Utilizing Psychophysiological Measures in Role-playing Studies

Abstract: Role-playing studies encompass diverse and dynamic experiences, from tabletop role-playing games (TTRPGs) and wargames, to live-action role play (larp). These activities offer rich opportunities for examining interpersonal interactions, emotional engagement, and creative problem-solving. Employing psychophysiological measures—such as eye-tracking, galvanic skin response (GSR), heart rate, and facial and vocal emotion analysis—provides a means to quantify these phenomena. The considerations for incorporating psychophysiological methods into role-playing studies are outlined here, including an overview of the methods, their relevance to role-playing studies, and considerations for their implementation. Additionally, this paper details the importance, utility, and potential insights these measures bring, as well as challenges and limitations.

Keywords: role-playing games, game studies, wargames, table-top role-playing (TTRPGs), live-action role-playing (larp), psychophysiological methods, game design, player engagement

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1. INTRODUCTION

Role-playing games, in their various forms, have gained widespread popularity and academic interest (Sidhu et al. 2024; MacCallum-Stewart et al. 2018, 172-187; Vukojević et al. 2024, 7-21). Table-top role-playing games (TTRPGs) like *Dungeons & Dragons* and live action role-playing (larp) events create unique environments where participants adopt personas, collaborate, and navigate complex narratives. Another often overlooked category of role-playing games are wargames, including matrix games, kriegsspiel, and hex-and-counter games (Hirst 2022). These games share foundational elements with traditional role-playing games, including strategic decision-making, detailed rulesets, and conflict resolution often involving dice or probability. Wargames may also use game masters, narrative-driven focus, miniatures, and maps to structure and visualize gameplay. Together, these contexts have been used and studied as tools for psychological growth (Bowman and Leiberoth 2018, 245-264; Coe 2017), learning (Bowman and Standiford 2015, 4-25), personal transformation (Daniau 2016, 423-444), fostering creativity (Chung 2013, 56-71), or improving social skills in therapeutic or educational contexts (Corsini 2017). This paper outlines considerations for incorporating psychophysiological methods into role-playing studies, including the category of wargames, and provides an overview of different psychophysiological methods, their relevance to role-playing game research, and considerations for their implementation.

Ethnographic methods, such as participant observation and interviews, are commonly used to analyze how players negotiate roles, develop narratives, and engage in imaginative play (Bowman 2010). However, similar to the field of game studies during its establishment, I argue there is a need for role-playing studies to integrate new directions from fields such as psychology, communications, education, and health sciences. From a design perspective, research may focus on the mechanics and narrative structures that shape player experiences. Game designers and scholars may analyze rules, storytelling frameworks, the role of a game master, and the balance of improvisation versus structure to understand how these elements create engagement and

agency for players. These capture a wide range of phenomena to study, including both artifacts and practices (Lieberoth and Roepstorff, 2015, 271-289). I want to echo the opening words of Lieberoth and Roepstorff's chapter on mixed methods in game research:

> Designers and researchers who only observe a game through one instrument...will pick up on a limited fraction of the information available. If we are interested in both players and games, as well the moments where they merge into play, a mixed methods approach is called for. (Lieberoth and Reopstorff 2015, 271)

Research on games and players, and design and behavior, constantly intersect; as the study of game design informs insights into how games mediate social interactions, while behavioral research highlights how players adapt and innovate within the designed systems. Psychophysiological methods can provide valuable insights into the cognitive and emotional responses of players, offering a deeper understanding of how game mechanics, social dynamics, and immersive experiences influence behavior and engagement.

While this paper is not meant to be a comprehensive review of psychophysiological methods, it aims to introduce commonly used measures from other fields that can enhance levels of observation and complement existing ethnographic methods in role-playing studies. More is not better; but understanding how different types of data collection and analyses play together and utilizing them in a priori investigations can yield novel insights into role-playing experiences.

1.1 What are psychophysiological measures?

In the field of psychology and behavioral sciences, psychophysiological measures are commonly used in research to assess the relationship between physiological responses and psychological processes (Andreassi 2010; Ax 1964; Hodges 2010). These measures capture real-time, objective data about bodily functions, such as heart rate, skin conductance, brain activity, emotional arousal, and muscle tension, which are often linked to specific emotional, cognitive, and behavioral states. These methods allow researchers to explore concurrent mechanisms of behavior, such as the physiological correlates of stress, emotion regulation, attention, or cognitive load, providing valuable insights that complement self-report or observational data (Andreassi 2010; Ax 1964; Hodges 2010; Shi et al. 2007, 2651-2656). These can then be important indicators of learning and transformation through gameplay.

Psychophysiological measures provide unique benefits in the study of behavior and game design. They offer a window into the concurrent cognitive and emotional processes of players and the relationships with game mechanics (Kivikangas et al. 2011, 181-199). While role-playing studies have traditionally relied on qualitative and observational data, psychophysiological tools can enable researchers to quantify the experiences of participants in real time. There are, however, limitations to psychophysiological measures, including both perceived and practical barriers.

This paper discusses the potential of several psychophysiological measures: eye-tracking, galvanic skin response (GSR), heart rate monitoring, and facial and vocal emotion analysis, as tools to deepen our understanding of role-playing experiences. The paper discusses the benefits and limitations of each, including practical examples within the context of role-playing studies, along with recommendations for researchers. The aim is to inform, inspire, and address a gap in current role-playing research. I first introduce each measure, describe how they have been used in other areas of research, and discuss how they might contribute to the field of role-playing studies. I then describe practical considerations, including strengths and weaknesses of each measure, as well as commonly used tools and equipment. Finally, I end with describing the benefits of combining multiple measures in a single study and future directions for role-playing studies utilizing psychophysiological measures.

2. PSYCHOPHYSIOLOGICAL MEASURES AND THEIR RELEVANCE TO ROLE-PLAYING STUDIES

2.1 Eye-Tracking

Eye-tracking measures capture and quantify various aspects of eye movements (gaze) to provide insights into visual attention, cognitive processing, and perception (Rosch and Vogel-Walcutt 2013). Common metrics include fixations (moments when the eye is relatively stationary and focused on a specific area), saccades (rapid movements between fixations), dwell time (the total time spent looking at a specific area of interest), revisit count (how often an area is revisited), and time to first fixation (how quickly the eye is drawn to a specific element). In some cases, pupillometry (the dilation of the pupil) can also be used under highly controlled contexts. These measures are often used in research to understand how individuals process visual information, such as identifying which elements of a stimulus attract attention, how information is prioritized, and how patterns of visual exploration relate to cognitive and emotional responses.

The eyes are often thought of as the window to the brain. This phrase reflects the idea that eye movements and gaze patterns reveal underlying cognitive and neural processes. When we track where and how long someone looks at something, we gain insights into attention, decision-making, memory, and emotional responses. In role-playing studies, for instance, eye-tracking can reveal important aspects of social interaction (Rogers et al. 2018, 4271). For example, it can help researchers analyze how players observe and respond to other participants during interactions, shedding light on social dynamics, leadership roles, and levels of engagement. The ability to track visual attention in real time offers valuable data about how players connect with each other during collaborative storytelling or conflict resolution.

