# A Game-Based Multimodal Data Capture Pipeline for Research on Emotional Regulation in Autistic Adults

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## Abstract

Research on emotional regulation in autistic adults requires methods that effectively capture physiological responses and behavioural context. This paper introduces a game-based multimodal data capture pipeline that integrates a controlled environment with synchronised physiological sensing to facilitate future studies. The pipeline records key gameplay events as candidate regulation-relevant anchors and aligns them with multimodal recordings for event-centred analysis. Session outputs are stored with structured metadata and event logs to ensure quality control and reuse. The focus is on technical implementation and feasibility, establishing a foundational pipeline for future ethically approved research on emotional regulation in autistic adults.

## 1. Introduction

Emotional regulation is an important and under-explored area of research in autistic adults, particularly in interactive contexts where behavioural and physiological responses unfold over time rather than appearing as isolated events. Studying such processes requires instrumentation that can capture both what the person is doing and what is occurring across multiple physiological channels concurrently. Game-based environments provide a useful foundation for this instrumentation, offering environments in which repeatable tasks can be modelled, along with structured event sequences and controllable interaction conditions. In this work, SuperTux is used as an interchangeable gameplay environment within a multimodal capture pipeline designed to support future research on emotional regulation in autistic adults. The aim is to complete each level as quickly as possible while collecting as many coins as possible, avoiding enemies that cause the player to respawn and lose some of their collected coins and any power-up abilities.

SuperTux was selected because it is open source, lightweight, modifiable, and provides a repeatable game structure in which events such as coin collection, enemy contact, power-up loss, and respawning can be logged consistently and autonomously. The first level provides familiarisation, while later increases in task demand create candidate regulation-relevant event anchors without assuming a fixed emotional response.

The contribution of this paper is therefore technical and infrastructural: it presents the implementation of a synchronised data-capture pipeline that links gameplay events with multimodal physiological signals in a structured, reusable form. This work lays the foundation for later HCI studies by establishing the acquisition and synchronisation layer needed for later ethically approved studies. This paper builds on previous work by extending the broader multimodal gameplay framework from Buxton et al. (2026), implementing a focused pipeline for future research on emotional regulation in autistic adults.

| **Modality** | **Location** | **Sample Rate** | **Channels** | **Parameters and Notes** |
|---|---|---|---|---|
| EEG | Scalp | 250 Hz | 10 | Dry active electrodes,<br>F1, F2, C3, Cz, C4, P3,<br>Pz, P4, O1, O2 |
| ExG | Forehead | 250 Hz | 0-2 | Passive EEG<br>Fp1, Fp2 |
| EMG | Facial | 250 Hz | 4-6 | Contains ExG |
| EOG | Facial | 250 Hz | 2 | 4 EMG electrodes |
| PPG | Ear clip | 250 Hz | n/a | Red & IR light<br>A2 clip placement |
| IMU | Forehead | 250 Hz | 6-axis | Accelerometer with +/- 4g range<br>Gyroscope with +/- 500 deg/s |
| IMU (MAG) | Forehead | 25 Hz | 3-axis | Magentometer with +/- 1300 uT |

*Table 1: Available Galea Beta headset modalities (Buxton et al. 2026, Table 1).*

## 2. Background

Emotional regulation is increasingly recognised as an essential area of autism research. However, it is methodologically challenging to investigate this among autistic adults due to the subjective nature of the required judgment (Fok et al. 2025). Existing research suggests that individuals with autism spectrum condition (ASC) may experience variations in emotional reactivity and recovery. However, the evidence on study design in autistic adults is heterogeneous (Mazefsky 2015). This creates a need for longitudinal research to capture events in real time. For autistic adults, this is increasingly important as their experiences are under-represented and differ when compared to their child counterparts (Fok et al. 2025).

