ACN

The Psychology of Live Performance

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Summary

With the rise of Netflix, Youtube, and on-demand movie content, Encore wanted to understand what makes performances "best live". Using biometric wristbands that can track physiological signals linked to the autonomic nervous system, which in turn relates to emotion and arousal, ACN researchers monitored audience response to a live Dreamgirls performance and found remarkable changes in their heart rates.

Despite being seated for the performance, the audience's hearts spent an average of 28 mins beating in elevated range between 50% to 70% of their maximum heart rate – the zone is identified by the British Heart Foundation as the optimal for promoting cardiovascular fitness and stamina.

Further, the performance was so arousing, that the audiences' hearts not only beat faster, they actually started to beat together in synchrony. The audiences' hearts were literally beating together. As psychologists are discovering, this sort of physiological coordination between people is a crucial aspect of human social life and bonding.

Introduction

Recent advances in wearable technology have allowed scientists to gauge the emotional engagement of groups spectating and participating in performance, ceremony and social interactions. They can track various physiological signals linked to the autonomic nervous system, which in turn relates to emotion and arousal. These signals can then be averaged across audience members give an indication of the time-course of a shared experience. For example, Bligh (1998) tracked the heart rate of students during a lecture, using it as a measure of their interest and engagement.

Messages from the heart are not as straightforward, however. A higher average heart rate does not necessarily indicate a higher overall emotional or cognitive engagement in a performance or a lecture. This is because sometimes at moments of deeper engagement and concentration, arousal and heart rate can decrease (Jola et al, 2011). What might be indicative of a richer experience is a greater range of heart rate responses, from a low heart rate of concentrated engagement to a peak of arousal. For example, Shoda and colleagues (2016) tracked heart rates of audience members listening to either a live performance by a pianist, or a video recording of that performance. They found that only during the live performance did the audience's heart beat shift in response to the tempo of the music.

As well as measuring the audience's overall emotional arousal, scientists can quantify how much individual audience members have synchronized their arousal with each other. They are discovering more and more that this sort of behavioral coordination between people is a crucial aspect of human social life (Dale, Fusaroli, Duran & Richardson, 2013).

Two people interacting with each other often become more similar in their behaviour. They

implicitly imitate each other's accent, speech rate and syntax; they look at the same things and use the same words; they adopt similar postures, gesture alike and will gently sway together (Chartrand & van Baaren, 2009; van Baaren et al. 2003; Shockley, Richardson & Dale, 2009). This social mimicry can change the size of a waitress' tip (van Baaren et al. 2003), and improve the quality of the client-therapist bond (Vrobel, Roessler, Marks-Tarlow, 2008), and from a lifetime spent together mimicking each other, married couples' faces will become more and more similar (Zajonc et al. 1987).

What is more surprising is that people do not only synchronise their surface features and visible behaviours, they also synchronised their physiology; their hearts literally beat together. During extraordinary experiences, people's heart beats can become synchronised, which in itself is astounding. Why should an internal, invisible autonomic response coordinate with another person? And yet they do. What is more, the degree to which two or more people's autonomic systems are in synchrony can tell us about their emotional relationship to each other (Palumbo et al, 2017).

Perhaps the most dramatic illustration of physiological coordination was provided by Konvalinka (2011) and colleagues. They visited San Pedro Manrique, a rural Spanish village during the summer solstice. After a night of music and dancing, a small number of villagers walk across burning coals, watched by their friends and family. The scientists measured the heart rate of the fire walkers, as well as various observers, and quantified the degree to which they were synchronised with each other as they stepped on the hot coals. Not only did observers' hearts beat in time with the firewalkers, they were more synchronised the more closely the two were related by family or marriage.

It doesn't take a pit of burning coals to synchronise heart rates, however. McAssey and colleagues (2013) found that romantic couples who simply sat blindfolded next to each other would synchronize their heart rates, and that this coordination would increase if they looked into each other's eyes. Heart rate synchronization can also capture the emotional dynamic of the relationship between a parent and child (Ghafar-Tabrizi, 2008) and a therapist and client (Marci et a 2007).

