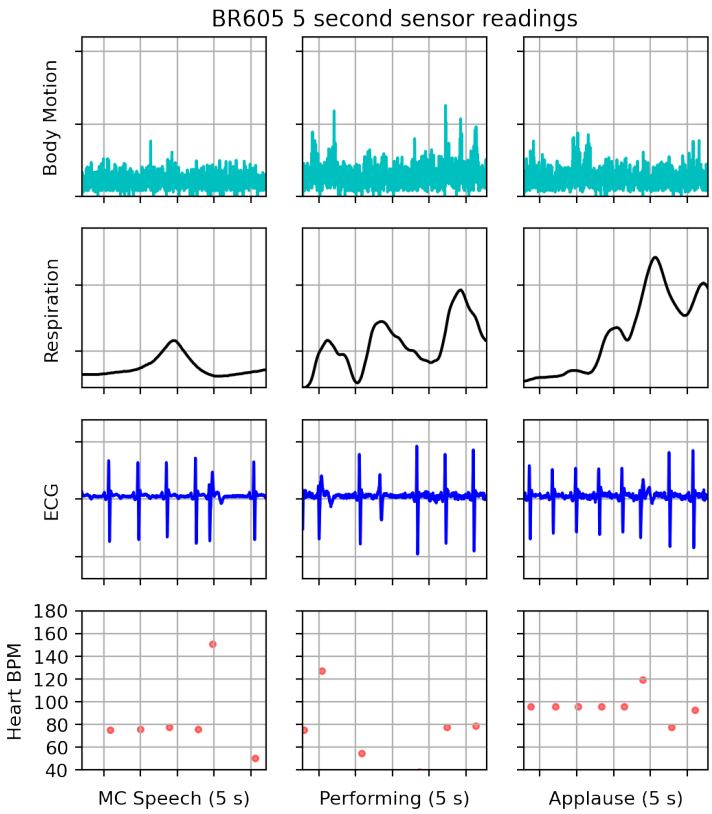
Bodies in Concert: Performer summary



Performance measurements

February 14-18th, 2023, researchers from University of Oslo's RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion visited the *Stavanger Symfoniorkester* and collected measurements during a series of Lydo concert performances. You were one of the performers who volunteered to wear sensors while on stage, and requested a summary of your personal data. The following is a short report showing some of your own measurements, plotted to highlight patterns of interest, as well as a few views of the measurements across the ensemble from the researchers' initial explorations. The information presented is not medical advice, the analyses are for scientific research and are not clinical assessments. You are the only recipient of this report.

Individual Participant

BR605 wore the Equivital monitor vest while performing the 2023 Lydo concerts, on Trombone. This section presents some views of their physiological states during these performances.

In an experiment of this scale, with many technologies and devices recordings over several days outside of laboratory conditions, there is always some data loss. Malfunctioning sensors and changes in conditions compromised some portion of measurements from a third of performer participants, resulting in a loss of 9% of respiration and 16% of cardiac measurements, less than expected under the circumstances. Fortunately, this participant's recordings were consistently of decent quality.

The compound figure above shows 5 second snapshots of sensor measurements when this performer was at rest (while the MC spoke to the audience), when they were playing, and just after playing while the audience applauded. The ECG and heart beat Interbeat Intervals (IBI) show what looks like a form of arrhythmia, however this behaviour is also similar to some forms of sensor noise. After aligning signals with recordings of the performances and extracting various features, the researchers inspect these base measurements for patterns between conditions, between performances, and between musicians.

