Audience Evaluation and Biometric Technology: Challenges and Opportunities

*Completed Research*

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**Abstract**

Evaluating the audience experience for performing arts events is notoriously challenging. Yet proving the impact of arts events is increasingly important, particularly when seeking to apply for much needed government and philanthropic funding. Researchers in the field of affective computing have turned to biometric technology to gather vital data on the audience experience in a rigorous and robust manner. Unfortunately, arts researchers have been more reluctant to use such technology for audience evaluation.

This paper reviews the literature on audience evaluations, with a focus on how biometric technology is being used to capture the audience experience. This review highlights a gap in existing methodologies and makes a case for the use of Facial Recognition Technology to be explored and further developed, in order to gather important information on an audience's emotional reactions to the performing arts events, as well as their demographic characteristics.

**Keywords**

Cultural industries, audience evaluation, biometric technology, Facial Recognition Technology

**Introduction**

Biometric technology concerns the use of physiological characteristics (fingerprint, face, hand geometry etc.) and behavioral characteristics (voice, gait, signature etc.) of individuals. A review by Unar et al. (2014) illustrates that biometric data can be collected from fingerprints, palm-print and geometry, hand vein patterns, finger knuckle prints, face, ear shape, tongue prints, iris, retina, sclera, voice, keystroke dynamics, gait and signature (Unar et al. 2014), with the data obtained through both static and moving images (Zhao et al. 2003). While biometric technology has been used for identity management and security purposes, there has been a shift in its application towards civilian and private-sector usage (Prabhakar et al. 2003), and broadening the scope of purpose to include individual behaviours as opposed to identifiers (Norval and Prasopoulou 2017).

This presents exciting opportunities for arts and culture organizations. Gathering data from the audience is paramount for many reasons. Yet this important data is not only difficult to obtain but the measures used to evaluate the audience experience have been questioned (Radbourne et al. 2010; Walmsley 2016). There have been strong cries for more in-depth evaluation yet methodologies to address these concerns have not captured the attention of many arts scholars. By contrast, there is a wealth of literature from affective computing that has used biometric technology to assess human emotional reactions. This is a useful well-spring from which to draw given that ‘quality’ arts events are one's that engender an affective response from attendees.

This paper reviews the extant research on the use of biometrics to evaluate an audience’s experience of an arts event. The main technologies used are galvanic skin response (GSR) and electroencephalography (EEG), with the findings pointing to such technology being valid and useful measures for an audience’s
emotional response. What has yet to be explored in the use of facial recognition technology (FRT). Thus the contribution of this paper is an original case for the use of FRT as a valid, cost-effective and scalable tool to assess an audience’s emotional response to an event thereby contributing to a more robust evaluation. It will also be argued that the affordances of FRT could potentially extend to the gathering of important demographic details about attendees. However for this to occur, much needed further research is needed to refine the technology whilst also being mindful of the ethical implications of the data collected.

Biometric technology: A brief overview

Biometric data has been predominantly used for identity management and/or authentication for security purposes (Jain et al. 2000; Van der Ploeg 2003). As can be seen in Table 1, there have been a number of notable shifts in biometrics. The first has been an evolution in the technology from first to second generation biometrics (Norval and Prasopoulou 2017) the latter of which has a greater focus on behaviors as opposed to individual identifiers. Schumacher (2012) characterizes this shift as moving from ‘who you are’ to ‘how you are.’ There has also been noted shifts in purpose and application, from security to safety (Norval and Prasopoulou 2017), and from government to civilian and private-sector applications (Prabhakar et al. 2003).

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Table 1. Generational Shifts In Biometric Technology

For example, a 2003 literature review of the applications of FRT (Zhao et al. 2003) identified four main uses of the technology: entertainment, smart cards, information security, and law enforcement. These activities can also include (but are not limited to) border control, forensics, criminal identification, access control, computer logins, e-commerce, welfare disbursements, missing children identification, id cards, passports, user authentication on mobile devices, time and attendance monitoring systems (Unar et al. 2014). With the generational shift to second-generation biometrics, the uses of the technology are extending beyond identity management. For Norval and Prasopoulou (2017: 649) what we are seeing is ‘a shift from what has been called “societies of surveillance” to “societies of traceability.”’ This includes the evaluation of the audience experience.

