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Assessment of a Novel Electroencephalography (EEG) Headband for Neurofeedback In Pediatric Dentistry: A Pilot Study

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INTRODUCTION

Severe dental anxiety and inability to cope with treatment remains a challenge in Dentistry especially when it comes to children. While pharmacological behavior guidance and physical monitoring continue to be the mainstay for dental anxiety management, there are no tools that offer the clinician a chairside, real-time measure of a patient's state of mind. The following study assesses a novel, brain sensing headband (Muse 2™) in a dental setting for the first time. Muse is an EEG device with a companion APP that uses advanced signal processing to interpret mental activity while providing audio-guided neurofeedback cues that help focus on breath and calming the mind. Monitoring EEG brain activity, as we monitor conventional vital signs via wearable devices, may offer a new understanding of anxiety management as it relates to dentistry.

OBJECTIVE

To assess and compare Muse 2 EEG monitoring data and neurofeedback effects with conventional dental anxiety measures in a dental setting.

METHODS

Data Collection:
A cohort of 4 children between ages 7-13 were recruited at the Columbia University CDM undergraduate pediatric dental clinic for enrollment in the Muse case group and compared to 4 control subjects randomly selected from a related study.
- Patients in the control group wore conventional sunglasses (CS) for the duration of the treatment.
- Patients in the Muse group wore the Muse 2 headband (M2) and underwent a 1-5 minute neurofeedback session with EEG recording prior to and for the duration of the dental procedure. Clinical events were mapped to EEG brain activity.
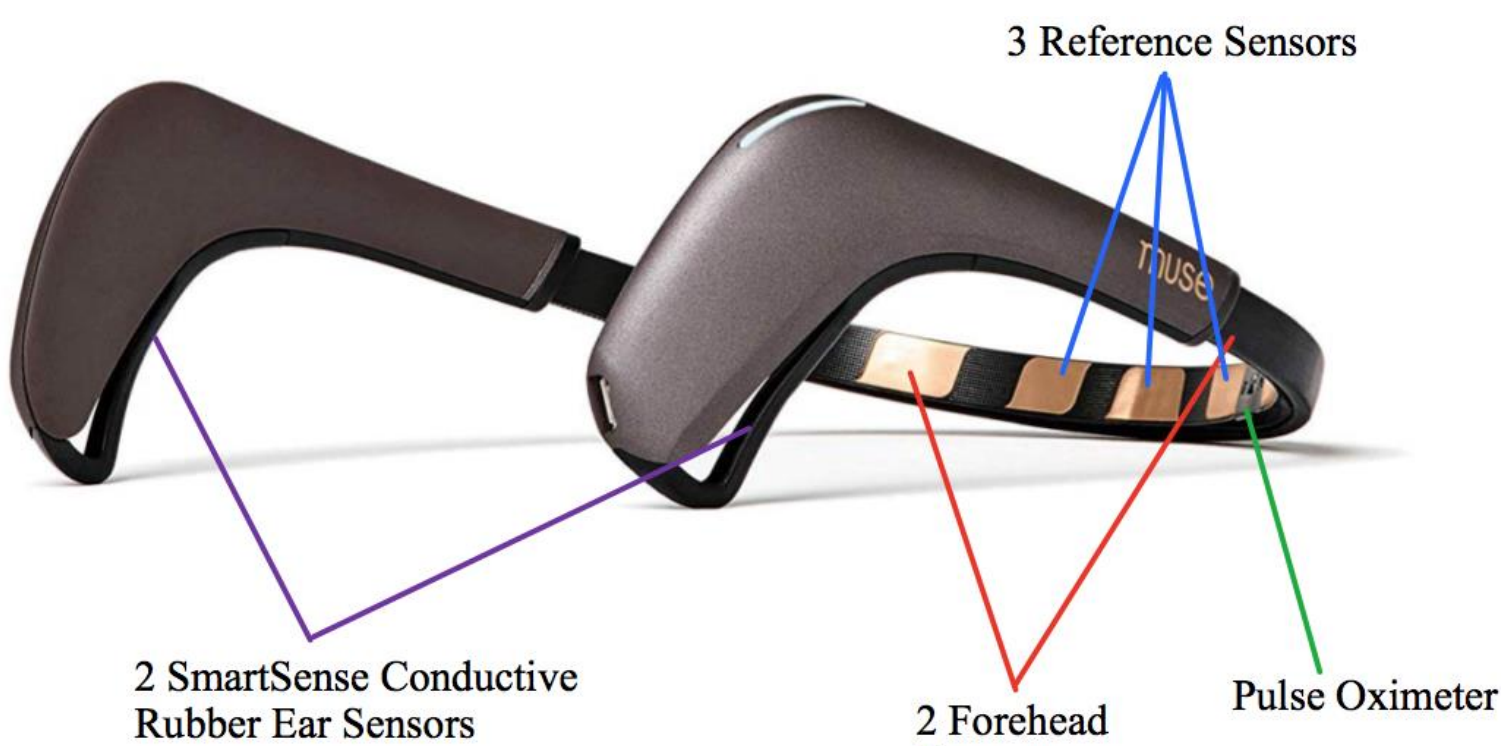

