Supplemental materials for "Unconscious physiological response of healthy volunteers to dynamic respiration-synchronized couch motion"

Authors

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Content

1. Sheet for Questionnaire 1

Fragebogen 1   **1**

Versuchspersonnummer: _____

Geschlecht: ☐ weiblich   ☐ männlich

Körpergewicht (in kg):   _____

Alter (in Jahren):   _____

Fragen zu Ihrer Vorgeschichte

Wurde Ihnen schon einmal schlecht aufgrund von Bewegungen (auf dem Schiff, im Auto…)?

☐ Ja   ☐ Nein

Wenn ja, wie oft?

☐ 1-2 mal

☐ manchmal bei bergigen Autofahrten

☐ manchmal bei Schifffahrten

☐ häufig bei bergigen Autofahrten

☐ häufig bei Schifffahrten

☐ immer bei bergigen Autofahrten

☐ immer bei Schifffahrten

☐ bei anderen Dingen, bitte Häufigkeit und bei was angeben:

_____

Bitte nicht ausfüllen:

☐ Kopfabstand (cm): _____

ETH zürich   Fragebogen 1   pd|z

Fig. 1: The first questionnaire (in German), which was filled in by each volunteer before the measurement procedure.

The first part of the questionnaire shown in Fig. 1 asks for the gender of the volunteer (female, male), the body weight in kg, and the age in years. The second part asks for the history of motion sickness, whether it has happened before (yes, no), and if yes, how often. The possible answers to tick are:

- once or twice
- sometimes on a winding road
- sometimes on a boat
- often on a winding road
- often on a boat

- always on a winding road
- always on a boat
- Any other possible situations. In such a case, the volunteers were asked to describe the situation and write how often it happened.

2. Sheet for Questionnaire 2

Fragebogen 2   **1**

Versuchspersonnummer: _____

Fragen zu Ihren Empfindung beim Versuch

Bitte bewerten Sie jede Aussage mit einer Nummer zwischen 1 und 9. Eine 1 bedeutet, dass Sie dieser Aussage gar nicht zustimmen und Ihr Zustand gar nicht beeinträchtigt ist. Eine 9 bedeutet, dass Sie dieser Aussage zustimmen und Ihr Zustand derart beeinträchtigt ist, dass das Experiment abgebrochen werden muss.

Mir wurde schlecht   _____

Mir wurde schwindlig   _____

Ich fühlte mich genervt / irritiert   _____

Ich habe geschwitzt   _____

Ich habe mich unwohl gefühlt   _____

Ich fühlte mich benommen   _____

Ich habe mich schläfrig gefühlt   _____

Ich hab kalten Schweiss gespürt   _____

Ich fühlte mich verwirrt   _____

Ich habe mich müde gefühlt   _____

Mir wurde übel   _____

Mir wurde heiss   _____

Es war Schwindel erregend   _____

Es hat sich angefühlt, als ob sich alles drehen würde   _____

Ich fühlte mich, als ob ich mich übergeben müsste   _____

Ich war beunruhigt   _____

Fig. 2: The second questionnaire (in German), which was filled in after the volunteers left the couch after the measurement procedure. This questionnaire is the German version of the questionnaire developed in [1].

The English version of the statements are (in the same order as shown in Fig. 2 and taken directly from [1]):

- I felt sick to my stomach (G)
- I felt faint-like (C)

- I felt annoyed/irritated (S)
- I felt sweaty (P)
- I felt queasy (G)
- I felt lightheaded (C)
- I felt drowsy (S)
- I felt clammy/cold sweat (P)
- I felt disoriented (C)
- I felt tired/fatigued (S)
- I felt nauseated (G)
- I felt hot/warm (P)
- I felt dizzy (C)
- I felt like I was spinning (C)
- I felt as if I may vomit (G)
- I felt uneasy (S)

The single characters in the brackets after each line indicate to which of the four dimensions of motion sickness the statement belongs:

- G: Gastrointestinal
- C: Central
- P: Peripheral
- S: Sopite-related

3. Age histogram
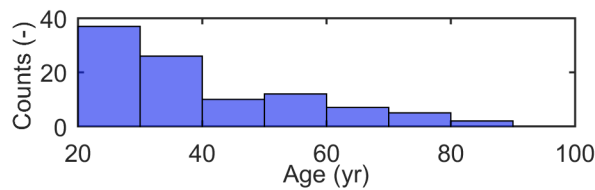
Fig. 3: Age histogram of all volunteers. The age range was 23 to 84 years and the median was 32 years.

4. Fictitious tumor motion amplitudes
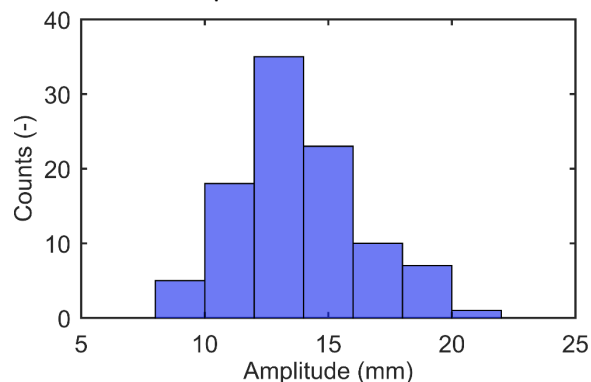
Fig. 4: Histogram of the overall mean peak-to-peak amplitudes of the fictitious tumors of the volunteers.

