion and our development of a physiologic sensor, algorithm, and software suite that measures immersion. Our studies show that immersion predicts enjoyment, recall of information, and actions after an experience with 75%-95%% accuracy depending on the outcome measure. We discuss the trade-offs when developing sensor technologies designed for non-laboratory environments.

1 WHAT IS IMMERSION?

Immersion, an experience of deep involvement with an aspect of the environment, is a psychological and neurological process that is not well understood but has very strong and meaningful implications in everyday life. The concept of immersion has its roots in prehistory as bands of homo sapiens related stories of hunts and travels in order to instruct and perhaps entertain members of their clans. Aristotle's two great books, *Poetics* and *Rhetoric* lay the theoretical foundation for immersion. While *Poetics* created a structure for a dramatic play or narrative reading to have an emotional impact on audiences, *Rhetoric* identifies how a speaker can persuade others by structuring his or her narrative. Combining these two approaches led to the development of the dramatic arc used in nearly all storytelling. The five parts of the dramatic arc (exposition, rising action, climax, falling action, and dénouement) were meant to transport audiences into the narrative so they would experience a simulacrum of the story. In the 1990s, psychologists coined the term "narrative transportation" and showed that a key aspect of transportation occurred when an audience member empathized with story characters (Gerrig, 1993). Empathy for characters can persuade audiences to change their attitudes and opinions. For many viewers, watching the physical training the boxing movie *Rocky* or the self-sacrifice in the film about the Battle of Thermopylae, *300*, combined with an emotionally-compelling reason for the suffering, motivated audience members to join a gym or take up boxing or enroll in a boot camp-type training program.

Immersion is similar to "flow" (Csikszentmihalyi, 1997), a state of concentration or absorption in an activity, like work or performance. While flow states require an active participation in a task, immersive experiences can be purely passive, but have similar positive psychological effects like deep concentration and feelings of awe or transcendence. Immersion encompasses the concept of flow, defining it beyond active boundaries to include passive experiences like transportation in a story.

Herein, we present a review of the work we have done to quantify individual and group immersion using commercial wearable sensors.

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2 WHY SHOULD WE MEASURE IMMERSION?

The experience economy depends on creating highly immersive experiences for employees and consumers alike.

2.1 Organizations

Companies strive to engage their employees in their work beyond extrinsic motivation. The burgeoning field of positive organizational behavior (POB) provides increasing evidence that traditional extrinsic motivators such as pay and benefits only weakly engage employees (Seligman & Csikszentmihalyi, 2000; Peterson & Seligman, 2004). Seligman and Csikszentmihalyi (2000, p. 5) point out that today's employees are increasingly "seen as decision makers, with choices, preferences, and the possibility of becoming masterful." POB reflects an increasing emphasis on "psychological capacities that can be measured, developed, and effectively managed for performance improvement" (Luthans, 2002: 59). Flow states are more likely to occur at work than during recreation due in part to having clearly defined goals (Gardener, Csikszentmihaly, & Damon, 2002). Flow has been tied to performance by improving concentration and motivation (Engeser & Rheinberg, 2008).

2.2 Consumer Experiences

Consumers are increasingly demanding, and paying for, extraordinary experiences. As Joseph Pine and James Gilmore articulate in *The Experience Economy* (2012), premium pricing and differentiated products and services require that experiences faced by consumers be extraordinary. This means the entire customer journey, from messaging, to online information gathering, to in-store interactions, to the purchasing ceremony, needs to be integrated and customized for each client.

The push toward immersive content is seen in marketing and advertising. For instance, the last few years have seen a rise in 360-degree video, augmented reality, and virtual reality technologies. Virtual reality has been shown to increase emotional engagement and longer engagement periods over traditional content. Retail companies like Sephora are creating augmented reality apps that allow the consumer to engage with their products outside the store. Indeed, there may be substantial hype around the use of immersive technologies in marketing and advertising, but it is clear that immersion itself is becoming key component to build quality content.

2.3 The Self

Our previous research on immersive experiences suggests that there is much we can learn about the impact of immersive experiences on human flourishing. If immersion is a positive state people seek out, then it is likely that people will want to learn about what experiences are immersive for them specifically. Coupled with the rise of the quantified self, particularly with information to improve psychological well-being and productivity, we expect that the need to quantify immersive experience by the individual will grow in the coming years.

3 MEASURING IMMERSION

3.1 Traditional Measures

We can be immersed in stories, entertainment, work, and consumer experiences, but not always. The same experience can play out differently for different people. The current state of the art to measure the quality of experiences for consumers is to ask people their opinions in a survey that might not be answered for days or weeks after the experience. For instance, there exist several scales for story immersion including the Narrative Engagement Scale (Busselle & Bilandzic, 2009) and the Narrative Transportation Scale (Green & Brock, 2000). Task flow has been measured via self-report using Flow Short Scale (Rheinberg et al., 2003), the Flow State Scale-2 (FSS-2) and Dispositional Flow Scale-2 (DFS-2) for physical activities (Jackson & Eklund, 2002).

