

Enhancing visual abilities with transcutaneous vagus nerve stimulation



Deutsche Sporthochschule Köln
German Sport University Cologne

Dominik von Hertlein, Kaja Wolff, Soma Szabó



Introduction

- In sports like baseball, object perception and trajectory are paramount for successful task completion. The iris sphincter and dilatory pupil muscles are under the control of the parasympathetic and sympathetic nervous system (DiCriscio et al., 2018).
- We used the critical flicker fusion frequency (CFFF) as a measurement of visual perception and transcutaneous auricular vagus nerve stimulation (TaVNS) for the manipulation of the ANS.
- CFFF has been used frequently for the assessment of cognitive performance (Muth et al., 2023; Rota-Bartelink, 1999)
- **The aim of this study was therefore to enhance visual perception by influencing cardiac vagal activity.**

Hypotheses

We hypothesised

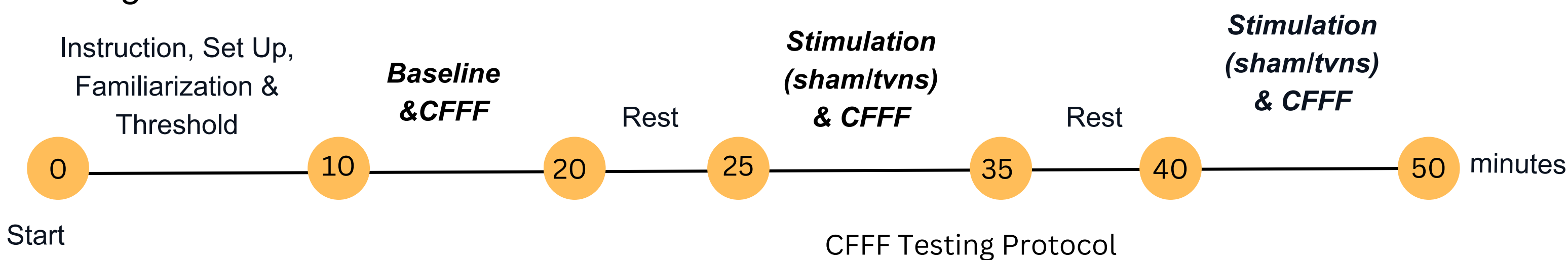
- (I) that taVNS would **increase** vagally-mediated HRV (vmHRV) and
- (II) that cognitive performance on the CFFF task would **increase**.

Materials and methods

- A manually operated flicker device (Scaleo, Esslingen, DE; one LED: 8,000 K)
- Three conditions for 22 healthy participants (age 24.3 ± 2.8 , 14 female).
- Frequencies were steadily increased from 20Hz until the participants perceived the flickering stimulus as constant.
- Randomised order (Baseline, TaVNS, sham).
- TaVNS (NEMOS) attached to the right ear and Bittium Faros 2-lead ECGs to record heart-rate variability (HRV).

Figure 1

Testing Protocol with Timeline



0s-300s (Min 0-5)	300s-360s (Min 5-6)	360s-420s (Min 6-7)	420s-480s (Min 7-8)	480s-540s (Min 8-9)	540s-600s (Min 9-10)
	CFFF.		CFFF		CFFF