5. Normalization of external respiratory signal

The normalization of the peak-to-peak amplitude of the external respiration signal required an estimate of the actual peak-to-peak amplitude of the external signal as a normalization value. The

estimation approach was to detect the inspiration and expiration peaks and sequentially computing their differences. Then, the normalization value was the mean of these differences. However, the real-time detection of the peaks tended to lag behind the actual peaks, especially the inspiration peaks (Fig. 5). The detection approach was to do a linear fit of the last 0.8 s and consider the zero-crossings of the slope of the linear fit. This approach caused a systematic underestimate of the peak-to-peak amplitude. The underestimate explains the difference between the resulting median fictitious tumor motion peak-to-peak amplitude of 14 mm and the preset multiplication value of 11 mm for the fictitious tumor motion (see section Motion trajectory).
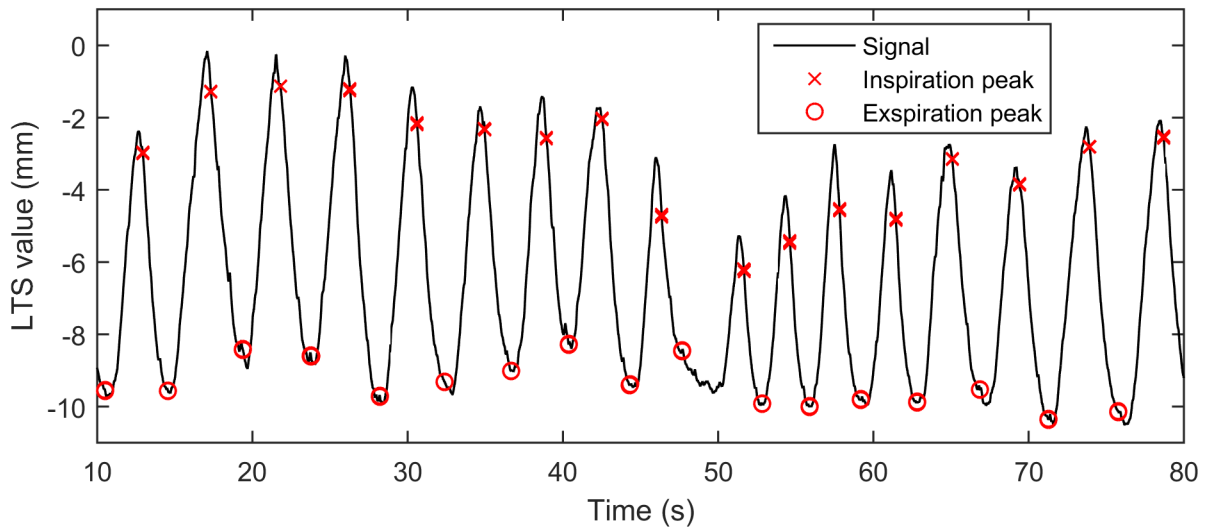
Fig. 5: Example for the peak detection results. The peak detection of the inspiration peaks lagged behind, which led to an estimate of the peak-to-peak amplitude smaller than the actual peak-to-peak amplitude.