Previous multimodal systems have demonstrated richer analyses than unimodal applications (D'mello & Kory 2015). Physiological sensing, modalities, such as EEG and PPG, are widely explored for the recognition of emotional states due to changes in attention and arousal that may not be visible from studying behaviour alone (Ahmad & Khan 2022). However, these modalities are only useful when they are observed in relation to specific events, which makes synchronising context and physiology a core requirement for any pipeline.

Game-based environments offer an engaging setting for this work as they provide repeatable tasks, controllable events, and a structured environment in which behavioural and physiological responses can be observed in tandem. Although previous autism-gaming research has focused on educational intervention rather than adult emotional regulation, it supports the idea that game-based environments can provide accessible, observable data-collection opportunities for co-produced autism research López-Bouzas & Del Moral-Pérez (2023). Building on this, there is a clear need for concrete technical pipelines that use gameplay events with synchronised sensing capabilities to support research on emotional regulation in autistic adults.

Existing work has established the broader rationale for synchronised multimodal games and the multimodal infrastructure for future research applications (Buxton et al. 2026). However, there remains a need for a concrete implementation tailored to the requirements of future adult autism research, particularly where repeated sessions, structured event annotation, and downstream explainable analysis are anticipated.

## 3. Methodology

Due to the lack of research on emotional regulation in adults with ASC, the foundation presented by Buxton et al. (2026) is extended using the Galea headset. The available modalities for the headset are shown in Table 1. With the focus of this implementation on emotional regulation among autistic adults, the locations of interest are the Frontal, Parietal, and Occipital regions of the brain (Gkintoni et al. 2025). The Galea electrode placement is shown in Figure 1, excluding the frontal-pole 1 and 2 (Fp1/2) passive ExG electrodes.

These regions were selected for their relevance to game-based tasks: Frontal electrodes for cognitive control, Central for movement planning, Parietal for attention and sensory integration, and Occipital for visual processing. This mapping aids in channel selection, rather than providing precise neural source localisation.

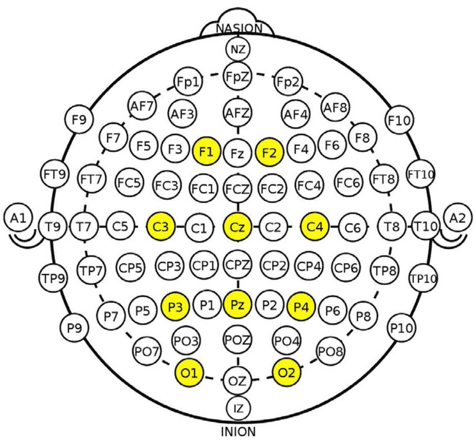
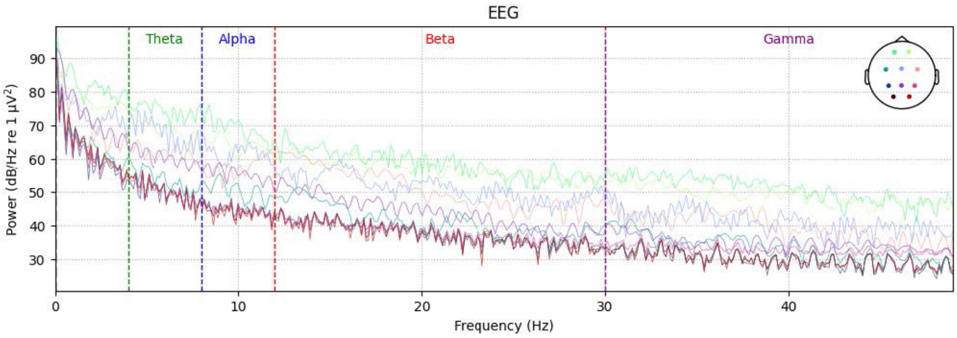
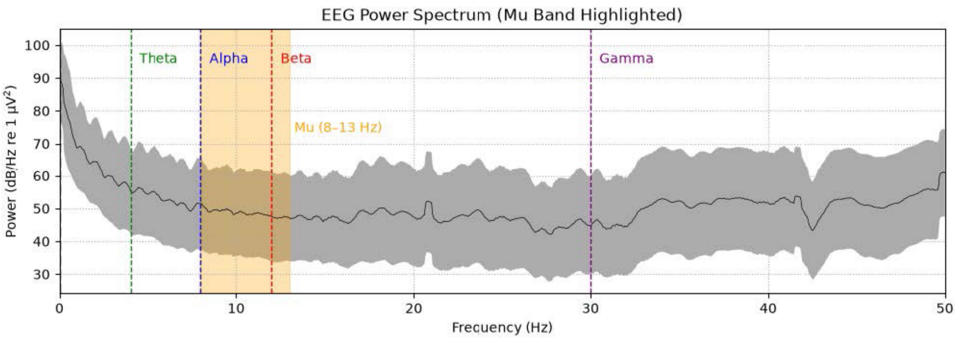