In addition to social dynamics, eye-tracking is a powerful tool for assessing how players engage with the environment (Gidlöf et al. 2013), including game materials. By monitoring gaze patterns, researchers can evaluate how participants visually interact with maps, character sheets, props, or other elements of the game world. This provides insights into narrative engagement and cognitive processes, such as how players process complex game information or identify key elements during decision-making moments. Similarly, eye-tracking also taps into decision-making processes (Fiedler and Glöcker 2012, 335) by capturing the sequence of visual attention during critical moments in gameplay, revealing how participants prioritize information and make strategic choices. Because we process information when our eyes are fixated on certain stimuli (Bhat and Hussein 2021, 113-119), the number and order of fixations can tell us what information was being processed before a key decision was made, as well as what information was ignored.

2.2 Examples of Eye-Tracking Technology

Eye-tracking research employs various tools and equipment (see Figure 1), tailored to the specific goals and contexts of the study (Rosch and Vogel-Walcutt 2013). Screen-based eye-trackers are among the most common, involving fixed devices like infrared cameras or high-speed sensors mounted below a monitor. These systems track participants' gaze as they view content on a screen, making them ideal for studying visual attention to digital stimuli such as websites, images, digital games, or videos. Head-mounted eye-trackers are portable devices, often resembling glasses, equipped with miniature cameras to record gaze direction and the participant's field of view. These are commonly used in studies requiring free movement, such as navigating real-world environments, interacting with physical objects, or participating in social interactions. For a review of best practices in eye-tracking, see Carter and Luke (2020, 49-62).
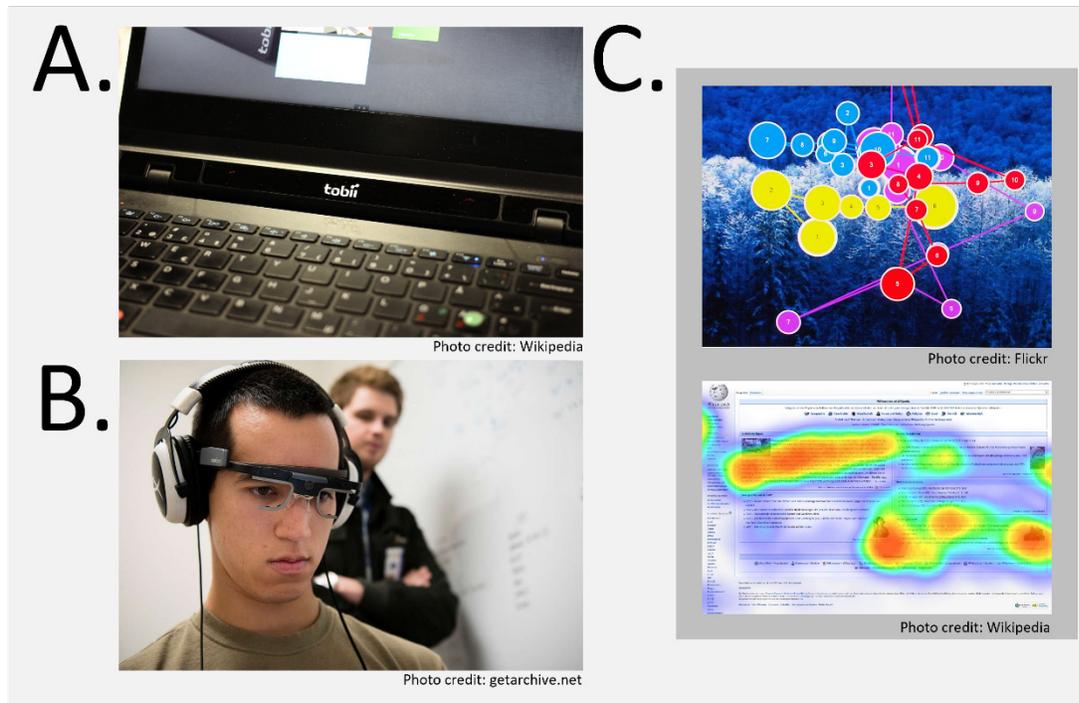
Figure 1: There are several different types of eye-tracking tools, such as screen mounted eye-trackers (A) and mobile head-mounted eye-trackers (B). Data from eye-tracking can be visualized in a variety of ways, such as scan path patterns and heat maps (C).

For most role-playing studies, where participants engage with dynamic or physical settings, live or mobile eye-tracking systems are often necessary (Pérez-Edgar et al. 2020, 286-292). Mobile eye-trackers are lightweight, wearable devices that allow for natural movement and interaction, often combined with external cameras to capture the broader context of the participant's activity. In tabletop settings, such as wargames, other configurations can be used, albeit with careful calibration to mitigate interference from environmental factors such as lighting, cluttered tables, and varied seating arrangements. In immersive environments like virtual reality (VR), integrated VR headsets with built-in eye-tracking measure gaze within three-dimensional spaces, enabling studies of attention and behavior in simulated environments (Juvrud et al. 2018, 305). However, live eye-tracking testing can also be configured using traditional screen-based units (Thorup et al. 2016, 1-10). In this study, an eye-tracker unit was calibrated to a space in the room that allowed for tracking of a real-time social interaction. Results reveal how participants follow gaze during live social interactions. More complex designs even utilize joint eye-tracking (Oberwelland et al. 2016, 248-260). Such designs can reveal levels of understanding by the participants of the events being observed; successful prediction of events indicated by eye-movements demonstrates an inherent understanding of the action being observed.

Two prominent companies in the field of eye-tracking are Tobii and Smart Eye. Tobii offers a range of products, including portable glasses and desktop systems, with user-friendly software that integrates seamlessly into research workflows. Their technology is well-suited for both tabletop and larp studies, though the high cost of some Tobii devices may be a limitation for smaller research budgets. Smart Eye, on the other hand, provides advanced solutions with a focus on analyzing human behavior in dynamic environments, such as automotive or behavioral research. While their technology is robust and reliable, it may require additional setup and expertise, especially in non-laboratory settings.

2.3 Strengths and limitations

Eye-tracking has the potential to be a valuable tool in role-playing studies, whether for tabletop or live-action role-playing (larp), offering a unique and insightful perspective on how participants engage with the environment and stimuli during these interactive experiences. Visual attention plays a critical role in how individuals process and prioritize information, an important component of learning, shaping their decisions and interactions within the game environment (Krucien et al. 2017, 251-267).

One of the primary advantages of eye-tracking in role-playing studies is its ability to provide precise, objective data on where participants focus their attention. This can be critical for understanding how different stimuli, such as objects, characters, or narrative elements, capture attention during the role-playing experience. For example, in TTRPGs and wargames, eye-tracking can be used to study how players divide their attention among various elements like the game master, specific parts of the game board, character sheets, dice, or cards. If a researcher is investigating how the narrative unfolds, they may find that players tend to focus more on the game master when key story moments are introduced, or that certain types of dice rolls, such as those that trigger pivotal events, hold players' attention longer. This kind of data moves beyond subjective reporting and provides insight into which elements of the game truly captivate players' cognitive resources and drive engagement.

More specifically, eye-tracking can reveal how players interact with specific visual cues, such as artwork on character sheets or maps. For example, a study could investigate whether players with visually rich maps spend more time scanning over specific areas, such as locations with hidden treasures, locations with heavy enemy presence, or areas tied to the narrative, compared to other areas of a map. This helps researchers understand the impact of visual stimuli on decision-making, learning, and immersion. What information is visually attended to is predictive of what information is learned (Evans et al. 2011, 503-514). Similarly, if researchers are interested in how players negotiate or cooperate, they might use eye-tracking to observe whether players look to each other for cues or focus on game mechanics when discussing strategies or solving problems.