Image 1: The Muse 2 headband

3 Reference Sensors
2 SmartSense Conductive Rubber Ear Sensors
2 Forehead Sensors
Pulse Oximeter

Image 2: Patient wearing the Muse 2 headband

Anxiety Measurement:
Anxiety levels were measured before, during and after the procedure by Venham's anxiety scale, consisting of Venham's picture test and Venham's rating of clinical anxiety.

Figure 1: The Venham picture test is a card comprised of 8 pairs of drawings, where each pair represents one anxious figure and one non-anxious figure. The patient is asked to point to which figure represents them the most before, during, and after the appointment. If the child points to the anxious figure, a score of 1 will be assigned to that child. If the child points to the non-anxious figure, a score of 0 will be recorded. The final score will range from 0 (least anxious) to 8 (most anxious).

Venham's Anxiety rating scale	
Rating	Features
0	Relaxed, smiling, willing and able to converse
1	Uneasy, concerned. During stressful procedure may protest briefly and quietly to indicate discomfort. Hands remain down or partially raised to signal discomfort. Child willing and able to interpret experience as requested. Tense facial expression, may have tears in eyes.
2	Child appears scared. Tone of voice, questions and answers reflect anxiety. During stressful procedure, verbal protest, (quiet) crying, hands tense and raised, (not interfering much -- may touch dentist's hand or instrument, but not pull at it). Child interprets situation with reasonable accuracy and continues to work to cope with his/her anxiety
3	Shows reluctance to enter situation, difficulty in correctly assessing situational threat. Pronounced verbal protest, crying. Using hands to try to stop procedure. Protest out of proportion to threat. Copes with situation with great reluctance.
4	Anxiety interferes with ability to assess situation. General crying not related to treatment. More prominent body movement. Child can be reached through verbal communication, and eventually with reluctance and great effort he or she begins the work of coping with the threat.
5	Child out of contact with the reality of the threat. General loud crying, unable to listen to verbal communication makes no effort to cope with threat. Actively involved in escape behavior. Physical restraint required.

Figure 2: Venham's rating of clinical anxiety consists of six divisions (0-5). This objective measure scores the child's level of anxiety with a correlating behavior description. A score of 0 indicates no anxiety while a score of 5 represents the highest anxiety. A rating is made by the researcher before, during, and after the appointment.

