

An Overview of Video Game Biometrics Collection and Considerations for Cyberbiosecurity

Lucas Potter¹, Christen Westberry and Xavier-Lewis Palmer¹

¹BIOSView Labs, Oswego, KS, USA

Lpott005@odu.edu

Biosview@protonmail.com

Abstract: Over the past fifty years, the global cost of consumer electronics has significantly decreased, leading to greater accessibility to both biosensing systems and interactive entertainment platforms. This increased access has naturally resulted in higher usage of medical and entertainment electronics. However, the intersection of these technologies, combined with invasive data harvesting practices, has raised concerns about the potential misuse of biological signals to manipulate individuals' behavior both within and beyond the video game environment. Currently, biometric data in video games are employed in various ways, such as using Heart Rate Variability (HRV) as a performance metric and integrating eye tracking to enhance hardware capabilities (Hughes & Jorda, 2021). Moreover, patents filed by companies in the interactive entertainment industry indicate ongoing efforts to use personalized data, including biometric and behavioral information, to identify and exploit gambling-like behaviors in players. These technologies, when combined with demographic data, can be utilized to predict and modify behavior to maximize profits. The implementation of these analyses varies across platforms, ranging from general-purpose mobile devices capable of offering interactive entertainment to specialized technologies designed exclusively for video games. Additionally, the concept of "truth decay" is explored in relation to video game-based advertisements, highlighting the blurring of lines between entertainment and persuasion. Furthermore, video games are increasingly recognized as potential training environments, where behavior can be influenced or conditioned in specific ways. As these technologies continue to evolve, the ethical implications of using biometric data in such contexts become ever more critical, warranting careful consideration and regulation to prevent the exploitation of players and to ensure that these powerful tools are used responsibly. Potential solutions to the exploitation of younger users of interactive entertainment are offered, demonstrating failures of current mechanisms and the abdication of responsibility of entertainment conglomerates. A collection of policies in the style of GDPR that could be used to safeguard users from unwanted interactions with their technologies are offered as a conclusion.

Keywords: Video games, Neurocapitalism, Biosignatures, Biometrics, Human performance, Biocybersecurity, Cyberbiosecurity

1. Introduction

Video games are a relatively new medium of entertainment. Available for domestic use in the global north since the mainstream acceptance of household electronics in the 1980s, the availability of video game consoles for home use preceded the widespread availability of home use medical electronics like fitness trackers, electronic glucose monitors, and health IOT and health-instruction related applications (Affia et al, 2023; Cabanilla et al, 2023). This is directly connected to the rise of easily available biometric data collection tools. While heart rate measurements tended to only be deployed in hospital environments, they began to be popular for personal use starting around 2009 with the advent of the FitBit (Santo, 2019). The combination of video games and biometric data can be combined with big data analytic tools to create pipelines for destabilizing biocyber threats. This can be seen as an example of disruptive innovation (Finch, Abasi-Amefon, Jung, Potter, & Palmer, 2023).

Currently, there are 3 broad groups of products that could be considered relevant. Namely these groups are the three main mechanisms of playing a video game. These range from specially built non-mobile units (i.e. home consoles, like the PlayStation or Xbox, including Virtual Reality units), to specially built mobile units (i.e. mobile consoles, like the GameBoy or PlayStationPortable), and non-specially built mobile phones (SmartPhones, like iPhone or Android devices). While the cost can be variable, generally the platforms for exclusive use as a video game system are more expensive. The capabilities for biometric collection range commensurately. For instance, while some Virtual Reality (VR) consoles could theoretically capture EEG and head mounted NIRS measurements (Neurospec, 2024), a smartphone would have degraded data collection abilities (though it is possible for it to still collect eye tracking data).

