

Rakastajat Data Analysis Report

➤ Title and Overview

- **Title:** Understanding emotional and behavioural responses through physiological signal analysis recorded during theatrical performances.
- **Study duration:** December 2025 till April 2026
- **Location of Study:** Pori, Tampere, Finland
- **Performance name:** Isin tyttö
- **Purpose of study:** The purpose of this study is to examine emotional and behavioural responses during theatrical performances through the analysis of physiological signals, with the objective of identifying underlying patterns and correlations between physiological activity and emotional states.

➤ Participant and Context

- **Number of participants:** 17
- **Demographics:** A total of 17 participants were included in the study. The sample comprised 35% male and 65% female participants (Figure 1). Participants ranged in age from 20 to 68 years, with the majority between 36–50 years (Figure 2). The cohort included all participants with Finnish nationality. Overall, the sample reflects a diverse demographic distribution suitable for the study objectives.

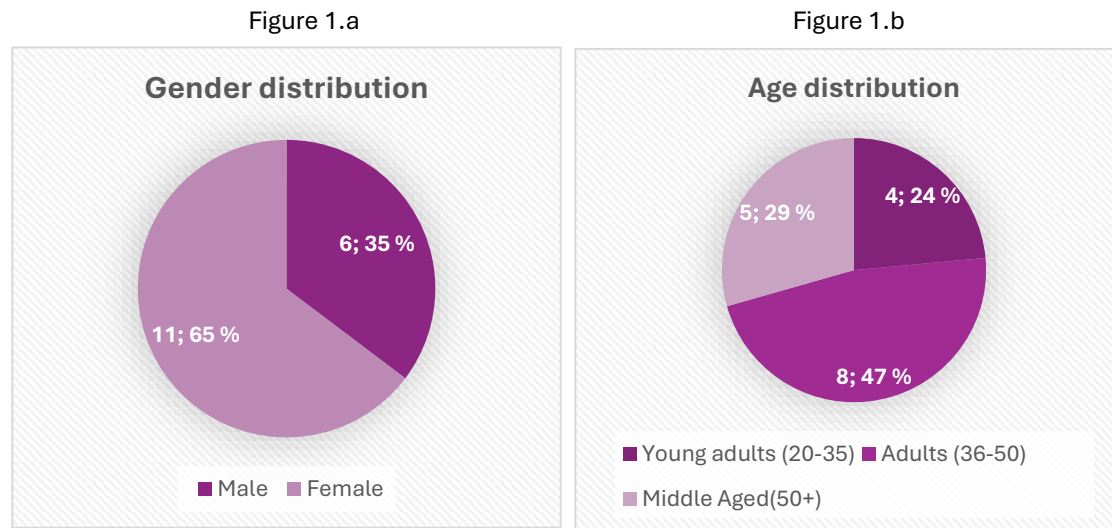


Figure 1: Demographic summary

- **Seating arrangements:** Participants were seated in the top row to avoid any disturbances to other audience members due to measurement setup.
- **Performance summary:** *Isin tyttö* (Daddy's Girl) is a cutting-edge black comedy and thriller about family dynamics and survival.
- **Key scenes:** Key scenes within the theatrical performance were identified based on their potential to evoke strong emotional and behavioural responses. These scenes represent critical moments in the storyline where changes in tone, intensity, or audience engagement are expected. Furthermore, some of these key scenes corresponds to flashing lights and loud sounds. These key scenes were selected to capture a range of emotional and narrative dynamics, enabling a structured analysis of audience's physiological responses across different phases of the performance. Table below shows the events, time when the scene happened and its description.

Table 1: Important Events and their occurrences in performance

Loud noises and bright light		
Loud noises	18:30-18:40	Friends playing, tooth came off, daughter screaming, daughter playing in snow, fathers arrives gets angry, punishes
Loud noises and bright light	19:40-19:50	Sabine trying different methods to get sick, argument between father and daughter, daughter shoots father
Loud noises	19:55-20:05	Sudden reactions from father and loud noises (ambulance)
Common scenes with reactions		
Multiple scenes with amusement, anger and surprise	18:30-19:00	1. Daughter's getting excited over birthday gift. 2. Daughter playing in sandbox, hits friend for calling Nazi. 3. Daughter gets worried 4. Daughter gets punished for playing in snow 5. Father n mother intense discussion 6. Summer cottage scene with shouting 7. Family meeting with father making stricter rules 8. Father getting angry for auction mocking
Multiple scenes with amusement, anger and surprise	19:40-20:05	1. Sabine trying different methods to get sick 2. Sabine's father forces her to come to cottage, argues and shoots father. 3. Father making sauna unbearable for boyfriend 4. Sabine, her brother's and mother's joke about father. 5. Father getting angry over no salt in dish 6. Father arguing and got hit by the wall. 7. Mother's story about not leaving father.

➤ **Signals Collected**

In this theatre study, physiological data were collected using multiple sensors to capture participants' emotional and cognitive responses during live performance.

- **Electrocardiography (ECG)** was used to measure heart activity, particularly heart rate and heart rate variability, which are indicators of emotional arousal and stress. ECG was collected using Shimmer sensing device using 3 electrodes.
- **Galvanic Skin Response (GSR)** sensors were employed to assess changes in skin conductance associated with sweating, providing insights into emotional arousal and autonomic nervous system activity. For GSR also, Shimmer sensing device was used, and electrodes were placed on fingers.
- **Photoplethysmogram (PPG)** sensors were used to measure the blood flow, and it was collected using Shimmer sensing device with electrode placed at fingertip.
- **Electroencephalography (EEG)** was used to record brain electrical activity, enabling analysis of attention, engagement, and cognitive processing during different scenes. For some participants EEG was recorded using Emotiv EPOCX, which has 16 electrode setups to record brain's activity. But due to technical restrictions, we had to switch to MUSE Athena for recording EEG after couple of performances. Muse bands have textile-based electrodes to record from 5 channels.

These sensors were chosen to provide a multimodal understanding of audience experience, combining physiological signals from the cardiovascular, autonomic, and central nervous systems. Data were continuously recorded throughout the theatre performance to ensure temporal alignment with specific narrative events. The combination of ECG, GSR, and EEG provides complementary insights into emotional arousal, cognitive load, and neural engagement in real time.