RESULTS
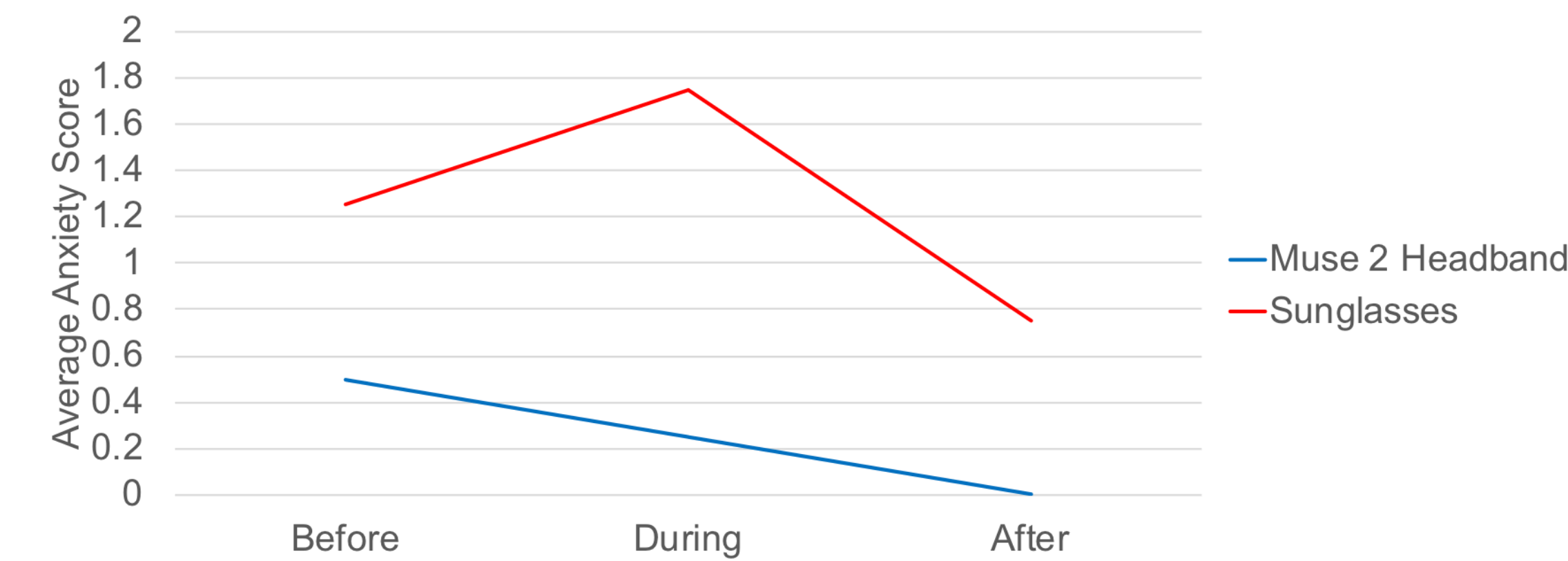
Venham's Picture Test:

