

Somnox sleep robot scientific background

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Preface

Scientific validity is one of the key values Somnox aspires to. Our team of researchers has conducted an extensive scientific literature review regarding the effects of breathing and music on the sleep quality. Beyond researching, user testing is a key component for validating a product or an idea; therefore we gathered the feedback from over 5,000 people to validate the functions of the Somnox sleep robot over the past two years. We also set up multiple testing rounds in collaboration with sleep specialists, hospitals and somnologists, and assessed our various prototypes with potential users. Over 80 test sleepers have already slept with the Somnox robot and participated in our extensive research. In our white paper you will find the inspiration and validation of the Somnox sleep robot: why did we build a sleep-robot and how can it help people? What were the results of our testing rounds? You will find the answers in this document.



Mission

"Our mission is to help 100,000 people achieve a good night's rest with the world's best natural sleep solution by 2025."

Introduction

The basic principle behind the Somnox sleep robot is the concept of breathing as a source of deep relaxation, in combination with soothing music/sounds. Although it is underestimated by many as it is an action that we constantly do without even realizing it, if done in a certain way, breathing is able to stimulate particular receptors in our body thus bringing us to a state of peace and tranquility. Consequently, the Somnox sleep robot was primarily conceived as the guide to the deep breathing during the night. To better understand how breathing can have a positive effect on our state of quiet, let's briefly illustrate the science behind the Somnox sleep robot.

The science behind the Somnox sleep robot: sleeping by breathing

The science behind the Somnox sleep robot is pretty straightforward; the human autonomic nervous system contains two branches, the sympathetic branch, also known as "fight or flight" or stress response, and the parasympathetic branch, also known as the relaxation response [1]. Ideally, we want both systems to be balanced, but as stress accumulates, our system can get overwhelmed with stress chemicals, and the sympathetic nervous system can be continuously activated without the normal counteraction of the parasympathetic nervous system [2]. The result of that is that imbalances in the body arise, including poor digestion, indigestion, constipation, anxiety, shallow breathing, increased heart rate, poor quality sleep etc. [3]. Simultaneously, our autonomic nervous system becomes unbalanced and our relaxation response becomes hard to retrieve. And here is where breathing comes into play; conscious deep breathing activates the parasympathetic response [4].

Music and sounds as tension and stress relieving

Pleasant music and sounds play a key role in relaxation and in attaining a person's quiet feeling. In fact, music is considered to be a key to peace and serenity, its healing skills are considered to be its natural quality, and it is no coincidence that it might be used as noninvasive therapy even in clinical environments [5]. Also some kind of sounds are considered beneficial to some people.

How to use the Somnox sleep robot

To fall asleep with the Somnox sleep robot, place the the Somnox sleep robot close to your body, positioning either your arm or your hand on its "belly" so that you can feel its breathing. Lay in bed with your eyes closed, use whatever position you prefer, feel the robot's respiration and listen to its music/sounds. Breath in synchronicity with the Somnox sleep robot. Do not worry if at the beginning your breathing goes out of synchronicity. Breath in and breath out deeper and deeper as the the Somnox sleep robot's breathing rhythm slows down until eventually, you fall asleep.

Problem Description

Today's society, due to excessive workload and frantic lifestyle, leads us to be stressed and to bring stress with us even when we go to bed, thus depriving us of a good night rest. Furthermore, habits that we might have such as drinking caffeine before going to bed [6] or consuming products containing nicotine or alcohol [7] contribute to deteriorating the quality and continuity of our sleep. As a consequence, nowadays, sleep deprivation is becoming a serious public concern, leading to daytime dysfunctions [8], poor studying performance [9], memory deficits, depressive moods, involuntary sleep episodes and increased risk of future diseases as well [10]. We can not eliminate the concerns of everyday life that prevent us from a good sleep, but we can find a way to get relaxed in bed despite worries. This is the reason why the Somnox sleep robot was born; it was created to guide people through relaxation in bed by means of respiration techniques and relieving sounds.