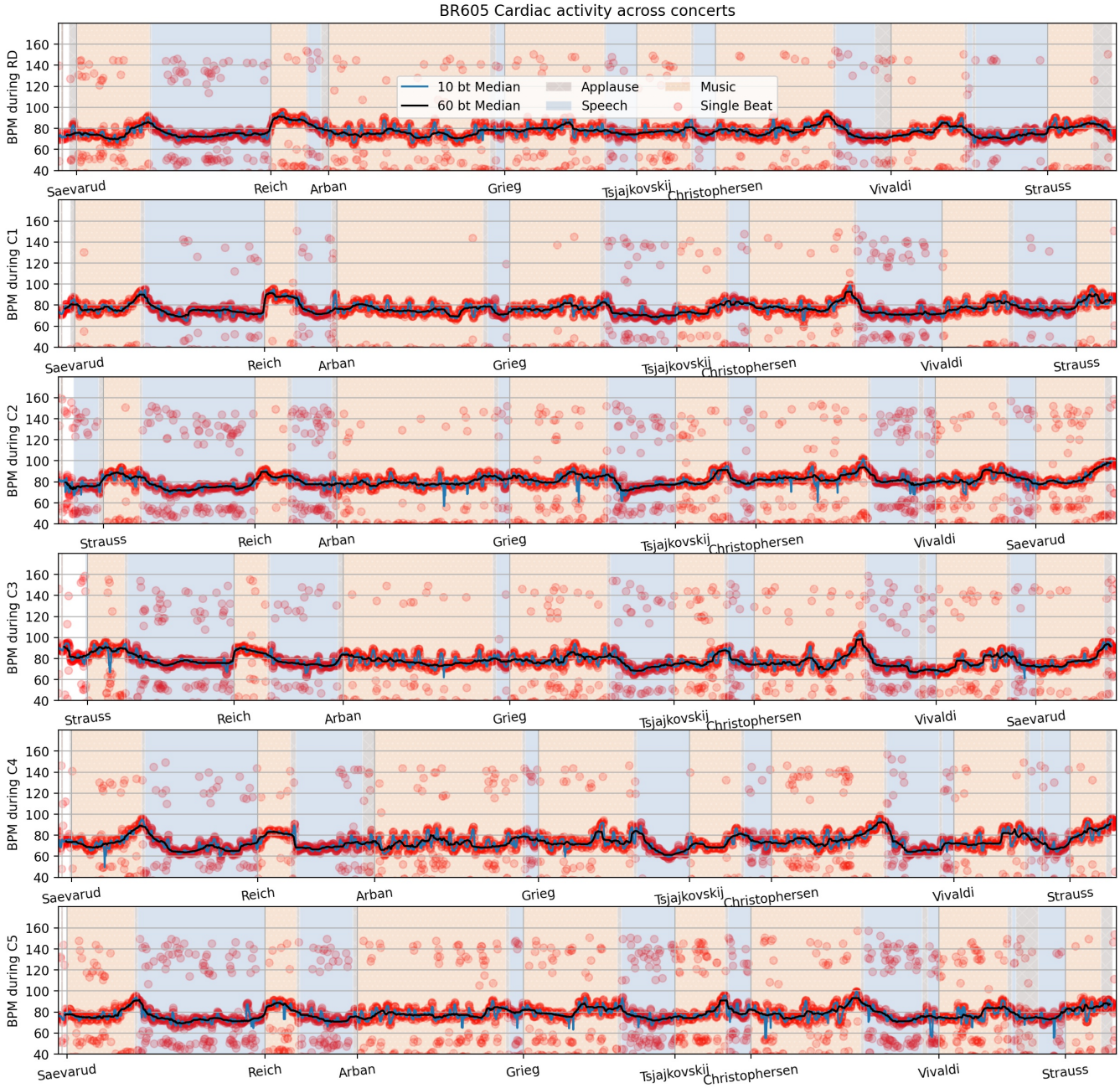


Figure 1: BR605 Heart beats and local heart rate during all captured performances, from the dress rehearsal (RD) at the top through the two days of school concerts (C1-C2, C3-C4) and the final family concert of the Lydo series (C5). Each plot indicates when the orchestra was playing (beige) or listening (blue), with the beginings of each piece labeled on the x-axis. The black line reports the median heart rate over a 60-beat interval, centred, and red dots mark the inferred heart rate from each measured beat. While these sensors are generally quite good, movement can introduce artifacts, and some of the scattering of red dots may be sensor errors. ’ ’