Synchronised heart rates do not always mean love and trust. Heart rates are linked to arousal, which can be positive or negative. When married couples discuss an issue of contention, their heart rates will often synchronize even more (Timmons, et al, 2015). This because they are escalating their conflict, becoming more emotional with each other.

How can these findings – from the laboratory to the therapist's couch to the coals of a firepit – be applied to the particular experience of a live theatre performance? We can speculate that there are three psychological aspects to live performance that distinguish the experience from recorded drama or music.

First, during a live (rather than pre-recorded) performance, an audience member will have a richer, more embodied experience. They will look at the faces and bodies of the performers differently if they are real people rather than recordings (Risko, Richardson & Kingstone, 2016). Their heart rates will be more attuned to movements in live music when they are in the room with the performer (Shoda et al, 2016). Jola and colleagues (2013) even found that when people watch live (but not recorded) dance, there is increased corticospinal activity, as the brain's motor systems echo the dancers' movements.

Second, audience members are embedded in social context, surrounded by others. This shared emotional experience is not abstract but is embodied in the synchronisation of audience members' physiology. The coordination between their autonomic nervous systems has consequence for the audience's experience of the show and each other.

Finally, once the lights come up, the audience members will turn to each other and talk. This group interpretation of their shared experience will become their memory of the event. Psychologists term this the 'shared reality' of an event (Hardin & Higgins, 1996; Echterhoff, et al 2009). Experiments show that human memory is not like a video recording of an experience that we can replay. Memories are reconstructed, like stories that are retold (Bartlett, 1932). When we experience something as a group, this re-telling becomes a social activity, with each member contributing. It is not just that people take into account each other's opinions of an event; by discussing their experiences and beliefs a group will literally form each other's memories.

Methods

Twelve (12) volunteers agreed to participate in an experiment to monitor their physiological responses to the live Dreamgirls show. All of them wore portable monitors that measured heart rate and electro-dermal activity (EDA, also known as galvanic skin response). Both heart rate and EDA are indirect measures of emotional arousal and can be strong indicators of engagement. It is important to note that within the total set of volunteers there were four sub-groups who came to the performance together: one couple, two sets of three friends, and a single group of four friends.

To account for overall differences in cardio fitness across the 12 participants, heart-rates were normalised before calculating the group average.

Cross recurrence analysis was used to measure the degree of heart-rate synchronisation within the group and sub-groups.

Results

Live theatre gets the heart pumping

During the performance of Dreamgirls, the audience's hearts spent an average of 28 mins beating in elevated range between 50% to 70% of their maximum heart rate (see Figure 1). This zone is identified by the British Heart Foundation as the optimal heart rate to promote cardio fitness and stamina. So, although they were seated for the performance, audience members spent an average of 28 minutes engaged in healthy cardio exercise.

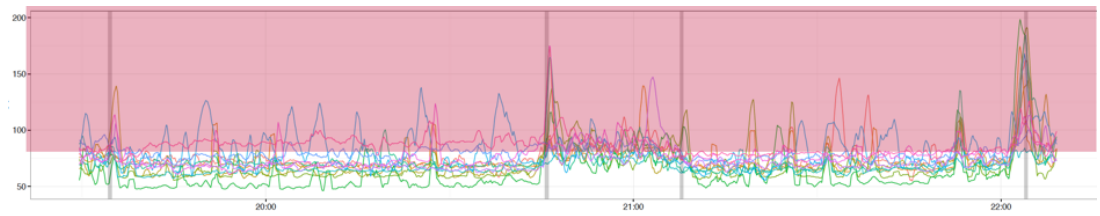

Figure 1
Individual heart rates of 12 audience members. The red zone indicates the zone of increased heart rate that is recommended for healthy exercise. Vertical lines (here are in other figures) show the start of the show, the start and end of interval, and the end of the show

To see how heart rates changed for the audience as a whole, we first normalised values for each person, to account for overall difference in cardio fitness, and then averaged those values (Figure 2). It can be seen that heart rates were elevated during the interval, as expected, because audience members were rising from their seats and walking up stairs. But the important parts are the sections outside of the interval. Here you can see that their hearts were responding to events on stage. Specifically, heart rates increased during several emotional peaks during the show, including half way through each act, and more dramatically, in the events leading up to the end of each act.