Figure 3: Overall anxiety scores throughout appointment for each cohort using Venham's picture test. Scores range from 0 to 8.
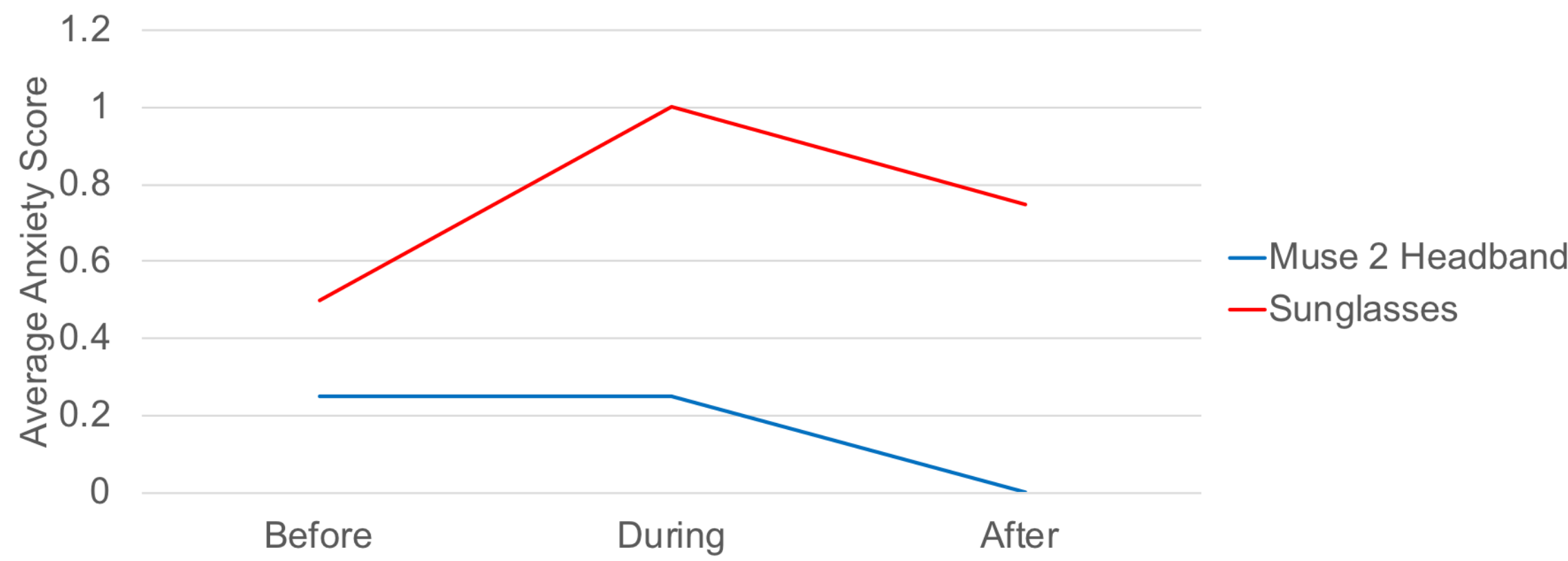
Venham's Rating of Clinical Anxiety:

Figure 4: Overall anxiety scores throughout appointment for each cohort using Venham's rating of clinical anxiety. Scores range from 0 to 5.

