**Study A — Wₘ (Bio‑Somatic) Coupling: Hippocampus ↔ Insula ↔ Vagal Tone**

**Title**

Hippocampal–Insular Coupling and Vagal Dynamics During Symptom‑Safe Trauma Imagery: A Test of Wₘ (bio‑somatic) Collapse/Reentry

**Rationale (WFT → Neural)**

WFT posits that Wₘ(bio‑somatic) anchors somatic recursion independent of symbol; collapse appears as somatic flashback and temporal desync. Neural substrates (insula/interoception) should couple with hippocampal systems during triggered imagery, with autonomic (vagal) shifts indexing collapse and reentry.

**Hypotheses**

1. **Coupling↑ under load:** During trauma imagery (vs neutral), hippocampus↔anterior insula functional connectivity increases.
2. **Autonomic shift:** HRV (RMSSD) decreases and respiration irregularity increases during imagery; magnitude correlates with coupling.
3. **Reentry metric:** Post‑run guided reentry (breath cadence) restores HRV toward baseline and reduces coupling to neutral levels; incomplete restoration predicts higher next‑day intrusion severity.
4. **Clinical moderation:** PTSD group shows larger coupling↑ and slower reentry vs matched controls.

**Design**

* Mixed factorial: Condition (Neutral, Symptom‑Safe Imagery, Reentry) × Group (PTSD, Control).
* Within‑subject counterbalanced blocks; therapist present; stop rules pre‑registered.

**Participants**

* N=60 (30 PTSD, 30 controls), 18–65, right‑handed, vision normal/corrected.
* PTSD diagnosis via CAPS‑5; controls screened negative. Exclude: cardiac arrhythmias affecting HRV, psychotropic dose changes <6 weeks.

**Tasks/Stimuli**

* **Imagery scripts**: participant‑generated, clinician‑edited to be symptom‑safe; 30–45s audio blocks.
* **Reentry**: paced breathing (e.g., 6 cpm) + brief grounding script.

**Measures**

* 3T/7T fMRI (hippocampus, insula, PCC as covariate); multi‑echo if available.
* Physiology: HRV (ECG), respiration belt, EDA, pupillometry.
* Self‑report: SUDS (per block), PANAS; next‑day intrusions diary (24–48h).

**Procedure**

1. Baseline rest (5 min, eyes open).
2. Neutral blocks ×3.
3. Imagery blocks ×3 (with safety monitoring).
4. Reentry block after each imagery (paced breath 2 min + grounding 1 min).
5. Debrief + safety check; next‑day diary.

**Primary Outcomes**

* FC(hipp↔insula) per condition; HRV change (ΔRMSSD) per condition; correlation between FC and HRV.

**Secondary Outcomes**

* Next‑day intrusions ~ reentry restoration index (HRV back‑to‑baseline % + FC normalization).

**Analysis Plan**

* **First‑level:** GLM with block regressors; nuisance (motion, physio). Extract ROI timeseries.
* **Connectivity:** PPI for imagery>neutral; β‑series or gPPI robustness check.
* **Autonomic coupling:** Linear mixed models: FC ~ Condition\*Group + HRV + (1|subject).
* **Reentry index:** Composite z of HRV restoration + FC normalization. Predict next‑day intrusions.
* **Correction:** FDR across ROI pairs; preregistered ROIs to limit multiplicity.

**Power & N**

* Detect fMRI FC Δ of d=0.5 within‑subject (α=.05, power=.80) → n≈34; inflate for groups and attrition → N=60.

**Exclusions**

* Excess motion (>0.5 mm FD in >20% volumes), panic stop, equipment failure.

**Prereg Items**

* ROIs (hippocampus head/body; anterior insula), HRV metric (RMSSD), primary contrasts, reentry composite formula, stop rules.

**Ethics & Safety**

* Clinician present; real‑time distress monitoring; immediate abort allowed.

**Reentry Protocol**

* Paced breath + grounding after any provocative block; post‑scan debrief; resource handout; optional follow‑up call.

**Data/Code**

* BIDS; prereg analysis scripts; de‑identified derivatives shared on OSF.

**Notes for All Studies**

* **Blinding:** Analysts blinded to condition/group where feasible.
* **Multiple Comparisons:** Limit to prereg ROIs; FDR for exploratory.
* **Reporting:** Deviations from prereg documented; null results reported.
* **Generalization:** Templates are modular—swap tasks for population‑specific variants (e.g., grief instead of trauma; dyadic tasks for Wₑ).