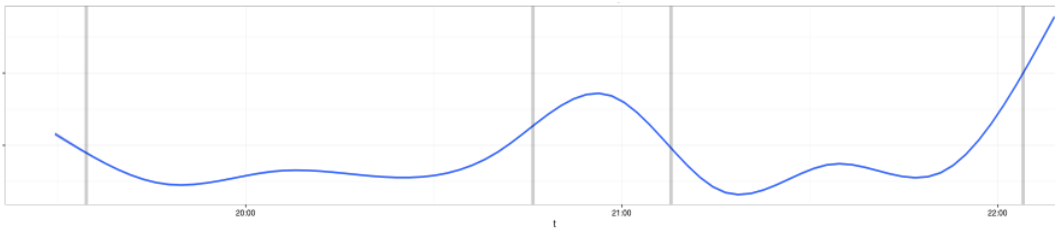

Figure 2
Averaged group heart during the course of the performance

In other words, these data provide an index of the overall emotional engagement of the audience throughout the musical. Importantly, there was a large dynamic range in the heart rate data consistent with the fact that being in a live audience increases the emotional intensity of the experience. By the end of the first act, heart rate nearly doubled from its resting state at the beginning while in the second act, it tripled! You see comparable changes in heart rate in professional tennis players during burst of highly intense exertion such as long and fast rallies (Fernandez et al., 2006).

Audience hearts beat together

For the Dreamgirls performance, we also quantified the degree of synchrony between audience members using a technique called cross recurrence analysis, the same tool used by researchers to examine autonomic synchrony in fire walkers and couples. Figure 3 plots the time course of heart rate synchrony throughout the evening. Just as in the overall heart rate data, there are peaks of synchrony in the middle and the end portions of each act. The audience was not just responding emotionally to the drama as individuals, their hearts were responding in unison.

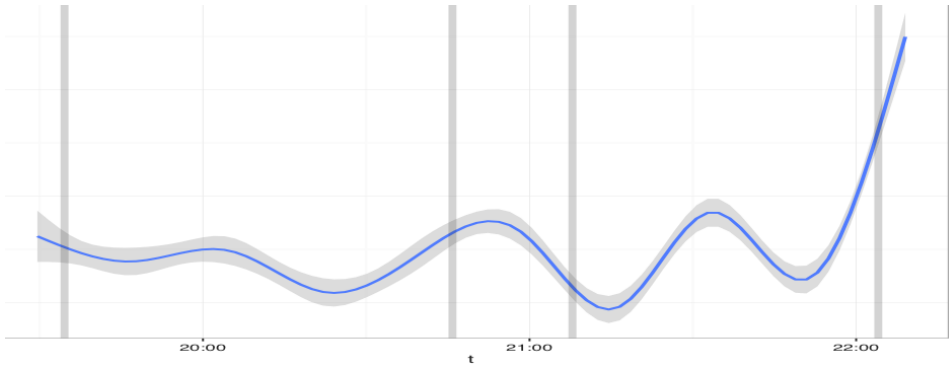

Figure 3
Heart rate synchrony between audience members

What is fascinating is that during the show, this heart rate synchrony was found across all of the participants and did not differ between the sub-groups, even though before that evening that had never met one another before. That is, experiencing the live performance of Dreamgirls was extraordinary enough to overcome group differences and produce a common physiological experience in the audience members.

This pattern changed during the interval, however. Once the show stopped, audience members broke into smaller social groups at the bar and in the lobbies, typically chatting with the people who came to the show with them. During this period of time, their heart rates increased for the simple reason that the audience were physically exerting themselves and heart rate synchrony decreased. We can avoid this confound by studying electrodermal activity (a.k.a. galvanic skin response) – a technology most frequently seen in polygraph 'lie detectors'. This measure provides a further window into subconscious emotional arousal but is less directly linked to exertion.