6. Histograms of respiration characteristics and physiological signals
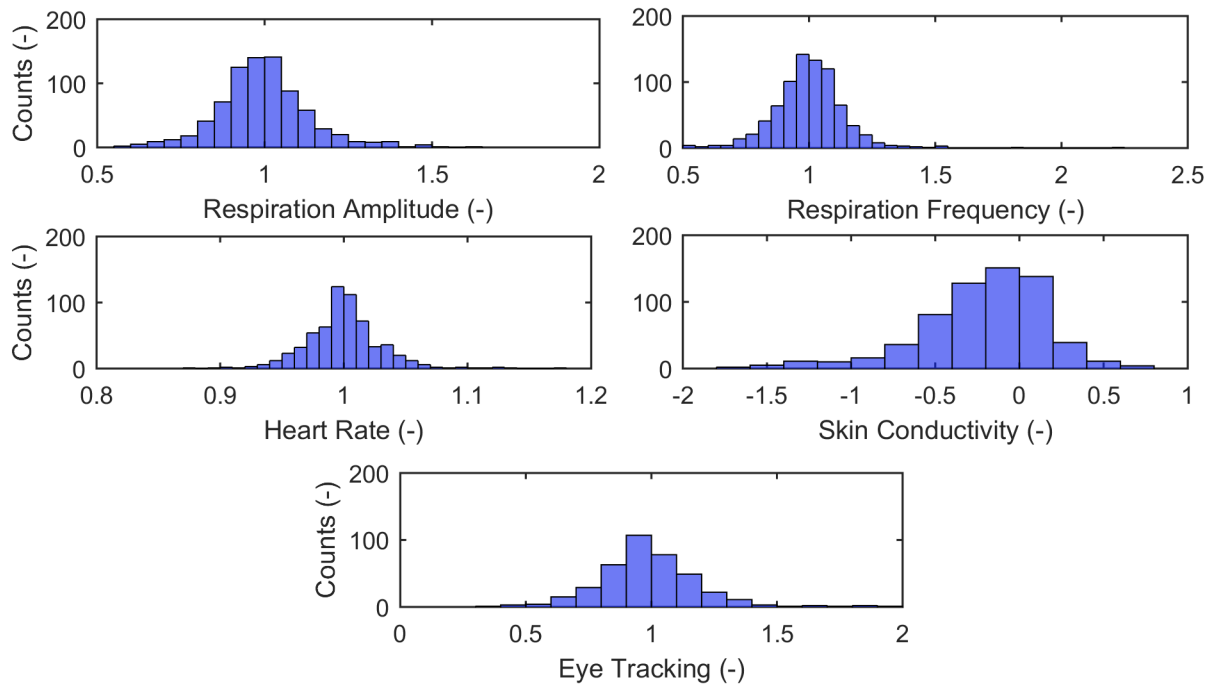

Fig. 6: The histograms of the respiration characteristics and the physiological signals after taking their respective mean values over all segments. There were eight values (three tracking, four static, and one chirp) per volunteer included. The histograms contain all segment mean values of each included volunteer, as they were used in the hypothesis tests. All values were normalized.
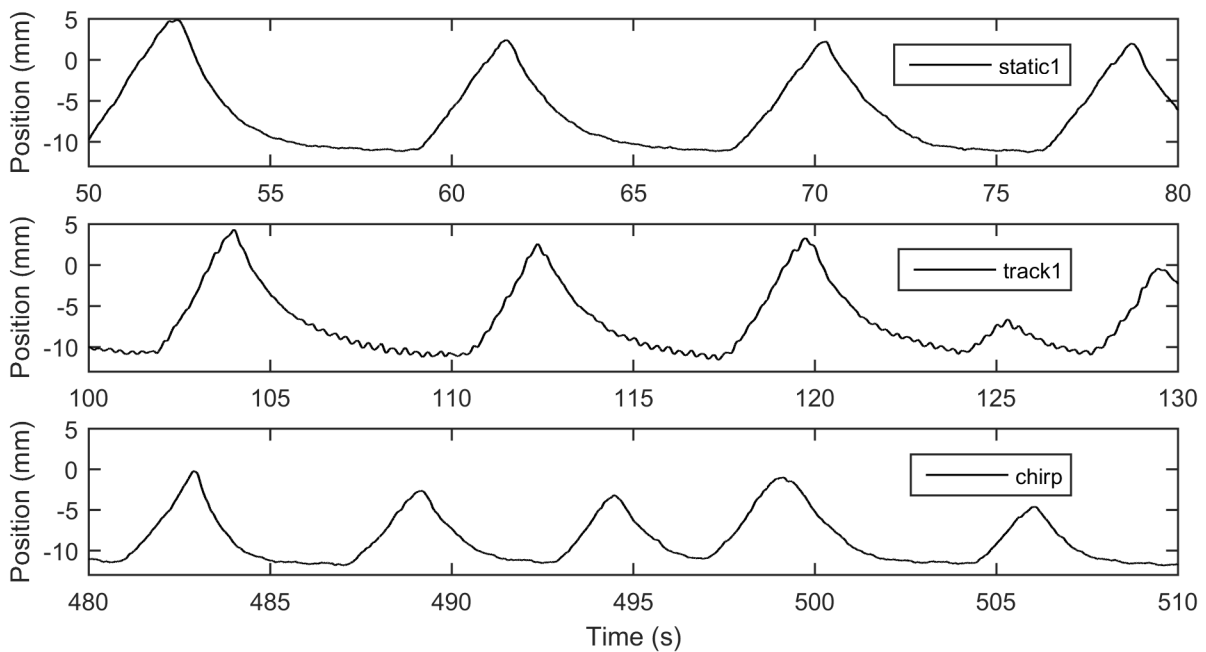
5

7. Small oscillations of respiration measurement

Fig. 7: The respiration measurements of one volunteer. Three short intervals taken from the first static segment, the first tracking segment, and the chirp segment. The middle panel shows the small oscillation (see Section 4. Discussion in the original manuscript) at frequencies above 1 Hz, which do not occur in the other segments. These small oscillations might be the cause of the respiration frequency increase during the tracking segment.