Data Analysis:
Patient and provider scores were then adjusted to a 0 (least anxious) to 8 (most anxious) rating and the means of both ratings for both cohorts (for each time period) were calculated. A paired two-tailed t-test was run to compare the average 'during-treatment' anxiety ratings between the cohorts: a 1.67 anxiety score for the CS cohort and a 0.32 anxiety score for the Muse cohort. The results revealed a statistically significant difference: a t-value of -2.6 with a $p < 0.05$.
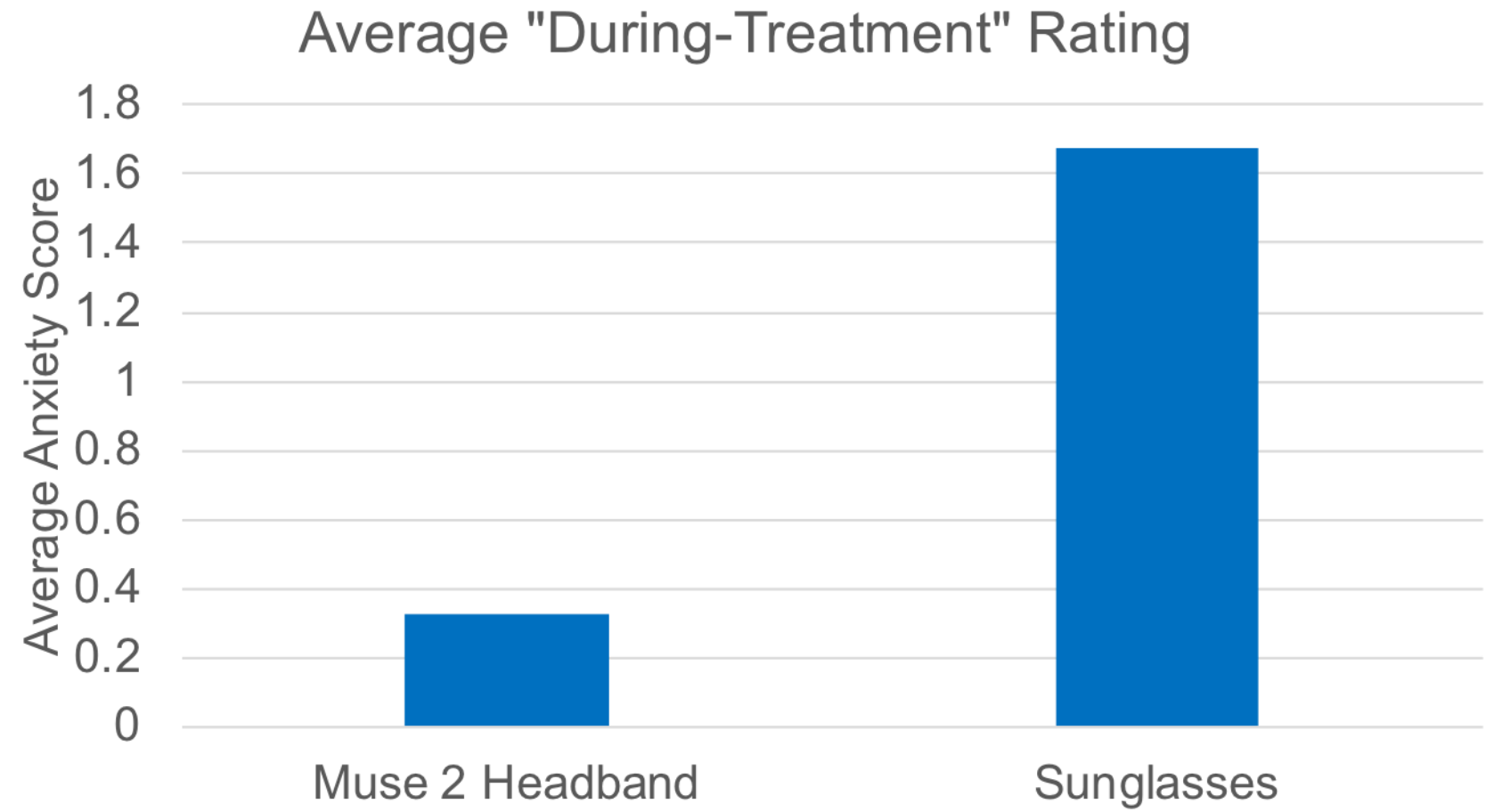

Average "During-Treatment" Rating

Figure 5: Overall anxiety scores during the appointment for each cohort by combining Venham's picture test and an adjusted Venham's rating of clinical anxiety. Scores range from 0 to 8.