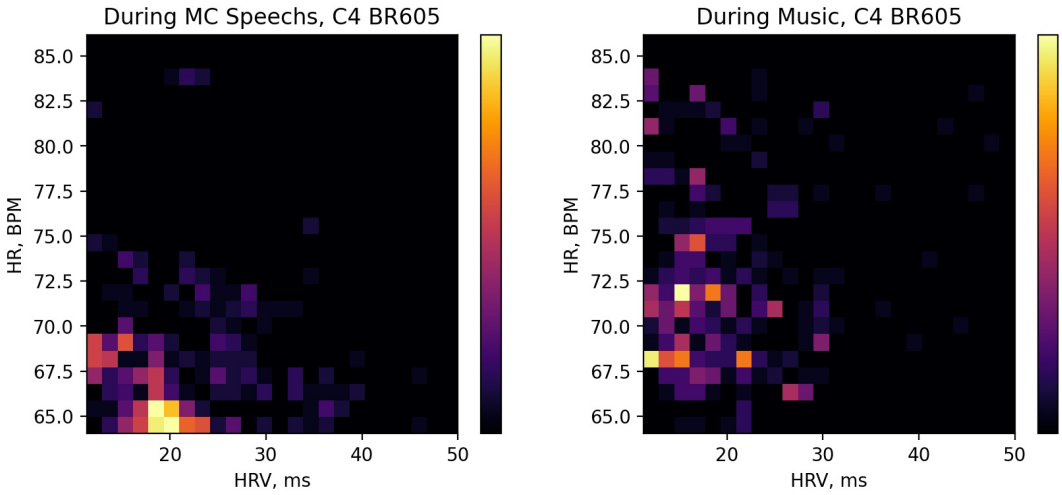


Figure 2: To give a sense of how listening and performance differ, these plots show the joint-distributions of Heart Rate (HR) and Heart Rate Variability (HRV) during the times (Left) that the MC was Speaking vs (Right) when the Orchestra was playing in one whole concert. Brightness indicates the concentration of moments with specific combinations of HR and HRV values, highlighting common cardiac states. Heart Rate Variability (HRV) is most often studied in people being still, so the change in distribution while this performer was actively performing is scientifically interesting and will be investigated more closely. Note: this representation of Heart Rate Variability filters out much of the type of scattering seen in this participant's ECG recordings. The remainder shift to less variability during performance seems to be a common pattern during music performance.

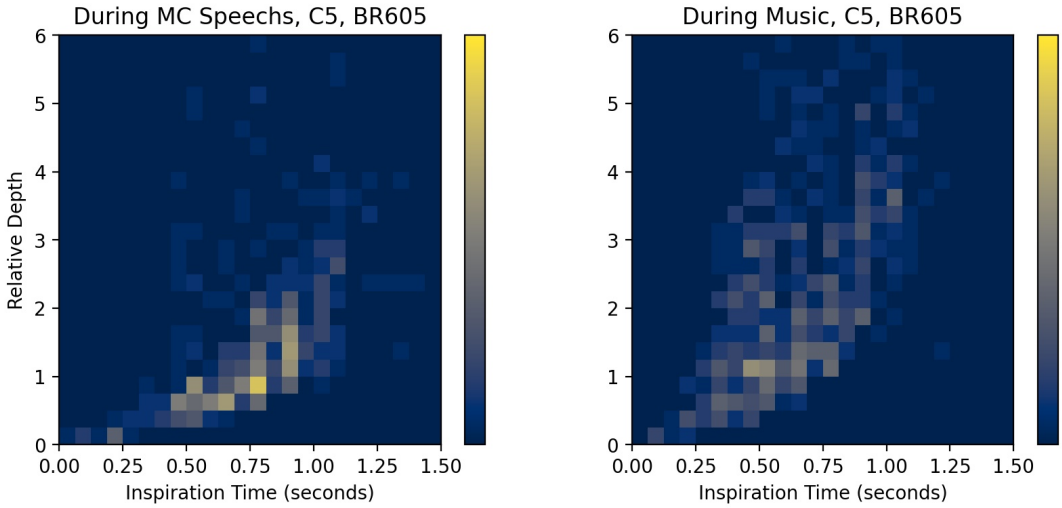


Figure 3: To compare breathing during performance and listening, these plots show the joint-distributions of Inspiration Depth (Relative Depth) and Inspiration Duration (Inspiration time) of the performer's measured breaths during the times (Left) that the MC was Speaking vs (Right) when the Orchestra was playing over one whole concert. Inspirations are often more slow, shallow, and variable during listening, while respiration shape during performance depends closely how they performed. Like most brass players, breaths taken during performance include softer breaths while tacet and deep inspirations to play.

