PROJECT ARC

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We are Year 9 biology and engineering enthusiasts from Merchant Taylors' School in Northwood, London!

THE PROBLEM

Stress is a significant global problem today. We as human beings are exposed to a variety of stressors on a daily basis associated with such factors including work, family, lifestyle and pollution, to name but a few.

While small levels of stress can be beneficial (for example the natural feeling we experience ahead of examinations), longer term stress can lead to more chronic conditions such as anxiety or panic attacks. In turn, these can result in abnormally increased heart rate (tachycardia), chronically elevated blood pressure and heart rhythm disturbances (arrhythmia) – all adversely and dangerously affecting the heart.

5 MILLION people across the globe die each year from mood and anxiety disorders", says a study by the NIH.

79% say the most common cause of stress is work-related stress. (Source: Statista).

Tachycardia and arrhythmia are a particular problem associated with stress.

Key to relaxing the body in times of stress is the parasympathetic nervous system – a network of nerves responsible for the body's relaxation following periods of stress.
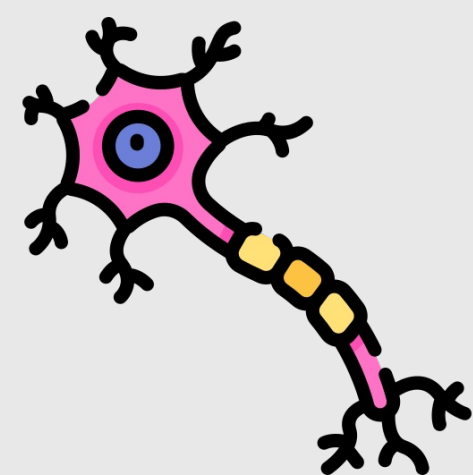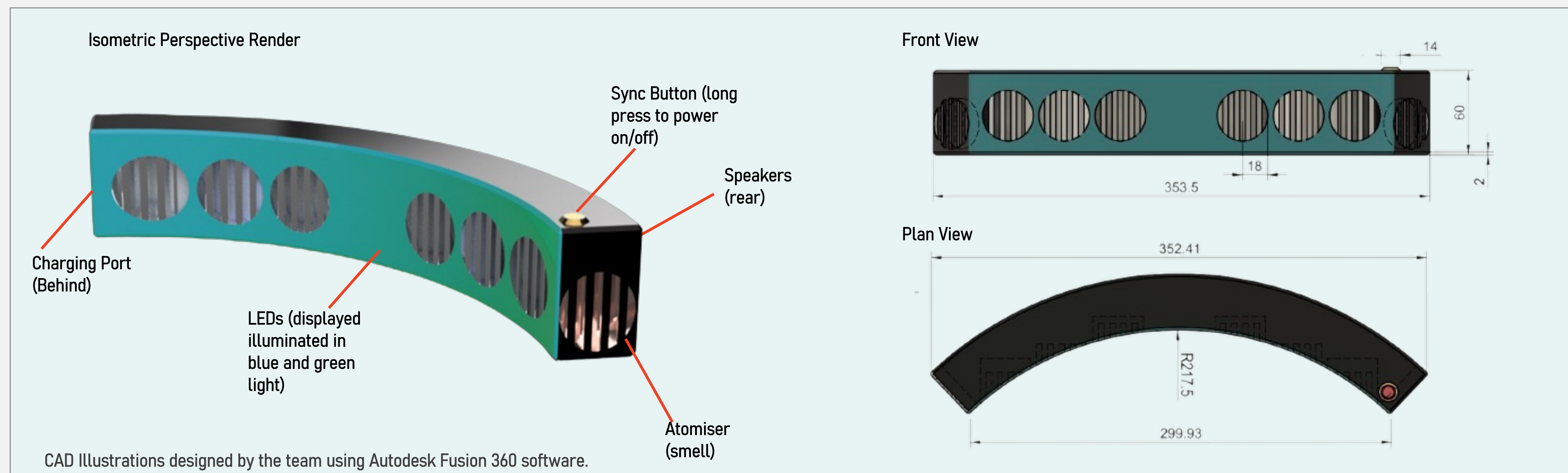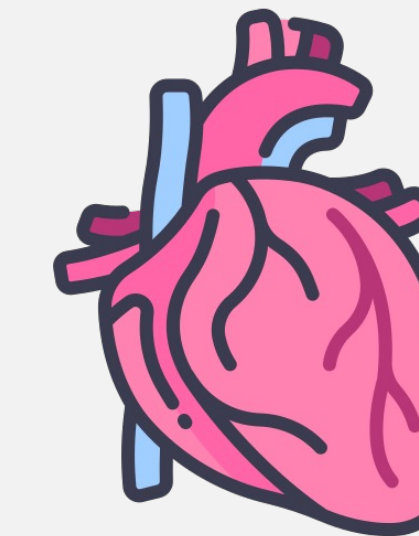
EXISTING SOLUTIONS