8. Eye tracking results
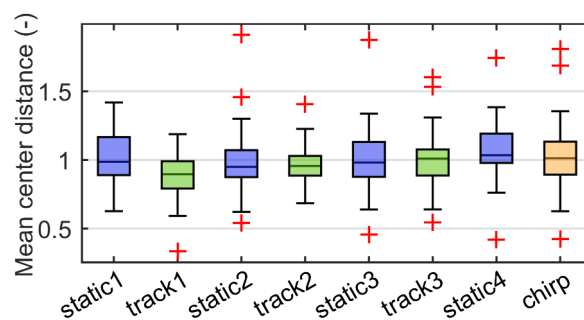
Fig. 8: Box plot of the mean center distances of the current gaze location. The center is defined as the average gaze location over the complete measurement procedure. For each segment and volunteer, the mean distance of the gaze location from the center was computed.

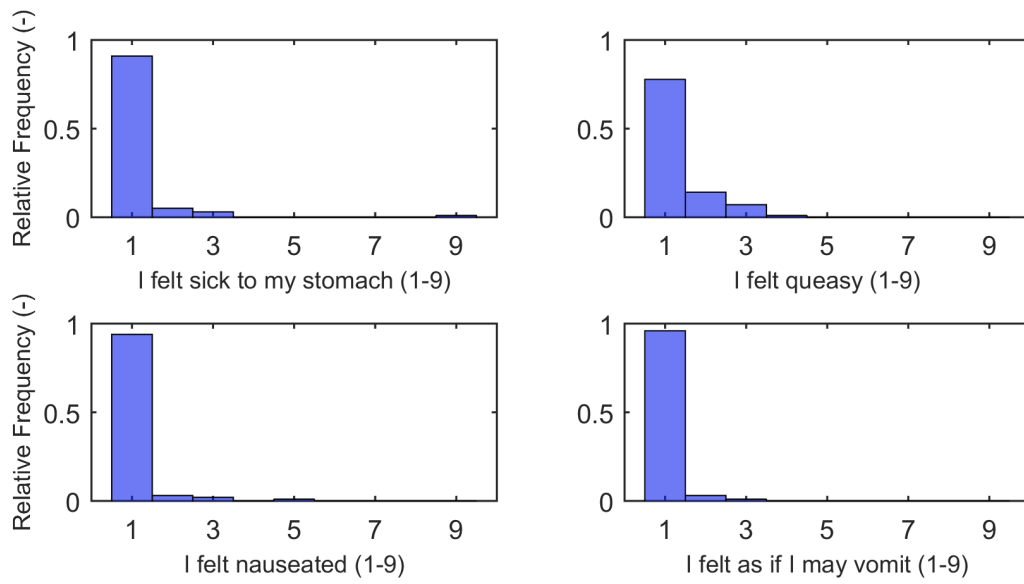# 9. Score histograms of Questionnaire 2

Fig. 9: Histograms of the scores for the statements of Questionnaire 2 associated with the gastrointestinal dimension of motion sickness [1].
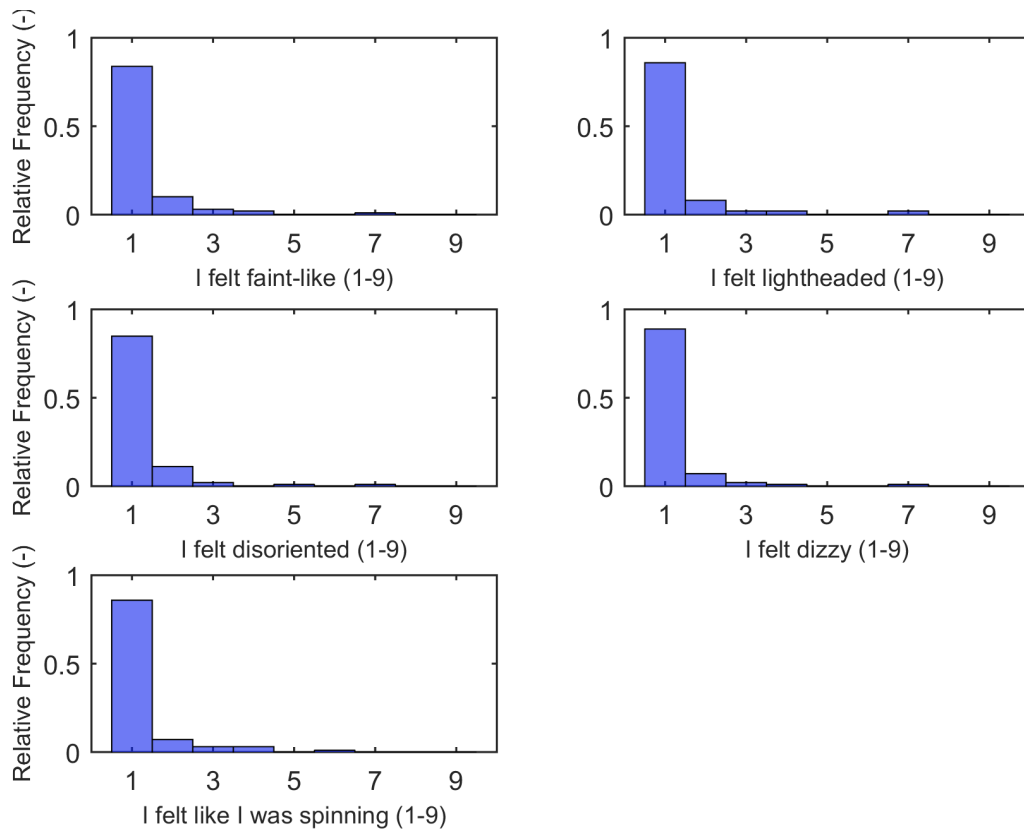