Evaluating arts and culture audiences

Rationale and traditional approaches

Evaluating the audience experience has been an ongoing challenge for arts and culture organizations and yet this information is extremely important. It is particularly relevant for public funding applications and audience development activities (Radbourne et al. 2010; Walmsley 2016), as well as informing future
performances and exhibitions (Martella et al. 2017). As identified by Radbourne et al (2010), bids for financial support are predominantly evaluated on the achievement of certain measures, such as ‘quality or excellence.’ Traditionally, arts organizations have used objective measures such as attendance and income, as well as more subjective measures such as peer review and reputation (Radbourne et al. 2010). Yet existing methods have several notable flaws. The reliance on surveys and interviews as primary methodologies limits the size and scope of the data collected (Silveira et al. 2013), as well lacking suitable response rates (Martella et al. 2015). When surveys are used successfully, they questions are often inconsistent across events, limiting comparability (Wang and Cesar 2017). Furthermore, responses to both surveys and interview questions are argued to have positive bias, (Johanson and Glow 2015).

These issues are concerning. For Johanson and Glow (2015), the ‘positive evaluation phenomenon’ is the most significant and can be attributed to two factors. First, those who design the research often have a conflict of interest. Arts organizations need to prove their value to obtain funding and thus biased research instruments are either intentionally or unintentionally constructed (Davies and Heath 2014). Second, the methodologies and approaches used often means that audiences don’t want to participate (Johanson and Glow 2015). For example wanting to leave quickly after an event has concluded. It is therefore unsurprising that scholars such as Radbourne and colleagues (2010: 308) are calling for methodological advancement to refine the arts evaluation process.

It can be argued that any methodological progress has to have a strong focus on gathering data on the audience’s emotional response to events. The emotional impact is of extreme import, as it was argued by Brown and Novak (2007) that an audience’s perception of the quality of the art is related to their emotional reaction, particularly ‘captivation’, which in turn leads to audience satisfaction. This is supported by Walmsley (2011) who also identifies the importance of moods, emotions and feelings when evaluating an entertainment experience and similarly notes captivation as an important emotional reaction for evaluation. In fact, his research points to the emotional reaction being the most important factor when determining an audience’s motivation to see an arts and culture event such as the theatre (Walmsley 2011). It is worth noting that any pursuit of methodological alternatives (or complements) has its challenges. Kirchberg and Tröndle (2012) draw from the work to Reussner (2010) to highlight reservations from museum directors, curators, and educators to visitor studies; yet these reservations seem to be more related to their changing role in light of the research, namely a loss of power, authority and control, rather than the utility of the research itself. They also point to the inherent methodological challenge of evaluating an aesthetic experience but also identify the discipline of empirical aesthetics that despite its long history, has yet to be embraced in evaluations (Kirchberg and Tröndle 2012; Kirchberg and Tröndle 2015). However evaluating an audience’s emotional reaction, which is key to understanding the audience’s experience, is not the same as evaluating the art itself.

Evaluating an individual’s emotional reaction to various stimuli is a common approach in research streams outside of the arts, particularly affective computing. It can therefore be argued that using biometric technology is a highly suitable way forward to gather this important information, as it can also provide a more objective source of data for audience researchers and arts organizations, something that has yet to be fully realised (Wang and Cesar 2017). What’s more, this approach can provide data on an audience’s unconscious reactions to an event (Wang and Cesar 2017) making a significant contribution to the provision of deep feedback, as articulated by Radbourne, et al (2012).