The Somnox sleeping robot has a specific breathing rhythm, which is slower than your usual one. By holding the Somnox robot you will automatically synchronize your breathing rhythm to its own, thereby making your breathing rhythm gradually slow down.

Why does the Somnox sleep robot induce you to sleep?

Scientific researches have proven the benefits of sleeping with a breathing object. A research conducted by Evan Ingersoll and Evelyn Thoman, from the university of Connecticut, revealed that infants that slept with a breathing bear adapted their irregular breathing (usual respiration during the sleeping time is commonly dysrhythmic and chaotic [11]) to the regular one of the bear and improved their sleeping quality[12] and had a less negative temperament[13]. The Somnox sleep robot exploits the concept of entrainment, that states that an irregular rhythm would gradually match the phase, or entrain, to a more regular rhythm[14]. The entrainment is experienced daily by people who sleep with their partner; although the breathing pattern (or frequency) is different among people, people who sleep hugged together are well known to synchronize their breathing.

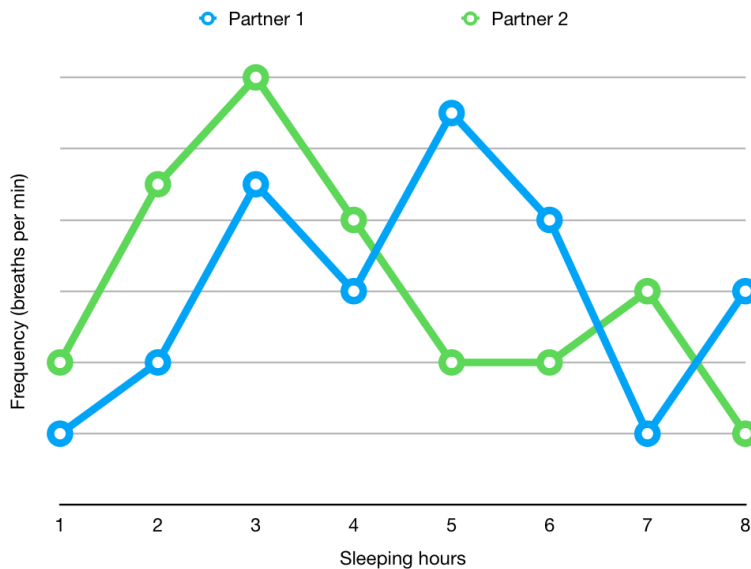


Figure 1: Breathing frequency of two partners when they sleep separately is different.

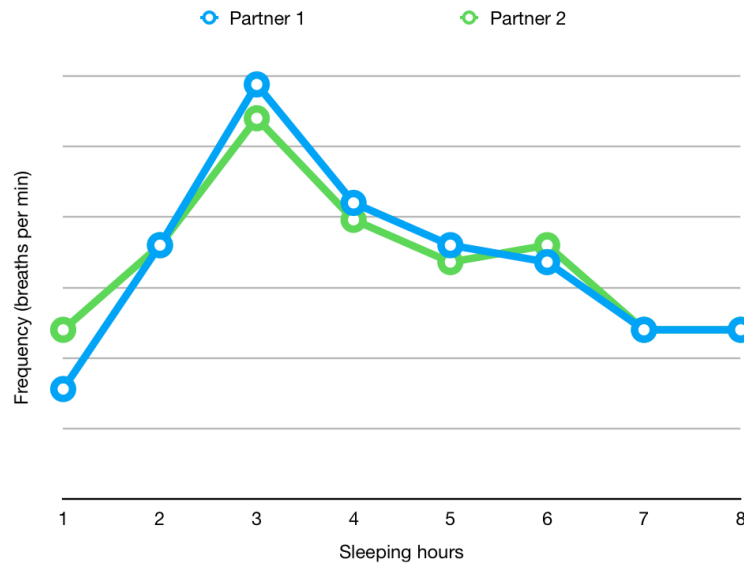


Figure 2: Breathing frequency of two partners when they sleep together tend to be the same.