Drugs are often prescribed to those with arrhythmia and tachycardia (caused by stress) or to treat anxiety or panic disorders. For example, SSRIs (selective serotonin reuptake inhibitors) are a type of drug used to treat anxiety and panic disorders and work by increasing the level of serotonin in the brain. These however take a few weeks to start working in the body. Agitation, nausea, and digestive issues are common side-effects of this anti-depressant. These are a good solution but must be prescribed carefully by a medical expert.

Scan the QR Code to visit our website for more product renders and for the bibliography (research sources)!

RESEARCH

Our goal was to find a 100% non-invasive method to treat tachycardia and arrhythmia by bringing down stress levels within the body. We discovered during our research that the only effective non-invasive method was through the use of sensory stimuli (light, sound and smell). Some statements from key research:

"… 432 Hz music [was] effective for reducing preoperative dental anxiety in impacted third molar surgery." – National Institute of Health

"These research results regarding the physiological response to environmental colour stimulation suggest that warm colours such as red and yellow stimulate the ANS to increase heart rate and skin conductivity response. By contrast, cool colours such as green and blue relax the ANS to reduce them." – National Institute of Health

"Findings with regard to heart rate variation are similar: generally, unpleasant odours evoke an increase in heart rate, while pleasant scents lead to a decrease." – Oxford Academic

OUR SOLUTION – THE ARC

We engineered a novel solution named the Arc - a non-invasive device designed to lower heart rate using a combination of light, sound and smell. The device can be wall mounted or placed on a bedside table, making it versatile.

Isometric Perspective Render

Sync Button (long press to power on/off)

Speakers (rear)

Charging Port (Behind)

LEDs (displayed illuminated in blue and green light)

Atomiser (smell)

Front View

Plan View

CAD Illustrations designed by the team using Autodesk Fusion 360 software.

DESIGN

The device features a translucent body (displayed in blue-green on the CAD model) behind which energy efficient 255 RGB LEDs (Light Emitting Diode), will be placed. Even though these LEDs can display 60 million colours, mainly light of wavelength of 450nm to 550nm will be used. The translucency of the body means that the light is spread ambiently, which contributes towards creating a calming atmosphere.