**Biometric technology and audience evaluation: a review of the literature**

There has been significant research on audience evaluations using biometric technology yet to-date FRT has been largely overlooked. One of the first studies to highlight the utility of biometrics was by Latulipe, Carroll and Lottridge (2011) who acknowledged the considerable work of neurophysiologists who have long proven a link between an individual’s emotional response to an event and a physiological response. They draw our attention to the two dimensions of emotional responses: valence and arousal. ‘Emotional valence describes the extent to which an emotion is positive or negative, whereas arousal refers to its intensity, i.e., the strength of the associated emotional state’ (Citron et al. 2014:79-80). Studies that have sought to measure the emotional responses of audiences using biometrics have tended to measure one or both of these dimensions.
The technology that is most often used in laboratory studies of audiences are ‘methods such as eye tracking, measurements of brain activity through electroencephalography (EEG), and measurements of psychophysiological changes via electro-dermal activity’ (Gregerssen et al. 2017: 3) also known as galvanic skin response (GSR). The latter technology is a common means of capturing data in media studies research and measures the arousal of the sympathetic autonomic nervous system of the respondent; this approach has been proven to be a reliable measure of emotional responses in a performing arts audience (Latulipe et al. 2011). Gregersen et al (2017) draw attention to the longstanding psychophysiological research (see for example Ravaja, 2004) that has used such approaches to capture data. As identified by Wang et al (2014), it has also been used across psychology, medical, gaming and education research, as well as audience market research for TV and cinema (Lisetti and Nasoz 2004) and market research in general.

In their empirical laboratory study, Gregersen et al (2017) used GSR to measure interest and engagement, manifested as physical arousal, with their findings illustrating that GSR could be effectively used as a methodology to gather meaningful data on an audience’s emotional state. This built on the findings of Bartsch (2012) who similarly found that measuring the physical arousal of an individual also elicits important information about the individual’s emotions, namely empathetic sadness. Wang et al (2016) note that physiological sensors are commonly used when movies are being audience-tested (see also Fleureau et al. 2013; Silveira et al. 2013). However when assessing live arts and culture events, ensuring the technology is unobtrusive and does not detract from the performance is vital yet extremely challenging (Wang et al. 2016).

Wang et al (2016) propose a participatory biosensor system that can be used in theatres, with a segment of the audience wearing the biosensors to obtain audience evaluation data. They tested it in a 150 person audience in China with the resultant findings forming a seven-step heuristic for deploying a biosensor network in theatres (Wang et al. 2016). This heuristic was developed after their research indicates that biosensors and GSR data is a valid source to measure audience engagement and corresponds with self-report evaluations (Wang et al. 2014), and supports the earlier work of Latulipe and colleagues (2011). Wang et al (2016) acknowledge that in practice there are significant uncontrollable variables for live events such as the size and type of the venue and audience. For public outdoor events, these variables increase exponentially and such a network would not be a viable option.

Biometric data gathered through GSR is not the only approach to assess an audience’s response to an event. While not in the area of arts audience research, Hassib et al (2017) developed a proprietary system called EngageMeter that measures the brain computer interfaces (BCI) of audience members to presenters by capturing electroencephalography (EEG) signals. They developed head-mounted consumer brain-computer interfaces (BCIs) to collect physical, emotional, and cognitive data from participants (Hassib et al. 2017), with the data being made available to presenters in real-time so that they can adjust their presentation as they go. While this would be unfeasible to provide for all audience members (and real-time data would not be of use to the performers), it could also provide another source of post-event data. Rostami et al (2017) argue that a real-time feedback system would be useful to inform an interactive arts performance, presenting design ideas for how biometric technology can be incorporated. Their research was not explicitly about using the technology for audience evaluation however the data captured in real-time could also be used for post-hoc evaluations. Soleymani, Asghari-Esfeden, Pantic and Fu (2014) similarly used EEG technology to facilitate continuous emotion detection with a focus on emotional valence, a recognized approach that has seen emotional ‘tagging’ of responses to visual stimuli (Koelstra et al. 2012). Their work shows that facial expressions provide valid measurements of emotional states and that there is technology available that can facilitate the collection of this valuable data (Soleymani et al. 2014).

Webb and colleagues (2016) argue that sophisticated technology such as GSR and EEG is not necessary to gather biometric information. An individual accelerometer has been argued to predict an audience’s enjoyment of a fine arts exhibition with 90% accuracy (Martella et al. 2015) Wearable technology such as AppleWatch and Fitbit have the potential to gather physiological data from individuals, which is enhanced by corresponding phone apps to capture and track data. Webb et al (2016) further submit that audience members could actively opt-in to their data being forwarded to the arts organizations and venues that they attend. Several scholars (Gedik 2016; Martella et al. 2015; Martella et al. 2017) propose using accelerometers and proximity sensors that are stock standard within smartphones to measure such things.
as audience interactions with each other as a useful way of potentially measuring collective engagement, one the dimensions of the audience measurement framework proposed by Radbourne, et al (2010).