While the methods of data collection may vary, the purposes to collect biometric data are, at the moment, fairly static. For instance, Heart Rate Variability (HRV) has been used in order to increase the passive interactivity of a game, or as a scoring mechanism (Fairclough & Gilleade, 2013). A considerable broad use has been for personalized advertising within the game environment (Lee et al, 2018; Russoniello et al, 2013; Hong et al, 2018; Ivarsson et al, 2009; Ivarsson et al, 2018; Chin et al, 2024). In general, in-game advertising via biometric means is a potentially lucrative option for generating funds and having more reliable inputs from users (Ohme et al,

2011; Abbasi et al, 2021; King et al, 2023). At the same time it has a meaningful use in gauging health, temperament, sentiment, and addiction levels of users (Frachi et al, 2022). To avoid abuse, scrutiny of use is ever valuable as with other technologies collecting biometrics that could cross with adverse or otherwise (Lesaja and Palmer, 2020; Potter et al, 2021).

2. Methods

The first act presented in this paper is a review of literature (including reports from data breaches) about the data currently being collected via video games. Currently available literature was sparse, as there is no current legal requirement or commercial incentive for such organizations to release such data. Thus, patent filings were also utilized in order to hypothesize what data could be collected. Additionally, as there is a strong overlap between video game biometrics and hyper-personalized marketing, many patents and available sources using social media as a database to create personalized marketing tools were additionally used. The literature concerning the amount of possible medical data taken from video games, and the utility of hyper-personalized marketing will be combined in a greater context in the discussion. The table below lists the papers used and their focus areas.

Table 1: Table of Video-Game Biometrics and Biocybersecurity/Cyberbiosecurity Papers Engaged

Authors	Year	Title	Publication/Source	Key Focus Area
Ivarsson, M., Anderson, M., Åkerstedt, T., Lindblad, F.	2009	Playing a violent television game affects heart rate variability	<i>Acta Paediatrica</i>	Impact of violent games on heart rate variability
Ohme, R., Matukin, M., Pacula-Lesniak, B.	2011	Biometric measures for interactive advertising research	<i>Journal of Interactive Advertising</i>	Biometric measures in advertising
Fairclough, S., & Gilleade, K.	2013	Playing Dark Escape 4D	<i>Physiological Computing (Blog)</i>	Physiological response to horror video games
Ivarsson, M., Anderson, M., Åkerstedt, T., Lindblad, F.	2013	The effect of violent and nonviolent video games on heart rate variability and emotions	<i>Psychosomatic Medicine</i>	Video games' effect on emotions and sleep
Russoniello, C.V., Zhirnov, Y.N., Pougatchev, V.I., Gribkov, E.N.	2013	Heart rate variability and biological age: implications for health and gaming	<i>Cyberpsychology, Behavior, and Social Networking</i>	Biological health indicators and gaming
Donati, M.A., Chiesi, F., Iozzi, A., Manfredi, A., Fagni, F., Primi, C.	2018	Gambling-related distortions and problem gambling in adolescents	<i>Frontiers in Psychology</i>	Adolescent gambling and cognitive distortions
Lee, D., Hong, S.J., Jung, Y.C., Park, J., Kim, I.Y., Namkoong, K.	2018	Altered heart rate variability during gaming in internet gaming disorder	<i>Cyberpsychology, Behavior, and Social Networking</i>	Gaming disorder and physiological changes
Zhang, X., & Yuan, S.M.	2018	An eye tracking analysis for video advertising	<i>IEEE Access</i>	Eye tracking in video advertising
Rich, M.D.	2018	Truth decay: An initial exploration of the diminishing role of facts	<i>Rand Corporation</i>	Decline of facts and analysis in public discourse

