Neuroimaging Insights into Trauma Experienced Under Psychoactive Substances

Ophir Netzer[1], Noa Magal[1], Yonatan Stern[1], Tzuk Polinsky[1], Raz Gross[2,3], Pia Rotshtein[4], Kristoffer C. Aberg[5], Edna Furman-Haran[5], Rony Paz[5], Roee Admon[1,6,7], Roy Salomon[1,6,7,8]

1. School of Psychological Sciences, University of Haifa, Haifa; 2. Division of Psychiatry, Sheba Medical Center, Ramat Gan; 3. Department of Epidemiology and Preventive Medicine; and Department of Psychiatry, Faculty of Medicine, Tel Aviv University, Tel Aviv;

4. Neuroimaging Research Unit, University of Haifa, Haifa; 5. Weizmann Institute of Science, Rehovot; 6. The Integrated Brain and Behavior Research Center (IBBRC), University of Haifa, Haifa; 7. Department of Cognitive Science, University of Haifa, Haifa; 8. SafeHeart NGO

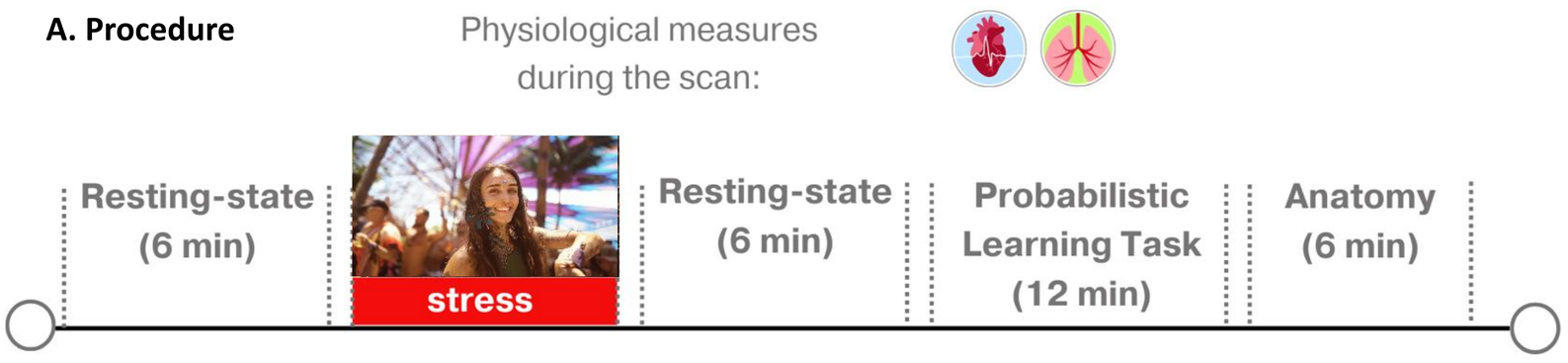
Introduction

On October 7, 2023, the Supernova festival became the site of a large-scale terror attack, exposing attendees to life-threatening traumatic events (TEs). Trauma exposure induces profound psychological and neural changes[1,2], particularly in functional connectivity of key brain networks, such as the Default Mode Network (DMN), Salience Network (SN), and Central Executive Network (CEN)[3,4], which are linked to stress responsivity and regulation[4,5]. Uniquely, many survivors of this event were under the influence of mind-altering substances, raising questions about the interaction between trauma-related and substance-induced neural alterations. This study investigates the neural and psychological impacts of this unprecedented event, evaluating the consequences of trauma experienced under the influence of psychoactive substances.

