

# Moonbird whitepaper

The overall number of people reporting stress-related problems is increasing worldwide, with a 13% rise in the last decade and even a 30% increase during the Covid-19 pandemic. Such problems can interfere with a normal lifestyle. They slowly drain our resources for both mind and body. Chronic stress can manifest as anxiety and sleeping problems, but also as pain, low energy and lack of focus. Several studies show that practicing slow-paced breathing has a calming effect on the body, increasing heart rate variability (HRV). The exact breathing rate at which HRV is maximal varies between 5-7 breaths/min. To help people relax, calm down or fall asleep faster, moonbird developed and commercialized an intuitive, tactile and handheld breath pacer. The device expands and contracts, providing the user with a slow pace to match their breathing rhythm. The first user tests (N=90) with moonbird are promising. Results indicate improvement in emotional and physical well-being and an increase in sleepiness, sleep quality, restorative sleep, drowsiness and relaxation.

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While medication is traditionally considered a potential way to address these problems, it is associated with several side-effects, addiction, dependency and increasing tolerance. Recently, consumers' mindset shifted towards non-pharmacological solutions. Mindfulness, meditation and breathing practices gained popularity to relieve stress.

With breathing techniques, one consciously and voluntarily changes its breathing rate. The resting breathing rate of healthy adults is around 10-20 breaths per minute. Slow breathing is a breathing technique with controlled inhalations and exhalations, within the range of 4-10 breaths per min. In contrast to uncontrolled fast breathing, generally linked to anxiety and stress, slow-paced breathing techniques have been associated with relaxation and well-being.

One of the mechanisms that controls our breathing is the autonomic nervous system, consisting of the sympathetic and parasympathetic nervous system. The first one activates an alarm response in our body, the so-called 'fight or flight' response. The other one stimulates the so-called 'rest-and-digest response' that activates when the body is at rest. Normally, both systems are in balance with each other. Stress however, disrupts this balance, due to an overactive sympathetic system.

The heart is another system involved in the breathing process. A normal heart rate is irregular, as a result of its interaction with the nervous system and other influences (age, temperature...). The time intervals between heartbeats are thus highly variable. This variation between successive heartbeats is referred to as heart rate variability (HRV, Fig 1). A high HRV is considered a sign of good health and reflects the ability to cope with stressful situations. A low HRV is related to stress, anxiety, and sleeping problems.

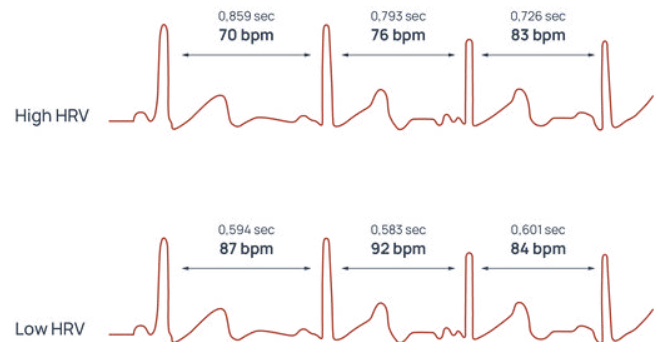


Figure 1

Several studies show that practicing slow-paced breathing has an activating effect on the parasympathetic nervous system and a decelerating effect on the sympathetic nervous system, increasing HRV (Figure 2). The exact breathing rate at which HRV is maximal depends on the person however always lies between 5 and 7 breaths per minute. HRV can thus be maximized by breathing at a frequency of around 6 breaths/min, which may be individually optimized.

Researchers found that practicing breathing exercises led to a significant 15% increase in reported relaxation, 15 minutes decrease in sleep onset latency, halving in number of awakenings, 30% reduction in time awake during sleep and 20% reduction in state anxiety. Consequently, slow-paced breathing has been identified as an effective management tool for stress-related problems.