Figure 2

Flicker Tool



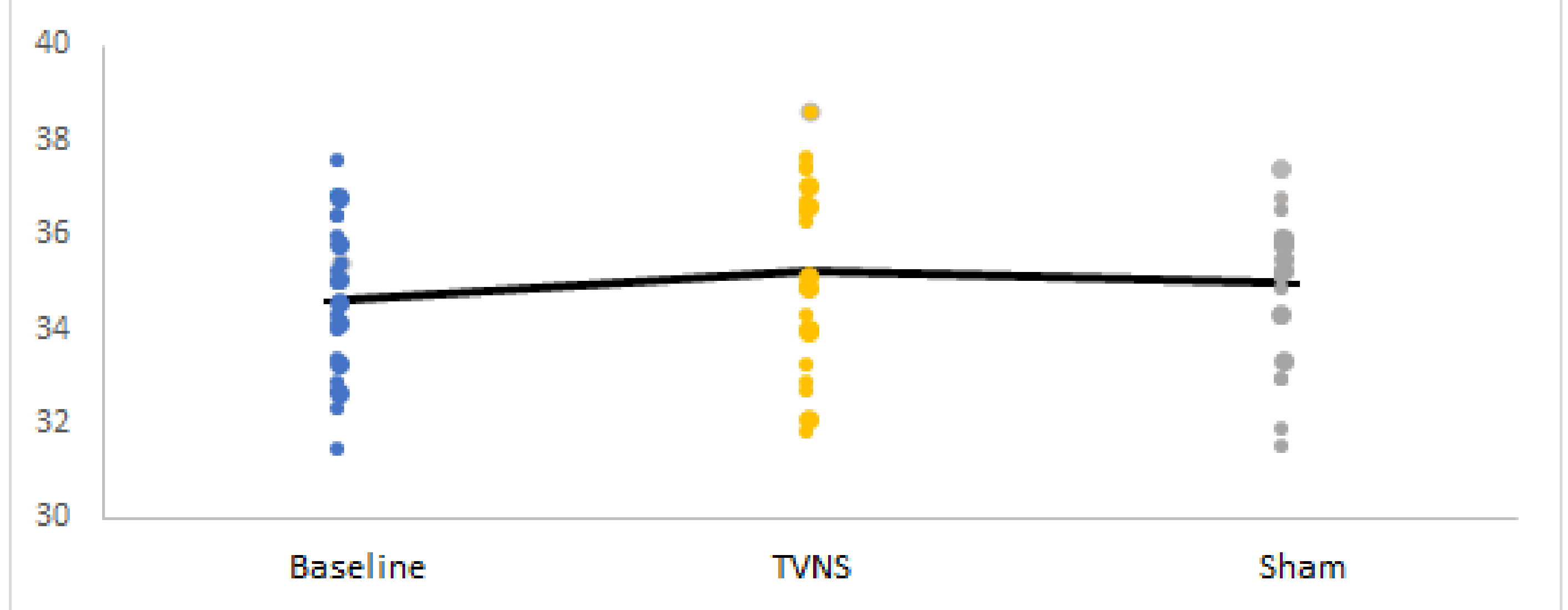
Figure 3

TVNS electrodes



Results 2/2

Figure 5
Mean Values for CFFF



Discussion

Contrary to our hypothesis the auricular stimulation of the vagus nerve did not result in enhanced performance in CFFF. Data was therefore analysed in three categories: **TaVNS vs. vmHRV**, **CFFF vs. vmHRV**, and **CFFF perception**. Most studies have used the left ear to stimulate the vagus nerve. The right side used here was suggested to exhibit stronger cardiac effects (Farmer, 2021) but those effects were not found in our sample, as can be seen in Figures 4 & 5. However, carry-over effects between the conditions cannot be ruled out completely. Since CFFF is used as a diagnostic for cognitive functions, and numerous studies have shown a relation between vmHRV and cognition (Arakaki, 2023; Nicolini, 2024), we assumed a positive correlation between CFFF and vmHRV (RMSSD). This correlation could not be established with our data set. Whereas previous studies indicated a potential stability of the CFFF measurement against confounding variables (Mewborn, 2015; Muth, 2023; Rocco, 2019), this may not be suited to test our hypothesis. Though the CFFF measurement tool has shown stability against another confounder (vagal stimulation), we propose that enhancing perception is (I) not an entirely cognitive endeavour, and (II) cannot be quantified with the CFFF diagnostic.