In Figure 4 we show the synchrony between audience members, contrasting the synchrony between those that were friends and came together (the in-group) with those that were strangers to each other. In their arousal synchrony throughout the performance itself, in- and out-groups were the same as each other. This suggests that the audience, even though they don't know each other individually, are having a synchronized emotional response to the performance. But interestingly, they separate during the interval. Our hypothesis is that at this point the audience members are engaged with each other, discussing the show within their social groups. During this social interaction with each other, we can see that their in-group arousal synchronises with each other but not with the audience members as a whole. This clearly

demonstrates that the physiological synchrony observed during the performance was strong enough to overcome social group differences and engage the audience as a whole.

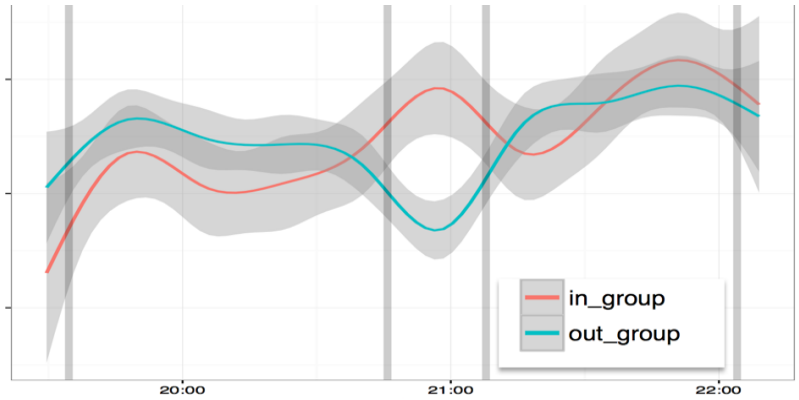

Figure 4
In and out groups differences in arousal synchrony, measured by electro dermal activity

Synchronized activity such as walking, dancing, drumming or even rocking on a chair together, results in people liking each other more and acting pro-socially (Launay et al 2013; von Zimmermann 2017; Wiltermuth & Heath, 2009). Moreover, in small groups of people, heart rate coordination has been linked to team performance (Henning et al, 2001, 2005), trust (Mitkidis et al, 2015), empathy and liking of each other (Järvelä, et al 2013). In other words, the coordinated physiological response seen during the live performance can help to break down pre-existing social barriers and bring people together.

Monkeys groom each other; people go to the theatre – some scientists have argued that these activities might have the same social function. Many primates establish and maintain their social bonds through grooming. This sort of one-way, individual bonding is less practical, however, for the larger social groups that have existed in the course of human evolution (Dunbar 1991). Some anthropologists and psychologists have argued that the collective, synchronised activity of performance, music, dance and ritual evolved to fulfil the same social bonding function (Launay, Tarr & Dunbar, 2016). Indeed, just as with grooming in non-human primates, there appears to a close link between synchronised activity and the production of a range of neurohormones that regulate emotion and social bonding.

For example, scientists found that when people watched live stand-up comedy their threshold for enduring pain was increased, indicating that their bodies had produced endorphins. Critically, this effect only occurred when engaged in the activity with other people, though like our theatre audience, those people could be either friends or strangers (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Dunbar, Baron, et al., 2012). Group synchronized activity such as singing has also been shown to benefit mental health. In one study, after participating in weekly choir session, around 60% of mental health patients reported less mental distress and lower depression, with some no longer fulfilling diagnostic criteria for clinical depression (Clift & Hancox, 2011; Coulton et al 2015; Skingley et al 2015). Crucial to all of these effects appears to be the group social experience of the music and the activity.

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REFERENCES

Bachrach, A., Fontbonne, Y., Joufflineau, C., & Ulloa, J. L. (2015). Audience entrainment during live contemporary dance performance: Physiological and cognitive measures. Frontiers in Human Neuroscience, 9, Article 179.

Bartlett, F. (1932). Remembering: A Study in Experimental and Social Psychology, Cambridge University Press.

Bligh, D. (1998) What's the use of lectures. Intellect Books

Chartrand, T. L., & van Baaren, R. (2009). Human mimicry. In M. P. Zanna (Ed.), Advances in experimental social psychology. (pp. 219-74). Burlington: Academic Press.