Authors	Year	Title	Publication/Source	Key Focus Area
King, D.L., Delfabbro, P.H., Gainsbury, S.M., Dreier, M., Greer, N., Billieux, J.	2019	Unfair play? Video games as exploitative monetized services	<i>Computers in Human Behavior</i>	Monetization practices in video games
Santo, B.	2019	The Consumer Electronics Hall of Fame: Fitbit	<i>IEEE Spectrum</i>	Wearable technology and health tracking
Vasiljevic, G.A.M., De Miranda, L.C.	2020	Brain-computer interface games based on consumer-grade EEG Devices	<i>International Journal of Human-Computer Interaction</i>	Brain-computer interface games
Fennimore, J.J.	2020	Are They Really Just Cosmetic? The Impact of Cosmetic Items on Fortnite's Gameplay	<i>University of Milwaukee Theses and Dissertations</i>	Cosmetic items and game design
Kim, J., Kim, H., Kim, D., Im, S., Kim, M.	2021	Identification of Video Game Addiction Using Heart-Rate Variability Parameters	<i>Sensors</i>	Heart rate variability and video game addiction
Abbasi, A.Z., Rehman, U., Hussain, A., Ting, D.H., Islam, J.U.	2021	The impact of advertising value of in-game pop-up ads in online gaming on gamers' inspiration	<i>Telematics and Informatics</i>	In-game ads and gamer inspiration
Hughes, A., Jorda, S.	2021	Applications of biological and physiological signals in commercial video gaming	<i>Frontiers in Computer Science</i>	Biological signals in gaming
Potter, L., Ayala, O., Palmer, X.L.	2021	Biocybersecurity: A converging threat as an auxiliary to war	<i>ICCWS</i>	Biocybersecurity risks and warfare
Lim, J., Mountstephens, J., Teo, J.	2021	Emotion Recognition Using Eye-Tracking	<i>Sensors</i>	Eye-tracking for emotion recognition
Frachi, Y., Takahashi, T., Wang, F., Barthet, M.	2022	Design of emotion-driven game interaction using biosignals	<i>International Conference on Human-Computer Interaction</i>	Emotion-driven game interaction
Calvo-Morata, A., Freire, M., Martínez-Ortiz, I., Fernández-Manjón, B.	2022	Scoping Review of Bioelectrical Signals Uses in Videogames for Evaluation Purposes	<i>IEEE Access</i>	Bioelectrical signals in video games
Powell, E., Akogo, D., Potter, L., Palmer, X.L.	2022	Co-leadership and cross-pollination of university and DIY bio spaces	<i>Future Technologies Conference</i>	Biocybersecurity and DIY bio spaces

Authors	Year	Title	Publication/Source	Key Focus Area
Vazquez, J., Abdelrahman, S., Wasden, C., Jardine, S., Judd, C., Davis, M., Facelli, J.C.	2022	Using biometric data to measure and predict emotional engagement of video games	<i>BioRxiv</i>	Biometric data in gaming engagement
Kröger, J.L., Raschke, P., Campbell, J.P., Ullrich, S.	2023	Surveilling the gamers: Privacy impacts of the video game industry	<i>Entertainment Computing</i>	Privacy and data surveillance in gaming
Finch, H., Abasi-Amefon, A., Jung, W., Potter, L., Palmer, X.	2023	Commentary on healthcare and disruptive innovation	<i>18th International Conference on Cyber Warfare and Security</i>	Disruptive innovation in healthcare
Cabanilla, Q., Teofilo-Orencia, F., Cafino, R., Isla, A., Maglaya, J., Palmer, X.L., Potter, L., Marcial, D., Velasco, L.	2023	Technology Adoption of Computer-Aided Instruction in Healthcare: A Structured Review	<i>International Journal of Emerging Technologies in Learning (IJET)</i>	Tech adoption in healthcare education
Stephen, S., Alexander, K., Potter, L., Palmer, X.	2023	Implications of Cyberbiosecurity in Advanced Agriculture	<i>Proceedings of the 18th International Conference on Cyber Warfare and Security</i>	Cyberbiosecurity in agriculture
Skaramagkas, V., et al.	2023	Review of Eye Tracking Metrics Involved in Emotional and Cognitive Processes	<i>IEEE Reviews in Biomedical Engineering</i>	Eye-tracking metrics and emotional processing
Skaramagkas, V., Ktistakis, E., Manousos, D., Kazantzaki, E., Tachos, N., Tripoliti, E., et al.	2023	Emotional State Estimation Based on Eye-Tracking Dataset	<i>Brain Sciences</i>	Emotion estimation with eye-tracking
Long, K., Zhang, X., Wang, N., Lei, H.	2023	Heart Rate Variability during Online Video Game Playing in Habitual Gamers	<i>Brain Sciences</i>	Heart rate and gaming addiction
Sharmin, S., Barmaki, R.L.	2024	A Scoping Review of Functional Near-Infrared Spectroscopy Applications in Game-Based Learning	<i>arXiv</i>	Functional neuroimaging in game-based learning
Boyraz, F.T.	2024	Protection of in-game behavior data as biometric data under the GDPR	<i>Interactive Entertainment Law Review</i>	GDPR and in-game behavioral data
Potter, L., Palmer, X.	2024	Social Murder in Another Century: Technologies That Enable Misinformation to Instigate Assault	<i>Journal of Information Warfare</i>	Social impacts of biocybersecurity