Conclusions

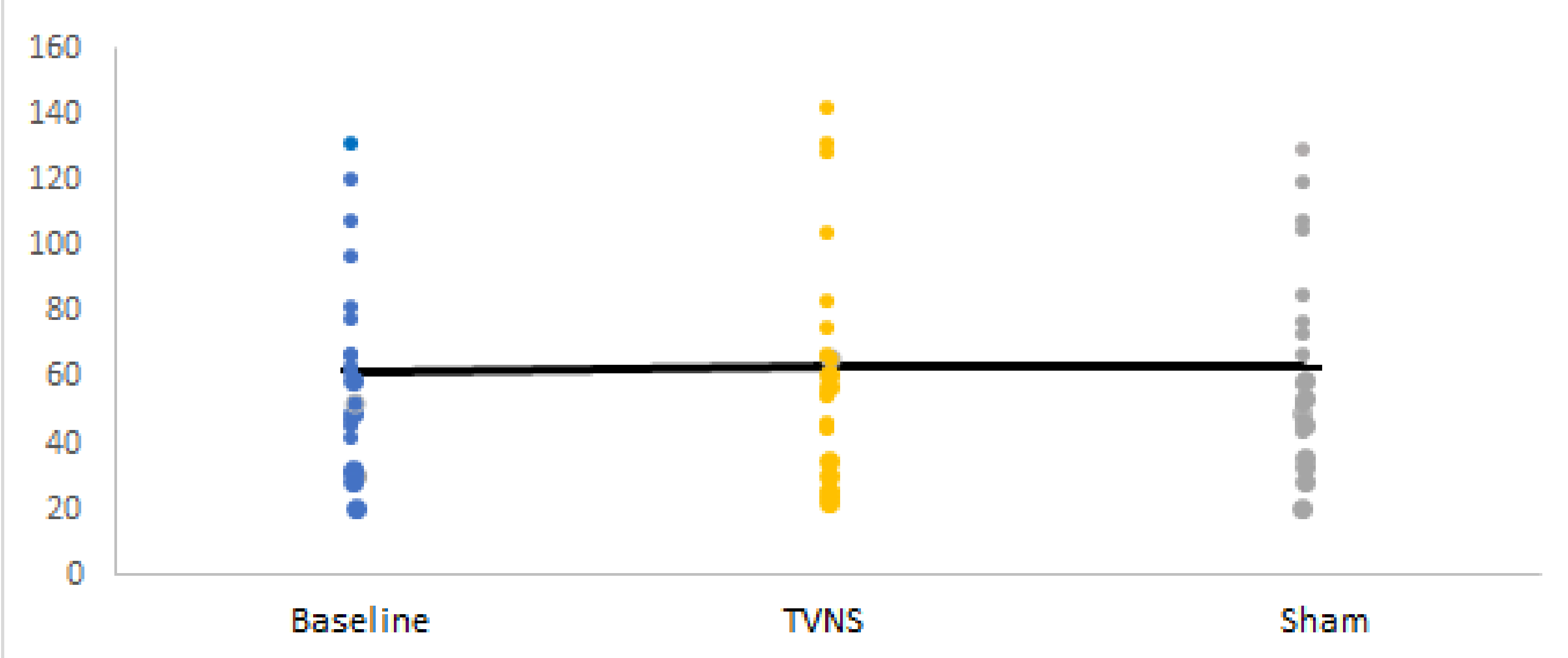
Contrary to our hypotheses, neither did TaVNS increase vmHRV, nor did it result in improved Flicker task performance.

- **How are TVNS and vmHRV related ?**
- **CFFF correlated to cognition but cannot quantify perception**
- **CFFF is stable against vagal stimulation**

Results 1/2

Paired samples t-tests revealed no significant differences in CFFF between taVNS and sham conditions ($p=.208$, $d=.177$; taVNS: 35.2 Hz, sham: 34.9 Hz), and taVNS showed no clear effect on vmHRV ($p=.420$, $d=.044$; taVNS: 63.5ms, sham: 63.1ms).

Figure 4
Mean Values for HRV



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Dominik von Hertlein
d.vonhertlein@dshs-koeln.de
German Sport University
Cologne