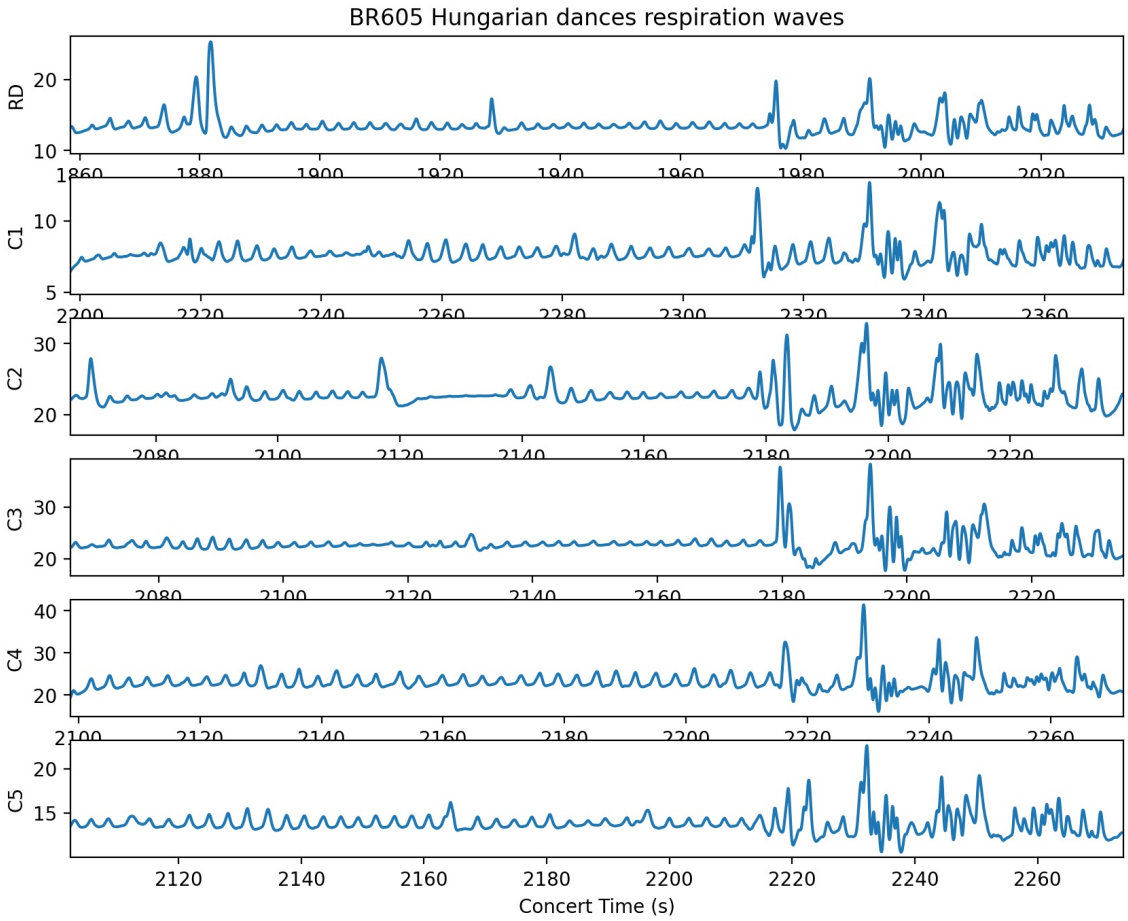


Figure 4: Above are this performer's measured respiration waves during each performance of a single piece, showing the different types of breaths used in performance and how they (roughly) align. These measurements are scaled to their most common inspiration depth while listening. Active breaths for coordination or physical exertion are often much deeper, while performance breaths for winds are deeper still. The consistencies, both deep inspirations and longer flatter regions, highlight when this brass player was playing.