*Figure 1: International 10-20 EEG electrode placement of the Galea headset (OpenBCI 2023).*

Data recorded from the Galea was converted from CSV to BDF format using a custom script, combining both raw ExG and PPG/EDA based on the recorded time. This time-synchronised BDF file was then imported into MNE-Python for analysis and preprocessing. As the Galea system applies a hardware bandpass filter, a 50 Hz notch filter was applied to reduce mains electrical interference. Example PSD outputs are shown in Figures 2a and 2b.




**(a)** *EEG PSD with individual electrodes colour-coded.*




**(b)** *PSD with Mu highlighted in orange.*

*Figure 2: EEG Power Spectral Density (PSD; up to 50 Hz) sectioned into relevant bands Theta (θ; 4-7 Hz), Alpha (α; 8-12 Hz), Beta (β; 13-30 Hz) and Gamma (γ; > 30 Hz).*

In addition to broad EEG band inspection, the same PSD output enables calculation of the Mu rhythm, typically examined in the 8–13 Hz range over central sensorimotor electrodes. Although this frequency range overlaps primarily with the alpha range, Mu activity is interpreted as sensorimotor processing rather than general posterior alpha activity. The current pipeline supports future Mu power calculation by averaging or integrating spectral power within the central channels. In future participant studies, event-related changes in Mu power could be examined around gameplay events such as enemy collisions or respawns. This would allow the pipeline to explore motor engagement and response preparation during game interaction, while avoiding claims that Mu activity alone indicates emotional state.

## 4. Discussion

The principal contribution of this paper is the implementation of a reusable capture pipeline motivated by the methodological needs of future adult autism research on emotional regulation. The work establishes the technical foundation needed for future HCI studies by integrating repeatable gameplay, structured event annotation, OpenBCI Galea multimodal physiological capture, and synchronised export. In practice, gameplay events such as coin collection, enemy collision, power-up loss, and respawning can be recorded as timestamped markers during acquisition and aligned with the Galea recording timeline during conversion to BDF. This creates an event alignment layer in which physiological and inertial data can be segmented around specific gameplay anchors for later event-centred analysis and explainable modelling.

The use of a game-based setting offers practical advantages in terms of repeatability, observability, and controllable task structure, but also introduces important limitations. In-game events should be understood only as candidate proxies for regulatory relevance, not as direct indicators of internal affective state, while the current implementation does not establish biomarkers, validated labels, or autism-specific findings.

## 5. Conclusion

This paper has presented a game-based multimodal data capture pipeline for future research on emotional regulation in autistic adults. The present contribution is technical rather than inferential, demonstrating implementation readiness and data capture feasibility rather than validated participant-level conclusions. As a result, the paper serves as a foundational component by establishing the acquisition, synchronisation, and event-annotation infrastructure required for subsequent ethically approved studies involving autistic adults.

Future work will combine this infrastructure with participant recruitment, headset comfort and adherence checks, suitable ground truth measures, and camera recordings reviewed by a neuropsychologist to support behavioural annotation of observable emotional regulation states. These annotations can then be compared with self-report, gameplay markers, and physiological change to validate event-to-signal alignment.

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