Clift, S. and Hancox, G. (2011) The significance of choral singing for sustaining psychological wellbeing: Findings from a survey of choristers in England, Australia and Germany, Music Performance Research, 3, 1, 79-96.

Cohen, E. E. A., & Ejsmond-Frey, R. (2010). Rowers' high: behavioural synchrony is correlated with elevated pain thresholds. Biology Letters, 6(1), 106–8. doi:10.1098/rsbl.2009.0670

Coulton, S., Clift, S., Skingley, A. and Rodriguez, J. (2015) Effectiveness and cost- effectiveness of community singing on mental health-related quality of life of older people: randomised controlled trial. British Journal of Psychiatry, 207(3): 250-255.

Dale, R., Fusaroli, R., Duran, N. D., & Richardson, D. C. (2013). The self-organization of human interaction. In B. H. Ross (Ed.), The Psychology of Learning and Motivation (pp. 43–96). Elsevier Inc., Academic Press.

Dunbar, R. I. M. (1991). Functional significance of social grooming in primates. Folia Primatologica, 57(3), 121–31. doi:10.1159/000156574

Dunbar, R. I. M., Baron, R., Frangou, A., Pearce, E., Van Leeuwen, E. J. C., Stow, J., ... van Vugt, M. (2012). Social laughter is correlated with an elevated pain threshold. Proceedings. Biological Sciences / The Royal Society, 279(1731), 1161–7. doi:10.1098/rspb.2011.1373

Echterhoff, G., Higgins, E. T., & Levine, J. M. (2009). Shared reality: Experiencing commonality with others' inner states about the world. Perspectives on Psychological Science, 4, 496-521.

Engel A. K., Fries P. (2010). Beta-band oscillations-signalling the status quo? Current Opinions in Neurobiology, 20, 156–16510.

Fernandez, J., Mendez-Villanueva, A. & Pluim, BM. (2006) Intensity of tennis match play. British Journal of Sports Medicine, 40(5): 387–391.

Ghafar-Tabrizi, R. (2008). Reversal theory and physiological link- age in the low-conflict and high-conflict mother-daughter dyadic interactions. Contemporary Psychology, 3, 62-75.

Hardin, C. D., & Higgins, E. T. (1996). Shared reality: How social verification makes the subjective objective. In E. T. Higgins & R. M. Sorrentino (Eds.), Handbook of motivation and cognition: The interpersonal context (Vol. 3). New York: Guilford.

Henning, R. A., & Korbelak, K. T. (2005). Social- psychophysiological compliance as a predictor of future team performance. Psychologia, 48, 84-92.

Henning, R. A., Boucsein, W., & Gil, M. C. (2001). Social- physiological compliance as a determinant of team performance. International Journal of Psychophysiology, 40, 221-232.

Interpersonal Autonomic Physiology: A Systematic Review of the Literature

Järvelä, S., Kivikangas, J. M., Kätsyri, J., & Ravaja, N. (2013). Physiological linkage of dyadic gaming experience. Simulation & Gaming, 45, 24-40.

Jarvelainen J., Schurmann M., Hari R. (2004). Activation of the human primary motor cortex during observation of tool use. Neuroimage, 23, 187–19210.

Jola, C., & Grosbras, M. H. (2013). In the here and now: enhanced motor corticospinal excitability in novices when watching live compared to video recorded dance. Cogn Neurosci, 4(2), 90-98. doi:10.1080/17588928.2013.776035

Jola, C., & Grosbras, M. H. (2013). In the here and now: enhanced motor corticospinal excitability in novices when watching live compared to video recorded dance. Cogn Neurosci, 4(2), 90-98. doi:10.1080/17588928.2013.776035

Jola, C., Grosbras, M.-H., Pollick, F. E. (2011). Arousal decrease in 'Sleeping Beauty': audiences' neurophysiological correlates to watching a narrative dance performance of 2.5 hrs. Dance Research Electronic. 29.2, 378–403.

Konvalinka, I., Xygalatas, D., Bulbulia, J., Schjødt, U., Jegindø, E. M., Wallot, S., & Roepstorff, A. (2011). Synchronized arousal between performers and related spectators in a fire-walking ritual. Proceedings of the National Academy of Sciences, 108, 8514-8519.

