Changes in Heart-Brain Integration precede Psychogenic Pseudosyncope

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Introduction

Psychogenic pseudosyncope (PPS), psychogenic non-syncopal collapse (Heyer 2018), or functional syncope (Benbadis 2022) is a condition characterized by transient subjective loss of consciousness that mimics syncope, but without the associated drop in blood pressure. PPS is routinely diagnosed based on history and examination but can be confirmed with simultaneous ECG and electroencephalography (EEG) recordings during a tilt-table test (TTE).

The heartbeat-evoked potential (HEP) is an event-related potential time-locked to the heartbeat. It has been shown in experimental settings to correlate with both state and trait variables, including attention towards or away from the body, and with psychiatric diagnosis. It is thought to be a marker of heart-brain integration, and an implicit measure of Interoception.

Interoception is sensing, interpretation and integration of signals originating from within the body across both conscious and unconscious levels of processing (Khalsa, 2018). Interoceptive abnormalities have been identified in patients with functional seizures, both as state and trait abnormalities of interoceptive processing and implicitly measured by the HEP. Similarly, patients with PPS exhibit autonomic changes that precede the onset of the event in tilt-table testing, distinct from cardiac syncope (Heyer, 2018).

Aim

The present study aimed to explore HEP, as an implicit measure of heart-brain integration, in the context of PPS, recorded during routine TTE with simultaneous EEG. An increase in heart-brain integration, as would be implied by an increase in HEP, prior to the onset of the event may suggest an increase in attention towards the body (Elkommos 2023), while a decrement may imply a dissociative phenomenon (as seen in patients with FS, Elkommos 2023).

Comparison with patients with vasovagal syncope (VVS) permitted the exclusion of effects on the HEP that relate to changes in cardiac artefact due to the TTE. EEG and polygraphy data was collected from 30 patients with PPS and 30 with VVS undergoing a tilt-table test.

Method

Artefact Subspace Reconstruction (ASR) and Independent Component Analysis (ICA) were then performed on the raw EEG data. Baseline (-40 minutes), syncopal, and successive 2-minute segments were clipped from the EEG in the lead-up to the onset of the syncopal episode.

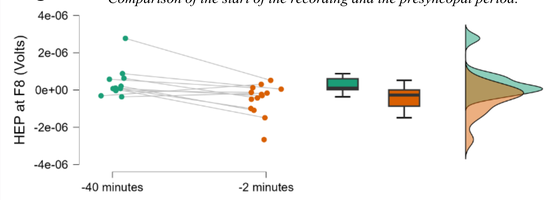
R-wave segments with excessively high amplitude (over 120μV) were excluded from calculations. Baseline correction was applied between 0.2 and 0.05s pre-R wave. Following findings from previous research, we examined the HEP at F8 and C4.

The HEP was computed between 0.455 and 0.595 seconds after the R wave. This processing was performed in Python; statistical analysis was performed in JASP.

Results

The was a significant drop from the before the tilt table procedure (40 minutes before PPS onset) to the preictal period (2 minutes before PPS onset) in the F8 lead in the PPS group (Figure 1, p=0.014, Wilcoxon signed-rank test). This was not present at the C4 lead, but there was also no significant change in the HR in this period. This baseline period was present only for a minority of recordings.

Figure 1: *Comparison of the start of the recording and the presyncopal period.*



Measure 1		Measure 2	W	z	df	p
2400 seconds before event_meanHR	-	120 seconds before event_meanHR	93.000	−1.369		0.176
2400 seconds before event_F8	-	120 seconds before event_F8	51.000	2.395		0.014
2400 seconds before event_C4	-	120 seconds before event_C4	61.000	0.057		0.978

Note. Wilcoxon signed-rank test.

We also examined the presyncopal and syncopal periods in more detail and compared them with those of the VVS group. Only six of the thirty VVS patients had definite vasovagal syncope on the record.

There was no significant difference in the change from preictal to ictal period in the HEP at F8 or C4, between Preictal and ictal periods (each 2 minutes long, Figure 2). The data was highly non-normal, so bootstrapping was performed at a patient level to allow ANOVA analysis. While there is a significant increase from 10 minutes to 2 minutes presyncope in both VVS and PPS, there is a significant interaction between the time and the patient group at the onset of the syncope. There is a decrease in the F8 HEP in VVS, but a small increase in the F8 in PPS. There was no significant change in cardiac field artefacts during that period.

Figure 2:

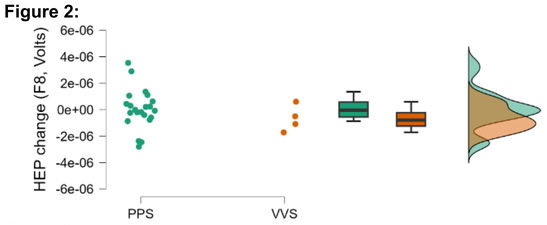
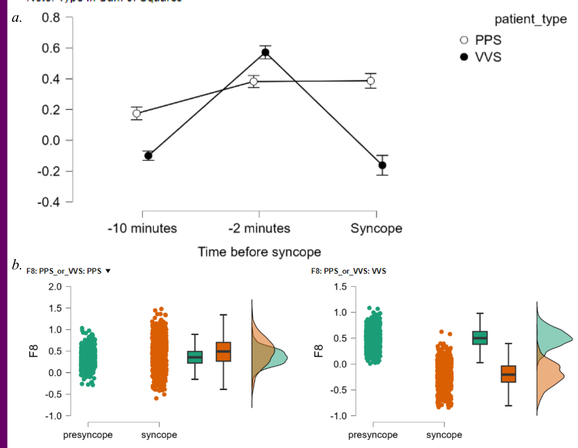


Figure 3:

ANOVA - F8

Cases	Sum of Squares	df	Mean Square	F	p
period	2192.318	2	1096.159	1071.665	< .001
patient_type	381.965	1	381.965	373.430	< .001
period ✻ patient_type	1065.473	2	532.737	520.833	< .001
Residuals	89024.268	87035	1.023		

Note. Type III Sum of Squares



(a) Patient-level, bootstrapped analysis of the change in the HEP at F8 between -10 minutes, -2 minutes and syncopal periods (in μV), for both psychogenic pseudosyncope (PPS) and vasovagal syncope (VVS) groups. (b) F8 HEP in PPS (left) and VVS (right) in the presyncopal and syncopal epochs.

Conclusion

The differences in the HEP between PPS and VVS groups at the onset of syncope may suggest that patients with VVS have reduced heart-brain interaction as a result of reduced cerebral perfusion and/or that patients with PPS experience an increase in bodily attention at the onset of the event. The fact that both groups show an initial increase in HEP from baseline may suggest both groups may attend more to their body in the first part of the test; the absence of a significant change in cardiac field effect is reassuring that this finding is not artefactual.

The dataset's paucity of definite VVS events limits this study, as it is unclear how representative this sample is. The absence of detailed behavioural information from this analysis also prevents us from correlating HEP with attention or symptomaticity.

Subsequent research should aim to include more events of different types and combine them with more behavioural information. Also, while HEP may vary with attention, it may also vary with other state and trait variables, and so combination of the HEP data with other variables may also elucidate further the meaning of the changes in the amplitude of the HEP.

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