3. Results

The results of this exploration of how much data different modalities of interactive entertainment could acquire varied widely on the nature of each method. We will begin with mobile gaming.

Many smartphones have both rear and forward-facing cameras. Noting this, it is important to know that these cameras can acquire eye tracking data – the quality of which may be variable based on the quality of the camera. Emotional states can be tracked via these cameras, demonstrated previously (Skaramagkas, et al., 2023). The emotionally relevant features of eye tracking include pupil diameter, pupil position, fixation duration (how long the eye remains on a single target), distance between sclera and iris, eye motion speed, and pupillary responses (Lim, Mountstephens, & Teo, 2020). In addition to these features, basic fixations, saccades, smooth pursuit motions, and eye blinks can also be used (Skaramagkas & al, Review of Eye Tracking Metrics Involved in Emotional and Cognitive Processes, 2023). This falls in line with additional information showing that visual attention was more easily discriminated against on a mobile device rather than a desktop machine (Hwang & Lee, 2020). These visual features and the ensuing emotional state could, hypothetically, all be extracted by a mobile video game system that has a front-facing camera which has a view of the player's face and eyes.

This modality (video data focusing on the participant's eyes and expression) is usually not offered for console-based games. This is where a user typically has a controller that is finger based. Typically, each console offers their own type of controller; yet there is a convergent evolution for 8 face buttons, 2 joysticks, and 4 trigger style buttons, where the controller is gripped with both hands. This leads to the ability to collect signals such as electrodermal activity (EDA), electromyography (EMG) and electrocardiography (ECG) (Calvo-Morata, Freire, Martínez-Ortiz, & Fernández-Manjón, 2022). While this may result in a less dense dataset than eye tracking, it can still be useful. For instance, HRV, a derivative of ECG, can be used to identify Internet Gaming Disorder (Long, Zhang, Wang, & Lei, 2023), and video game addiction (Kim, Kim, Kim, Im, & Kim, 2021).

While VR gaming is a relatively unpopular system (due in no small part to its exorbitant cost) it does offer the unique opportunity to use both NIRS (Near-Infrared Spectroscopy) and EEG (ElectroEncephaloGraphy) as biosignals gathering modalities (Lesaja and Palmer, 2020; Vasiljevic and De Miranda, 2020; Sharmin and Barmaki, 2024). Through these technologies, the ability for reducing cognitive loads on users and expanding versatility in gaming or overall experience is amplified. These technologies can also be used for surveillance by a similar token and this is an issue for the industry to grapple with as these find their way into adoption (Kröger et al, 2023). Immense value exists in the use of biometrics to study and improve engagement with video games and adjacent media; anything touching on biometrics and biological signatures benefits well from community engagement (Zhang and Yuan, 2018; Vazquez et al, 2022; Powell et al, 2022). However, it is not clear that the ability to capitalize on this will be universal across the world. Frameworks like the GDPR and those adapted from its principles might both present lessons and obstacles in development and adoption (Boyras, 2024).