Group signals

Analysis of these measures across performers is ongoing, with many patterns to be discovered. The orchestra is an exceptional example of human coordination, with many bodies simultaneously producing sound with great control and replicability. In the next months, we will carry out different analyses on the performers' data that will show us how they coordinate with the others in the orchestra and how musicians' bodies engage with the music. For example:

- **Performance variability**: We will look at when in the concerts the ensemble played very similarly, and when they were more variable. Our research on small ensembles has found more variablity in moments that are more emotionally expressive. Is this the same for an orchestra, with more people to coordinate?
- **Inspiration alignment**: When do musicians from different sections breathe together? Entries, accents, section changes,... something in the music is prompting this coordination, even in string players and percussionists.
- **Rhythmicity and Synchrony with the Conductor**: Conducting gestures change with the rhythmic character of the music, does this translate to different qualities of synchrony across the ensemble? We expect that synchronization is more precise when the music is very rhythmical, but let's see what the data says.

Below are some previews of emergent patterns.

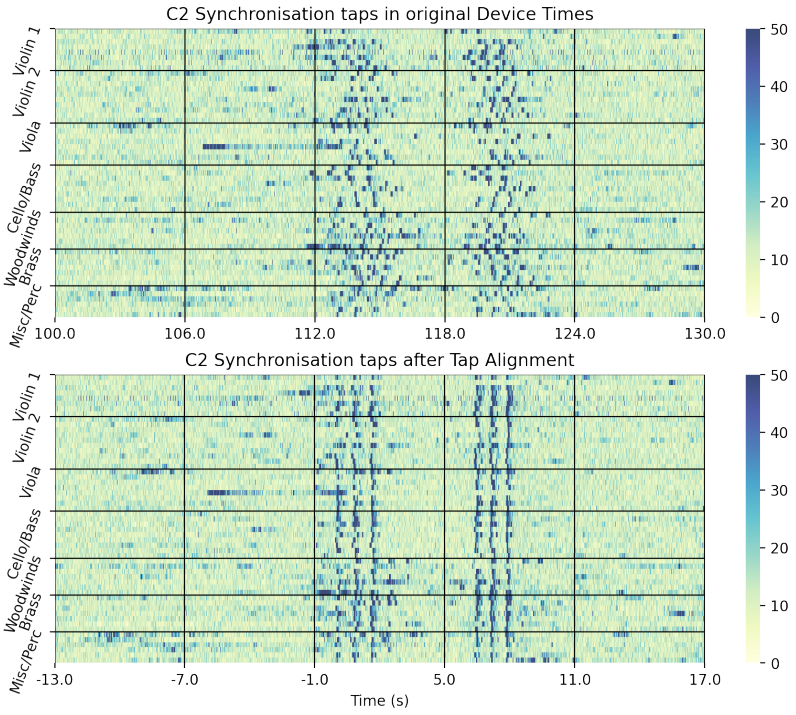


Figure 5: This figure shows the quantity of motion measured from each participant's physiology sensor in a specific interval of time, ordered by section. Here it is zoomed into the 30 seconds around the synchronisation taps performed by the orchestra during the second Lydo concert, showing the original device time alignment above and the effect of correcting those timings by aligning the taps. (The beginning of Clapping music was also used as a secondary check on clock alignment.) Thank you for tapping along to the beeps! This essential task allows us to study your collective coordination with much greater temporal precision.