➤ **Methodology**

The study employed a quantitative experimental design to investigate audience responses during a live theatre performance. Participants were recruited and briefed about the procedure prior to data collection. Theatre groups were responsible for selection of participant and research group was responsible for sending the consent forms prior to the recording day.

Physiological data were collected using multiple sensors including ECG, PPG, GSR, and EEG. All sensors were non-invasive and attached before the performance started to ensure participant comfort and data reliability. Data were recorded continuously throughout the theatre performance to capture real-time physiological responses. In addition, video recordings of each performance were taken and time-synchronized with the physiological data to enable precise alignment of participant's physiological responses with specific scenes and events. Since the performance took place in two parts including a break in between so sensors were removed during the 20 minutes break time and also the video recording were stopped for the duration of break. After data collection, signals were preprocessed to remove noise and artifacts. The cleaned and synchronized

datasets were then analyzed to identify patterns of emotional and cognitive responses. The detailed visualization framework is given in the subsections below.

- **Analytical framework**

The analytical framework of this study was designed to examine audience engagement through multimodal physiological and contextual data. The main idea behind this framework was to visualize the features such as heart rate and skin conductance level that are closely related to emotional arousal.

In data visualization block, collected ECG, GSR, and EEG signals were first pre-processed and filtered to extract features. ECG data were analysed to extract heart rate and GSR signals were processed to identify skin conductance responses reflecting emotional arousal. These features were visualized to identify overall patterns of emotional arousal and to determine the key scenes that elicited significant emotional responses from the participant. All physiological signals were time-synchronized with video recordings of the theatre performance to ensure accurate mapping between physiological responses and specific scenes.

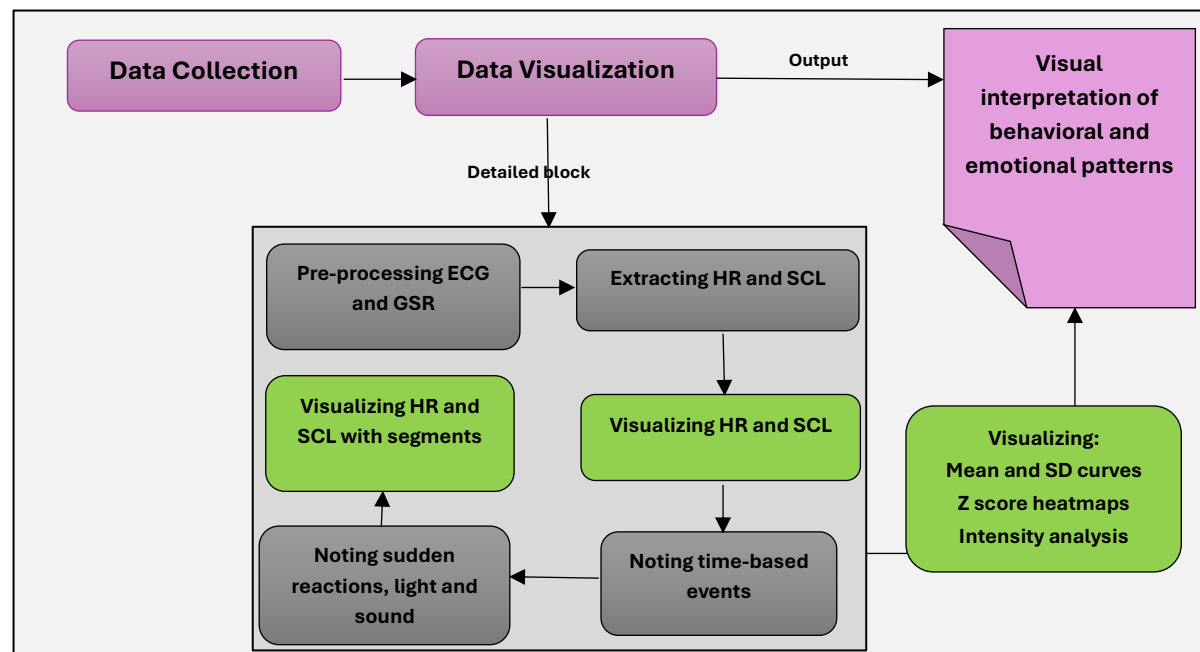


Figure 2: Analytical Framework

- **Event-wise visualization**

To identify key moments within the performance, a manual segmentation approach was followed. First, the overall heart rate and skin conductance signals were visualized to detect periods of elevated physiological arousal. These periods were then cross-referenced with the time-synchronized video recordings of the performance. By carefully reviewing the videos, the onset and offset times of potentially significant events were manually annotated and recorded. The annotated timestamps were subsequently used to segment the physiological data into event-specific intervals. These segments were then plotted and analysed to examine participant responses associated with scenes and performance events.

- **Intensity Analysis across scenes**

To quantify overall physiological intensity during the theatre performance, an intensity index was computed by combining HR and SCL responses. Both HR and SCL were first transformed into z-scores to standardize the data across participants. The z-score represents how much a given value deviates from an individual's baseline mean. In this context, it captures whether physiological responses are above or below each participant's typical resting level, making it suitable for assessing arousal. Higher positive z-scores indicate stronger deviation from baseline and therefore higher physiological arousal, while lower or negative values indicate reduced arousal relative to baseline. This normalization allows meaningful comparison across participants with different baseline physiological levels. The final intensity measure was computed as the average of HR and SCL z-scores for each time segment, providing a unified representation of autonomic arousal.

The synchronized video and signals enabled segmentation of the performance into meaningful narrative events. Patterns of peak arousal and engagement were identified and correlated with performance moments observed in the video. This multimodal integration allowed interpretation of participant responses in both physiological and contextual dimensions. The framework provided a systematic approach to understanding how theatrical elements influence emotional and cognitive states in real time.