Fig. 10: Histograms of the scores for the statements of Questionnaire 2 associated with the central dimension of motion sickness [1].
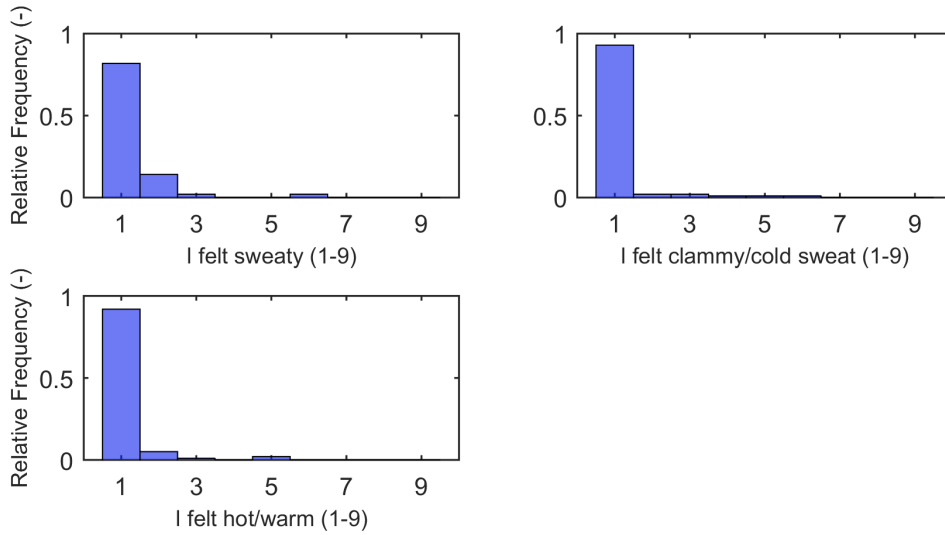
Fig. 11: Histograms of the scores for the statements of Questionnaire 2 associated with the peripheral dimension of motion sickness [1].
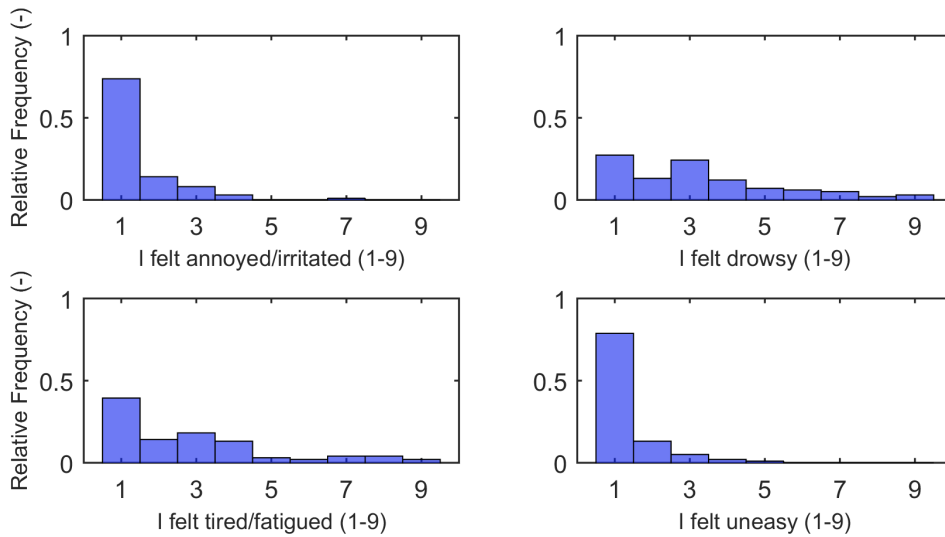

Fig. 12: Histograms of the scores for the statements of Questionnaire 2 associated with the sopite related dimension of motion sickness [1].