Physiological sensors (similar to Bluetooth found in smartphones) have been used to track the physical movement of attendees to museum exhibitions, as well as their reactions and social behaviors (Kirchberg and Tröndle 2015; Martella et al. 2017). Martella, et al. (2017) caution that their findings don’t provide a qualitative evaluation of the audience experience but the correlation between time spent at an exhibit and the reaction of the attendee shows that it can provide another useful point of data to inform a fulsome audience evaluation. However Latulipe et al’s (2011) study using GSR did show that there was a strong correlation between a physiological response in the participant and the extent to which they ‘loved’ or ‘hated’ a performance. As such, biometric data can be both descriptive and evaluative depending on the methodologies and techniques chosen.

A logical criticism of using wearing technology to gather biometric data would be the reticence of the audience to go through the rigmarole of acting as a research participant. Yet Wang and Cesar (2017) found that the 150-strong audience did not have issues with wearing the biosensors and only took 15-20 minutes to induct the participants into the research process, which included testing the technology when the sensors were on the participants and answering the participants’ questions. There could also be the criticism that arts professionals may also have a similar reticence to using biometric technology. However when Wang and Cesar (2017) interviewed one of the play’s producers after the event, he found the resultant data to be ‘exciting’ and helped with an understanding about some divergent views between him and the director of the play (Wang and Cesar 2017). The experts consulted in another study, were also ‘interested’ and ‘intrigued’ by the data provided by GSR (Latulipe et al. 2011), particularly around prolonged intervals of low emotional arousal in the audience. Webb and colleagues (2016) also found that subtle feedback from the audience also has relevance to the performers, who can sense cues to the audience’s emotional reaction through facial expressions and muscle movement, also forming emotional connections through similar physiological actions and reactions. The utility of the data gathered could therefore go a long way to offset a potential reluctance to embrace biometrics in audience evaluations. Reluctance to accept new methodologies is a real concern, with arts experts in Latulipe and colleagues’ (2011) study cautious about an over-reliance on biometric data, particularly by producers and financial decision-makers who could use the information against artists.

Yet there are compelling reasons to proceed with the use of biometric technology to gather useful information about an audience’s emotional response. It can provide a rich source of data on the intrinsic experience of the audience, contributing to the agenda of providing deep feedback as part of the evaluation process, as well as offsetting biases by providing objective readings from the participants. However scholarship to-date has used biometrics that are not scalable and thus encounters the same concern as traditional methods discussed in the previous section. Therefore this paper proposes a meaningful exploration of FRT to evaluate an audience response to an event. This can not only go towards an understanding of the emotional response but could also contribute to addressing an additional concern of arts organizations that will be discussed in a later section, that is, demographic characteristics of arts and culture audiences.

The case for and against using Facial Recognition Technology

Facial recognition technology has yet to be embraced by audience evaluation researchers and has the potential to gather biometric data of audiences at large-scale and public events, when individual readings may not be feasible. Such technology has not been readily adopted for audience evaluation studies yet it has been used to an extent in student-teacher evaluation research. D’Mello and colleagues (D’Mello et al. 2009; D’Mello and Graesser 2010; McDaniel et al. 2007) have a longstanding research interest in the mechanisms of facial expression and learning-centered affective states which has led to research using FRT to evaluate students’ responses to classroom learning. For example Grafsgaard, Wiggins, Boyer, Wiebe and Lester (2013) used FRT to measure student engagement and frustration in a classroom. Students had their webcams activated during a lesson in a computer laboratory. The researchers then used Computer Expression Recognition Toolbox (CERT) and the Facial Action Coding System (FACS) to examine the students’ responses to the learning activities. The results highlight that specific facial
movements predict outcomes of engagement, frustration, and learning (Grafsgaard et al. 2013). A similar study by Whitehill, Serpell, Lin, Foster and Movellan (2014) used machine learning to develop automatic engagement detectors, after using human observers to assess levels of engagement in a student cohort. They found that machine learning methods could be used to develop a real-time automatic engagement detector with comparable accuracy to that of human observers, who themselves had significant accuracy. Yet this accuracy was the result of extensive training and development for the observers to accurately assess a subject’s affective response and for larger cohorts it becomes unfeasible to assess at an individual human level (Whitehill et al. 2014). Therefore using FRT as a means to collect data from audiences goes directly towards addressing the key concerns plaguing existing arts evaluation methodologies: it is scalable in size and scope, allows for larger response sizes, and has the potential to uncover the implicit emotions of the audience, the key factor in arts evaluations.