➤ **Key Inferences**

The following analysis interprets the physiological responses observed during key performance events identified through visualization-based segmentation. By correlating ECG, and GSR measures with time-aligned video recordings, the study examines how specific theatrical moments affected participant arousal, attention, and engagement. The inferences are divided into three categories as shown:

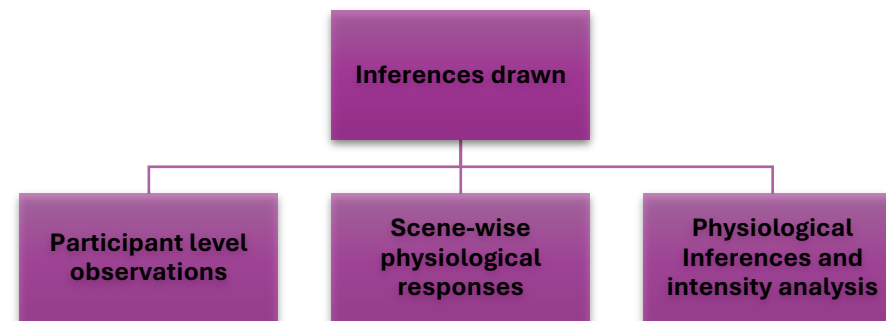


Figure 3: Categories of Inferences

○ **Overall Participant-Level observations**

Participant	Observations
P1	Arousal increased, with clear peaks in heart rate (HR) and skin conductance level (SCL), during humorous and entertaining scenes. Strong HR and SCL responses were also observed during sudden loud sounds, surprise moments and narrative climaxes. Moreover SCL and HR peak also coincided at multiple occurrences. During sad conversational scenes, lower GSR activity with only slight HR increases was observed, indicating more empathy-driven emotional engagement.
P2	Pronounced HR peaks were observed during surprise-driven, emotionally intense, and empathy-related scenes, indicating heightened physiological engagement. Moderate HR elevations were also evident during amusing moments. Additionally, notable HR peaks coincided with narrative climaxes. Inferences are only based on HR data.
P3	Spikes in HR were observed during loud sounds and sudden reactions, indicating automatic startle reflex and sympathetic nervous system activation due to sudden sensory input. In contrast, small to moderate increases in HR during amusement scenes may be attributed to laughter-induced physiological responses. GSR data for both parts was not so good.
P4	SCL exhibited lower amplitude peaks during amusement scenes, whereas higher peaks were observed during sudden reactions and loud sound events. HR showed frequent fluctuations, with occasional smaller peaks during amusing yet auditory-stimulating scenes. Similarly, SCL responses indicated concurrent elevations during these moments, reflecting amusement-related emotional arousal. Also, lower amplitude peaks were also observed in SCL and slight HR peaks during sad conversation indicating empathy driven engagement. GSR for part 1 was not there.

P5	Slight arousal was observed, reflected in smaller HR and GSR peaks, during amusing scenes as well as moments involving sudden reactions. Concurrent fluctuations in HR were likely driven by laughter-induced respiratory changes alongside dynamic emotional arousal. In contrast, sad and empathy-driven conversational scenes exhibited lower emotional arousal, characterized by reduced GSR activity and only mild increases in HR. Most of the observations were based on HR.
P6	Heart rate (HR) exhibited higher amplitude peaks during amusement-related scenes, particularly those involving loud sounds, likely due to increased emotional arousal and auditory stimulation. These peaks were followed by a return to baseline levels, indicating transient physiological activation. In contrast, other scenes showed comparatively stable HR responses. GSR was not good for both the parts so observations based on HR.
P7	The participant appeared highly sensitive to changes in lighting and sound, with sustained elevations in HR and frequent peaks following such events. Significant HR and SCL peaks were aligned with amusement-driven scenes. In contrast, emotionally or empathy-driven situations were characterized by lower SCL activity alongside relatively elevated HR.
P8	HR and SCL peaks were observed to align with amusement-driven scenes, as well as moments involving loud sounds, sudden reactions, and surprise events. Elevated HR and GSR responses were particularly prominent during entertaining and auditory-stimulating segments. In contrast, HR showed transient peaks during sudden sounds and reactions. while GSR tended to decrease during sad and empathy-driven scenes, indicating lower arousal.
P9	Significant elevations and pronounced peaks in HR and SCL were observed during humorous scenes, likely associated with laughter-related physiological responses, as well as during loud auditory events. HR exhibited noticeable peaks even where GSR remained comparatively lower, particularly in scenes combining funny and loud sounds. Additional peaks were also observed during narrative climactic moments. Overall, the second part of the performance elicited a calmer physiological response compared to the first part for the participant.
P10	SCL exhibited elevated arousal during entertaining scenes, particularly those involving loud sounds and reactions, likely reflecting laughter-related physiological activation. In contrast, HR showed sudden decreases during scenes with abrupt loud music, possibly indicating a brief autonomic response to unexpected auditory stimuli. Lower SCL peaks were observed during sudden reaction and angry scenes, while SCL values generally declined after peak responses, suggesting a transition toward more empathetic emotional processing.
P11	Arousal during sudden reactions, loud sounds, and amusing moments was reflected in concurrent peaks in both HR and SCL, indicating heightened physiological activation. Mild elevations were also observed during intense discussions. HR and SCL peaks often coincided during sudden reaction events, while empathy-driven scenes were characterized by lower GSR activity alongside relatively stable HR responses.
P12	Strong arousal during intense reaction scenes was primarily reflected in pronounced peaks in SCL values. Some of these peaks also coincided with amusement-related scenes. HR remained relatively stable overall, with occasional concurrent peaks observed alongside SCL, particularly during sudden reactions. During neutral scenes, SCL values gradually

	returned toward baseline levels. Lower SCL peaks were observed during intense discussions, whereas the highest GSR responses occurred during emotionally intense and surprise-driven moments.
P13	HR exhibited prominent peaks primarily during loud sounds and sudden reactions. SCL levels ranged from moderate to high during amusement-related scenes, with the highest peaks observed during sudden intense moments. Sequences involving abrupt reactions followed by amusing elements also showed elevated SCL responses. Additionally, increased SCL activity was noted during empathy-driven scenes, indicating sustained emotional engagement.
P14	SCL exhibited relatively infrequent peaks, with values remaining largely stable throughout the performance. Only occasional elevations were observed in SCL during amusement-related scenes and sudden intense moments. Overall, the arousal level reflected in SCL remained low. In contrast, HR showed more frequent peaks, particularly during amusement, sudden reactions, flickering lights, and loud auditory stimuli, indicating greater sensitivity to dynamic and unexpected events.
P15	SCL values largely remained within a normal range, showing minimal fluctuations and indicating no substantial change in overall arousal. However, following a single intense reaction scene, a slight increase in SCL was observed, which remained elevated for an extended period. HR was generally stable, with occasional peaks occurring during amusement-related scenes.
P16	No substantial changes were observed in SCL values during most of the performance; however, occasional peaks appeared during amusing scenes, some of which coincided with HR responses. HR showed transient decreases during scenes involving loud sounds, fluctuating lights, and sudden reactions. In contrast, HR also exhibited fluctuations and peaks during amusement-related scenes, indicating variable physiological responses depending on the nature of the stimulus.
P17	HR exhibited continuous fluctuations throughout the performance, which may be influenced by the participant's underlying cardiac condition. Despite this variability, noticeable HR peaks were observed during amusing scenes. In contrast, GSR showed minimal variation and no substantial peaks overall, although a few elevations coincided with amusing moments, suggesting mild emotional arousal in response to these scenes.