Surveys are known to be rife with biases, including poor recall of event details, providing socially acceptable answers, and easier recall of negative experiences. Focus groups, having participants turn dials, and mass emails all suffer from a fatal flaw: people cannot accurately or consistently report their unconscious emotional reactions to experiences. Moreover, there is a dynamic nature to experiences that cannot be measured simply by asking static post-experience questions.

Although it would seem that simply asking people about their experiences could reveal how immersive they were, self-report is often unreliable and difficult to compare across individuals. Moreover, how people respond to traditional survey scales is heavily impacted by culture, current physiologic state outside the target experience (e.g. fatigue, hunger), and socioeconomic status.

3.2 Biosensor Measurement

3.2.1 Defining Immersion Biologically

Our decade-plus of research has shown that immersion depends on two key elements: attention to the experience and emotional engagement during it.

Both sympathetic and parasympathetic systems are indicative of attention and emotional engagement. Attention is associated with energy expended. People are more likely to attend to stimuli eliciting sympathetic arousal (Boucsein, 2012; Kensinger, 2004; MacLeod & Matthews, 2004). Activity in both sympathetic and parasympathetic systems occurs in response to emotional stories (Eisenberg, Fabes, et al., 1988; Eisenberg, Fabes, Schaller, Miller, et al., 1991; Eisenberg, Schaller, et al., 1988). A key component of the parasympathetic nervous system, the vagus nerve, is proposed to be central to the mammalian "social-engagement system" (Porges, 2007), with vagal activity being linked with affective experiences, most notably empathic concern (e.g., Oveis, Cohen, Gruber, Shiota, Haidt, & Keltner, 2009) and trait and state experiences of positive emotion (DiPietro, Porges, & Uhly, 1992; Oveis et al., 2009).

3.2.2 Research

Our lab first uncovered this effect by studying the immersive properties of stories (Barraza & Zak, 2009; Barraza et al., 2015; Lin et al., 2013; Zak, 2015). This series of studies measured and manipulated neural activity, showing that narratives that sustain attention and generate emotional resonance with the story's characters are judged as more enjoyable, the information better remembered weeks later, and are more likely to motivate prosocial costly actions than those that lack one or both of these responses. For instance, our DARPA (Defense Advanced Research Projects Agency)-funded research identified predicted costly actions after a narrative with 82% accuracy in 2014 (Barraza, et al., 2015).

The key, we found, is that both neural signatures for attention and emotional resonance must be present for costly actions to occur. We have measured attention in a variety of ways, but an increase in heart rate and/or in electrodermal activity are robust measures of the energy expended to sustain attention. Our research has shown that emotional resonance corresponds to an oxytocin response measured in blood samples that correlate with increases in vagal tone as measured with an electrocardiogram (ECG).

4 TECHNOLOGY

In the last year, our lab has developed software that uses wearable sensors to capture neural signals associated with attention (increases in heart rate and electrodermal activity) and vagal tone (increases in heart rate variability). Our published research shows that immersion predicts both individual and group *behaviors*, not just intentions or other self-report measures (Barraza et al., 2015; Zak, 2017). The behaviors we have been able to accurately forecast include: donations to charity, recall of brands and information two weeks after viewing messages, YouTube views, social media shares, and sales bumps.

We are currently using off-the-shelf (OTS) sensors for data collection and have built algorithms to measure key neurologic variables by testing these devices against research-grade peripheral neurologic sensors. Our scalable sensor solution provides algorithms that quantify one's immersion that varies form 0-10, so everyone can understand it: higher score means more immersion. Using advanced signal processing techniques, we can now measure and display immersion in real-time.

4.1 How It Works

Participants are invited to put a small sensor on a stretchy band on a forearm. We call this the IN Band. The IN Band can be hidden underneath one's shirt sleeve or worn showing. The IN Band automatically syncs to a PC or mobile device and collects individualized, real-time immersion data from four different signals associated with the brain's control of the heart and gut. Our signal processing algorithms show immersion data for one person or 100 within 10 seconds after activating the sensor. It will collect data for up to 10 hours on a single charge. The cornerstone algorithm is called the Immersion Quotient^{TM} (IQ) that shows second-by-second immersion while a participant watches an ad, or shops, or attends a sales training, or works.

4.2 Using Commercial Sensors

In the last year, our lab has developed a passive wearable forearm sensor and software suite that will allow us to capture the neurocorrelates of immersion in field experiments. The sensor uses the Valencell® biometric chip which has been benchmarked for providing above 99% reliability as compared to a cardiac chest strap. A primary reason for our investment in this new technology is to permit us to run field experiments that provide ecologically valid data to identify immersive experiences.

