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Monitoring engagement in an inaugural lecture

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Synopsis Interpersonal physiological synchrony (PS) refers to simultaneous changes over time in a physiological signal recorded from multiple individuals, and has been described as a marker of attentional engagement. Using wearable devices, we recorded PS in skin conductance in live audience of an inaugural lecture. Part of the recorded audience members had a personal relation with the speaker (n=14) and part a professional relation (n=12). We expected these two groups to differ in pattern of attentional engagement. We found that PS could be reliably detected, that PS varied with the occurrence of pre-defined engaging events, and that PS differentiated to some extent between the two groups. These results are promising for PS as a tool to assess attentional engagement continuously and implicitly out of the lab.

Background

Similarity of EEG brain signals between individuals who perceived the same stimulus, such as a movie, has been found to be a marker of willfully focused attentional engagement (Dmochowski et al., 2012). This can be understood when considering that when individuals all attend to certain aspects in the external world, their physiological responses will be triggered by similar events, whereas this is less the case when they are not attending. We demonstrated before that this principle of physiological synchrony (PS) also applies to skin conductance (electrodermal activity or EDA) and heart rate, and that this predicts cognitive performance. For instance, in Stuldreher et al. (2020a) we showed that the more participants' signals correlated to others' signals when attending an audiobook, the more questions about the audiobook they answered correctly later.

However, our results were gathered in the lab, using data from successively recorded participants who were exclusively focused on their task. Is PS in signals from the peripheral nervous system also an informative marker in real life, when participants experience different types of distractions? Do we obtain PS higher than chance in such noisy conditions? Does PS over time identify engaging events? How does mentally induced PS compare to PS associated with physical movement? Can we distinguish between groups that are expected to differ in pattern of attentional engagement?

We investigated these questions by recording part of the audience during the inaugural lecture 'Monitoring Mental State: From Lab to Life', given by Anne-Marie Brouwer, in October 2023 at the Radboud University in Nijmegen.

Methods

Approval of the Radboud Ethical Committee was obtained. Fifteen individuals with a close personal relationship with the speaker, and 15 individuals with a professional relationship, were fitted with EdaMove4 skin conductance sensors (Movisens GmbH, Karlsruhe, Germany, Figure 1). They sat with the rest of the audience in the lecture hall.

In the fifty-minute lecture (online at https://www.youtube.com/watch?v=dBRgakLTmm4), several events were embedded that were hypothesized to increase attentional engagement: participants were asked to silently count spoken k's for about three minutes of the lecture; they were instructed to sing a song after a count-down had elapsed (Brouwer & Hogervorst, 2014); and the lecturer announced to display a ranking of participants' names in terms of measured attention on the screen (which she did not actually do). Events that were hypothesized to increase attentional engagement especially in the personal group were: displaying slides that contained pictures of a person known to them (the lecturer's brother, Figure 1); and displaying a video message of the lecturer's son (in the context of a paradigm meant to induce positive emotion). Also, the audience was asked to stand up, in order to examine PS during synchronized movement.

EDA artifacts were automatically marked and data were processed to obtain the phasic component of EDA (Thammasan et al., 2020; Stuldreher et al., 2023). Four participants were removed from analysis because more than 10 percent of their data were marked as artifactual. We computed PS as inter-subject correlations in 15 s windows sliding at 1 s increments for each participant with of each the other participants (Stuldreher et al., 2020b, 2023). Averaging over the correlations results in the participant-to-group inter-subject correlations.

FIGURE 1
Pictures of the lecture (left), the EDA sensors (top right) and one of the slides in which pictures of the lecturer's brother were integrated (bottom right).

To test the significance of inter-subject correlations over chance level, we used the circular shuffle statistic (Pérez et al., 2021; Madsen & Parra, 2022).

To test whether inter-subject correlations differed between participants with a personal and professional relationship with the speaker, we determined the average participant-to-group inter- subject correlation for each participant with each other participant in the same (personal or professional) and in the different group. Using paired-sample t-tests we then investigated whether participant-to-group inter-subject correlations differ between 'same' and 'other' group.

Results

All 26 participants show inter-subject correlations significantly higher than chance level.

The left panel in Figure 2 shows PS over time during a part of the lecture where pictures of the speaker's brother were shown, and the audience was asked to stand up, separately for the personal and professional groups. As expected, PS seems higher for the personal group than the professional group upon viewing the speaker's brother. PS increases for both groups when standing up. The effect does not seem to be much stronger than the effect of the picture, which is not associated with large body movements.

The right panel in Figure 2 shows that participants that have a personal relationship with the speaker have significantly higher within-group than between-group PS. For 11 out of 14 participants, responses are more similar to other participants in the personal group than to participants from the professional group. Participants that have a professional relationship with the speaker do not have significantly higher within-group than between-group PS. For 7 out of 12 participants the within-group PS is higher than the between-group PS.

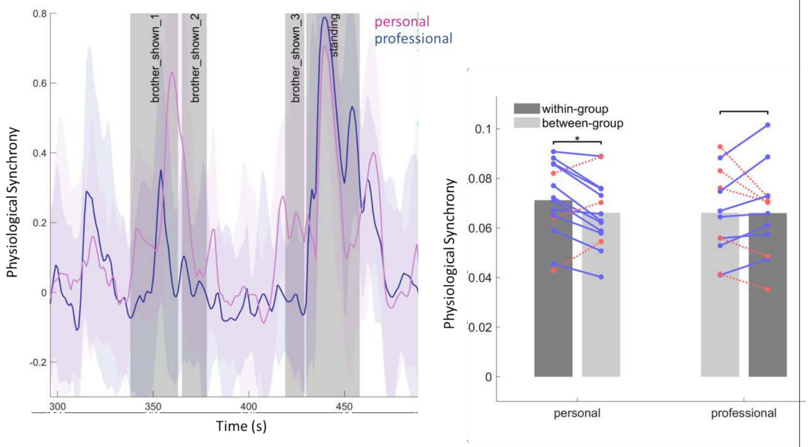

FIGURE 2

Physiological Synchrony (PS) as determined through inter-subject correlations in EDA. Left panel: PS over time separately for participants with a personal (pink) and professional (blue) relation with the speaker, for part of the lecture in which pictures of the lecturer's brother were shown and the audience was asked to stand up (grey bars). Right panel: PS for each of the participants in the personal group (left data points – average values indicated by bars) and professional group (right datapoints – average values indicated by bars) with other members of their own group (dark bar) or participants in the other group (light bar). As expected, for most participants, within-group PS is higher than between-group PS (blue) though not for all (red).

Discussion

Results indicated that we are able to reliably and meaningfully monitor mental processes related to attentional engagement in a real life environment using PS in EDA recorded through a wearable sensor. Advantages of PS as a marker of engagement over other types of physiological markers are that it does not require labeled, personal training data and that it may be used in real life circumstances where onsets of potentially relevant stimuli are not known.

Continuous, implicit and unobtrusive evaluation of attentional engagement could support evaluation of educational or entertainment material and team performance. Real time insight may help to intervene when a lack of attentional engagement is detected.

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