Observations:

- Approximately half of the participants (8 out of 17) exhibited coinciding peaks in both HR and SCL during amusement-driven scenes. Similar concurrent peaks in HR and SCL were also observed during scenes involving loud sounds, sudden reactions, and surprise events, indicating synchronized physiological responses to elevated emotional and sensory stimulation.
- ~ 18% of the participants (3 out of 17) exhibited pronounced HR and SCL responses during narrative climactic moments.

- ~ 47% of the participants (8 out of 17) showed that SCL effectively captured emotional reactivity, with medium to high amplitude peaks corresponding to sudden reactions and humorous moments. In contrast, lower amplitude peaks were observed during empathy-driven scenes, reflecting comparatively lower but sustained emotional arousal. Furthermore, it was also observed that for ~ 24% of the participants (4 out of 17) there were little to no substantial change in overall SCL levels throughout the performance, indicating relatively stable physiological arousal. For some of these participants, one section of the performance appeared noticeably calmer than the other.
- Some of the participants (~24%) exhibited frequent fluctuations in heart rate (HR) during amusing yet auditory-stimulating scenes. These variations are likely associated with laughter-induced respiratory changes combined with dynamic emotional arousal, leading to continuous short-term modulation of HR during such segments.
- Certain participants demonstrated distinctive physiological responses in HR that differed from the overall trends:
 - For some participants HR values dropped and lowered during sudden sounds and lights may be due to unexpected auditory stimuli.
 - Some participants exhibited prolonged elevations in HR and SCL, likely due to heightened sensitivity to changes in lighting and sound or following a single intense scene that triggered sustained physiological activation.

○ **Scene-wise physiological changes**

Part 1 of performance

Participant	Scene 1 Sabine gets excited over birthday gift Amusement	Scene 2 Sabine's tooth came off while playing and she gets worried Amusement	Scene 3 Sabine gets punishment Empathy	Scene 4 Sabine's parent's intense discussion Intense	Scene 5 Summer cottage Olympics Amusement/Happy	Scene 6 Family meeting with father making strict rules Amusement	Scene 7 Father getting angry for auction mocking Sudden reaction
P1	-	SCL and HR low peak	SCL and HR high peak	-	-	SCL, HR medium peaks	SCL high peak
P2	-	-	HR high peak	HR high peak	HR medium peaks	HR medium peaks	-
P3	HR high peak	-	-	-	HR high peak	SCL, HR medium peaks	-

P4	-	HR medium peak	-	HR medium peaks	HR medium peaks	HR medium peaks	-
P5	HR low peaks	HR low peaks				HR medium peaks	
P6	-	-	-	-	-	-	-
P7	SCL high peaks, HR low peaks	SCL low peaks, HR high peaks	-	-	SCL low peaks, HR medium peaks	SCL low peaks, HR medium peaks	-
P8	SCL low peaks, HR low peaks	SCL low peaks, HR high peaks	SCL low to slightly high, HR low to slight high	SCL and HR both up after scene	SCL low peaks, HR medium peaks	SCL, HR medium peaks	SCL and HR high peak
P9	-	SCL and HR low peak	-	-	SCL high peaks, HR high peaks (shouting)	SCL high peaks, HR medium peaks	-
P10	-	SCL high peaks and HR stable	SCL medium peaks, HR stable	SCL low peaks, HR stable	SCL low peaks, HR stable but dropped	SCL low, HR stable	SCL low but peak
P11	SCL high peaks, HR high peaks	SCL high peaks, HR high peaks	SCL low, HR stable	SCL low peaks, HR low peaks	SCL high peaks, HR high peaks	SCL and HR medium peaks but HR has sudden drop	SCL and HR medium peak
P12	HR medium peaks	SCL high peaks, HR medium peaks	SCL low, HR stable	SCL medium peaks, HR stable	SCL high peaks, HR stable	SCL medium peaks, HR stable	SCL and HR medium peak
P13	SCL low, HR high peak	SCL high peaks, HR high peaks			SCL low peaks, HR medium peaks	SCL low, HR stable	SCL medium peak, HR stable
P14	-	SCL stable, HR medium peaks	SCL stable, HR medium peaks	-	SCL stable, HR high peaks	-	-
P15	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable
P16	-	SCL low peaks, HR medium peak	SCL stable, HR stable	SCL stable, HR stable	SCL stable, HR stable but dropped	SCL high peak, HR high peak at one point	SCL and HR medium peak

P17	-	SCL low peaks , HR high peaks	SCL stable , HR high peaks	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL low peak , HR high peaks	SCL stable , HR stable and fluctuating
-----	---	--	---	---	---	---	---

Part 2 of performance

Participant	Scene 1 Olympic game and Sabine won and cries in joy Amusement	Scene 2 Sabine trying to get sick Amusement	Scene 3 Sabine argument with father and she shoots him Surprise	Scene 4 Father making sauna unbearable for boyfriend Amusement	Scene 5 Sabine's and family jokes about father Amusement	Scene 6 Father getting angry over no salt in dish. Sudden reaction	Scene 7 Father got hot by wall Surprise	Scene 8 Mother's story about father and not leaving him Empathy
P1	SCL and HR High peak	SCL and HR medium peak	SCL and HR High peak	SCL and HR medium peak	SCL and HR medium peak	-	SCL High peak	SCL low, HR medium peak
P2	-	-	-	HR high peak	-	-	HR high peak	HR medium peak
P3	HR high peak	-	-	-	-	-	-	-
P4	SCL low peak , HR fluctuations	SCL medium peaks	SCL high peak	-	SCL low high	SCL medium peak	SCL medium peak	SCL low , HR medium peak
P5	HR high peaks	-	SCL low peaks , HR low peaks	-	HR high peaks	-	SCL low peaks , HR high peaks	HR Fluctuations , SCL low peaks
P6	HR high peaks	-	-	-	-	-	-	-
P7	-	SCL and HR high peak	SCL high peaks , HR medium peaks	SCL low , HR medium peak	SCL low , HR medium peak	-	SCL low peaks , HR high peaks	HR Fluctuations , SCL low peaks
P8	-	SCL high peaks , HR low peaks	-	SCL and HR low to medium peak	-	-	SCL high peaks , HR high peaks	HR Fluctuations , SCL low peaks