Lalo E., Gilbertson T., Doyle L., Di Lazzaro V., Cioni B., Brown P. (2007). Phasic increases in cortical beta activity are associated with alterations in sensory processing in the human. Experimental Brain Research, 177, 137-45.

Launay, J. , Tarr, B. and Dunbar, RIM. (2016) Synchrony as an adaptive mechanism for large-scale human social bonding. Ethology. 22(10): 779-789.

Live Analytics/Ticketmaster (2013). State of Play: Theatre UK.

Marci, C. D., Ham, J., Moran, E., & Orr, S. P. (2007). Physiologic correlates of perceived therapist empathy and social-emotional process during psychotherapy. Journal of Nervous and Mental Disease, 195, 103-111.

McAssey, M. P., Helm, J., Hsieh, F., Sbarra, D. A., & Ferrer, E. (2013). Methodological advances for detecting physiological synchrony during dyadic interactions. Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 9, 41-54.

McAssey, M. P., Helm, J., Hsieh, F., Sbarra, D. A., & Ferrer, E. (2013). Methodological advances for detecting physiological synchrony during dyadic interactions. Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 9, 41-54.

Mitkidis, P., McGraw, J. J., Roepstorff, A., & Wallot, S. (2015). Building trust: Heart rate synchrony and arousal during joint action increased by public goods game. Physiology & Behavior, 149, 101-106.

Palumbo RV, Marraccini ME, Weyandt LL, Wilder-Smith O, McGee HA, Liu S, Goodwin MS. (2017) Personality and Social Psychology Review 21(2):99-141.

Risko EF, Richardson DC, Kingstone A, (2016) Breaking the Fourth Wall of Cognitive Science: Real-World Social Attention and the Dual Function of Gaze, Current Directions in Psychological Science 25(1):70-74

Scholz, S., Schneider, SL., & Rose, M. (2017) Differential effects of ongoing EEG beta and theta power on memory formation. PLoS One. 2017; 12(2): e0171913.

Shockley, K., Richardson, D. C. & Dale, R. (2009) Conversation and coordinative structures, Topics in Cognitive Science, 1, 305–319

Shoda H, Adachi M, Umeda T (2016) How Live Performance Moves the Human Heart. PLoS ONE 11(4): e0154322. https://doi.org/10.1371/journal.pone.0154322

Skingley, A. Martin, A. and Clift, S. (2015) The contribution of community singing groups to the well-being and older people: Participant perspectives from the United Kingdom, Journal of Applied Gerontology, 23, 1-23, doi: 10.1177/0733464815577141.

Soto, J. A., & Levenson, R. W. (2009). Emotion recognition across cultures: The influence of ethnicity on empathic accuracy and physiological linkage. Emotion, 9, 874-884.

Theatre UK (2015). Theatre Matters! UK Theatre 2015.

Timmons, A. C., Margolin, G., & Saxbe, D. E. (2015). Physiological linkage in couples and its implications

for individual and inter- personal functioning: A literature review. Journal of Family Psychology, 29, 720-731.

van Baaren, R. B., Holland, R. W., Steenaert, B., & van Knippenberg, A. (2003). Mimicry for money: Behavioral consequences of imitation. Journal of Experimental Social Psychology, 39, 393–398.

von Zimmermann, J., & Richardson, D. C. (2016). Verbal Synchrony and Action Dynamics in Large Groups. Frontiers in Psychology, 7. doi:10.3389/fpsyg.2016.02034

Vrobel, S., Roessler, O.E. & Marks-Tarlow, T. (2008). Simultaneity: Temporal Structures and Observer Perspectives. Singapore: World Scientific.

Weisberg, DS., Keil, FC., Goodstein, J., Rawson, E., & Gray, JR. (2008) The seductive allure of neuroscience explanations. Journal of Cognitive Neuroscience, 20(3): 470-477.

Zajonc, R. B., Adelmann, K. A., Murphy, S. T., & Niedenthal, P. M. (1987). Convergence in the physical appearance of spouses. Motivation and Emotion, 11, 335–346.

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