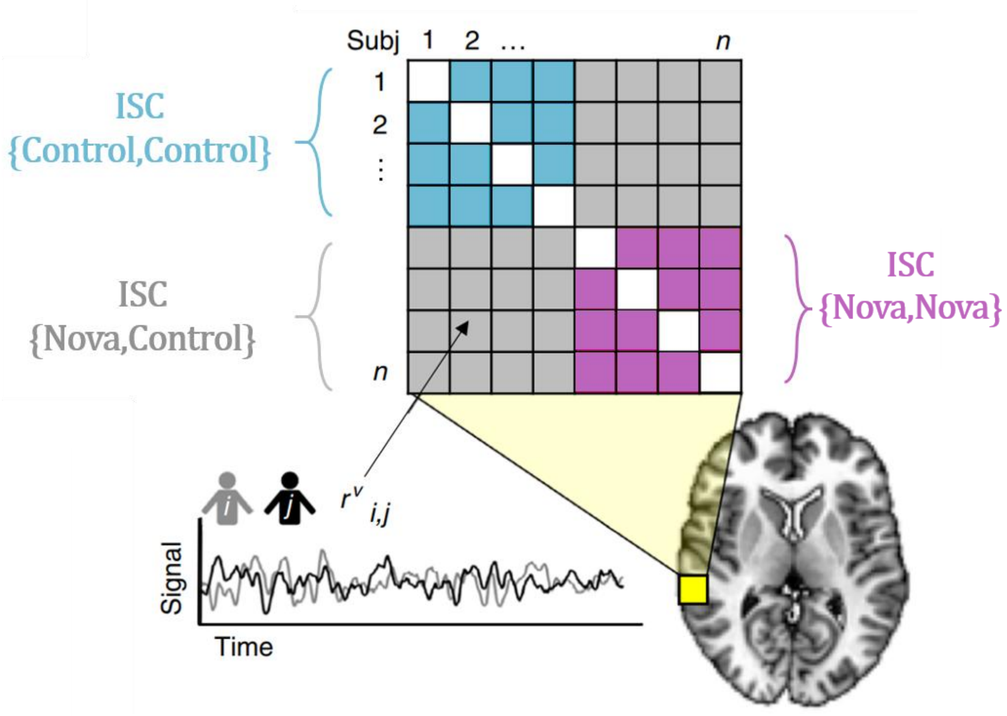
Methods

This study included 136 adults (65 males; mean±SD age: 28.62±6.91 years), comprising 72 survivors of the Supernova festival attack and 64 demographically matched controls. Data were collected 4–9 months post-TE to investigate psychological and neural correlates of trauma. Participants completed self-report questionnaires assessing demographics, substance use, and trauma-related constructs, along with clinical measures of mental distress (K6) and posttraumatic symptoms (PCL-5). Participants then attended an fMRI session (Fig. A), during which resting-state fMRI scans (6 minutes each) were conducted both before and after exposure to a 6-minute music festival-themed stressor video. Participants also performed a probabilistic learning task in the fMRI scanner. Neural responses during the video viewing were analyzed using inter-subject correlation (ISC), a method that measures the similarity of neural activity across participants in response to shared stimuli, reflecting group-level patterns of neural processing (Fig. B). We hypothesized lower brain synchronization in the experimental group than in controls during the video, as trauma survivors may respond more variably based on mental state and symptom severity.

A. Procedure



B. Inter-subject functional correlation analysis



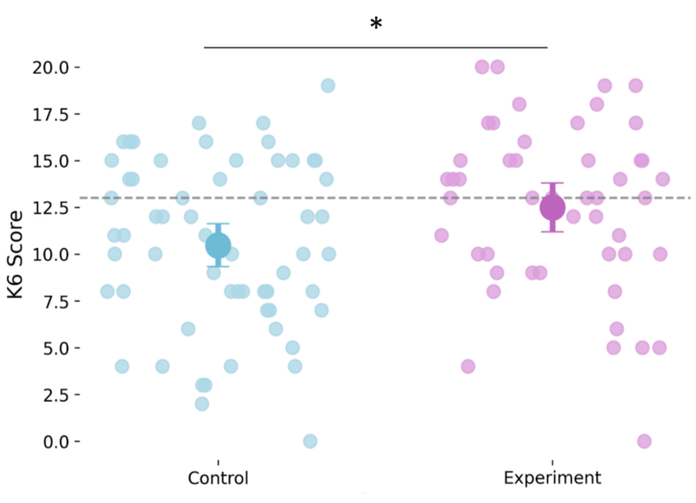
Results

In this cohort, 76% of survivors reported being under the influence of mind-altering substances during the TE. Survivors exhibited significantly higher mental distress (K6: 12.5±4.5, t=2.35,p=0.02; Fig. C) and posttraumatic symptoms (PCL-5: 40.0±15.7, t=4.83,p<0.001; Fig. D) compared to controls (K6: 10.5±4.4; PCL-5: 24.9±16.2).

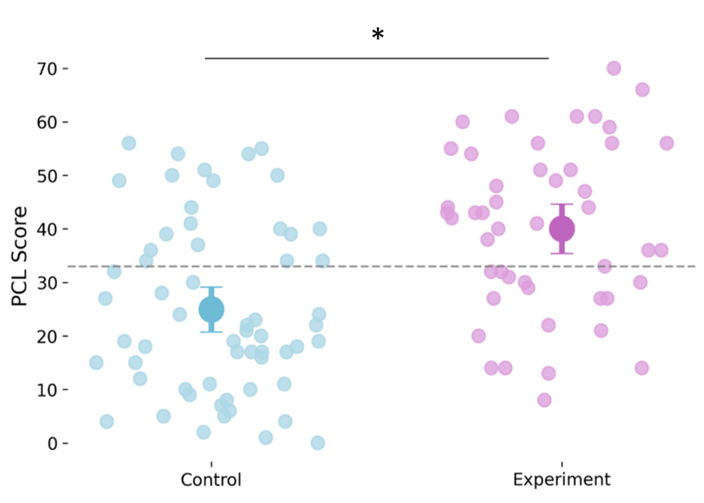
Preliminary fMRI analyses (n=20) revealed significant ISCs across widespread brain regions during exposure to the stressor movie in both groups (Fig. E). Pairwise voxel-wise ISC analysis (all $p < 0.05$, uncorrected) demonstrated (Fig. F):

- Experimental group: Higher ISC in the ventromedial prefrontal cortex (vmPFC).
- Control group: Higher ISC in the orbitofrontal cortex, middle temporal (MT) region, superior parietal lobule, and premotor areas.