4. Discussion

The main issue, as explored in previous papers, is that the sum of the effective decaying of behavioral regulation being a positive from the perspective of a seller of video game microtransactions has broader effects (Alexander, 2023; Potter & Palmer, 2024). This is most noted in the context of truth decay (Rich, 2018). At present, the effects are limited. Not everyone plays video games. Not every game has microtransactions. Not every player participates in microtransactions. However, it is important to note the following phenomenon. Via identification of who demographically is most prone to purchasing a product, and what physiological signals are linked to purchasing these products, an organization can find superficially, who is most amenable to buying a product on a video game service. Yet, there is something deeper in this purchase than in other commercial activities. Typically, the purchase represented by a microtransaction does not confer upon the purchaser any typical advantage. No performance improvement is usually gained, and typically the purchase is entirely cosmetic (Fennimore, 2020). In effect, by finding both the demographic, and the distinct physiological signals that typify a person most likely to take an action that has a result in the physical world (that action being detrimental financially) one has identified a cohort of people that are able to be manipulated via signals from a virtual reality into making a change in reality.

This scenario raises critical ethical questions. Unlike standard advertising, where consumers are generally aware of persuasive attempts, microtransactions tap into deeper psychological responses, creating a blurred line between choice and manipulation. An examination of advertising patents and technological specifics reveals that this line can be easily bypassed (Lesaja and Palmer, 2020; King et al, 2023). The physiological signals, such as arousal and response patterns, which companies monitor to predict consumer behavior, suggest that these

microtransactions are not merely spontaneous decisions. Rather, they may exploit neurological and behavioral susceptibilities, rendering some players more vulnerable to making repeated and non-essential purchases, potentially leading to financial harm. The potential utilization and asymmetric benefit of using targeted pop-ups based on user weaknesses is high (Lesaja and Palmer, 2020; Abbasi et al, 2021; King et al, 2023). Protections for those prone to gambling is an easy important low hanging fruit to address with this in mind (Donati et al, 2018). Further, as gaming and virtual environments continue to grow, the broader societal effects could be significant. The design of microtransactions and the identification of high-risk consumer groups may contribute to a model that undermines individual autonomy, influencing not only consumer behavior but also broader social interactions. This influence highlights the ethical concerns of targeting individuals based on their psychological and physiological profiles, particularly when the outcomes could contribute to financial harm and diminished self-regulation.

The video gaming industry is amassing vast amounts of personal analytics for the purpose of enhancing consumability and increasing profit. The collection, storing, and usage of personal data raises questions around privacy and informed consent (Russell, Reidenberg, & Moon, 2019). With increasing video game usage and advancing technologies, there needs to be a greater conversation amongst policy makers, private industries, and the general public regarding the evolving nature of privacy concerns stemming from new technology (Kroger, Raschke, Campbell, & Ullrich, 2023). In an article written by Lesaja and Palmer (2020), the concept of neurocapitalism, or the commodification of neural information, is discussed. According to the article, the use of consumer-grade Brain Community Interfaces, including Functional near-infrared spectroscopy (fNIRS) and Electroencephalography (EEG) provide means by which physiological brain states can be measured and commercialized. Lesaja and Palmer further posit that without rigorous oversight, neurocapitalism can lead to the corporate exploitation of individuals' emotions and behaviors for profit (Lesaja & Palmer, 2020). Kroger et al., (2023) state that "Due to the variety of existing user identification methods, it is extremely difficult, if not impossible, to guarantee for any gaming data that it is and will remain truly anonymous" (Kroger, Raschke, Campbell, & Ullrich, 2023). Federal privacy legislation, such as the Health Insurance Portability and Accountability Act (HIPAA) and Children's Online Privacy Protection Act, or COPPA, offers gaming consumers, including minors, some privacy protections. Likewise, a handful of states have enacted their own policies targeting the use of biometric information. Presently however, there is no single federal legislation that exists specifically safeguarding consumers' biometric data (Carpenter, 2024). In Terms of inclusion: Data, discourse, violence, Hoffmann (2024), highlights how "big data" and algorithmic data processing perpetuates systemic power structures and reinforces oppression and inequity. Hoffmann (2024) writes, "...the ways data are labeled, people are classified, or systems are implemented may inflict symbolic or representational violences—that is, they may reproduce racist, sexist, and other norms and stereotypes that position some people as subordinate, inferior, or irredeemably "other"" (Hoffmann, 2024). Uniform federal privacy legislation and strict oversight are essential steps in protecting personal information from being misused and abused for the purpose of commercial profit. Additionally, regulations requiring transparency on data collection, storing, and processing, would set limits on video gaming industries and place greater control and protection of sensitive data in the hands of consumers.