P9	SCL low , HR fluctuations	SCL low and HR medium peak	-	-	-	-	-	SCL low to high , HR high peak (Climax)
P10	SCL low , HR dropped	SCL high peaks , HR stable	SCL medium peaks , HR stable	SCL low , HR stable	-	-	SCL high peaks , HR high peaks	HR stable
P11	SCL and HR medium to low peaks	SCL high peaks , HR high peaks	SCL low peaks , HR medium peaks	-	-	-	SCL low peaks , HR low peaks	SCL low , HR high peak (Climax)
P12	SCL and HR medium peaks	SCL high peaks , HR high peaks	SCL high peaks , HR medium peaks	SCL low peaks , HR stable	SCL high peak , HR stable	SCL high peak , HR high peak	SCL high peak , HR low peak	HR Fluctuations , SCL low peaks
P13	SCL low , HR high peaks	SCL low peaks and HR stable	SCL medium peaks , HR stable	SCL low , HR high peak		SCL medium peak , HR stable	SCL low peaks , HR stable	SCL high peaks , HR stable
P14	-	SCL high peaks , HR stable	SCL high peaks , HR high peaks	SCL low , HR high peak	-	-	-	HR Fluctuations , SCL low peaks
P15	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR medium peak	SCL stable , HR medium peak	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR stable
P16	SCL stable , HR stable but dropped	SCL stable , HR medium peaks	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR stable	SCL stable , HR medium peak	HR Fluctuations , SCL low peaks
P17	SCL low peak , HR high peaks	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL stable , HR stable and fluctuating	SCL low peak , HR stable and fluctuating

Observations:

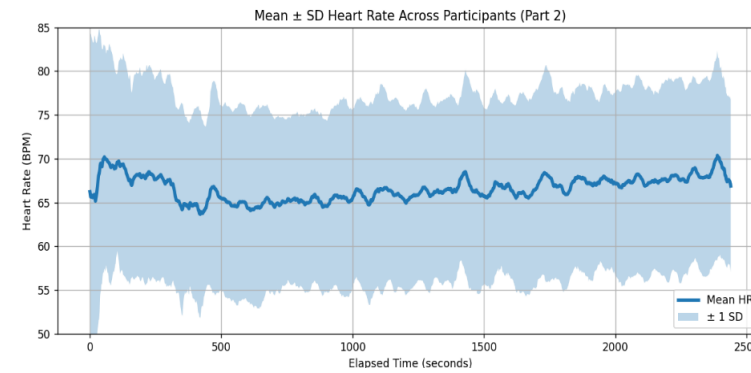
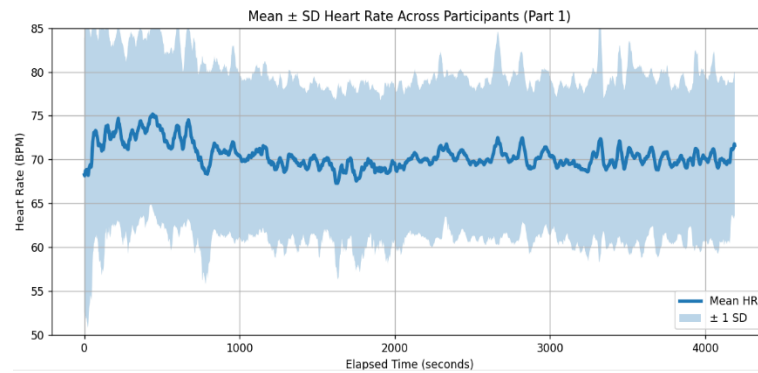
Part 1			
Scene	HR Observation	SCL Observation	Overall
Scene 1 (Amusement with screaming)	The amusement scene showed generally elevated HR responses, with medium to high peaks in several participants, likely reflecting increased arousal during humorous and loud/screaming moments, while a few remained low/stable .	SCL responses were more variable, ranging from low to high peaks , with higher values appearing during intense amusement and screaming segments, and lower/stable activity in less reactive participants.	The scene elicited mixed but predominantly moderate-to-high physiological arousal, indicating varied emotional engagement across participants driven by amusement and sudden loud stimuli.
Scene 2 (Amusement with changing sound and lights)	The amusement scene showed overall mixed HR responses, ranging from low to high peaks . Several participants exhibited elevated HR during intense or loud moments, while others showed only mild or stable fluctuations.	SCL responses varied widely, with low to high peaks across participants. Higher SCL activity was observed during emotionally intense and loud amusement segments, whereas some participants showed stable or low responses.	The scene elicited heterogeneous physiological arousal, reflecting a combination of amusement, emotional intensity, and sensory stimulation (screaming and crying), leading to varied engagement across participants.
Scene 3 (Calm and later Empathy)	Heart rate showed generally low to moderate responses during the calm portions of the scene, with occasional high peaks observed, particularly towards the later empathy-driven segments, indicating brief emotional engagement.	SCL responses were mostly low to stable , with a few participants showing medium to slightly elevated peaks during empathetic moments, reflecting mild autonomic arousal.	The scene was largely calm followed by mild increases in both HR and SCL during empathy-related segments, suggesting low to moderate emotional engagement across participants.
Scene 4 (intense discussion and reaction)	Heart rate responses were mixed, with occasional medium to high peaks during the intense discussion, while several participants remained stable or showed low fluctuations .	SCL activity was generally low to moderate , with a few participants showing medium peaks during the discussion. Some participants exhibited stable or low responses, while a slight post-scene increase in SCL was observed in certain cases.	The intense discussion scene elicited variable physiological responses, with mild to moderate arousal during the event and occasional post-scene increases due to intense reaction at the end.
Scene 5 (Amusement with loud sound and reactions)	Heart rate showed predominantly medium to high peaks across participants, indicating elevated arousal during amusement, loud sounds, and screaming segments. A few instances of stable or slight drops were also observed, reflecting response to unexpected auditory stimuli	SCL responses varied from low to high peaks , with stronger elevations occurring during shouting and highly stimulating moments, while some participants maintained stable or low activity throughout.	The scene elicited moderate to high physiological arousal overall, driven by a combination of amusement, loud auditory stimuli, and screaming, with variability in individual emotional and autonomic responses.