When looking at the use of biometrics to assess student and audience engagement, the aim is to investigate the intellectual and affective states of the data subjects without having them state their reactions explicitly. Latulipe and colleagues (2011) suggested using high-resolution computer vision or thermal imaging techniques to detect facial expressions. As technology may be limited, they also suggested equipping seats with Body Posture Measurement System (BPMS), a posture sensor to gauge peoples’ movement during a performance. Despite this idea being raised several years ago, and research on student evaluations pointing to its utility, FRT has yet to be readily embraced. Further research using FRT in audience evaluations is therefore much needed.

**The affordances of FRT and capturing audience diversity**

Admittedly, there is also the need for further development of the technology to gather data on the emotional reactions of audiences. It is argued that any technological development must be directed towards capturing the emotion ‘captivation’, as it is the key antecedent to audience satisfaction (Brown and Novak 2007). At present, ‘captivation’ is not an emotion that is captured by available FRT products. For example, Microsoft Face API can detect ‘anger’, ‘contempt’, ‘disgust’, ‘fear’, ‘happiness’, ‘neutral’, ‘sadness’ and ‘surprise.’ The Microsoft Emotion API also uses video to gather data that can ‘track how a person or a crowd responds to your content over time’ (Microsoft, 2018). Accuracy of the available software is also limited. However given the rapid pace of change, greater accuracy and a broader array of emotions will hopefully become features of FRT as there is a strong business case for doing so.

In addition to using FRT to gain a fuller understanding of the emotional reactions of audience members, it could also offer the potential to gain more detailed data on the demographics of audience members. Demographic characteristics of an audience are of interest to arts organizations that are seeking to diversify their audience base (Kawashima 2006) as well as funding bodies who often grant money based on social impact on the community. Usually demographic information is provided voluntarily at time of purchase if tickets are bought online but this does not guarantee a suitable response rate. Demographic details are also solicited when completing exit surveys which has been noted to also have poor response rates (Martella et al. 2015).

If we take the example of Microsoft Face API it can detect ‘Age, Emotion, Gender, Pose, Smile, and Facial Hair along with 27 landmarks for each face in the image’ (Microsoft, 2018). The API has the capability for face verification, similar face search and face grouping. If arts organizations were using FRT then they could potentially store the data for face matching to see if attendees came to multiple events. Age, gender and emotional response would be of interest for audience development. At present, nationality or race cannot be assessed however the grouping function would allow people of similar appearance to be clustered together. If a photo of the audience is run through the software then the greater the number of clusters, the more diverse the audience. The clustering approach would be preferred over distinct labeling. Even though the mechanical technological processes behind biometrics are ‘seemingly neutral’ (Schumacher 2012) it should never be forgotten that one’s racial, gender and sexual identity are ‘deeply politicized’ (Norval and Prasopoulou 2017). Thus using FRT to label people according to their race or ethnicity would be highly problematic in practice.

It is important to understand that biometric technology is not being advocated to replace traditional data collection methods but instead would be providing another robust source of data to inform the complex process of audience evaluations. Indeed, in existing studies where biometrics are used for data collection, questionnaires and/or interviews are used alongside the technology, enhancing triangulation of the
research findings (Bachrach et al. 2015; Latulipe et al. 2011; Martella et al. 2015; Martella et al. 2017; Wang and Cesar 2014; Wang et al. 2014). In research by Martella et al (2015) this was key, with the implicit responses captured by the technology proving very useful in light of ‘sparse’ explicit survey responses. Ongoing longitudinal studies should also be conducted to inform a greater understanding of the changing nature of arts audiences over time (Walmsley 2013). It is also important to recognise that the technology is by no means comprehensive or accurate enough to read the full gamut of human emotions with 100% accuracy, particularly if the individual is self-regulating their physicality in public or there are additional variables impacting the data collection process. This would be tantamount to mind reading (Sprokkereef and de Hert 2012), which is neither feasible, desirable or even ethical.