In the same way in which two partners adapt their breathing pattern, you will synchronize your own breathing pattern to the more relaxed one of the Somnox robot by sleeping while hugging it.

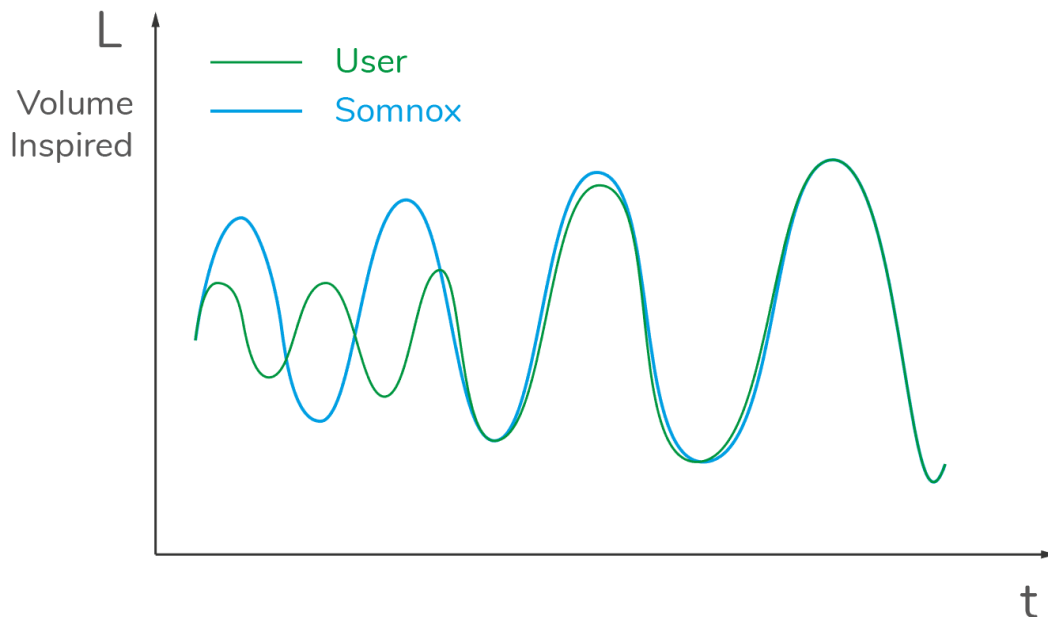


Figure 3: Breathing adaptation of the user to the Somnox sleep robot's respiration rhythm.

In order to understand why slow breathing positively affects our relaxation state, we need to briefly introduce the autonomic nervous system (also called the ANS). The autonomic nervous system is a branch of the peripheral nervous system that mostly unconsciously regulates bodily functions such as heart rate, digestion, respiratory rate, pupillary response, urination, and sexual

arousal[15]. The autonomic nervous system is divided into two branches: the sympathetic nervous(SNS) system and the parasympathetic nervous system (PNS). The sympathetic nervous system controls the body’s responses to a perceived threat and is responsible for the ”fight or flight” response whilst the parasympathetic nervous system (PNS) controls homeostasis of the body and is responsible for the body’s ”rest and digest” function [16]. Basically, when PNS is stimulated, relaxation is induced. Breathing is a natural and effective way to voluntarily stimulate the PNS[17]. When we breathe deeply (i.e. when the exhale time is greater than the inhale time), our body gets closer to the parasympathetic state [18].