Scene 6 (scene has funny segments)	Heart rate responses were predominantly in the medium range across participants, indicating consistent moderate arousal throughout the humorous segments. A few instances of high peaks and occasional drops were also observed.	SCL activity varied from low to high peaks , with several participants showing moderate elevations during engaging humorous segments, while others remained stable or low.	The scene elicited generally moderate physiological arousal with multiple humorous segments, leading to consistent but varying HR and SCL responses, and occasional brief peaks during particularly engaging moments.
Scene 7 (sudden loud reaction)	Heart rate responses were generally low to moderate , with a few pronounced peaks coinciding with sudden reaction moments. Most participants showed stable or mildly fluctuating HR, indicating brief and event-specific arousal.	Skin conductance levels showed more prominent reactivity, with several high and medium peaks observed during sudden loud reactions. Some participants also exhibited stable or low responses, reflecting variability in autonomic arousal.	The scene elicited transient but noticeable physiological arousal, primarily driven by sudden loud reactions, with stronger and more consistent responses observed in SCL compared to HR across participants.
Part 2			
Scene	HR Observation	SCL Observation	Overall
Scene 1	Heart rate showed predominantly high peaks and frequent fluctuations across participants, indicating elevated arousal during the amusing segments. The loud sounds and music likely contributed to these responses, with some participants also exhibiting transient drops in HR.	SCL responses were generally low to moderate , with occasional peaks observed during particularly engaging or stimulating moments. Several participants maintained stable or low SCL activity despite notable HR changes.	The scene elicited moderate to high physiological engagement, with HR reflecting strong amusement- and sound-related arousal, while SCL responses were more variable across participants.
Scene 2 (Amusement with funny scenes)	Heart rate responses were generally in the medium range across participants, with occasional high peaks during particularly engaging humorous moments.	Skin conductance levels showed greater variability, ranging from low to high peaks . Elevated SCL responses were observed during key funny moments.	The scene elicited moderate physiological arousal overall, driven by humorous content, with more consistent HR patterns and comparatively variable SCL responses across participants.
Scene 3 (Intense scene with intense reaction)	Heart rate showed variable responses across participants, ranging from low to high peaks , with several medium elevations during sudden intense and surprising moments.	Skin conductance responses were generally elevated, with multiple high and medium peaks observed during intense and surprising segments.	The scene elicited moderate to high physiological arousal, driven by sudden intense and surprising reactions, with stronger and more consistent responses observed in SCL compared to HR across participants.
Scene 4 (Amusement scene)	Heart rate responses were predominantly in the medium range , with occasional high peaks during engaging amusement moments. A few participants showed stable	Skin conductance activity was generally low, with low to moderate peaks observed during specific amusing	The scene elicited low to moderate physiological arousal overall, with HR showing relatively stronger responsiveness than SCL.

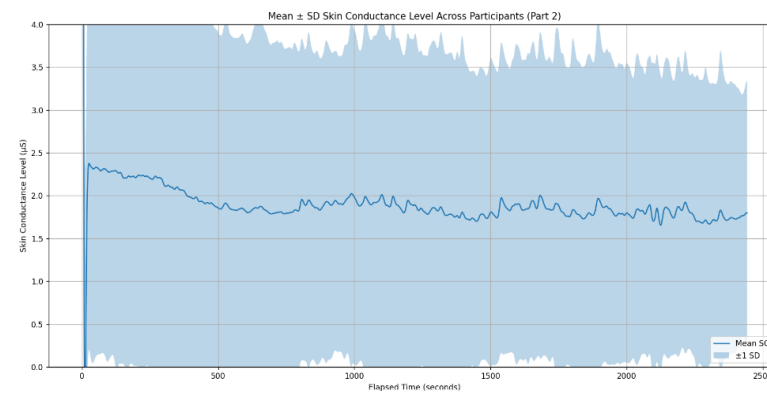
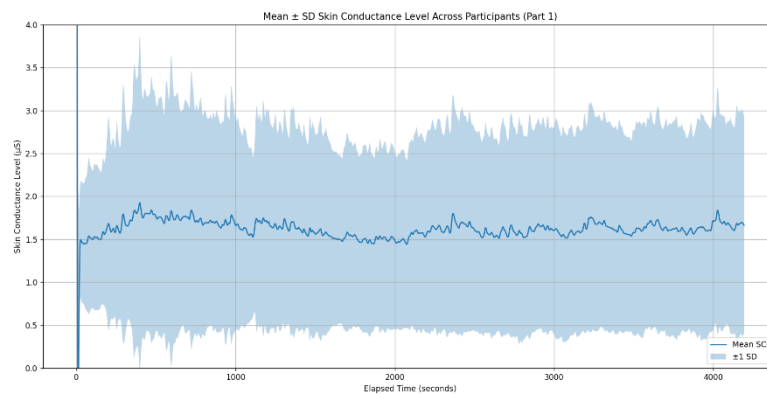
		or mildly fluctuating HR, indicating variable arousal levels across the scene.	segments, reflecting limited autonomic activation in comparison to HR.	
Scene 5 (Amusement scene)		Heart rate responses were mostly in the medium range , with occasional high peaks during engaging amusement moments.	Skin conductance levels were generally low to moderate , with high peaks observed during specific amusing segments	The scene elicited low to moderate physiological arousal overall, with HR showing more consistent responsiveness than SCL.
Scene 6 (Sudden loud reaction)		Heart rate responses were largely stable across participants, with only a few instances of elevated activity. High peak was observed in some cases during sudden reaction moments with loud sounds	Skin conductance showed more noticeable activity, with medium to high peaks during sudden loud reactions.	The scene elicited transient physiological arousal, primarily driven by sudden reactions and loud sounds, with SCL showing slightly stronger sensitivity compared to HR across participants.
Scene 7 (Surprise shocking)	n	Heart rate responses showed mixed but generally elevated activity during the surprise/shocking scene, with several participants exhibiting high peaks , while a few showed low or stable responses.	Skin conductance levels were also highly variable, ranging from low to high peaks across participants. Multiple high SCL responses aligned with shocking moments.	The scene elicited strong but heterogeneous physiological arousal, with several participants showing synchronized HR and SCL peaks.
Scene 8 (Empathy)		Heart rate responses were generally in the medium range with frequent fluctuations across participants, indicating sustained but variable engagement during the empathy-driven scene.	Skin conductance levels were predominantly low across participants, with occasional increases from low to high during key climax segments.	The scene elicited moderate and variable physiological arousal, characterized by fluctuating HR and generally low SCL, with distinct peaks during climactic empathy moments.