10. Questionnaire 2 scores and motion sickness history

The scores of Questionnaire 2 seem to be only very slightly dependent on motion sickness history. Volunteers with motion sickness history tended to report slightly higher scores.
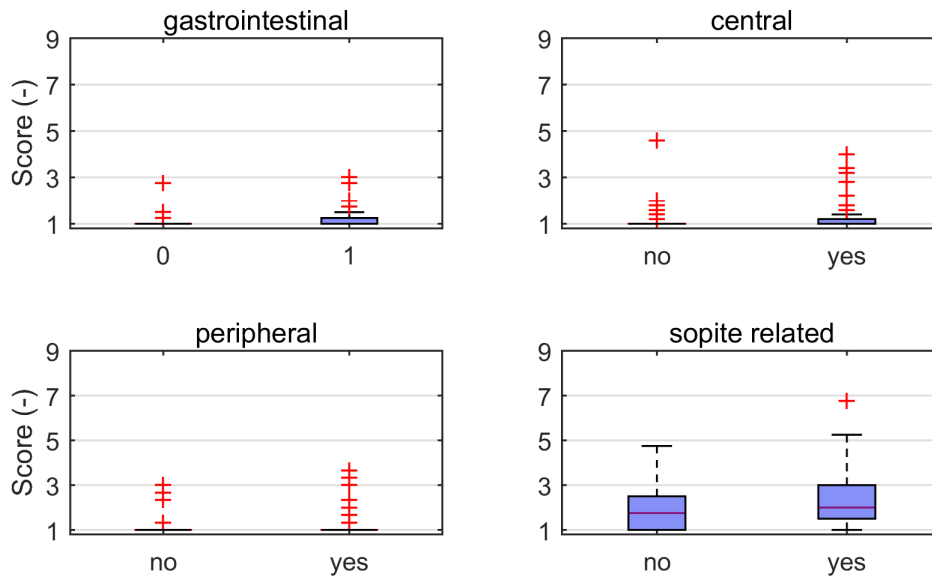
Fig. 13: Box plots of the four dimensions of motion sickness (Questionnaire 2). Each panel shows the scores (median, quartiles and whiskers, which include all data points below a given distance from the respective quartile) of volunteers that either reported in Questionnaire 1 to have experienced motion sickness before (yes) or did not (no).

11.   Respiration characteristics and scores of questionnaire 2

The respiration characteristics (amplitude and frequency) do not seem to correlate to the scores of Questionnaire 2 (Fig. 14 and Fig. 15). The Pearson correlation coefficients are generally small and the corresponding p-values not significant.
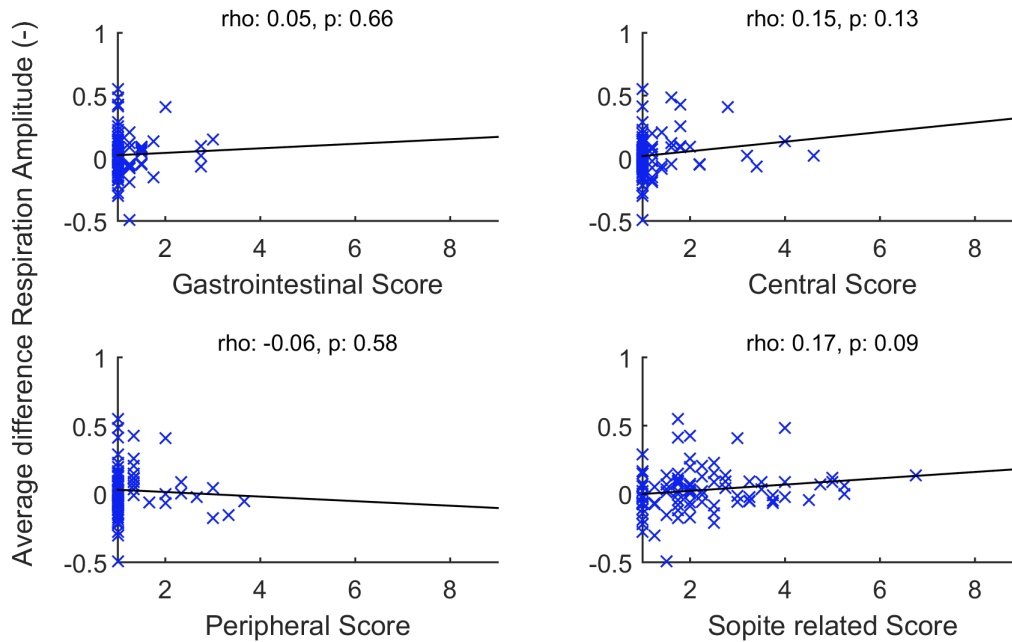