Wavelength in nanometres

550 475 450

Designed for surround sound

WALL/HEADBOARD
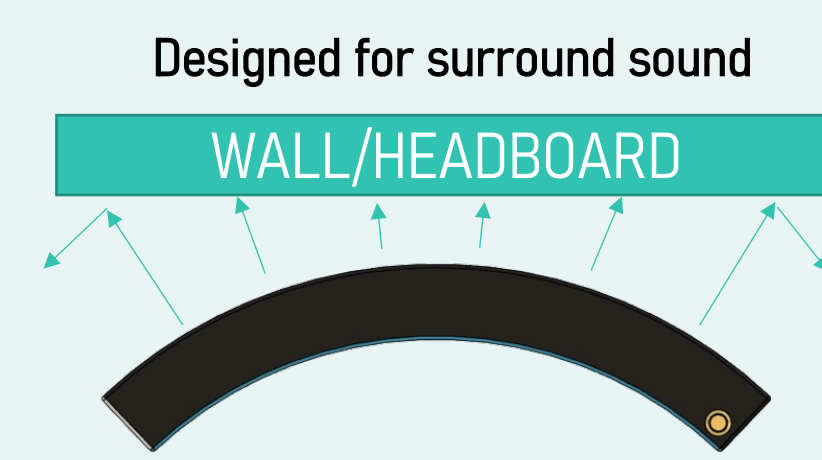
The auditory aspect will be executed through speakers which play multiple frequencies (mainly 432 Hz). The sound will be emitted by six speakers around the outer curve of the arc (displayed in black). These are placed there as the outer curve faces the wall of a room, creating an ambient sound system. As the sound waves bounce off the wall at different angles due to the curvature of the Arc, they travel around the room, as shown in the diagram.

The olfactory (smell-related) aspect is executed using a mini-atomiser (labelled on the CAD model). An atomiser is a device which separates liquid particles into a fine mist, which can easily evaporate to a gaseous form. This is often a component within medical nebulisers, which are used to treat asthma and COPD. A scented liquid comprised of essential oils will be atomised with the device, generating a scent within the room.

TECHNICALITIES

The Arc will support Bluetooth 5.0 (2016) and above as it will use the modern and faster Bluetooth standard to collect heart rate data from a smartwatch that the user will wear. This smartwatch can be medically prescribed or the property of the user. The device will then send the data via internet to a secure database and operations area in the cloud (stores 140TB), where it will run through a piece of conditional code, combined with machine learning algorithms running on data gathered over time, for continually fine-tuned results.

The device will be charged using a USB-C adapter, and as the device is calculated to have a high energy efficiency rating, the battery should last 16 hours of constant use on one full charge.

The output (smell, light hue/intensity and sound frequency and volume) from the code will then return to the Arc where it will be executed. These updates will happen in near-real time. The Arc will also make sure to use gentle transitions when adjusting the three variables to make it a smooth experience for the user.

The device will be manufactured using 3D printing for more complex internal structures and passageways, costing £15 per kg. We will use machined metal for the outer casing to make it more robust. The fans circulating the atomized water will be 40mm fans at £12 for both fans. We will be using 5 10-watt speaker modules for sound. These cost £5 each. All of this will be powered by an Arduino nano for £18. The atomisers cost £10 for the pair. Finally, the cloud database will be free of cost (140TB). The device will retail for £110. All the component links are on the website.

The Arc will be aimed at those who work a corporate lifestyle, ideally those who are more senior non-dependants (30-60). This can be prescribed by a doctor or bought individually through retail as mentioned above.

COHORT STUDY

Our invention will be tested through a cohort study.

The study will involve measuring the resting heart rate of subjects (collected using a smartwatch) in a darkened room with the Arc versus a control group of subjects in a room without the device for a duration of 45 minutes and with subjects lying in a sleeping position. Example pilot study design:

There will be a total of 90 subjects involved in this pilot study who will be divided equally into a control arm (not receiving the device) and a treatment arm (receiving the device). Each arm will be stratified by the following age categories: ages 18-30, 30-60, and 60+ (15 subjects per category). Their heart history will be verified to make sure that no underlying conditions are present, and that the patient has not consumed any drugs or alcohol in the last 48 hours. Each subject will be given the opportunity to sign informed consent to confirm their participation in the study.

