Biofeedback guided resonance breathing using the Oxa platform.

An observation.

Abstract This case report documents the journey of a volunteer using Oxa, to optimize the effects of resonance breathing exercises on the mind and body. It was observed that this volunteer was able to reach a bigger positive effect when using biofeedback guided breathing in comparison to fixed rate guidance as it's done with most apps or wearables today. This observation highlights the potential and need of personalized live biofeedback.

Introduction Slow-paced breathing exercises have been recognized for their potential positive effects on both the mind and body. These exercises stimulate the cardiac baroreflex and the autonomic nervous system (ANS), in particular the parasympathetic nervous system (PNS). By manipulating breathing patterns and finding an individual's so-called "resonance" or "coherence" frequency, it is possible to maximize temporal heart rate oscillations. Parameters like respiratory sinus arrhythmia (RSA) and heart rate variability (HRV) can be used to extrapolate the effects of breathing exercises on the ANS tone. Oxa shows the potential to optimize these exercises due to its high quality real-time feedback on the synchronization of breathing and heart rate.

Profile The study involved a physically active participant between the ages of 45 and 65 (exact age is kept confidential for user privacy). The reported baseline blood pressure measurements indicated an average systolic blood pressure of 129.5±0.7mmHg and diastolic blood pressure of 78.5±9.2mmHg. The participant had limited prior experience with breathing exercises and reported a perceived mood rating of 8.3±4.5 on an adapted Profile of Mood States (POMS) scale.

Results The focus of this data collection was on optimizing the effects of resonance breathing exercises for a single user utilizing Oxa and its available exercises.

1. *Difficulty in Identifying Resonance Frequency:* In the initial exercise, the participant performed breathing exercises at various rates (4-7.5 breaths per minute, Figure 1). However, no significant changes in heart rate or blood pressure were reported. After inspection, the resonance frequency (RF) was determined to lie between 4 and 5 breaths per minute. A resonance frequency of 4.5 breaths per minute was selected.

2. *RSA Reduction in 6bpm Exercise:* Using the classical "resonance pace" of 6 breaths per minute, like it is done in many breathing apps or breathwork youtube videos, the participant showed minimal heart rate oscillations, and no coherence was detected between breathing and heart rate (Figure 2, upper). The exercise did not improve mood or blood pressure (Table 1).

3. *Biofeedback Guided Resonance Breathing:* A biofeedback guided resonance breathing exercise was conducted the next day. The participant was breathing at the personal resonance frequency (4.5 breaths per minute) for one minute, and then used real-time biofeedback from Oxa to optimize heart rate oscillations. During this exercise, the participant achieved higher RSA, longer periods of high RSA, and cardiorespiratory coherence (Figure 2, lower). Blood pressure decreased by 9mmHg (systolic) and 5mmHg (diastolic), while mood improved (Table 1).

Conclusion Based on the data obtained from this product development project, it was evident that biofeedback-guided resonance breathing exercises using Oxa led to improved RSA, improved blood pressure, and enhanced mood in the presented volunteer. It is speculated that additional training could further improve the beneficial effects. These findings contribute to future product developments, focusing on the high-quality real time feedback of Oxa and its potential to optimize efficiency for resonance breathing exercises by personalization.

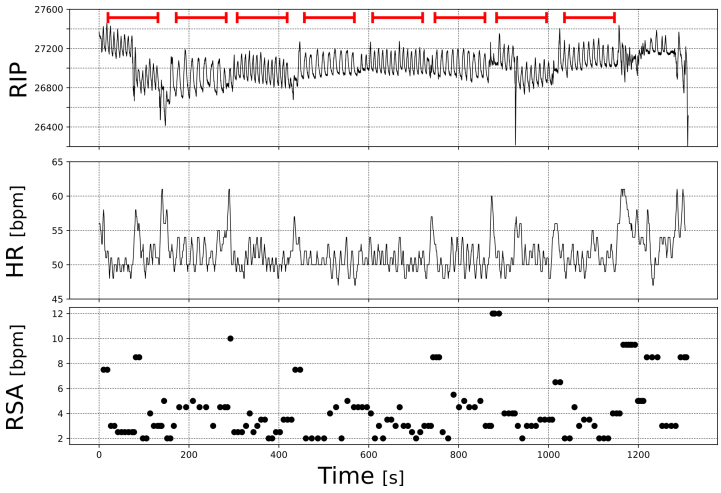

Figure 1: Depiction of the resonance identification exercise. Red bars indicate the onset and end of each rate. The following order of breathing rates was used: 7.5,4,7,4.5,6.5,5,6,5.5bpm.

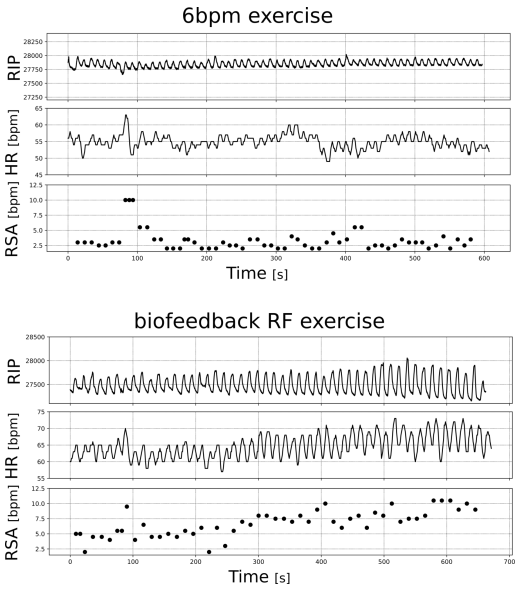

Figure 2: Breathing (RIP), heart rate (HR) and RSA signals of the 6bpm exercise (upper) and the biofeedback RF exercise (lower), indicate more cardio-respiratory coherence and bigger heart rate oscillations at RF with biofeedback. Outliers have not been excluded in these plots.

Table 1: Results for finding resonance frequency, 6 bpm and biofeedback guided RF exercise. For the find RF exercise, the Oxa parameters for 4.5bpm are shown. NA means not available, * means standard deviation was not calculated. post-pre = observed change post minus pre exercise. Data are shown as mean±stdev.

Parameter	f nd RF	6bpm	bfRF
HR_{mean} [bpm]	50.7*	54.8±1.7	64.6±3.0
HRV_{mean} [ms]	51.7±1.9	49.4±1.9	48.3±1.4
t_{seg} >mean HRV [%]	NA	16.7	15.6
mean RSA [bpm]	3.7±1.6	2.8±0.6	6.7±2.1
t_{seg} >mean RSA [%]	NA	3.3	23.5
RSA_{mean} at coherence[bpm]	5±0	0	7.4±1.9
Time in coherence [%]	7.6	0	83
post-pre			
systolic BP [mmHg]	-3	1	-9
diastolic BP [mmHg]	-2	10	-5
POMS TMD	NA	2	-1