Fig. 14: Scatterplot of the average difference of the respiration amplitude between the static segments and the tracking segments and the corresponding score of Questionnaire 2. Each blue cross corresponds to one volunteer. Above each panel is the linear Pearson correlation coefficient (rho) with the corresponding p-value (p). The black line shows the best linear fit.
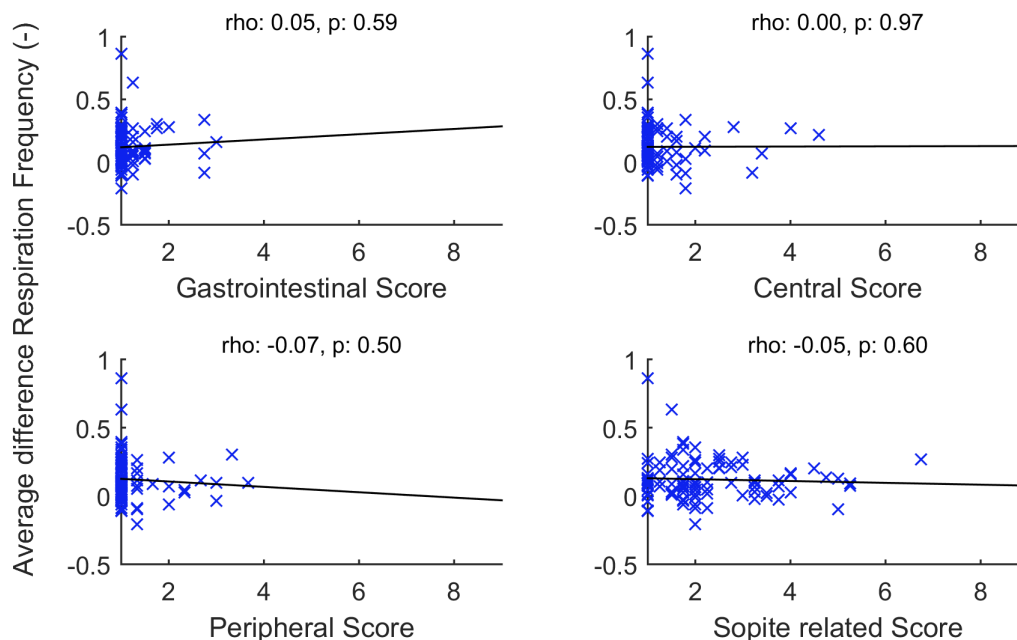

Fig. 15: Scatterplot of the average difference of the respiration frequency between the static segments and the tracking segments and the corresponding score of Questionnaire 2. Each blue cross corresponds to one volunteer. Above each panel is the linear Pearson correlation coefficient (rho) with the corresponding p-value (p). The black line shows the best linear fit.

12. Physiological measurements and scores of Questionnaire 2

The skin conductivity increase during the first tracking segment does not seem to correlate with Questionnaire 2 scores, see Fig. 16. The Pearson correlation coefficients are generally small and the corresponding p-values not significant.
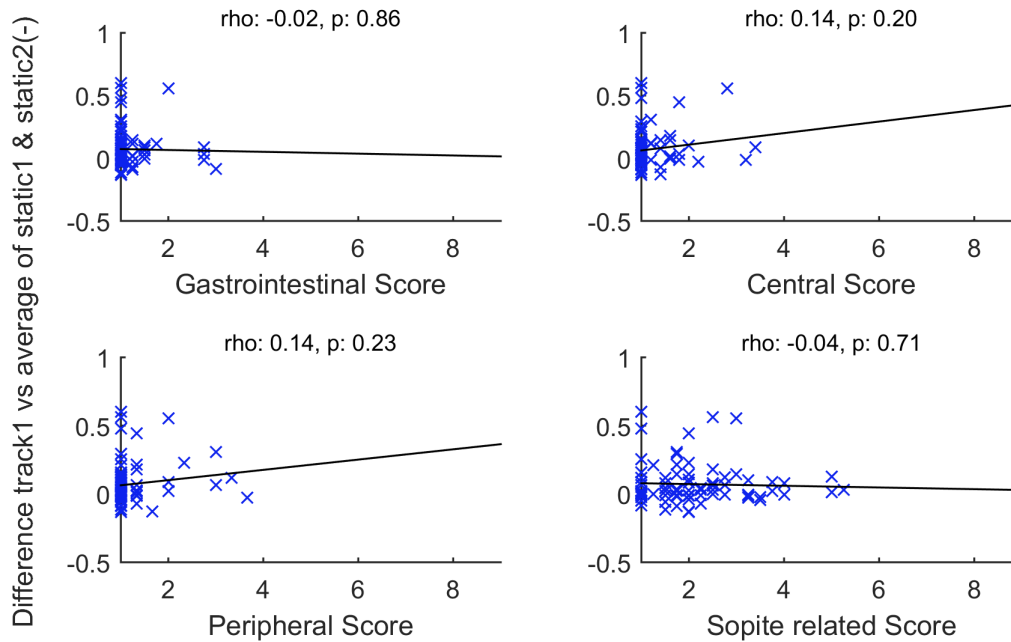

Fig. 16: Scatterplot of the difference of the skin conductivity during the first tracking segment and the mean of the first and second static segments, and the corresponding score of Questionnaire 2. Each blue cross corresponds to one volunteer. Above each panel is the linear Pearson correlation coefficient (rho) with the corresponding p-value (p). The black line shows the best linear fit.