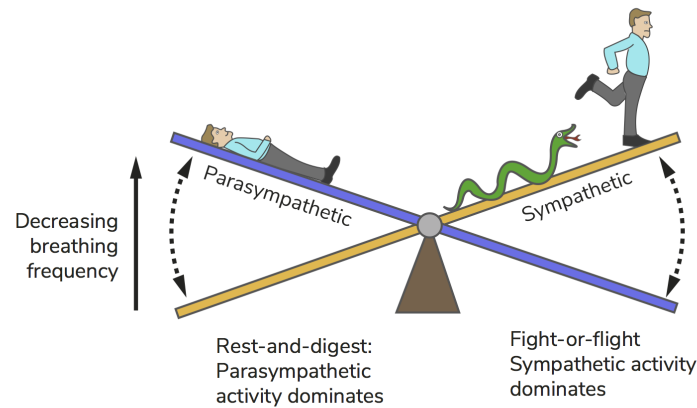


Figure 4: Parasympathetic vs. Sympathetic nervous system. Source: [19]

This is the reason why the Somnox sleep robot has been designed to slow down its breathing pattern during the night to a very relaxed rhythm chosen accordingly to different relevant yogic respiration techniques, also called pranayama.

Pranayama

Pranayama techniques are known to overcome stress and induce relaxation[20, 21] by eliciting alpha waves [22] and have been reported to induce parasympathetic activity [23] (and therefore induce relaxation) by means of inhibitory impulses generated by the lung stretch receptors that are stimulated during the respiration [24]. Hereby are some of the pranayamic respirations that are implemented in the Somnox sleep robot.

Sukha pranayama

Sukha pranayama is one of the simplest of all yogic breathing techniques. The name of this technique is derived from the Sanskrit, Sukha, meaning ”easy,” and pranayama, which refers to yogic breathing techniques. Sukha breathing consists of inhaling slowly for 4 counts and exhaling slowly for 4 counts as well [25]. The effectiveness of the Sukha pranayama includes the reduction of anxiety in clinical therapy as well [26].

Traditional pranayama

Traditional pranayama breathing consists of inhaling slowly for 4 counts and exhaling slowly for 8 counts and induces a great vagal activity [25]. Increasing vagal activity is correlated with the enhancing of the parasympathetic activity [27].

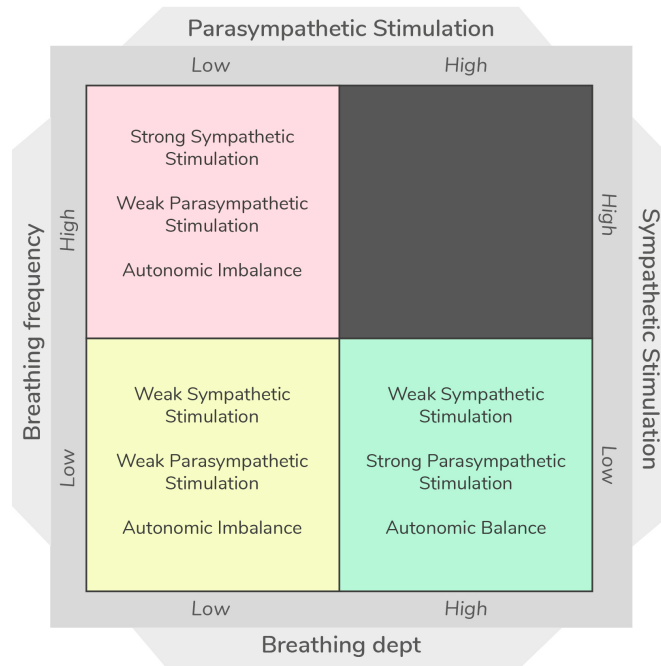


Figure 5: Deep breathing at a low frequency stimulates parasympathetic activity and reduces sympathetic activity thus giving us autonomic balance (green square).