In larp settings, where physicality and social interaction are central, eye-tracking offers an opportunity to study non-verbal communication, such as how often participants look at others' faces, observe body language, or track the movement of key characters or objects. For example, in a larp scenario involving a murder mystery, eye-tracking could help identify how players' gaze shifts between the murder victim, suspects, and potential clues. Researchers could analyze how players' visual attention correlates with social dynamics: do they look longer at suspects they suspect, or focus on key objects like a blood-stained knife or a letter with mysterious writing? Such insights help researchers better understand the ways players process information in a social, high-stakes environment.

In terms of practical application, eye-tracking offers the advantage of being minimally intrusive. Unlike methods that rely on interviews or surveys, eye-tracking allows participants to engage fully in the role-playing experience without being interrupted or distracted by the researcher or tools. This ensures that the data collected is more naturalistic and reflects the participants' true responses to the role-playing environment, rather than a potential bias introduced by the act of self-reporting or verbalizing their experiences. For example, a study that uses eye-tracking could explore how players process narrative information during a TTRPG session, where participants are free to immerse themselves in the game, and their gaze patterns would be recorded without the need for additional questions or interference during play.

Eye-tracking measures, while valuable, have several limitations. First, they provide data on where individuals look, but this is not necessarily always what they consciously perceive or attend to, which can lead to misinterpretation of attention. Second, eye-tracking equipment can be expensive and technically demanding, requiring careful calibration and controlled conditions to ensure accurate data. Third, the data can be sensitive to artifacts caused by participant movement, poor lighting, or individual differences such as glasses or eye

shape (Carter and Luke 2020, 49-62). Additionally, eye-tracking studies often require sophisticated data analysis to interpret results meaningfully. However, several software packages (such as Tobii Studio and iMotions) simplify and streamline this process, allowing for user-friendly tools for analyses.

3. GALVANIC SKIN RESPONSE (GSR) AND SKIN CONDUCTANCE RESPONSE (SCR)

GSR measures changes in the skin's electrical conductivity, which reflect physiological arousal (Sharma et al. 2016, 13-17). While GSR refers to overall changes in skin conductance, including both baseline levels and event-related fluctuations, skin conductance response (SCR) is another term used that specifically measures the short, transient increases in skin conductance triggered by discrete stimuli (Christopoulos et al. 2019, 394-420). Both are used to assess arousal, but SCR focuses on specific responses to events. Here, I will primarily refer to the broader term GSR. To set up and record for GSR and SCR, small electrodes are attached to the skin, usually on the fingers or palm, where sweat gland activity is prominent (see Figure 2). The electrodes measure changes in the skin's electrical conductance as the participant interacts with stimuli or tasks, and this data is recorded by a connected device or software for analysis. Many GSR units (such as those produced by Shimmer) are mobile, connected via wireless technology, allowing participants to freely move or walk around and navigate a space.

Figure 2: A GSR unit connected to a participant, ready for data collection.

In psychology and behavioral studies, GSR is commonly used to measure physiological arousal linked to emotional (Dutta et al 2022, 1235; Wilson 1967, 401-402), cognitive (Shi et al. 2007, 2651-2656), or stress-related states (Juvrud et al. 2018, 305). By detecting changes in skin conductance caused by sweat gland activity, GSR provides insights into changes in the autonomic nervous system activity (revealing shifts in physiological arousal, emotional states, and cognitive load), often in response to stimuli like images, sounds, or tasks, making it useful for studying processes such as fear, attention, decision-making, and stress regulation. For example, a study might investigate how individuals respond to stressful decision-making scenarios. Participants might be asked to complete a task where they choose between risky and safe options while their GSR is recorded. Higher skin conductance levels during riskier choices could indicate greater emotional arousal or stress, helping researchers explore the physiological correlates of risk-taking behavior and decision-making under pressure.

3.1 Examples of GSR technology

A benefit of GSR is its relatively low costs. Shimmer and Empatica are two companies providing widely used GSR devices. Shimmer's sensors are versatile and compatible with platforms like iMotions, making them suit-

able for both tabletop and larp settings. They are relatively affordable, though they require careful calibration for accurate readings. Empatica offers user-friendly, wearable devices that combine GSR with additional measures like heart rate. Their simplicity and comfort are advantageous, but the devices may be less customizable for specific research needs. To analyze GSR data, it is recommended to use a user-friendly software package, such as iMotions, that can assist in recording, marking, segmenting, and analyzing the data (see Figure 3).
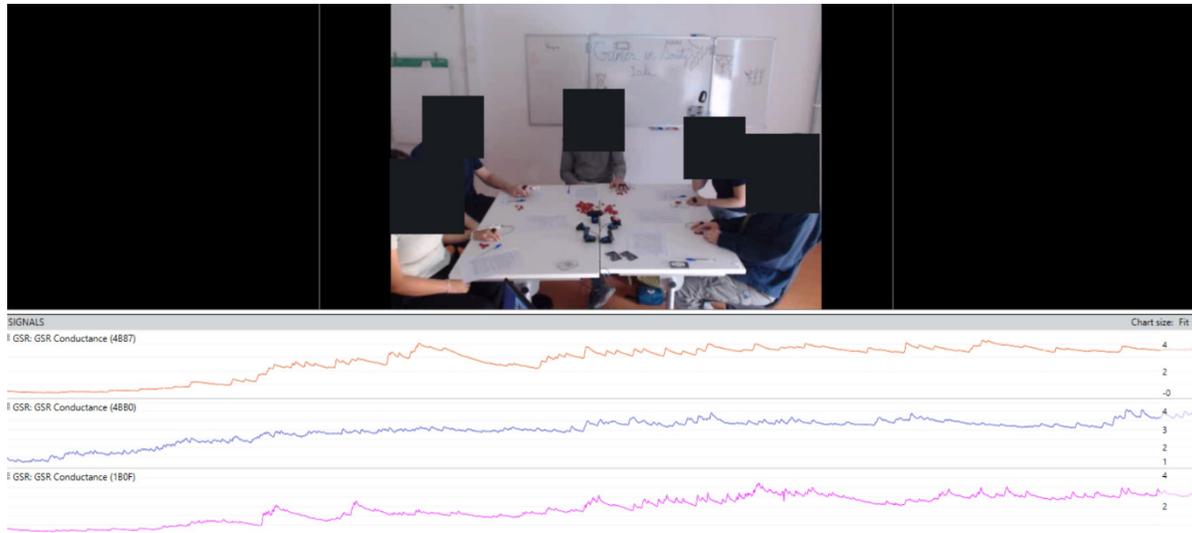

Figure 3: An example of GSR signal output from three synchronized players of a table-top game.

3.2 Strengths and limitations

GSR is a valuable tool for assessing emotional engagement (Caldas 2020, 1109-1116) in a wide range of game contexts, including role-playing games. Moments of heightened arousal, such as during challenges or during the buildup of tension in a critical game event, or a sudden narrative twist, can be identified through GSR data. By pinpointing these emotional peaks (often measured by number of peaks, peaks per minute, or the amplitude of peaks), researchers gain an objective understanding of players' emotional reactions. During a tabletop game, for example, players may experience heightened emotional reactions to certain events in the narrative, such as the reveal of a plot twist or the outcome of a critical dice roll. By using GSR, researchers can detect increases in the number and amplitude of peaks at these moments, which are indicative of emotional responses like excitement, surprise, or tension. This can provide a more accurate and objective measure of emotional engagement than self-reporting, which may be influenced by biases or a player's ability to articulate their emotional state in the moment, or recall how they felt in retrospective analyses. A researcher could, for example, observe a player's GSR spike just after a major loss of resources or when their character faces a moral dilemma, without needing to ask the player how they felt.