The heartrate difference between tracking and static segments does not seem to correlate with Questionnaire 2 scores, see Fig. 17. The Pearson correlation coefficients are generally small and the corresponding p-values not significant.
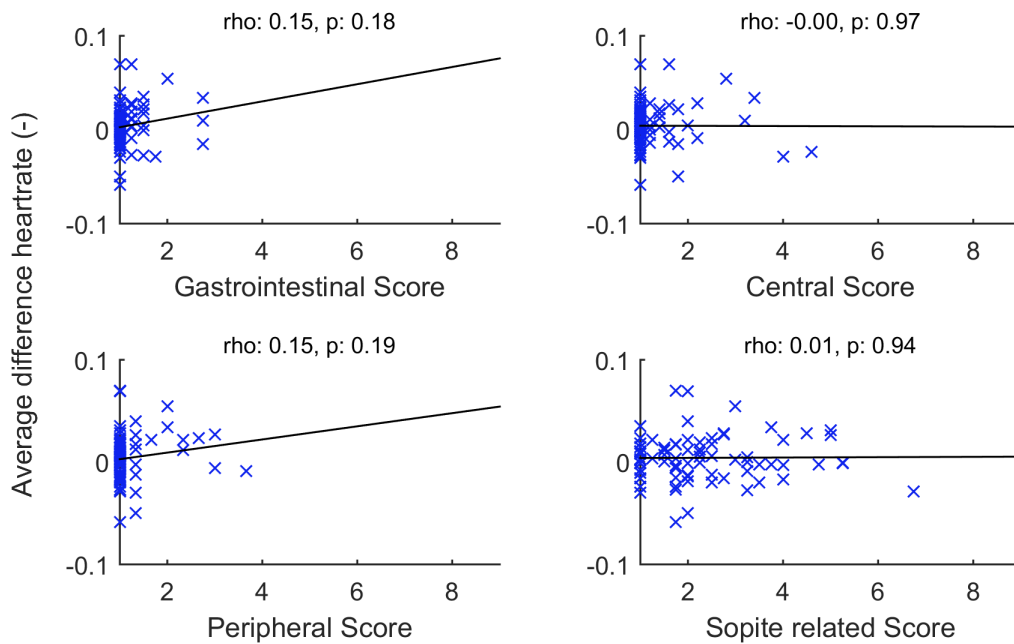
Fig. 17: Scatterplot of the average difference of the heartrate during the tracking segments and the static segments, and the corresponding score of Questionnaire 2. Each blue cross corresponds to one volunteer. Above each panel is the linear Pearson correlation coefficient (rho) with the corresponding p-value (p). The black line shows the best linear fit.

The gaze-point deviation difference between tracking and static segments does not seem to correlate with Questionnaire 2 scores, see Fig. 18. The Pearson correlation coefficients are generally small and the corresponding p-values not significant.
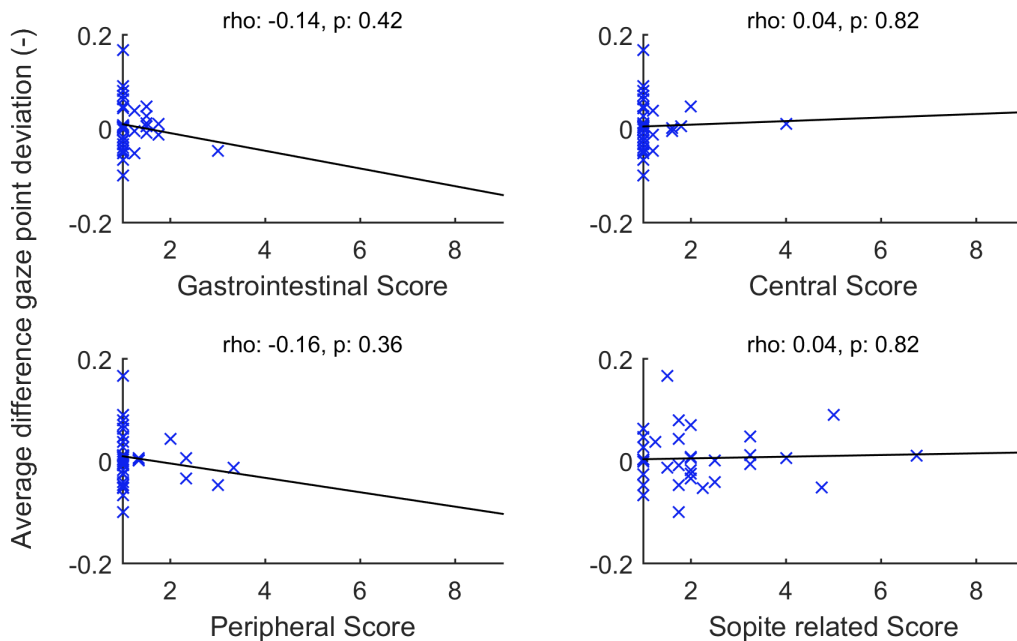

Fig. 18: Scatterplot of the average difference of the gaze-point deviation during the tracking segments and the static segments, and the corresponding score of Questionnaire 2. Each blue cross corresponds to one volunteer. Above each panel is the linear Pearson correlation coefficient (rho) with the corresponding p-value (p). The black line shows the best linear fit.

References

[1]   Gianaros PJ, Muth ER, Mordkoff JT, Levine ME, Stern RM. A questionnaire for the assessment of the multiple dimensions of motion sickness. Aviation, space, and environmental medicine, 2001;72:115–119.