- **Physiological Inferences from HR and GSR Data**

- Heart rate and standard deviation plots



The figures above show mean heart rate and standard deviation values across participants for both parts of the theatre performance, indicating overall heart rate trend and variability in HR responses among participants. The HR values observed during Part 1 were generally higher than those recorded during Part 2. This suggests a greater level of physiological arousal during Part 1. Although both parts contained almost similar number of scenes with loud sounds and music and intense scenes, but elevated HR in Part 1 may be attributed such as increased emotional engagement or anticipation. For example, participants may have experienced increased novelty, emotional engagement, or cognitive load during the initial phase of the performance. As the performance progressed, adaptation effects may have reduced the physiological response, resulting in comparatively lower HR values during parts despite similar auditory stimulation.

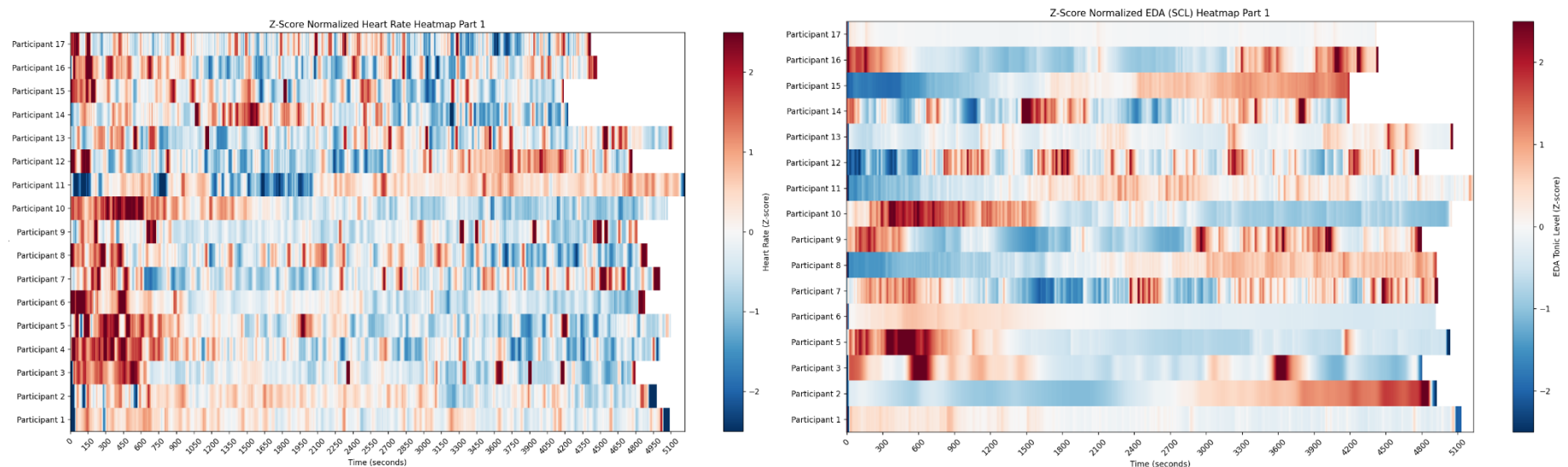


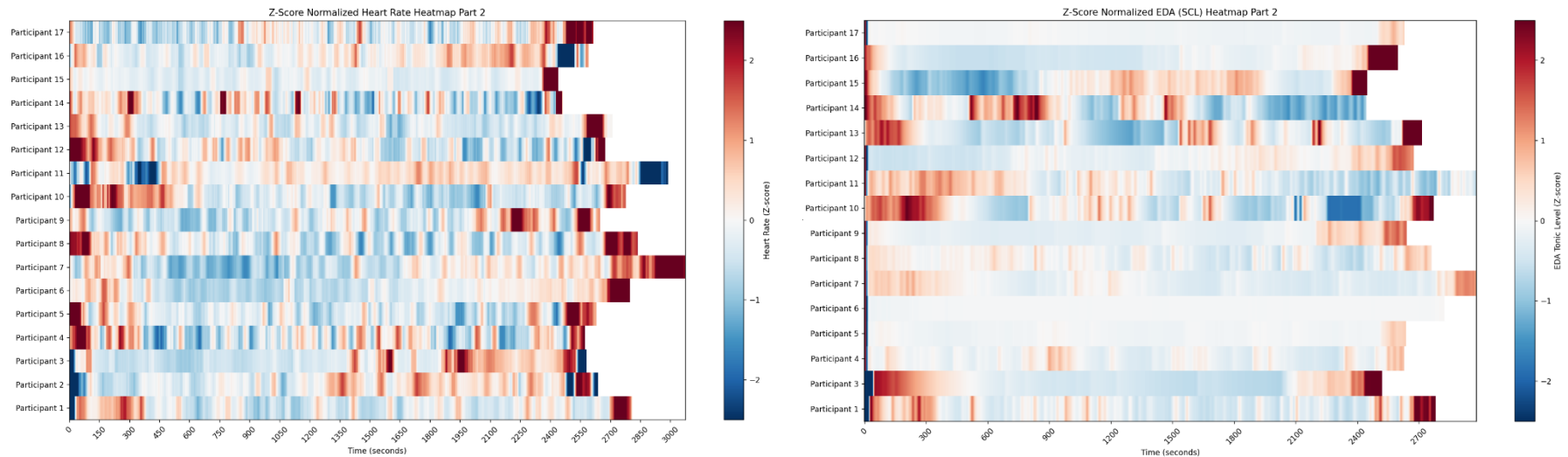
The figures above show mean Skin Conductance Level (SCL) amplitude and standard deviation values across participants for both parts of the theatre performance, indicating overall SCL amplitude trend and variability in responses among participants. In contrast to the HR responses, the SCL values were generally higher in Part 2 compared to Part 1. This suggests a stronger autonomic arousal during Part 2, particularly at the beginning of the segment. Concurrently, the HR values were also up during this period. The initial increase in SCL coincided with the onset of loud sounds and bright lighting, followed by an intense scene, which likely triggered a rapid sympathetic nervous system response. However, after this initial peak, SCL values gradually decreased and stabilized, becoming comparable to those observed in Part 1.