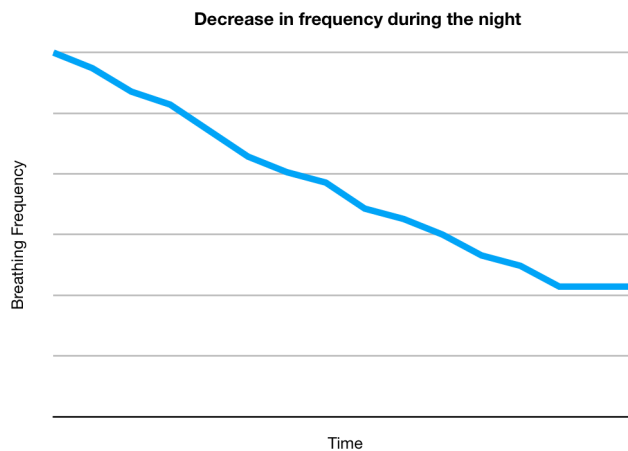


Figure 6: Somnox robot slowing down its respiration rhythm (or frequency) during the night.

Pranava pranayama

Pranava pranayama breathing consists of inhaling slowly for 4 counts and exhaling slowly for 12 counts [25]. Its benefits have potential therapeutic applications in day-to-day as well as clinical situations where blood pressure needs to be brought down as soon as possible [28].

Bhramari pranayama

Bhramari pranayama respiration consists of 5 seconds inhaling and 15 seconds exhaling. It has been reported to produce gamma waves indicating the parasympathetic activity[29].

4-7-8

The 4-7-8 method is a relaxation technique pioneered by Dr. Weil who claims that it works by calming the mind and relaxing the muscles. It is the most widespread respiratory relaxation pattern. It consists of inhaling slowly for 4 counts, holding the breath for 7 counts and exhaling slowly for 8 counts. The cycle is to be repeated 4 or 5 times.

[Try it yourself by clicking here.](#)

Variations to the aforementioned breathing patterns.

If you do not find a proposed breathing pattern that is comfortable, you could try to modify it as long as you keep the inhale/exhale ratio constant. For example, if you cannot perform the 4 seconds inhale 8 seconds exhale technique, you can reduce the inhale-exhale time to 3-6, 2-4 or 1-2.

Why sounds?

Sounds can be beneficial for helping people relax. For example, singers after a singing lesson show greater parasympathetic activity (index of relaxation) [30].

Why music?

Besides sounds, music has been considered beneficial as well. Certain kinds of music have a seemingly magical ability to induce a calmer state of being, reducing pain perception and relieving anxiety. Relaxing traditional classical music has been used as an effective treatment to reduce sleeping problems and has been suggested to nurses to be used in the hospital as a cheap and easy way to treat insomnia[31]. Music can also be as effective as hypnotic medication in improving quality of sleep in depressed people [32]. Music containing rhythms comparable to heart rate (60-80 beats per minutes) have been revealed as beneficial in improving sleep quality [33]. Music with a steady rhythm that has a rate somewhat lower than that of your heartbeat puts your mind and body in a relaxed state; songs containing a rhythm of 60 beats per minutes that gradually slows down allow the heart rate to gradually match that new phase thus allowing a reduction of heart rate and blood pressure (index of relaxation).

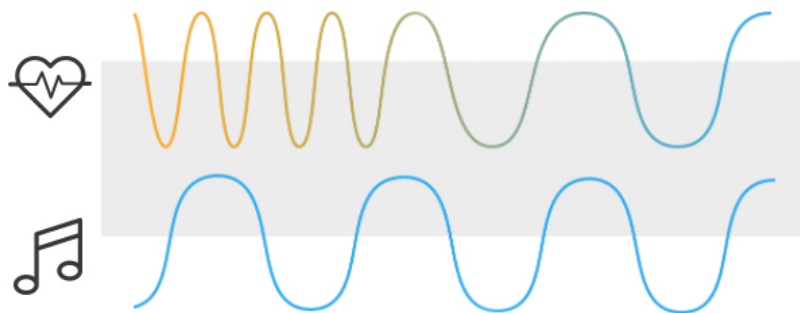


Figure 7: *The heart rate of the user adapt to the music beats.*

Here is the list of some of the sounds and music that you might find of help.