During a larp event involving conflict or intense drama between characters, participants may not only experience emotions through dialogue but also through physical actions, such as combat or social confrontations. Researchers using GSR could track increases in skin conductance during moments of conflict, such as when one character challenges another's motives, is accused of lying or deceit, or when a participant is caught in an unexpected role-playing scenario. Another example could be to explore the depth of character investment. Comparing physiological arousal levels during in-character and out-of-character moments provides insights into the degree of emotional immersion players experience. A player who exhibits heightened GSR responses while role-playing a dramatic confrontation is likely deeply connected to their character's emotions.

Additionally, variations in arousal during cooperative or adversarial interactions can provide clues about how players emotionally navigate social dynamics, such as resolving conflict or cooperating with others. The physiological data highlights the emotional intensity that a narrative or game event provokes, even if the player is not consciously aware of how strongly they are reacting.

GSR is well suited for long recording sessions (Sharma et al. 2016t, 13-17), and therefore can be used to study the emotional pacing of a role-playing experience. By continuously tracking skin conductance throughout a session, researchers can identify patterns of emotional intensity over time. For instance, a researcher might find that players experience steady arousal during a tense larp scenario, only to see a sharp decline in GSR when a more relaxed or humorous moment occurs. This type of data reveals how the emotional arc of a role-playing experience unfolds, showing how tension builds and releases over the course of a session. Such insights are invaluable for understanding how pacing, narrative structure, and player interaction contribute to the emotional engagement and overall flow of the game.

Researchers implementing GSR must ensure that the equipment is non-intrusive and compatible with the activities inherent to role-playing. In larp settings, where physical movement is common, sensors must be lightweight and securely attached to avoid interference. Too much physical movement of the sensors may add unwanted noise to the data. Synchronizing GSR data with precise timestamps is also crucial to align physiological responses with specific gameplay events for detailed analysis. Because the data output is a continuous signal, carefully timestamping key events through manual or automatic markers or video coding is crucial.

GSR is generally minimally intrusive, allowing players to engage fully in the game while their physiological data is being recorded. This makes GSR particularly useful in maintaining the natural flow of the role-playing experience, unlike methods such as interviews or questionnaires that may interrupt or alter the gameplay. Players can be immersed in their roles, with the GSR sensor unobtrusively tracking their physiological responses, ensuring that the data gathered is as natural and representative of their true reactions as possible.

Using GSR also comes with limitations and challenges. The data collected reflects overall arousal, but cannot distinguish between different emotions, such as fear versus excitement. While the data itself might show a particular peak in arousal, it is important to know the context of when that peak occurred. Pairing GSR with other measures, such as eye-tracking, can help determine what specifically may have been contributing to the arousal (such as what the player was looking at during the peak). Other mixed method approaches, such as self-reports, can help provide a qualitative assessment of observed arousal.

GSR is also sensitive to external factors like temperature, humidity, and movement, which can introduce noise into the data. Additionally, the setup requires careful calibration to ensure accuracy. Researchers should account for these factors by controlling environmental conditions, minimizing excessive participant movement, and applying proper signal-processing techniques to distinguish meaningful physiological responses from artifacts.

4. HEART RATE MONITORING

Heart rate (HR) and heart rate variability (HRV) are critical indicators of physiological states such as stress, relaxation, and excitement (Kleiger et al. 2005, 88-101; Kranjec et al. 2014, 102-112). Heart rate monitoring measures the number of heartbeats per minute to assess cardiovascular activity, often reflecting overall physiological arousal and stress levels. This is in contrast to GSR, which measures changes in skin conductance due to sweat gland activity, specifically reflecting sympathetic nervous system activation and emotional arousal. Heart rate monitoring provides insights into cardiac activity, capturing fluctuations in stress, relaxation, and autonomic balance (sympathetic vs. parasympathetic activity; Achten and Jeukendrup 2003, 517-538), whereas GSR specifically reflects changes in sympathetic arousal related to emotional or cognitive responses.

Both indicate arousal but provide different physiological insights. You might choose heart rate over GSR if you want to assess broader physiological states like stress recovery, relaxation, or physical exertion since heart rate captures both sympathetic and parasympathetic activity. It is also more accessible and affordable than GSR, requiring less specialized equipment.

A practical example of how heart rate differs from GSR can be seen in a hypothetical study of emotional responses during a larp combat scene. While GSR might show a spike in response to the visual and auditory stimuli of the fight, heart rate measurements can reveal the level of physical exertion involved. For instance, a player might experience a high heart rate from physical exertion, such as avoiding or running from the stress of the confrontation, providing a more accurate measure of the physical impact of the scene. This can be especially valuable in understanding how physical activity in larp influences emotional responses and immersion. GSR, while useful for tracking emotional intensity, does not solely capture the physical strain and excitement associated with an active larp experience, whereas heart rate can provide that layer of detail.

4.1 Examples of heart rate technology

Heart rate monitoring typically involves placing sensors on the body to detect cardiac activity (see Figure 4). Common equipment includes chest straps with electrodes that measure electrical signals from the heart or wearable devices like wristbands or smartwatches that use photoplethysmography (PPG) to detect blood flow changes. These sensors transmit data to a connected device or software for real-time monitoring and analysis Figure 4. An example of a heart rate monitor.

Figure 4: Smart watch. Photo credit Wikimedia Commons.

Polar and BioPac are widely recognized providers of heart rate monitoring equipment. Polar offers a range of wearable monitors that are both accurate and cost-effective, making them ideal for academic research. However, they may lack advanced features like multi-sensor integration. BioPac, on the other hand, provides high-end systems with extensive customization options and software integration. While their products are more expensive, they offer unparalleled precision and flexibility for complex experimental setups.

4.2 Strengths and limitations

Heart rate measures are relevant to role-playing studies, where intense narrative moments or high-stakes decisions often evoke stress-related responses. Monitoring players' stress levels during challenging scenarios provides an objective measure of how gameplay events impact their physiological state (Juvrud et al. 2021, 308-317). For example, an increase in heart rate during a suspenseful moment indicates heightened engagement.

Immersion, a cornerstone of role-playing experiences, can also be evaluated through heart rate data (Malińska et al. 2015, 47-54). Elevated heart rates during climactic events or critical decisions suggest that players are deeply invested in the narrative. Furthermore, analyzing heart rate synchrony among group members can reveal shared emotional experiences. For instance, a dramatic plot twist that elicits simultaneous increases in heart rate across participants suggests a collective emotional response, highlighting the shared nature of the experience.

One of the key advantages of heart rate measurements is the ability to capture a direct physiological response to game events, especially those that involve emotional or physical challenges (Achten and Jeukendrup 2003, 517-538). In a tabletop role-playing game session, for example, heart rate can be an indicator of how players react to pivotal moments in the narrative. If a player's heart rate increases during an intense encounter or when they face a tough decision for their character, this suggests a heightened physiological reaction. In contrast, if the heart rate remains steady or decreases, this could indicate that the player is less invested or that the event is not eliciting a strong physiological reaction. This real-time data allows researchers to pinpoint the specific moments in a game that lead to heightened emotional responses, providing insights into what drives engagement and immersion.

