

Assessing Cognitive Performance with Critical Flicker Fusion Frequency

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Introduction

- Critical Flicker Fusion Frequency (CFFF) is discussed as a diagnostic tool for cognitive function assessment^{1,2}
- Environmental factors are not well understood²
- In extreme environments (underwater & spaceflight) rapid cognitive diagnostic is necessary to determine task readiness and task procedures

The studies investigated the stability of the CFFF tool against multiple confounding variables:

- **Illumination** (Bright/Dark)
- **Immersion** (Land/Underwater)
- **Diving Mask** (Mask/No Mask)
- **Inspiratory O₂** (0.3 / 1.4 bar P_iO₂)
- **Vagal Stimulation** (TaVNS/Sham)



Figure 1: Light-shielded tube was used for CFFF in dark conditions both on land and underwater. Participants' view into the tube. Light source at the end (1.5 m)

Hypotheses

- (I) The different environmental conditions alter CFFF
- (II) TaVNS positively affects CFFF

Methods

Participants N = 19; 10 females; 24 ± 3 years / N = 22; 14 females; 24 ± 3 years

Instrumentation manually operated flicker device (Scaleo, Esslingen, DE; one LED: 8,000 K)
Bittium Faros 2-lead ECG (HRV)
NEMOS (TaVNS)

Measurements 9 cross-over randomised conditions.
Cognitive assessment as 3 CFFF means per condition. HRV continuous.

Statistics Paired samples t-tests were conducted on the sub-factors *Illumination*, *Immersion*, and *P_iO₂* in the 1st cohort and separately for the effects of *TaVNS* in the 2nd cohort



Figure 2: Flicker Tool as seen by the participant. The Flicker value is not visible during testing



Pictures and videos of the experiment



Figure 3: TVNS electrodes in the right ear on the cyma conchae

References and Material

¹Lafère et. al (2019). DOI: 10.28920/dhm49.2.119-126

²Schipke et. al (2023). DOI: 10.3390/medicina59040800

³Ackermann et. al (2023). DOI: 10.1111/psyp.14183

Further Reading



Results

- A significant effect was observed for **illumination** on land for **Bright** (p=.028, d=.467; Bright: 36.47 Hz, Dark: 35.84 Hz).
- Main effects were also observed for immersion in Bright (p=.009, d=.593/ Land: 36.28 Hz, Underwater: 37.9 Hz) and Dark conditions with **increased CFFF in immersion conditions** (p=.045, d=-.412/ Land: 36.38 Hz, Underwater: 37.3 Hz).
- **Tvns** showed no effects on CFFF (p= .208, d=-.246/ tvns: 35.4 Hz, sham: 35.0 Hz).