90 SUBJECTS

CONTROL (Arc ABSENT) — 18-30, 30-60, 60+

TREATMENT (Arc PRESENT) — 18-30, 30-60, 60+
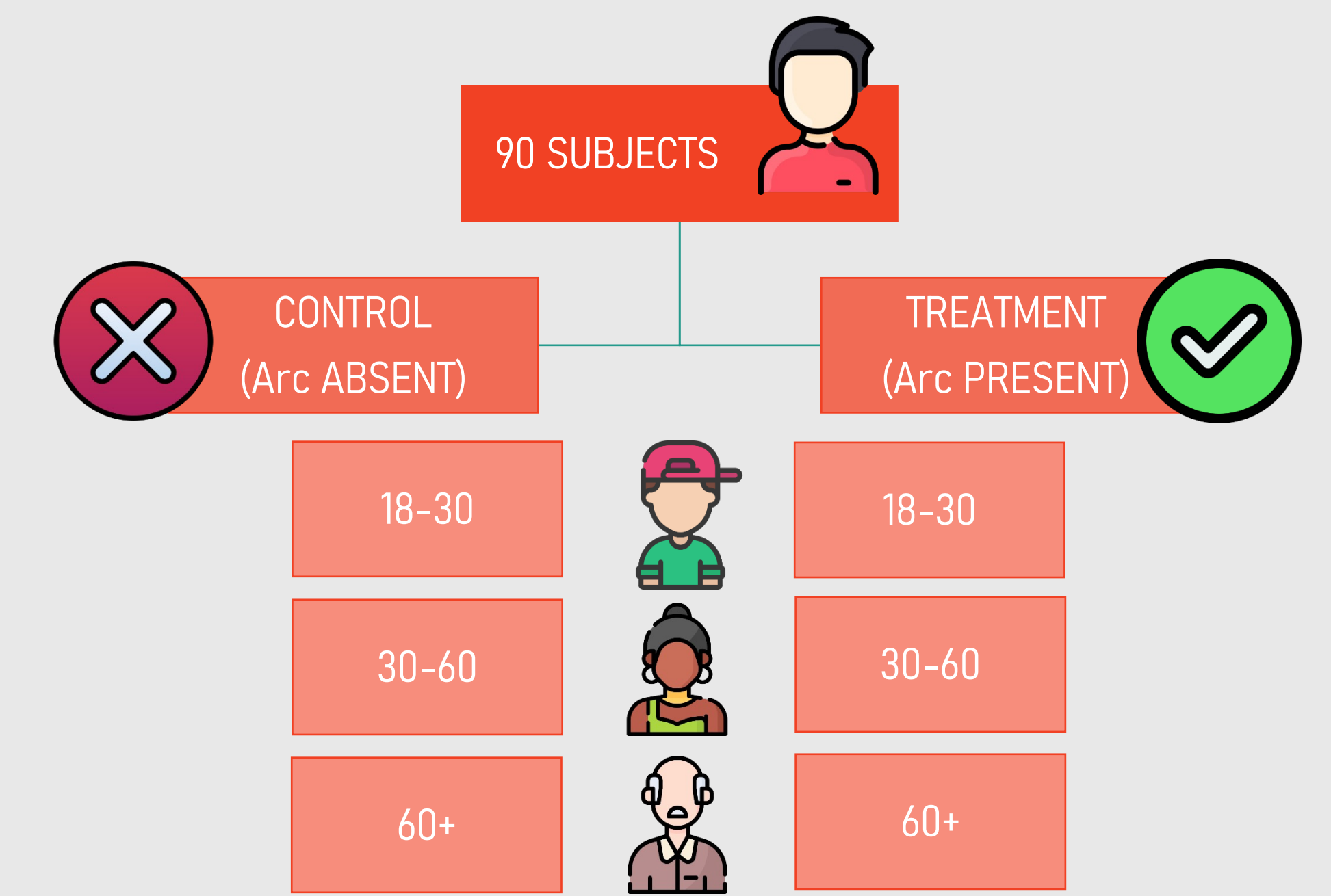
Each room will be kept at a constant 18 degrees Celsius temperature, and lights will be switched off for the duration of the study. A randomised controlled trial will be performed following the feasibility cohort study.