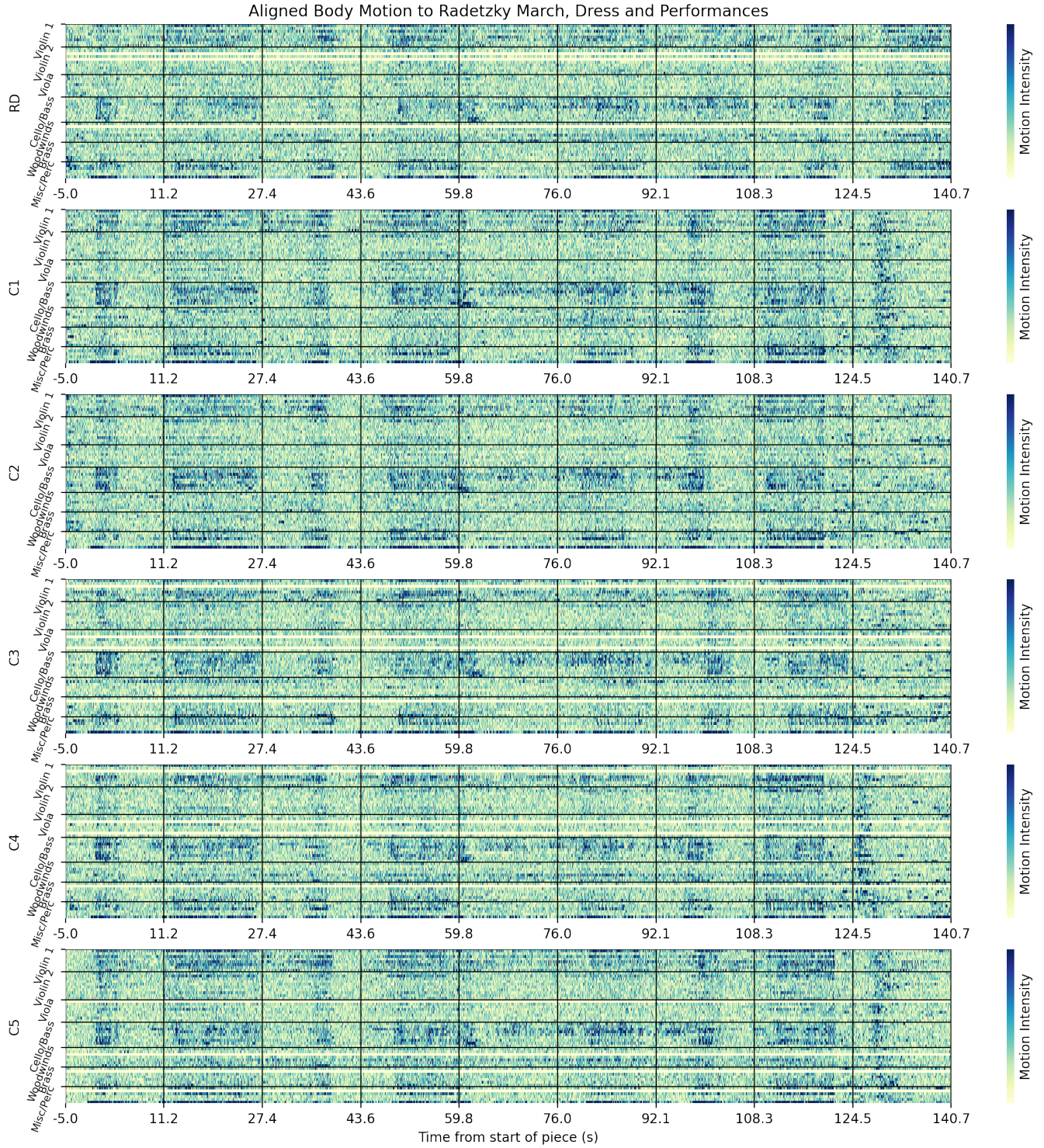


Figure 6: The concurrent body sway across performers during 6 performances of Strauss's Radzetsky March: the dress rehearsal (RD) at the top through the two days of school concerts (C1-C2, C3-C4) and the final family concert of the Lydo series (C5). Besides capturing the intensity and metricality of the music, these plots show differences between sections, with the lower strings working hard, and great consistency between performances. These measurements of motion will be combined with cardiac measurements, audio, and information from the scores to see how they interact.