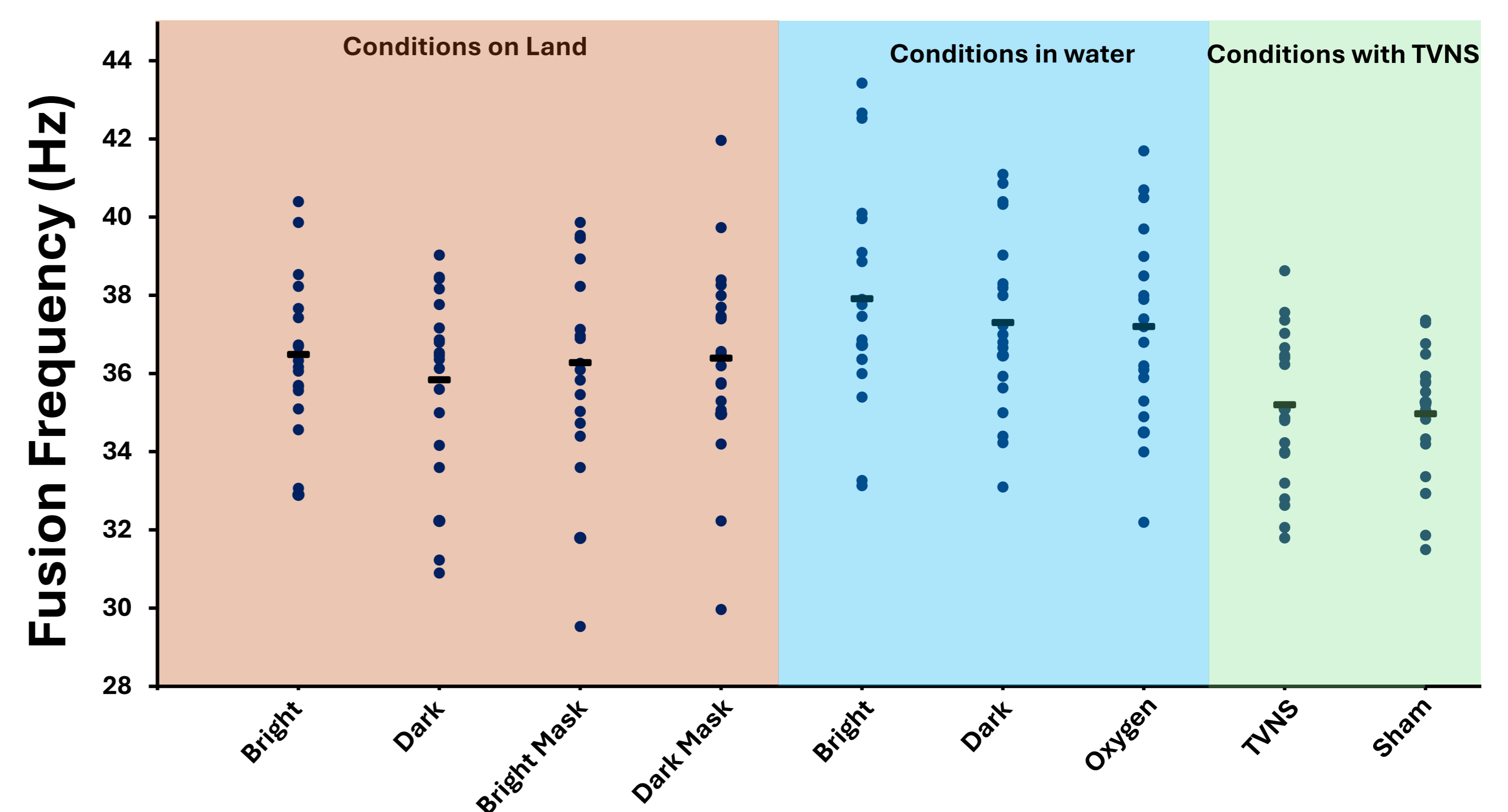


Figure 4: Individual values across all conditions. Three General Conditions (Land / Water / TVNS). Mean values taken after 5 minutes of acclimatisation from 3 CFFF Trials per condition.

Discussion

- (I) The first hypothesis was not confirmed
 - Despite the effects of **illumination** and **immersion**, the small absolute differences do not suggest a major impact on CFFF validity.
 - A potential explanation for the effect of illumination on CFFF is the eye's adaptation changes to ambient light.
 - (II) The second hypothesis was not confirmed
 - **No direct influence of vagal stimulation** on CFFF was observed, supporting robustness for an application in extreme environments.
 - Values in cohort 2 were considerably lower, could be explained by the absence of water immersion
 - Vagal stimulation should still show similar effects to water immersion (diving reflex)³.
- Future work** might focus on the link of **CFFF** to **executive function** and operational performance in extreme environments to increase safety for planning and decision-making and on **effects of vagal activity**.

Conclusions

- Critical Flicker Fusion Frequency (CFFF) seems to be **stable against environmental influences**
- **CFFF is slightly higher in immersion** conditions, but only minimal differences are observed
- Can **vagal stimulation** and **immersion** be compared? What are the physiological and psychological differences?



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