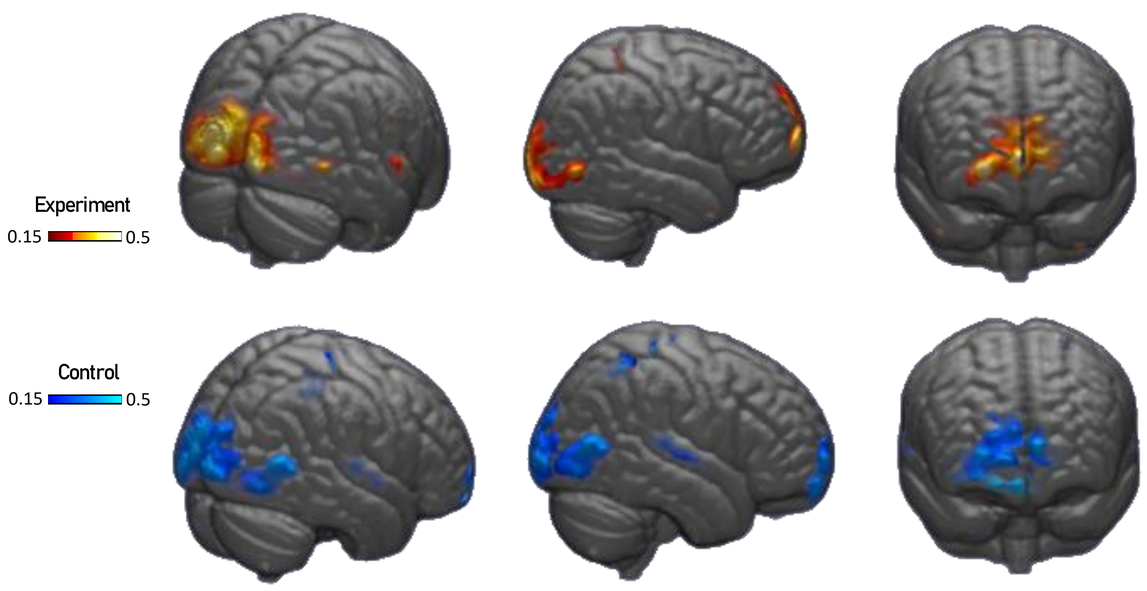
C. Mental Distress (K6)



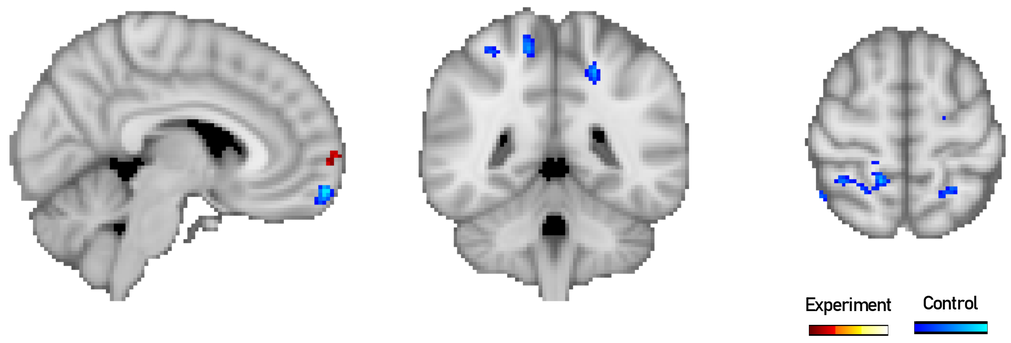
D. Posttraumatic Symptoms (PCL-5)



E. Group ISC



F. ISC Differences t>7



Conclusions

- ❑ Significant differences in distress and posttraumatic symptoms were observed between the control and experimental groups, driven by higher scores in trauma survivors.
- ❑ The experimental group exhibited stronger ISC values in the vmPFC, a key node of the default mode network.
- ❑ The control group showed increased ISC values in regions associated with visual motion, motor imagery, and autobiographical memory.
- ❑ Future analyses will integrate behavioral and neural measures through various methods such as ISC-RSA (representational similarity analysis). This approach will allow us to examine shared patterns across different measures, potentially revealing how neural and psychological responses to stress are interrelated.

References

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Contact

salomonlab.org

ophir.netzer@gmail.com