In larp, heart rate measurements can be equally insightful, particularly in understanding how participants react to physical activity, social conflict, and environmental challenges. For example, during a larp session involving a chase scene or a dramatic confrontation, researchers may observe a significant increase in heart rate, signaling that players are experiencing physical exertion or physiological arousal related to the perceived threat or action. The heart rate response during these moments can provide valuable insight into how players experience the physicality and intensity of larp scenarios.

A study by Yannakakis and colleagues (2008, 207-243) suggested heart rate monitoring for capturing and modeling individual entertainment, or fun. By analyzing heart rate dynamics, such as average and maximum heart rate, the study found significant relationships between physiological responses and self-reported fun during gameplay. The study demonstrated that heart rate features can help differentiate between engaging and less engaging game variants, providing a foundation for adaptive game design that responds to player preferences in real-time.

Like the previously mentioned measures, heart rate measurements also offer the advantage of being non-invasive. Players can wear heart rate monitors, such as wrist watches, while remaining fully immersed in the role-playing experience, and the data can be captured without interrupting gameplay. This is particularly useful in larp, where the action is continuous and players are often physically engaged in their characters. Unlike GSR, physical movement is an important variable being considered, and does not constitute noise in the data. Also, unlike methods that require players to pause for self-reporting or questionnaires, heart rate measurements capture data throughout the session, providing real-time insights into emotional and physical responses without disrupting the flow of the game.

Wearable heart monitors are ideal for minimizing disruption, allowing players to remain focused on the game, and are commercially available at relatively low cost. However, researchers must be aware of several limitations. Physical exertion, especially in certain larp scenarios, can elevate heart rate independent of emotional engagement (e.g., running or intense movements), making it difficult to disentangle possible physiological responses. Baseline heart rate can also vary considerably across individuals and even within the same individual. These can be impacted by factors that can easily be overlooked by the researcher, such as sleep, stress, or recent caffeine intake. One common practice is to request participants avoid caffeine intake prior to participation in the study or to report their level of prior caffeine intake. Moreover, heart rate reflects general arousal but cannot reliably indicate the specific emotional valence (e.g., excitement vs. anxiety). These confounds necessitate careful experimental design, such as using pre-session baselines and complementary measures, or pairing with other measures (e.g., eye-tracking) to interpret heart rate data meaningfully in role-playing research.

5. FACIAL AND VOCAL EMOTION ANALYSIS

Facial emotion analysis analyzes micro-expressions to identify emotional states (Canal et al. 2022, 593-617; Mohanta et al. 2022, 35). This advanced type of analysis uses advanced algorithms, based on the facial action coding system (FACS; Ekman and Friesen 1978), to detect and categorize facial expressions, providing researchers with real-time data on participants' emotional reactions based on their facial movements. Vocal emotion analysis, often paired with facial analysis, evaluates tone, pitch, and rhythm to capture subtleties in verbal communication (Dai et al. 2015, 777-788; Murray and Arnott 1993, 1097-1108). Together, these tools offer a comprehensive view of participants' social emotional expressions

The depth of role-playing is often reflected in how players express emotions in-character, or navigate social relationships through conflict and resolution (Dinapoli 2009). Facial and vocal emotion analysis can help differentiate between emotional expressions tied to the player's personal reactions and those performed as part of their character's persona. This allows researchers to explore how players inhabit their roles and navigate the boundary between self and character. Additionally, examining emotional responses during group interactions provides insights into conflict resolution and collaborative decision-making processes. For instance, vocal analysis might reveal rising tension in a heated debate, while facial expressions could indicate moments of agreement or hesitation.

5.1 Examples of Facial and Vocal Emotion Technology

The equipment required to record facial and vocal emotions is nothing more than a camera and microphone; however, specific software is needed for analysis. To ensure reliable data collection, researchers should use high-resolution cameras for facial analysis in tabletop settings, where participants are relatively stationary. In larp, portable microphones and robust noise-cancellation algorithms are essential to capture vocal data accurately amidst dynamic and potentially noisy environments.

In a study from our lab, we recorded table-top players' facial and vocal data using cameras and microphones attached to the table (see Figure 5 for the setup).

Figure 5: Setup for facial/vocal recording can involve a simple web camera and microphone attached to the table. More discrete setups can be achieved with equipment that is smaller in scale or hidden from view.

Affectiva and Emteq Labs are leaders in facial emotion analysis software. Affectiva's Emotion AI technology specializes in detecting nuanced emotional states through facial expression analysis, making it ideal for capturing subtle in-game reactions. However, its reliance on high-quality video input may pose challenges in dynamic larp settings. Emteq Labs offers innovative smart glasses with integrated facial movement sensors, providing a mobile solution for larp studies. While these glasses are cutting-edge, their cost may limit accessibility. For vocal analysis, software like audEERING, Praat, and Sonde Health provide robust tools for

analyzing vocal tone and rhythm. Praat is open-source and highly customizable, but it requires a steep learning curve. audEERING and Sonde Health are user-friendly and provides detailed vocal emotion insights but may lack the versatility of more advanced platforms. iMotions is a useful software with packages from Affectiva and audEERING with built-in user-friendly analyses options, including synchronizing facial and vocal data.

5.2 Strengths and limitations

The use of facial emotion analysis in role-playing studies can allow for a deeper understanding of how participants engage with and emotionally respond to various game scenarios, characters, and interactions. One of the primary benefits of facial emotion analysis is its ability to provide continuous, unobtrusive data on emotional responses throughout a role-playing session. Role-playing games, especially immersive ones like larp, often prompt players to respond emotionally in ways that they might not fully process or articulate. In contrast to self-report methods, which may be biased or fail to capture immediate emotional reactions, facial emotion analysis offers a direct measurement of participants' emotions in real-time. For example, in a tabletop role-playing game session, facial emotion analysis can track how players react to specific narrative developments, such as the introduction of a plot twist or the death of a beloved character. Researchers can observe how emotions like surprise, sadness, or joy manifest on players' faces at key moments in the game. This real-time data can be invaluable in understanding how specific game events trigger emotional engagement, providing insights into what aspects of the game are most emotionally impactful.

As an example, researchers could use facial emotion analysis to study the emotional response of players when a dramatic moment occurs, such as a character facing a moral dilemma or during a social conflict. The analysis might reveal that a player's expression shifts from neutral to a mix of surprise and concern, providing insight into how the gameplay moment is affecting them emotionally. This information can be used to gauge how well the game's storyline or the choices players are given resonate emotionally. If the emotional intensity is high, as shown by expressions like surprise, fear, or joy, researchers can assess the effectiveness of the narrative or the game's emotional pacing. This can offer valuable feedback on how the game design supports emotional engagement and immersion.

Vocal emotion measurements provide a unique advantage over other methods like self-reporting or physiological measurements, as it directly captures the emotional state through vocal expression, which is often an unconscious and immediate response to emotional stimuli. In the context of role-playing studies, vocal emotion analysis allows researchers to gain detailed insights into how players express emotions and how these expressions align with the events and dynamics of the game.