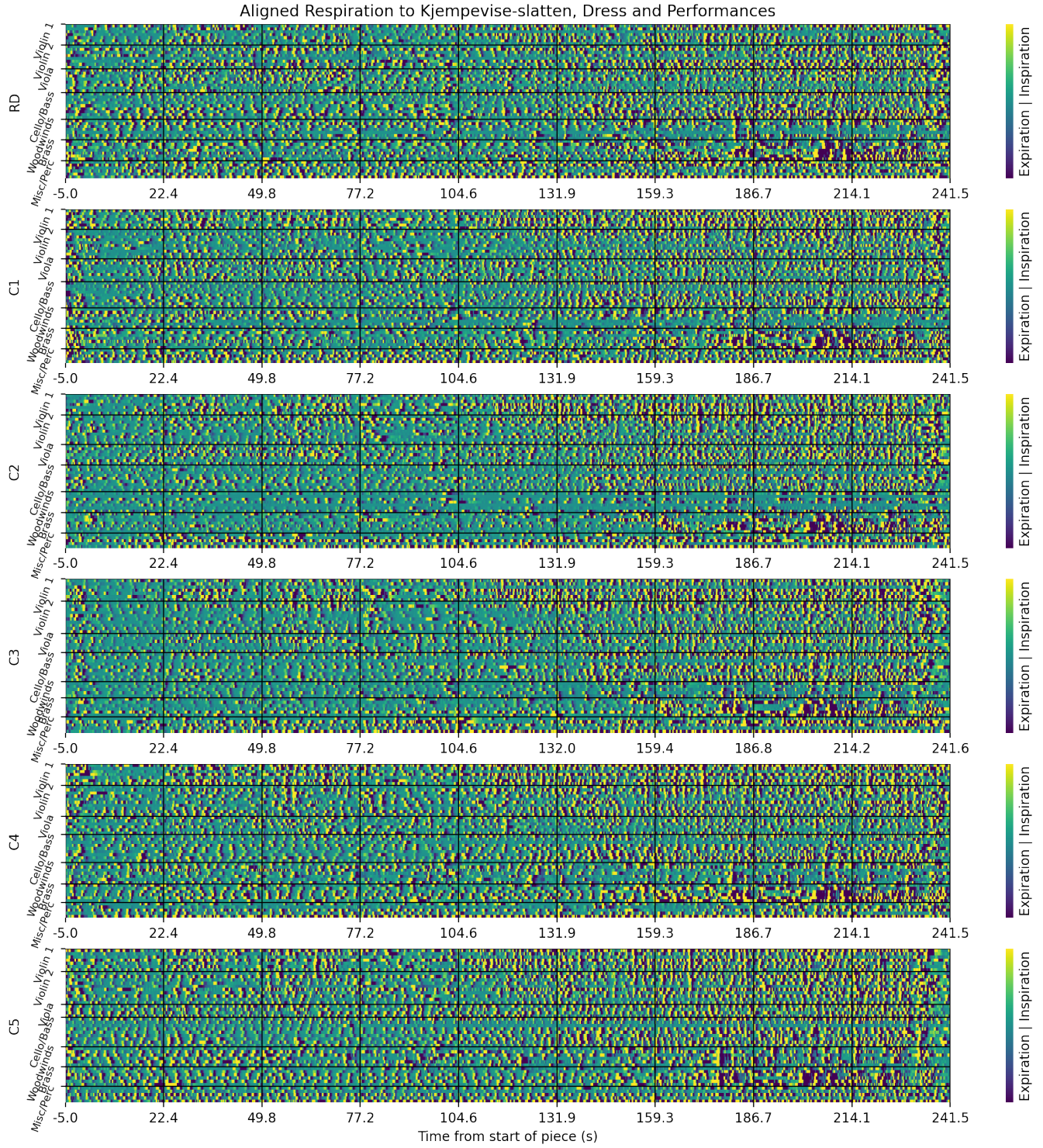


Figure 7: This figure shows aligned respiration across the orchestra during the performance of one piece, Kjempevise-slåtten. Yellow marks chest expansion, inspirations, while dark blue shows sharp expirations. The shifting texture of inspirations reflects this piece's escalation of intensity and the gradual accumulation of players. While musically aligned inspirations are expected across the winds, there are also many moments of strongly aligned inspirations across strings sections. This will be a special focus of future analysis.