The EEG to clinical mapping revealed a direct correlation to intraoral clinical events in the form of upward spikes in brain activity.
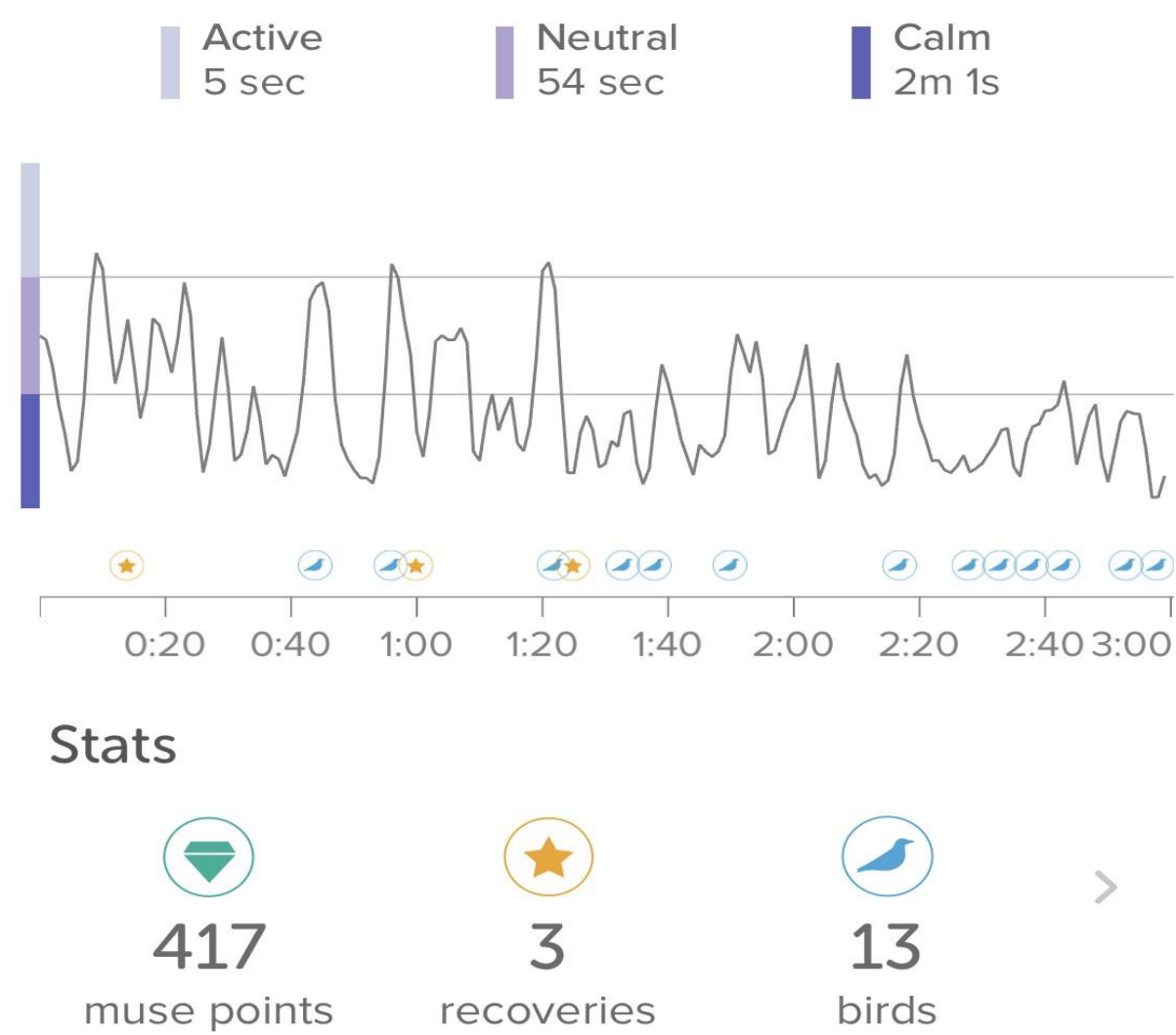

Figure 6: Sample EEG brainwave recordings from the Muse 2 headband.

DISCUSSION

The use of EEG monitoring has been historically absent from clinical dentistry due to complexities in brainwave study, hardware and perceived lack of applications. Advances in technology now offer algorithmic interpretation of EEG measurements and other vital signs in the form of a simple and reliable wearable device such as the Muse 2. Such devices are commercially marketed to the general public interested in mindfulness or meditation practices for $225. Easy access to a patient's brain activity/chairside EEG with neurofeedback interventions could open the door to several potential aspects of dental practice and research particularly in the areas of anxiety management, biofeedback therapies, sedation monitoring, sleep and seizure disorders and personalized care for children and adults.

CONCLUSIONS

- Our pilot study demonstrates proof-of-concept and feasibility using EEG-assisted neurofeedback devices in the management of dental anxiety and warrants further investigation.

ACKNOWLEDGEMENTS