**Limitations and considerations of FRT**

At this stage, off-the-shelf products are not accurate enough for organizations to use FRT to gather highly accurate affective responses and demographic information from audiences to inform robust audience engagement research. For example, the picture in Figure 1 below purchased from iStock by Getty Images and ran through the Microsoft Face API shows the recognition of twelve faces. When isolating the face of the young boy in the front row, the Face API results labeled him as female.

This is linked to concerns about the accuracy of demographic data obtained through FRT. For example, it has been highlighted in the public media recently that FRT is ‘racist’ as the technology was developed by Caucasian coders who created algorithms that failed to account for physical nuances in other races due to a commonly held own-race bias (Breland 2017) an argument that has empirical support (Klare et al. 2012). Yet there is a clear opportunity to have more exacting technology and make a strong contribution to the important sphere of audience engagement research in the arts.

If we are to take the stance that such solutions will be a case of ‘not if but when’, the deployment of the technology must be aware of the ethical concerns related to its usage. Biometric technology can be seen as an invasion of privacy, negatively impact on human behavior, contribute to a loss of autonomy and feeling under threat of constant surveillance with a growing police state, and may also lead to the discriminatory targeting of certain groups (Introna and Nissenbaum 2010; Milligan 1999). Additional arguments that critique the use of biometrics, including for commercial purposes, raise issues such as the commodification of self, the loss of property interest in personal identity and photographic image, can displace crime rather than prevent and interferes with rights of free speech and freedom of association (Alterman 2003; Introna and Nissenbaum 2010). When considering second generation behavioral biometrics there is the added concern of using an arguably ‘invasive’ means to extract ‘hidden’ and ‘privileged’ information from individuals which may want to remain hidden as it can speak to someone’s emotional and psychological state, information that people may feel is more sensitive than their demographic characteristics (Jain and Kumar 2012; Schumacher 2012; Van der Ploeg 2003). This is a different set of circumstances than first generation biometrics for security purposes when the main debate
is security versus liberty (Lodge 2012). Yet second generation biometrics raise new and troubling questions such as what happens when information is collected that is not intended or desired by the individual (Alterman 2003: 142)?

Many of the above concerns can be remediated by effective data governance (Jain and Kumar 2012; Schumacher 2012). Data governance specifically includes the management of the availability, usability, integrity, and security of the data, and subsequent validity and interpretation (Karkazis and Fishman 2017). It also includes attention to the reliability and accuracy of the data, who has access to the data, as well as ensuring the appropriate training of the individuals involved in the data collection, analysis and dissemination process (Karkazis and Fishman 2017). Schumacher (2012) points to encryption techniques to protect templates and securing data exchanges through Privacy Enhancing Technologies (PET) and Transparency Enhancing Technologies (TET). Access to privileged information can be readily tracked by secure and supportive information systems to ensure accountability for activities (Jain et al. 2011). Like the use of any technology that captures data from a subject, both wittingly and unwittingly, organisations have a responsibility to uphold both the legal and ethical principles inherent in its usage. Given the opportunity to gather important data using biometrics, it would behove developers to continue working on refining FRT, and for arts organisations to collaborate with such experts and expand their horizons, seeking ways to use more sophisticated technologies as methodologies in their audience research process.

Conclusion

Biometric technology has become widespread and has moved from security to non-security applications. Biometrics such as GSR and EEG are increasingly used in research that seeks to evaluate the audience experience of art and culture events. Whilst such technology can be readily adopted in controlled settings or for audiences of smaller numbers, it is somewhat cost prohibitive and limited in scalability. In this paper it is argued that unlike other biometric technologies, FRT presents a unique opportunity to gather important data on an audience’s affective response to arts and culture events, as well as demographic characteristics, two sets of data that are necessary for a fulsome audience evaluation. However at present, for accurate data collection to occur, the technology that is available to consumers needs significant improvement in terms of accuracy and nature of emotions captured. Arts organizations and developers should work together to enhance the offerings of biometrics and capture the vital data needed to show the true value and nature of the audience experience. With arts funding dwindling, proving the emotional impact of arts events, as well as showing the diverse audiences such events draw, is more important than ever.

REFERENCES


Audience Evaluation and Biometric Technology