5. Conclusion

In reflection, the findings and discussion point to a clear and present critical need for all authoritative parties to pursue proactive and strategic policymaking to effectively prevent the misuse of biometrics in video games. As advanced technologies increasingly capture personal biological signals, it is imperative to establish robust frameworks that fiercely protect users from exploitation and manipulation. Parties from the government, industry, and academia, would do well to prioritize implementation clear regulations that improve transparency in data collection, curation, harvesting, and maintenance of privacy, especially that of minors. By prioritizing ethical considerations and adopting policies similar to the GDPR, stakeholders can foster a safer gaming environment that respects individual rights while encouraging innovation. We, as a global community, need a proactive strategy to balance the advantages of both technological advancements with promises of great gameplay and rehabilitative potential along with the risks that they present, ensuring that the gaming industry remains a realm of creativity and enjoyment rather than a venue for unethical practices.

References

Abbasi, A.Z., Rehman, U., Hussain, A., Ting, D.H. and Islam, J.U., 2021. The impact of advertising value of in-game pop-up ads in online gaming on gamers' inspiration: An empirical investigation. *Telematics and Informatics*, 62, p.101630.

- Boyraz, F.T., 2024. It is not just a click: protection of in-game behaviour data as biometric data under the GDPR. *Interactive Entertainment Law Review*, 7(1), pp.12-24.
- Cabanilla, Q., Teofilo-Orencia, F., Cafino, R., Isla, A., Maglaya, J., Palmer, X.L., Potter, L., Marcial, D. and Velasco, L., 2023. Technology Adoption of Computer-Aided Instruction in Healthcare: A Structured Review. *International Journal of Emerging Technologies in Learning (IJET)*, 18(23), pp.160-181.
- Calvo-Morata, A., Freire, M., Martínez-Ortiz, I., & Fernández-Manjón, B. (2022). Scoping Review of Bioelectrical Signals Uses in Videogames for Evaluation Purposes. *IEEE Access*, 10, 107703-107715. doi:10.1109/ACCESS.2022.3213070
- Carpenter, S. (2024) Four Legal Insights into Biometric Privacy Laws and Regulations. Available at: <https://www.computer.org/publications/tech-news/trends/biometric-privacy-laws-and-regulations-insights> (Assessed 20 February 2024).
- Donati, M.A., Chiesi, F., Iozzi, A., Manfredi, A., Fagni, F. and Primi, C., 2018. Gambling-related distortions and problem gambling in adolescents: A model to explain mechanisms and develop interventions. *Frontiers in Psychology*, 8, p.2243.
- Fairclough, S., & Gilleade, K. (2013, Sep 13). Playing Dark Escape 4D. Retrieved from *Physiological Computing*: <http://www.physiologicalcomputing.net/?p=2471>
- Fennimore, J. J. (2020). Are They Really Just Cosmetic? the Impact of Cosmetic Items on Fortnite's Gameplay and Game Design. *University of Milwaukee Theses and Dissertations*, 2494.
- Finch, H., Abasi-Amefon, A., Jung, W., Potter, L., & Palmer, X. (2023). Commentary on healthcare and disruptive innovation. In R. L. Wilson, & B. Curran (Ed.), *18th International Conference on Cyber Warfare and Security* (pp. 77-84). Baltimore, MD, USA: ACI. Retrieved from <https://papers.academic-conferences.org/index.php/iccws/issue/view/16/18>
- Frachi, Y., Takahashi, T., Wang, F. and Barthet, M., 2022, June. Design of emotion-driven game interaction using biosignals. In *International Conference on Human-Computer Interaction* (pp. 160-179). Cham: Springer International Publishing.