One of the main benefits of vocal emotion measurements is their ability to capture the subtleties of emotional expression that might not be visible or easily quantifiable through other means. For example, in both TTRPGs and larp, players may not always show their emotions through facial expressions or body language, particularly when they are deeply immersed in their characters or trying to maintain a level of composure. However, their voice is a key indicator of their emotional state, often revealing feelings of tension, excitement, fear, joy, or frustration. A study using vocal emotion analysis can uncover how players' emotional states fluctuate as they engage with different aspects of the game, such as the narrative, interactions with other characters, or unexpected events.

In both tabletop role-playing games and larps, much of the emotional content arises from social dynamics, such as conflict, negotiation, collaboration, or competition between players (Balzac 2016; Bohart 1977, 15; Powers and Kirkpatrick 2013, 51-72). By analyzing changes in the voice (pitch, tone, and rhythm) and facial expressions, researchers can assess how players express and respond to the emotions of others in the game. For example, during a tense negotiation between characters, the voice of a player might become more controlled, lower in pitch, and slower in tempo to convey assertiveness or calm, while another player might speak more quickly or loudly to express agitation or frustration.

The use of facial and vocal emotional analysis in role-playing studies has several limitations. One major challenge is the potential for misinterpretation or oversimplification of complex emotions, as facial expressions and vocal tones do not always convey the full spectrum of an individual's internal emotional state. Cultural differences and individual variability in expressing emotions can further complicate accuracy, leading to biased or inconsistent results. Additionally, the context of role-playing may involve deliberate exaggeration or suppression of emotions, making it difficult to distinguish authentic emotional responses from those performed for the role. Technological limitations, such as the sensitivity and precision of emotion detection algorithms, can also result in errors, particularly in dynamic, interactive settings where overlapping stimuli and rapid shifts in emotion are common. These factors collectively highlight the need for cautious interpretation and complementary methods to ensure robust findings.

6. INTEGRATING MULTIPLE PSYCHOPHYSIOLOGICAL MEASURES

Integrating multiple methods offers unique and complementary insights into players' emotional and psychological engagement with the game. Each of the methods described here provides different kinds of data which, when combined, create a more holistic and nuanced picture of how participants interact with the game, their characters, and the narrative. For example, GSR data can reveal to me when there was an emotional arousal in a player; but combined with facial and vocal analyses, I can also determine the valence (positive or negative) of that emotion (see Figure 6). Paired with eye-tracking data, I could also identify what the player was looking at and what information was being processed that led to the emotional arousal.

Figure 2. Player B is first accused of being the werewolf (a), then Player B attempts to bluff/lie (b), following by the start of the voting of who to eliminate (c).
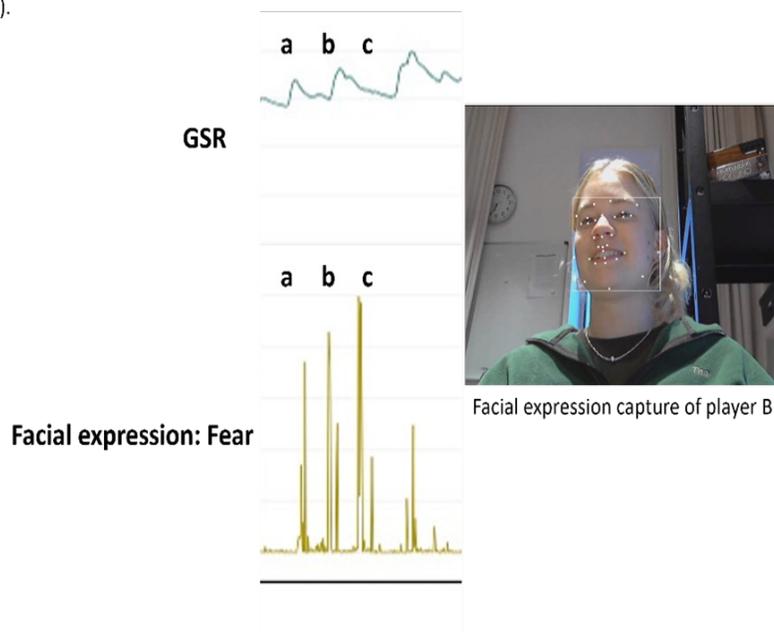
Facial expression capture of player B

Figure 6: An example of data with integrated GSR and facial analysis measures in a study looking at deceit and trust in a role-playing game in Player B. In this example, player B is accused of being deceitful (a), followed by Player B trying to bluff and lie (b), and finally the player is chosen to be removed from group by the other players because they do not trust her (c). The integration of GSR and facial analysis allows us to measure and synchronize the emotional arousal and facial expression of fear during these key events.

One of the primary advantages of integrating these methods is that each tool provides a different perspective on the player's experience. For instance, heart rate and GSR both measure physiological arousal, but

they reflect different aspects of emotional and physical engagement. When combined, these measures offer a more comprehensive understanding of emotional intensity. Similarly, combining eye-tracking with facial emotion analysis can provide insights into players' cognitive and emotional engagement. By combining these methods, researchers can correlate where players focus their attention with their emotional responses, offering insights into how specific game elements, such as a dramatic plot twist, a conflict with another character, or a challenging puzzle, impact both cognitive engagement and emotional reactions. This combination of data helps researchers understand not just what players are focusing on, but also how they feel about those elements and why they are drawn to them.

Integrating these methods also enhances the validity and reliability of the findings. By using multiple data sources, researchers can cross-validate results, ensuring that the emotional and physiological responses they observe are not an artifact of a single measure. For instance, if facial emotion analysis shows an increase in joy but GSR indicates a decrease in arousal, the combination of data would suggest that the player is experiencing a positive emotional response but at a lower level of physiological arousal, potentially reflecting a more relaxed form of joy or contentment.

7. CASE STUDY: INTEGRATING PSYCHOPHYSIOLOGICAL MEASURES IN A ROLE-PLAYING GAME

The case study explored deception and emotional responses in the context of a social deduction game involving light role-playing, *The Last Vampire*, using integrated psychophysiological measures. Specifically, we employed GSR, facial emotion analysis, and vocal emotion analysis to examine participants' reactions during key moments of social deception play, such as moments of accusation. These tools were chosen to provide a comprehensive assessment of arousal and emotional expression in scenarios involving deception. The full data analyses from this case study are prepared for publication in a separate manuscript; therefore, this paper will focus solely on the methodological considerations involved in designing and implementing the experiment.

Forty-one participants (22 female, 15 male, 4 other) participated in the study across 9 testing sessions ($n = 5$ per session). Participants ranged in age from 18 to 29 ($M = 21$, $SD = 1.94$). A total of 33 participants self-reported as white, six participants self-reported as Hispanic, Latino, or Spanish origin, three participants self-reported as Asian, two participants self-reported as Black or African American, three participants self-reported as multiethnic, and one participant self-reported as Middle Eastern or North African. All participants provided informed consent and received a 5€ gift voucher for participating. The study was conducted in accordance with the standards specified in the 1964 Declaration of Helsinki and approved by the local ethics committee.

The study was an experimental between-subjects design, with a focus on specific game events related to deception. GSR was used to measure participants' physiological arousal through skin conductance. This method tracked changes in arousal during critical moments of the game, particularly when participants were accused of being the vampire, requiring them to either lie or defend their innocence. The GSR device provided data on skin conductance peaks and average amplitude, offering insights into the physiological responses associated with these accusations.