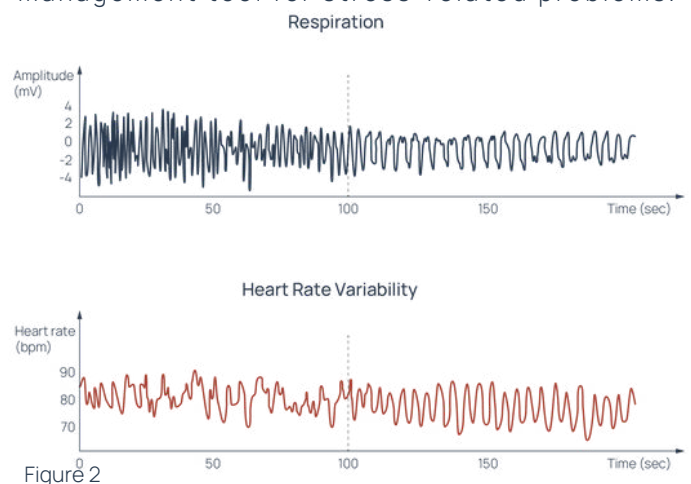


Figure 2

To help people relax, calm down or fall asleep faster, moonbird developed the world's first intuitive, tactile and handheld breath pacer, combined with a mobile app (Fig 3). The device expands and contracts in the palm of a hand, providing the user with a slow pace to match their breathing rhythm. Heart rate data are acquired from a photoplethysmogram sensor. The software derives real-time pulse rate and rest/activity data. The accompanying app presents real-time biofeedback on heart rate, heart rate variability and heart coherence (the synchronization between heart rate and breathing rate).

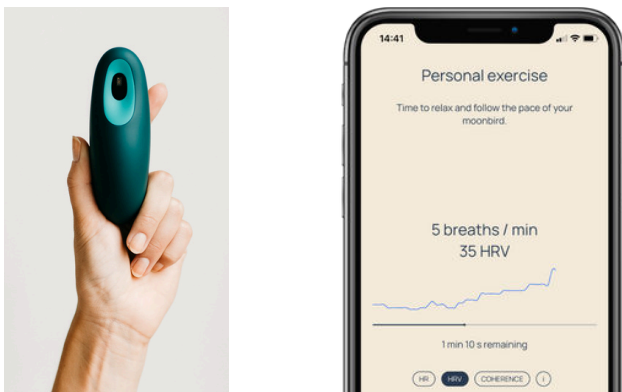


Figure 3

Breathing biofeedback provides an opportunity to learn and adapt breathing in real-time. This way users are more aware and get a better understanding of the impact breathing has on our body. Several studies indicate that HRV biofeedback helps to relieve stress, anxiety, and sleeping problems. Research also indicates that externally-paced (or guided) breathing is more effective in improving HRV than self-paced breathing. Breathing guidance is often expressed in graphics or numbers or via audiovisual cues, which is technical, cognitively demanding or performance-oriented. Moonbird offers breathing guidance via the sense of touch, the eldest and most intuitive sense. In everyday life. This is a powerful method of communicating safety. Studies show that interaction with tangible objects is important for those who have lost connection to their body and environment.

#### MOONBIRD RESEARCH

Over 6 months, we collected anonymised data from 1435 moonbird app users who rated their mood and energy level before and after each breathing exercise on a 5-point scale. Of 4807 valid mood ratings, 95% improved or remained stable. For 4396 valid energy ratings, 96% showed improvement or stayed the same.

In 2020, user tests were performed. Diagnosed insomniacs (n=21) were asked to use a moonbird prototype for 20 minutes every night before going to bed, over a four-week period. Participants rated their subjective sleep quality (using the Pittsburgh Sleep Quality Index) before and after the intervention. Results indicated greater use of the moonbird correlated with better (lower) post-intervention scores.

In a recent moonbird sleep study we involved 40 individuals. We measured the impact of moonbird on sleep quality and feeling fresh in the morning via the Pittsburgh Sleep Quality Index (N=37) and the Non-Restorative Sleep Scale (N=39). Scores on both scales improved significantly: PSQI ( $t(35)=5.692$ ,  $p=0.000$ ) and NRSS ( $t(38)=-5.401$ ,  $p=0.000$ ).

Breathing is closely linked to brain activity and can enhance cerebral flexibility. At moonbird, we analyzed the impact of moonbird guided breathing on brain functioning via a preliminary case study (n=1). We measured electrical brain activity using high density EEG with 256 electrodes. Afterwards we mapped brain connectivity both at rest and during the moonbird guided session. At rest, intense and widespread beta brain connectivity was found, which could result in negative effects such as stress, anxiety and sleeping problems. Breathing with moonbird, led to reduced beta connectivity with more brain connectivity around the midline. These findings indicate that with moonbird mind is calmed down by entering a wakeful but relaxed state of mind.

Available research thus shows that slow-paced breathing exercises have beneficial effects on overall health and on mental health problems. They have a positive effect on our autonomous nervous system, indicated by lower heart rate and higher HRV levels. Via slow breathing the interaction between the cardiac and pulmonary mechanisms enhances the activation of the parasympathetic nervous system, the body's brake pedal, inducing relaxation. At moonbird, we aim to make intuitive breathing exercises more accessible for everyone. We aspire to bring you into a desired state of mind by inducing a relaxation response and lowering stress and anxiety levels. Our device represents a useful tool that supports the needs of people suffering from stress and stress-related disorders.

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