- Hoffmann, A.L., 2021. Terms of inclusion: Data, discourse, violence. *New Media & Society*, 23(12), pp.3539-3556.
- Hong, S.J., Lee, D., Park, J., Namkoong, K., Lee, J., Jang, D.P., Lee, J.E., Jung, Y.C. and Kim, I.Y., 2018. Altered heart rate variability during gameplay in internet gaming disorder: the impact of situations during the game. *Frontiers in psychiatry*, 9, p.429.
- Hughes, A. and Jorda, S., 2021. Applications of biological and physiological signals in commercial video gaming and game research: a review. *Frontiers in Computer Science*, 3, p.557608.
- Hwang, Y., & Lee, K. (2020). An eye-tracking paradigm to explore the effect of online consumers' emotion on their visual behaviour between desktop screen and mobile screen. *Behaviour & Information Technology*, 41(3), 535-546. doi:10.1080/
- Ivarsson, M., Anderson, M., Åkerstedt, T. and Lindblad, F., 2009. Playing a violent television game affects heart rate variability. *Acta paediatrica*, 98(1), pp.166-172.
- Ivarsson, M., Anderson, M., Åkerstedt, T. and Lindblad, F., 2013. The effect of violent and nonviolent video games on heart rate variability, sleep, and emotions in adolescents with different violent gaming habits. *Psychosomatic medicine*, 75(4), pp.390-396.
- Kim, J., Kim, H., Kim, D., Im, S., & Kim, M. (2021). Identification of Video Game Addiction Using Heart-Rate Variability Parameters. *Sensors*, 21(14), 4683. doi:10.3390/s21144683
- King, D.L., Delfabbro, P.H., Gainsbury, S.M., Dreier, M., Greer, N. and Billieux, J., 2019. Unfair play? Video games as exploitative monetized services: An examination of game patents from a consumer protection perspective. *Computers in Human Behavior*, 101, pp.131-143.
- Kröger, J.L., Raschke, P., Campbell, J.P. and Ullrich, S., 2023. Surveilling the gamers: Privacy impacts of the video game industry. *Entertainment Computing*, 44, p.100537.
- Lee, D., Hong, S.J., Jung, Y.C., Park, J., Kim, I.Y. and Namkoong, K., 2018. Altered heart rate variability during gaming in internet gaming disorder. *Cyberpsychology, Behavior, and Social Networking*, 21(4), pp.259-267.
- Lesaja, S. and Palmer, X.L., 2020. Brain-computer interfaces and the dangers of neurocapitalism. *arXiv preprint arXiv:2009.07951*.
- Lim, J., Mountstephens, J., & Teo, J. (2020). Emotion Recognition Using Eye-Tracking: Taxonomy, Review and Current Challenges. *Sensors*, 20(8), 2384. doi:10.3390/s20082384
- Long, K., Zhang, X., Wang, N., & Lei, H. (2023, Dec 26). Heart Rate Variability during Online Video Game Playing in Habitual Gamers: Effects of Internet Addiction Scale, Ranking Score and Gaming Performance. *Brain Sci*, 14(1), 29. doi:10.3390/brainsci14010029
- Neurospec. (2024, Jan 01). DSI-VR300. Retrieved from *NeuroSpec.com*: <https://www.neurospec.com/Products/Details/1077/dsi-vr300>
- Ohme, R., Matukin, M. and Pacula-Lesniak, B., 2011. Biometric measures for interactive advertising research. *Journal of interactive advertising*, 11(2), pp.60-72.
- Potter, L., Ayala, O. and Palmer, X.L., 2021, February. Biocybersecurity: A converging threat as an auxiliary to war. In *ICCWS 2021 16th international conference on cyber warfare and security* (p. 291).
- Potter, L., & Palmer, X. (2024). Social Murder in Another Century: Technologies That Enable Misinformation to Instigate Assault. *Journal of Information Warfare*, Pending.