White noise

White noise is a steady, unvarying, unobtrusive sound that has equal intensity at different frequencies [34]. It is useful to mask unwanted or offensive sounds that may be present when you sleep (think for example of people that live close to the highway or sleep when the washing machine is turned on). The working principle of the white noise can be explained by the light analogy; if you are in a dark room and suddenly turn a flashlight on, you would immediately notice it. But if the room is already illuminated, the flashlight will be barely visible because it has been masked by the brighter room lights [35].

Therefore, by blocking distracting noises and by producing soothing sounds that are relaxing, white noise reveals useful in help you to sleep [36].

[Try it yourself by clicking here.](#)

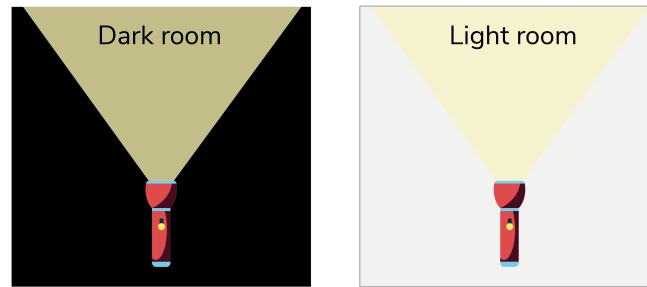


Figure 8: White noise explained by light analogy.

Pink noise

Like white noise, pink noise sound is distributed over all the frequency audible by the humans but its intensity is not constant but instead decreases with the increase of the frequency. A Chinese research demonstrates that people sleeping while listening to pink noise reported improvement in deep sleep and daily napping quality[37].

[Try it yourself by clicking here.](#)

Heartbeats

During the last trimester of pregnancy, the fetus brain develops enough to be able to recognize the heartbeat of the mother as something significant and the heartbeat of the mother is therefore imprinted into the brain of the fetus. Thus, those babies who come into this world are soothed by the sound of their mother's heartbeats and sleep to the lullaby of the soft beating sounds [38]. This very same relaxation effect is experienced by adults as well.

[Try it yourself by clicking here.](#)

Classical Music

Classical music has been discovered by scientists to help reducing stress by decreasing the cortisol level in our body [39] and to reduce anxiety in pregnant women [40].

[Try it yourself by clicking here.](#)

Bedtime stories

If you find storytelling relaxing, you can try bedtime stories containing relaxing sleep imagery that helps you fall asleep. Some of those include occasional vocal effects to better immerse you in the story.

Try some example of bedtime storytelling:

[Example 1](#)

[Example 2](#)

[Example 3](#)

Nature sounds

Natural whooshing sounds such as raindrops, ocean waves, and fire sparkles are well known to calm people and help them sleep. They may reduce muscle tension, pulse rate, and stress[41]. According to Orfeu Buxon, an associate professor of biobehavioral health at Pennsylvania State University, those sounds have a relaxing effect because they are perceived as sounds of non-threats, like they are saying "Don't worry, don't worry, don't worry".

Hereby are some example of nature noises:

[Try 'Raindrops' by clicking here.](#)

[Try 'Fire sparkles' yourself by clicking here.](#)

[Try 'Waves' yourself by clicking here.](#)

Voices

Some soft and gentle voices can have the power to generate goose-bumps in who is listening, displaying what is known as ASMR. ASMR, which stands for Autonomous Sensory Meridian Response, is an euphoric and tingling sensation that can be experienced by everyone when listening to unique soft voices like gentle whispering or when hearing certain soothing sounds such as tapping. This tingling sensation is generated in the scalp and the back of your neck [42] and can extend to all the rest of the body going down from the spine. ASMR generates a very calming and relaxing sensation. Scientific researchers suggest that ASMR may provide temporary relief in individuals with depression, stress and chronic pain [43].