Heat maps plots for HR and SCL arousal

Below are the heatmap representation of z-scores for HR and SCL to provide a visual representation of physiological arousal patterns across participants during entire performances parts (Part 1 and Part 2).

By converting raw signals into z-scores, individual differences in baseline physiological activity are normalized, allowing direct comparison of relative changes over time. In the heatmaps, warmer colours represent positive deviations from baseline (higher-than-average arousal), while cooler colours indicate lower-than-baseline activity. These heatmaps are useful for identifying temporal patterns and participant-level variability in physiological responses. They allow clear visualization of when and where arousal peaks occur. HR and SCL heatmaps were generated separately for Part 1 and Part 2 to compare physiological arousal patterns across the two segments of the theatre performance.





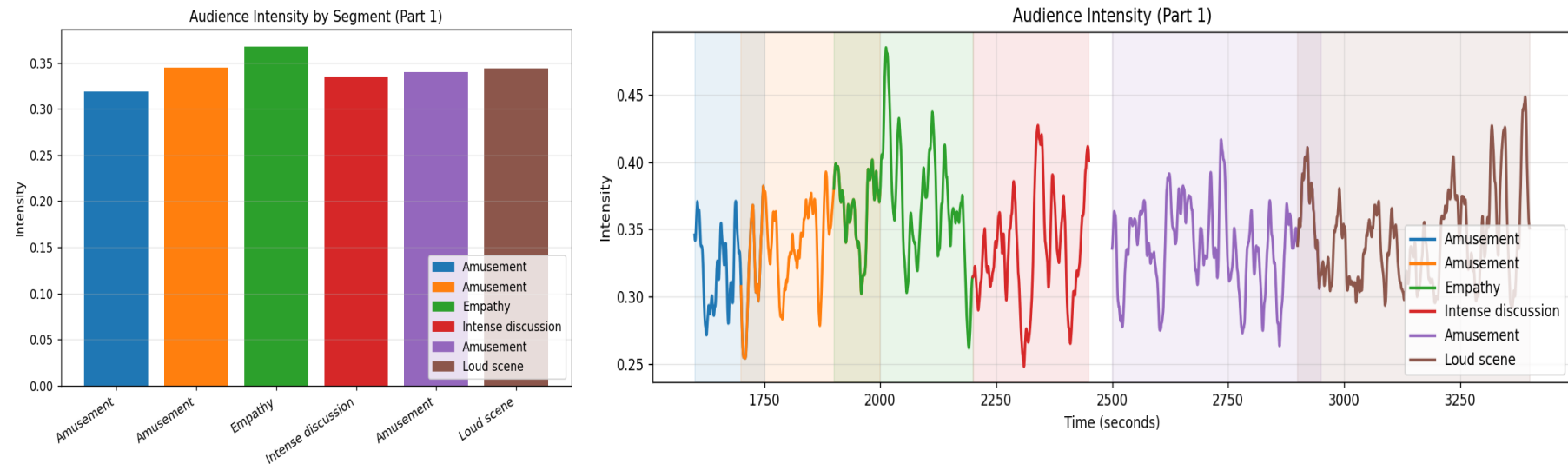
The heatmap analysis for Part 1 and Part 2 allows direct identification of similarities and differences in arousal patterns both between physiological measures and across individuals.

In Part 1, HR and SCL heatmaps show a relatively consistent pattern of elevated arousal across a subset of participants, indicating a group-level response to the same segments. Several participants exhibit synchronised increases in both HR and SCL during the same time windows, as can be seen from the darker/warmer segments.

In Part 2, the heatmaps show greater variability across participants, with fewer clearly synchronised instants of arousal between HR and SCL. These instants can be seen prominently at the beginning, may be because of amusement scene followed by intense scene and around narrative climax. Some participants exhibit elevated SCL with relatively stable HR, while others show the opposite trend. This suggests more individualized responses during Part 2, possibly due to differences in emotional interpretation, habituation effects, or attentional shifts. Overall, the comparison between HR and SCL across both parts indicates that Part 1 is characterised by more consistent and shared arousal responses across participants, whereas Part 2 shows weaker synchrony and greater inter-individual variability.

Intensity analysis

To examine the overall physiological arousal throughout the theatre performance, an intensity index was calculated by averaging the z-scored R and SCL. The resulting intensity measure provides a unified representation of autonomic arousal. Intensity was analysed using two complementary visualizations. First, line graphs were used to show the variation in intensity across different segments within Part 1 and Part 2. Second, bar graphs were used to summarize the average intensity for each part, providing an overall comparison of physiological engagement between the two sections of the performance.



For Part 1, the highest intensity values were observed during the empathy scene, indicating strong audience engagement and physiological arousal. Increased intensity was also observed during several amusement scenes, although these responses were less pronounced. However, from bar graph, among amusement scenes, it can be seen that initial amusement scene which involved loud noise and scream was more entertaining. Overall, both empathy and amusement contributed to audience arousal, with the empathy scene producing the most significant response.

The intensity values in Part 2 were lower than those observed in Part 1. However, in Part 2 several peaks were identified during amusement scenes and during scenes that combined entertaining elements with loud reactions. Elevated intensity was also observed during the empathy scene associated with the narrative climax, suggesting strong emotional engagement with the storyline. Although the overall intensity was reduced compared to Part 1, these findings indicate that both emotionally significant and highly engaging scenes continued to evoke audience responses throughout Part 2 as well.