- Powell, E., Akogo, D., Potter, L. and Palmer, X.L., 2022. Co-leadership and cross-pollination of university and DIY bio spaces: an exploration in consideration of Biocybersecurity. In Proceedings of the Future Technologies Conference (FTC) 2021, Volume 3 (pp. 610-621). Springer International Publishing.
- Rich, M.D., (2018). "Truth decay: An initial exploration of the diminishing role of facts and analysis in American public life." Rand Corporation.
- Russell, N.C., Reidenberg, J.R. and Moon, S. (2019). Privacy in Gaming. [online] FLASH: The Fordham Law Archive of Scholarship and History. Available at: <https://ir.lawnet.fordham.edu/iplj/vol29/iss1/4> [Accessed 23 Feb. 2025].
- Russoniello, C.V., Zhirnov, Y.N., Pougatchev, V.I. and Gribkov, E.N., 2013. Heart rate variability and biological age: implications for health and gaming. *Cyberpsychology, Behavior, and Social Networking*, 16(4), pp.302-308.
- Santo, B. (2019, Nov 07). The Consumer Electronics Hall of Fame: Fitbit. Retrieved from IEEE Spectrum: <https://spectrum.ieee.org/the-consumer-electronics-hall-of-fame-fitbit>
- Sharmin, S. and Barmaki, R.L., 2024. A Scoping Review of Functional Near-Infrared Spectroscopy (fNIRS) Applications in Game-Based Learning Environments. arXiv preprint arXiv:2411.02650.
- Skaramagkas, V., & al, e. (2023). Review of Eye Tracking Metrics Involved in Emotional and Cognitive Processes. *IEEE Reviews in Biomedical Engineering*, 16, 260-277. doi:10.1109/RBME.2021.3066072
- Skaramagkas, V., Ktistakis, E., Manousos, D., Kazantzaki, E., Tachos, N., Tripoliti, E., . . . Tsiknakis, M. (2023). eSEE-d: Emotional State Estimation Based on Eye-Tracking Dataset. *Brain Sciences.*, 13(4), 589. doi:10.3390/brainsci13040589
- Stephen, S., Alexander, K., Potter, L., & Palmer, X. (2023). Implications of Cyberbiosecurity in Advanced Agriculture. (R. Wilson, & B. Curran, Eds.) Proceedings of the 18th International Conference on Cyber Warfare and Security, 387-393. doi:10.34190/iccws.18.1.995
- Vasiljevic, G.A.M. and De Miranda, L.C., 2020. Brain-computer interface games based on consumer-grade EEG Devices: A systematic literature review. *International Journal of Human-Computer Interaction*, 36(2), pp.105-142.
- Vazquez, J., Abdelrahman, S., Wasden, C., Jardine, S., Judd, C., Davis, M. and Facelli, J.C., 2022. Using biometric data to measure and predict emotional engagement of video games. *BioRxiv*, pp.2022-02.
- Zhang, X. and Yuan, S.M., 2018. An eye tracking analysis for video advertising: Relationship between advertisement elements and effectiveness. *IEEE access*, 6, pp.10699-10707