Try to listen to some of the following AMSR videos with your eyes closed:

[Example 1](#)

[Example 2](#)

[Example 3](#)

the Somnox sleep robot has been designed to be a comfy, useful and easy to use product. Comfort is mainly ensured by the ergonomic shape of the robot and the material used to cover it. The shape of the Somnox sleep robot has been carefully designed with care to be both easy to hug and enjoyable to see. The material that is chosen to wrap it has been selected carefully after visiting several mattress factories including Auping. It is soft to the touch, yet it is also washable.

Why this shape?

Currently, neck and shoulder alignment during sleep is suggested among the population [44–46]. Therefore, the Somnox sleep robot's shape is designed such that people maintain a natural position when hugging it without deviating from the natural neck and shoulder alignment. The curved shape of the Somnox sleep robot and the absence of sharp edges give a sense of peace and calmness since, as stated by Oshin Vartanian of the University of Toronto at Scarborough, humans prefer curves because they signal lack of threat. The two-sphere-connected shape gives a sense of harmony since the sphere shape allows higher volume over surface area ratio (this is the principle why most of the natural objects ranging from the drops of water to planets are spherical). Moreover, the fetus shape of the robot accommodates the fetal position that many people natural adopt when they sleep.



Figure 9: *The Somnox sleep robot's shape accommodates the sleepers fetal position.*

As shown in the picture, the Somnox sleep robot's shape is meant to make you feel it like a sleeping companion through the night, like a living being instead of a mechanical robot. the Somnox sleep robot overcomes the archetype of robots by providing you all the good feelings that arise during the simulation of sleeping with someone.

The dimension of the Somnox sleep robot have been determined based on DINED, the TU Delft anthropometric database. The most important limbs that are in contact with the Somnox sleep robot are the arms and the chest; therefore, the Somnox sleep robot's dimensions are chosen carefully to allow the sleepers to comfortably place it on their chest and hug it with the arms.

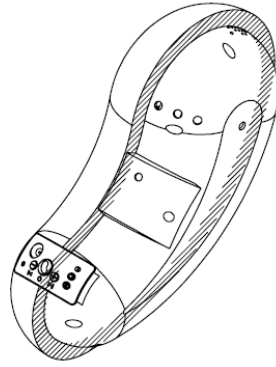


Figure 10: *Isometric view of the Somnox sleep robot.*

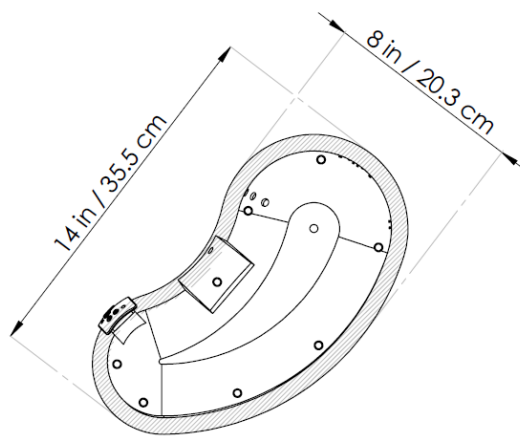


Figure 11: *Lateral view of the Somnox sleep robot and its relative dimensions [mm].*

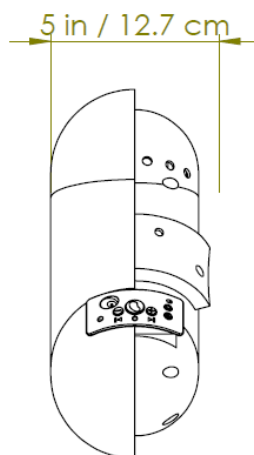


Figure 12: *Frontal view of the Somnox sleep robot and its relative dimensions [mm].*

The best way to validate ideas and products is by testing. Over the past two years, we gathered the feedback from over 5,000 people to validate the functions of the Somnox sleep robot. We also set up multiple testing rounds with sleep specialists, hospitals and somnologists, assessing our various prototypes with potential users. Over 80 test sleepers have already slept with the Somnox sleep robot and participated in our extensive research.