Facial emotion analysis was conducted using Affectiva AFFDEX, a technology that detects and categorizes emotional expressions from participants' facial cues. This analysis focused on emotions such as anger, joy, sadness, neutrality, and fear, allowing researchers to observe how these emotional states were expressed during accusations. Similarly, vocal emotion analysis was performed using AudEERING voice technology, which analyzed participants' vocal tones and patterns to identify emotions such as happiness, sadness, anger, and neutrality. Both facial and vocal emotion analyses aimed to capture participants' outward emotional responses as they navigated the game's accusations and social dynamics.

Six cameras and microphones were set up, one focused on each participant's face and voice, and one capturing the full table (see Figure 7 and Figure 8). Three participants wore Shimmer3 GSR+ devices, attached to their ring and middle fingers, to measure physiological arousal via skin conductance, while two others wore identical decoy devices to maintain role anonymity and prevent bias. Facial emotion analysis was conducted using Affectiva AFFDEX, which analyzed participants' facial expressions from video recordings, and vocal emotion analysis utilized AudEERING technology, capturing audio via microphones integrated with the cameras. All data streams, including GSR, facial expressions, and vocal cues, were synchronized and analyzed using iMotions software, which also annotated and extended accusation periods to ensure precise capture of physiological and emotional responses during gameplay.
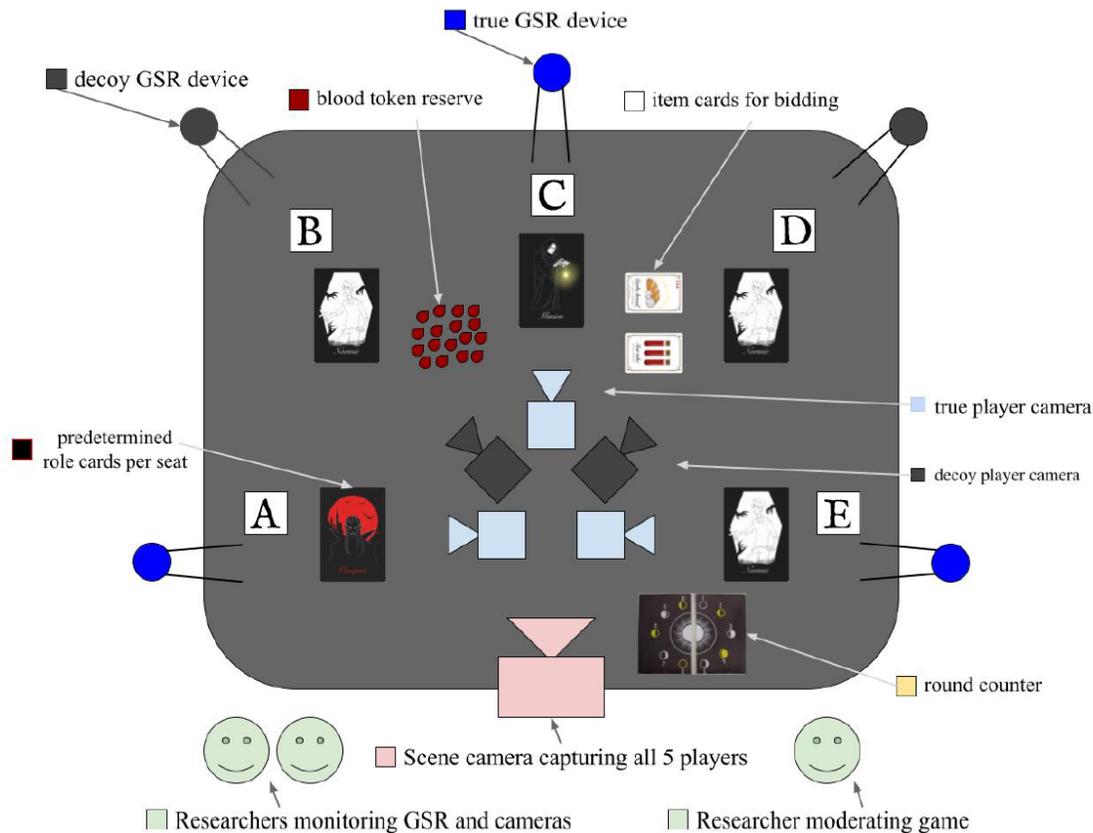

Figure 7: The diagram shows a setup for a table-top role-playing game, including the various game components and the equipment setup. In this study, participants were recorded via camera and microphone (center of table) for facial and vocal emotion analysis and were connected to GSR units to measure arousal. For the study design, only certain player roles were of interest to the research question; therefore, "decoy" units were used so that participants were not aware of whose data was actually being recorded.

Integrating GSR, facial emotion analysis, and vocal emotion analysis within this study allowed for a multidimensional examination of participants' responses during moments of accusation in the table-top game. Each method contributed unique insights into how individuals experienced and expressed emotions under pressure. GSR provided data on physiological arousal, capturing participants' heightened states of stress or engagement when accused of being the vampire. However, arousal alone does not reveal the nature of the emotional response: whether participants felt anxiety, anger, or excitement. Facial emotion analysis complemented this by identifying outwardly visible emotions, such as joy, anger, or fear, while vocal emotion

analysis provided additional layers of understanding by detecting emotional cues embedded in participants' speech patterns.

Figure 8: A photograph of the diagram presented in Figure 5, showing the setup of a table-top role-playing game. The experimenter sat at a separate table and monitored the various sensors (background) while the participants played the table-top game (foreground).

The integration of these methods was critical in uncovering the interplay between internal physiological states and external emotional expressions. For instance, the study revealed that while GSR data indicated similar arousal levels across guilty and innocent players during game moments of deception, facial and vocal analyses helped explore how emotions were outwardly displayed, highlighting nuances like anger or joy during specific types of accusations. Combining these measures also allowed us to identify potential inconsistencies between physiological and behavioral responses, offering insights into strategies participants may use to mask guilt or maintain credibility. By using these complementary methods together, the study provided a richer understanding of the complex dynamics of deception and emotional responses in social interactions.

8. MORE ADVANCED TOOLS: NEUROPHYSIOLOGICAL MEASURES

While this review has focused on peripheral psychophysiological, it is important to acknowledge that more direct measurements of brain activity are also being explored in role-playing research. These include electroencephalography (EEG), functional magnetic resonance imaging (fMRI), and functional near-infrared spectroscopy (fNIRS), each offering the potential to investigate the neural correlates of cognitive, affective, and social processes during role-play.

Hyperscanning techniques, in particular, are gaining traction as tools to study the neural synchronization between individuals engaged in social interaction. Wireless EEG systems, such as the Emotiv EPOC+,

have been used in exploratory studies attempting to capture multi-person brain activity in ecologically valid scenarios, such as tabletop role-playing game sessions, larp events, and even boffer combat practice. Similarly, dual-subject fMRI scanners are becoming available and allow simultaneous brain imaging of two participants, albeit within tightly constrained physical settings. fNIRS provides a promising middle ground, with greater portability and reduced intrusiveness compared to fMRI, though it offers lower spatial resolution and is still sensitive to movement artifacts and signal noise.

Despite their promise, these methods introduce significant practical and methodological challenges. They require more extensive technical expertise, involve complex preprocessing and analysis pipelines, and are typically constrained to highly controlled or stationary environments, conditions that are often at odds with the spontaneous, mobile, and improvisational nature of live-action role-play or even certain tabletop formats. Moreover, the financial and logistical demands of acquiring and operating neuroimaging hardware can be prohibitive for many researchers in the field.