The problem with neuroscience techniques is they are often uncomfortable, for example, having participants lie in an intimidating and noisy MRI scanner, or being poked with needles to draw blood, or being wired up to a scary looking electroencephalogram (EEG) machine. This is fine for laboratory research, but limits the ability to measure what real people do in real situations. Our initial research on immersion was funded by the U.S. Department of Defense and the U.S. Intelligence Community and we were required to create technologies that accurately predicted people's behaviors and could be used anywhere--even a theater of war.

We also needed to identify "robust" brain signals to predict people's behavior. A serious problem in all neuroscience studies is "signal extraction." Most of what the brain does is keeping people upright, breathing, and conscious. For any experience people have, a small portion of brain activity is responding to that stimulus. Over the course of 12 years, we very methodically traced pathways in the brain using functional MRI, drug infusions, and EEGs in order to find brain signals that consistently measured people's immersion in a message, ad, or experience, and accurately predicted their subsequent actions, including purchases, donations to charity, recall of information, and social media shares.

The other problem one encounters when measuring brain activity is that so much data is collected, it is difficult to extract robust predictive signals. "Robust" is a statistical term meaning that the signal predicts in all or most settings. Scientists seek to resolve the robustness problem by controlling the environment (running experiments in laboratories), using sophisticated equipment, and by using very well-trained PhDs to process the "big data" that are collected. From a business perspective, this means that, for example, the neuromarketing studies Zak and Barraza have been doing for businesses are expensive, must be custom-designed for each client, and take weeks to get results.

To resolve these issues, and build a large and scalable solution for businesses, we focused on building a scalable platform to provide a rapid measure of neural immersion that could be used outside the laboratory.

4.3 Creating a Platform

We have automated the signal processing by building a software suite that measures immersion in real time. It uses the off-shelf sensor wearable that wirelessly collects immersion data from the peripheral nervous system using our Immersion Quotient™ algorithm. Our signal processing and predictive algorithms work through in an online platform that clients use to collect their own data. Our web interface means that multiple events can be viewed by clients as they are collected. Data are archived and can be downloaded as data files for later detailed analyses and comparison.

4.4 Real World Application Problems

Going with an off-shelf sensor and automated algorithms comes with several potential problems. The sensors are not as reliable or accurate in measuring peripheral physiology as research grade sensors. Moreover, there is greater data drop off and motion artefact when collecting physiological data outside the laboratory. Fortunately, wearable sensors have vastly improved, even in the last five years, with many sensor manufacturers competing on quality and price. Moreover, the relatively low cost of the sensors makes it feasible to collect data from hundreds of people simultaneously.

Some concerns still exist, however. Wearable sensors still need to consider light absorption issues (e.g., skin tone) that may reduce signal fidelity. Also, with the ease of use, there is the possibility of less optimal placement by poorly trained users. As with any wearable autonomic sensor, optical noise and blood perfusion can introduce statistical noise into measurement as well.

5 CONCLUSIONS

Immersive experiences are high valued but until recently, could only be measured through unreliable retrospective self-reports. Our development of a wearable OTS sensor, paired with sophisticated algorithms to process data and a simple-to-use interface have produced the first passive real-time immersion sensor. Our research team will be exploring the many ways such a sensor can be used, from marketing and messaging, to employee motivation, to health and welfare in order to create more engaging and valuable experiences for consumers.

REFERENCES

Barraza, J.A., Alexander, V., Beavin, L.E., Terris, E.T. and Zak, P.J., 2015. The heart of the story: Peripheral physiology during narrative exposure predicts charitable giving. *Biological psychology*, *105*, pp.138-143.

Barraza, J.A. and Zak, P.J., 2009. Empathy toward strangers triggers oxytocin release and subsequent generosity. *Annals of the New York Academy of Sciences*, *1167*(1), pp.182-189.

Busselle, R. and Bilandzic, H., 2009. Measuring narrative engagement. *Media Psychology*, *12*(4), pp.321-347.

Csikszentmihalyi, M., 1996. *Flow and the psychology of discovery and invention*. New York: Harper Collins.

Gerrig, R.J., 1993. *Experiencing narrative worlds: On the psychological activities of reading*. Yale University Press.

Green, M.C. and Brock, T.C., 2000. The role of transportation in the persuasiveness of public narratives. *Journal of personality and social psychology*, *79*(5), p.701.

Jackson, S.A. and Eklund, R.C., 2002. Assessing flow in physical activity: The flow state scale–2 and dispositional flow scale–2. *Journal of Sport and Exercise Psychology*, *24*(2), pp.133-150.

Lin, P.Y., Grewal, N.S., Morin, C., Johnson, W.D. and Zak, P.J., 2013. Oxytocin increases the influence of public service advertisements. *PloS one*, *8*(2), p.e56934.