Method of our latest testround

Our latest test cycle of 10 people in the range of 25 to 55 years old was selected through questionnaires to participate in this study. Inclusion criterion was sleep alteration as a cause of daily discomfort. The exclusion criteria were physical disturbances that alter sleep and that, in order to be resolved, require medical intervention.

The participants were received at the Somnox headquarters; there the robot was delivered to them, instructions and recommendations were given as well. The recommendations principally concerned the ban on taking narcotic substances, sleeping pills or other substances that could unnaturally affect sleep and consequently alter the experiment. Everyone during the experiment respected the recommendations. The participants slept 5 consecutive nights with the Somnox sleep robot.

The Somnox sleep robot prototype they picked up had the following functionalities activated:

1. Breathing regulation (4:4, 4:6, 4:8, 4:12, 5:15)
2. Music/sounds (meditation, white noise, etc.)

The alarm functionality was not activated in this test. Also the senses of the Somnox sleep robot were not used for this research. The breathing pattern decreased from a regular breathing pattern (1.7s:2.6s) to the pattern chosen by the participant in 10 minutes. The length of the program could be determined by the user (the rhythm decreased in 10 minutes and then continued on this rhythm for [x] minutes).

In this research only the subjective validation of the Somnox sleep robot was examined. By an online questionnaire the participants were asked if:

1. they thought they fell asleep faster with the Somnox sleep robot
 - (a) if yes, how long does it normally take to fall asleep?
 - (b) if yes, how long did it take to fall asleep with the Somnox sleep robot?
2. they had a better night's rest with the Somnox sleep robot
3. they woke up more energized after a night with the Somnox sleep robot

Next to that we asked them:

4. on a scale from 1-5 how would you rate the Somnox sleep robot?

Table 1: *The results from our latest group of test sleepers (n=10)*

Participant nr.	Question 1	Question 1 (a) [min]	Question 1 (b) [min]	Question 2	Question 3
1	Yes	-	-	Yes	No
2	Yes	-	-	No	No
3	Yes	15	15	No	No
4	Yes	45	15	Yes	Yes
5	Yes	30	10	Yes	Yes
6	Yes	3	1	Yes	Yes
7	Yes	100	45	Yes	Yes
8	Yes	25	15	Yes	Yes
9	No	N/A	N/A	No	No
10	Yes	60	40	Yes	Yes

Results of our latest testround

In table 1 you will find the results of our latest testing round. Participants 1 and 2 didn't answer questions 1 (a) and 1(b) because these questions were added in a later stage of the research. For these questions the number of participants was 8.

It was found that 90 % of our participants experienced an improvement in the time they fell asleep. The people who experienced this had an average time to fall asleep of 40 minutes without the Somnox sleep robot. With the Somnox sleep robot the time to fall asleep decreased of 50 % up to 20 minutes. Including the participant who didn't notice an improvement in the time to fall asleep, an average improvement of 17 minutes was reached.

70 % of the participants noticed they had a better night's rest while sleeping with the Somnox sleep robot compared to the weeks before sleeping with the Somnox sleep robot.

Furthermore, 60 % of our test sleepers woke up more energized. A wake-up functionality wasn't used in this research. Moreover, Somnox sleep robot was given a rating of 4 out of 5 stars.



Conclusion

In the end we can see that most of the participants in this research subjectively fell asleep faster (90 %) with an average improvement of 17 minutes. Next to that 70 % had a better night's rest as well. Of course our test group consisted only of 10 participants. We aim to keep testing with our prototypes all the time, improve our product and prove the effect of the Somnox sleep robot on people sleep.

The 60 % that woke up more energized is not as high as we wanted to, but this could be explained by the fact that we didn't include the wake up function in this research. We will keep updating our sleep robots to make sure everybody will have a better night's rest and wake up more energized.

We always aim for the 100 %. 4 out of 5 stars is good, but not perfect. As said before we will keep gathering feedback continuously from our community to in the end reach the 5 star rating.

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