Given these considerations, we chose to focus this paper on more readily deployable, cost-effective, and minimally intrusive measures. These tools are not only more feasible for researchers operating in naturalistic gaming settings, but they also offer robust and meaningful insights into player engagement, emotion, and social interaction without disrupting the immersive flow of gameplay.

Nevertheless, neurophysiological approaches represent an important direction for future research. Their capacity to probe brain activity during role-play makes them a valuable complement to peripheral measures. Future work, particularly in more controlled or hybrid lab-field environments, may benefit from integrating these technologies to deepen our understanding of shared cognition, emotional synchrony, and embodied narrative experience in collaborative play.

9. CHALLENGES AND FUTURE DIRECTIONS

Despite the promise of psychophysiological measures, several challenges must be addressed to optimize their integration into role-playing studies. While these measurements offer valuable insights into emotional responses, interpreting the data can be challenging due to the complex nature of human emotions. Researchers should have clear a priori plans for these measures or be clear about their observations in an exploratory manner (Lieberoth and Roepstorff 2015, 271-289). Emotional expressions can be context-dependent, and participants may exhibit similar physiological or behavioral responses to different emotions. Each participant responds to stimuli differently, and this variability can complicate the interpretation of results. People with conditions like social anxiety or autism spectrum disorder (ASD) may show variations in psychophysiological measures (De Los Reyes et al. 2012, 308-322; Zantinge et al. 2017, 1499-1509). For example, individuals with ASD might exhibit different facial or vocal emotion expression patterns (Trevisan 2018, 1586-1601), which could influence the results of facial emotion analysis and vocal emotion measurements. Researchers must be cautious in interpreting individual variations.

Another key consideration is the incorporation of experimental design principles, particularly the use of appropriate control groups and baseline conditions. Across all measures described here, to isolate the specific effects of role-play and character immersion, researchers should consider collecting psychophysiological data not only during gameplay but also during structured pre- and post-session activities. These might include a quiet baseline condition (e.g., sitting still), as well as social interaction tasks that involve no gaming or role-playing elements. Such comparisons help control for general arousal or social engagement effects and provide a more precise understanding of what is unique to role-playing scenarios. Additionally, distinguishing between types of role enactment, such as narrative-driven character immersion versus strategic or rule-based decision-making, requires careful experimental contrasts to avoid interpretive confounds and ensure the validity of inferences drawn from physiological data. This may require experimental designs that utilize control groups or other comparison groups.

Ethical considerations also warrant careful attention. While the data collected is generally non-identifiable, there are still privacy concerns about the storage and potential misuse of such sensitive information. Facial emotion analysis, in particular, involves recording participants' facial expressions, which may be perceived as intrusive or invasive by some individuals. In some studies, participants might not fully understand the scope of the data being collected, leading to concerns about informed consent. Researchers must ensure that participants are fully aware of what data is being collected, how it will be used, and how their privacy will be protected. Psychophysiological data, while invaluable for understanding cognitive and emotional states, often intersects with sensitive health-related information. For instance, heart rate monitors may incidentally detect irregularities such as arrhythmias, and facial emotion recognition systems could infer depressive symptoms or other mental health indicators. This blurring of lines between behavioral data and medical data introduces complex ethical and legal considerations. Researchers should be aware that, depending on the jurisdiction, such data may fall under regulations typically reserved for health information, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States or the General Data Protection Regulation (GDPR) in the European Union.

The cost and resource requirements for using these tools can be a limitation, particularly in large-scale studies. Eye-tracking devices and analysis software in particular can be expensive, and implementing multiple measurement methods simultaneously can significantly increase the cost of the study. Additionally, these tools require technical skills for setup, calibration, and analysis, which can further increase the time and resources needed for the study. While many of the equipment and software are user-friendly, for researchers with limited budgets or those conducting studies with large groups, the use of such tools might not be feasible. Researchers may opt for more cost-effective measures, such as heart rate monitors, although potentially limiting the scope and scale of the research.

Moreover, given the potential sensitivity and complexity of psychophysiological research, especially in live or semi-naturalistic environments like role-playing studies, it is essential that researchers engage with institutional ethics bodies from the earliest stages of study planning. Submitting detailed experimental protocols to Institutional Review Boards (IRBs) or Ethics Committees, including procedures for participant recruitment, consent, data management, and debriefing, is not only a requirement in many jurisdictions but a foundational practice in ethical research. Researchers should also follow standards outlined in frameworks such as the Declaration of Helsinki, which emphasize participant welfare, transparency, and the dissemination of all results, including those that are inconclusive or negative. This is particularly important in a developing area like psychophysiological role-playing research, where a comprehensive body of evidence, including null findings, will be essential for building robust and reliable methodological standards.

It is also worth reiterating that some familiarity with the technology, software, and statistical analyses techniques is required. There are various complexities in analyzing and interpreting psychophysiological data. Integrating data from multiple modalities, such as combining eye-tracking with GSR and facial emotion analysis, requires more advanced analytical techniques. Handling these issues requires advanced analytical tools, expertise, and time, and may limit the scalability of studies that use these combined methods.

Finally, expanding the scope of psychophysiological research to include diverse participant populations and role-playing contexts will enhance the generalizability of findings. Exploring cross-cultural differences in emotional expression, for instance, could provide valuable insights into the universality and variability of role-playing experiences. Additionally, incorporating non-traditional role-playing formats, such as educational or therapeutic applications, may reveal new opportunities for leveraging psychophysiological tools.

10. CONCLUSIONS: WHY PSYCHOPHYSIOLOGICAL MEASURES MATTER IN ROLE-PLAYING STUDIES

Role-playing games, whether a wargame or a larp, are immersive experiences that demand high levels of engagement. Psychophysiological measures provide objective data on engagement, how participants interact

with the game world and each other. The inherently social nature of role-playing games also makes these measures ideal for studying group behavior and social engagement. Synchrony in heart rate among players, for example, may indicate shared emotional experiences, or facial emotion analysis can reveal subtle cues in group communication. Psychophysiological tools can therefore be valuable for researchers interested in uncovering patterns in areas such as leadership, collaboration, and conflict.

Immersion is a cornerstone of role-playing games, where, if designed well, players can lose themselves in their characters and the narrative. The ability to fully engage with the game world enhances not only the entertainment value but also the psychological and emotional experience. Psychophysiological measures offer a powerful means of assessing these immersive states by capturing physiological data that can reveal moments of deep emotional and cognitive involvement. Measures such as heart rate, skin conductance, and eye movements, can provide valuable insights into the intensity of immersion and presence, identifying when players are most deeply connected to the game. By analyzing these physiological responses, researchers and game designers alike can gain a clearer understanding of the factors that facilitate immersion, allowing for the refinement of game design and the creation of more engaging and impactful experiences.

Ultimately, incorporating psychophysiological data into game design processes holds the potential to enhance not only gameplay but also the emotional and cognitive effects, leading to learning and transformation, that role-playing games can have on players. Their contribution to levels of observation is further enhanced when integrated into a mixed-methods approach, combining them with ethnographic measures such as interviews and surveys. A mixed method approach treats each methodological approach as valuable on its own, while allowing for different levels of detail. It is highly beneficial for the field of role-playing studies to continuously challenge and push the boundaries of traditional ontologies and methodologies. This approach fosters innovation, expands analytical perspectives, and enhances the depth of understanding in the field.

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