CONNECTIVITY
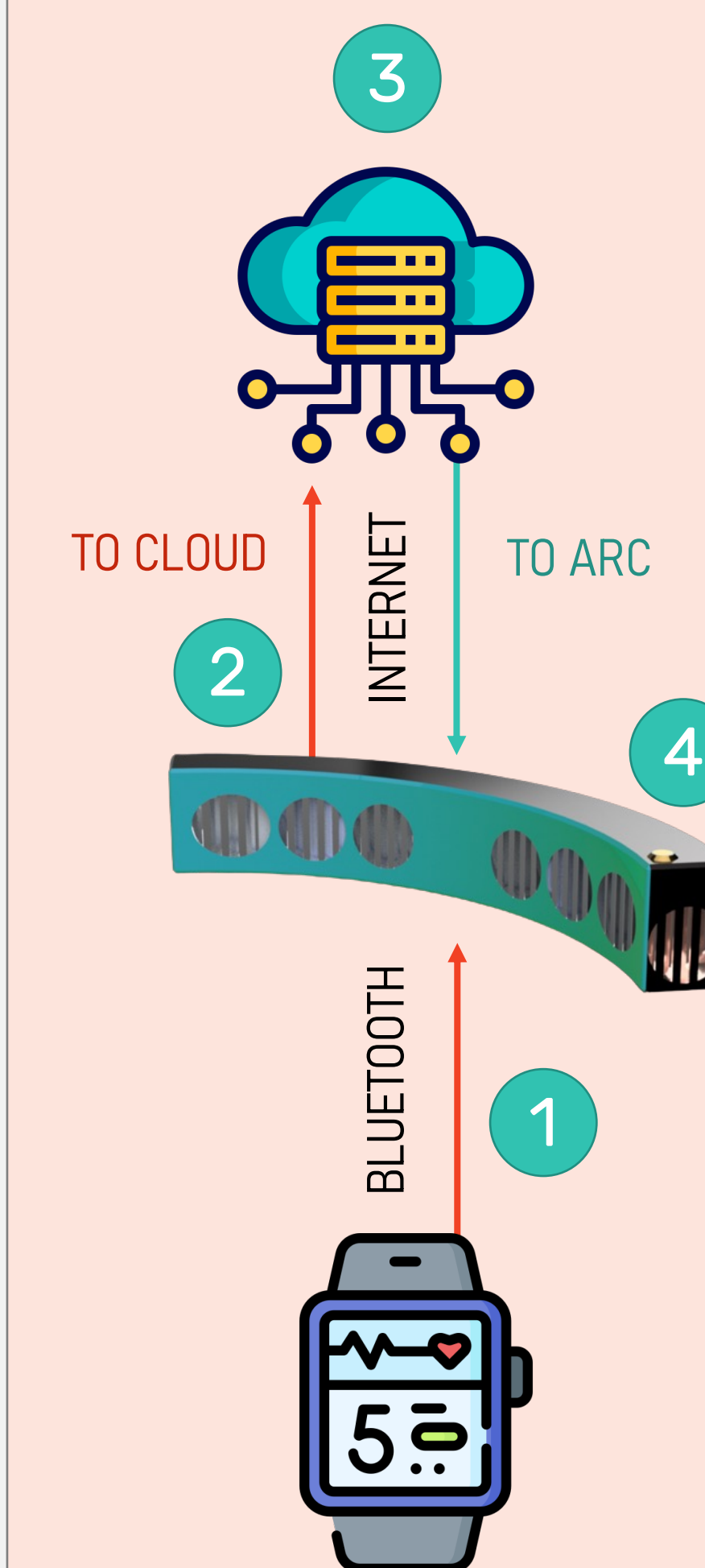
The Arc works simply but efficiently when it comes to connectivity.

TO CLOUD INTERNET TO ARC

BLUETOOTH

1) The smartwatch sends heart rate data to the Arc via Bluetooth.

2) The Arc sends the smartwatch's data over the internet to the cloud, where it will be processed.

3) The cloud contains a database, within which there is a piece of conditional code which determines the outputs. The heart rate data is used for this, and a certain light, sound and smell (outputs) are calculated. Over time, the cloud will collect millions of data points to 'learn' and fine tune the outputs for the user (machine learning).

4) The correct conditions for all senses are sent back and the Arc alters its outputs accordingly. This is done smoothly.