Research Article

Rudolf Arnold*

PLAY ME: interactive sonification of sexual arousal in long-distance relationships

<https://doi.org/10.1515/pjbr-2020-0014>

received October 1, 2019; accepted March 23, 2020

Abstract: Music is the best medium for expressing emotions and arousal nonverbally. PLAY ME is a gender-neutral Arduino-based system that allows partners in a long-distance relationship to perceive each other's sexual arousal and to provide stimulation of erogenous zones using music. PLAY ME's main parts are a tiny pneumatic anal probe connected to a pressure sensor and a bodysuit with integrated vibrators. Whenever both partners wear these devices, a real-time exchange of emotions and corporeal feelings can be enabled. Three sensors capture genital sexual arousal and transform it into music: a pulse sensor, a sensor for galvanic skin response and a pneumatic anal pressure probe. The anal probe measures pelvic tensions and contractions. Its signal controls the main voice. Higher arousal leads to stronger pelvic muscle tensions. Measured data are mapped to pitch, so the level of sexual arousal is audible in a comprehensive way, and orgasms can be clearly identified by regular pulsating sounds. The pulse sensor and the skin response sensor are the driving rhythm and drone frequency. The vibrators in the bodysuit are controlled by sound that is generated by the partner using any audio source. Mixing the sounds generated by the sensors and the instrument leads to interactive music that can enhance erotic feelings and sexual arousal in the way of biofeedback. This article describes the background and construction of the PLAY ME system and shows diagrams of sensor values recorded during sexual stimulation. After a discussion of the results, there is an outlook toward further development.

Keywords: teledildonics, sonification, long-distance relationships

1 Introduction

More and more couples live in long-distance relationships. Some people study far away from home or work in

foreign countries due to globalization. Thus, they cannot meet their partners in the flesh for a time. One of the challenges this leads to is a lack of intimacy. This does not only mean touching, hugging and kissing but also mutual sexual stimulation. Most devices that are available are designed for the sexual stimulation of the genitals. They can be remotely controlled by apps or over the Internet. Some examples of long-distance relationship sex toys are mentioned in *Cosmopolitan Magazine* [1]. Most of them are intended to stimulate women and are controlled by the partner. The number of devices made for men appears to be significantly lesser.

The aim of these devices is not only to facilitate remote tactile stimulation but presumably also to express love, tenderness and lust. In most cases, the feedback is restricted to audiovisual communication such as the so-called dirty talk. A direct corporeal feedback using biosignals is rare and can be found only in few prototypical arrangements such as the Neurodildo [2].

The innovative idea of PLAY ME is to implement musical structures to support remote tactile stimulation and moreover to get an emotional audio feedback of physical sexual arousal in the form of musical strains. It can thus be used to enhance self-perception during masturbation, to add a new level of life performances and to keep long-distance relationships thrilling.

The term PLAY ME was chosen to express that the system can be seen as an invitation to use one's own body as a musical instrument.

PLAY ME consists of two main components. The first component contains audio-controlled vibrators integrated into a bodysuit. They are designed to provide tactile stimulation of the genitals and other erogenous zones. The audio signal can come from any source. In the PLAY ME prototype, a synthesizer played by the partner was used to control the vibration intensity as shown in Figure 1.

The task of the second component is to provide acoustic feedback of sexual arousal from the person who is being stimulated. It consists of biosensors that capture corporeal changes caused by sexual arousal. Figure 2 shows that the sensor signals generate chords by sonification. Sonification is

* Corresponding author: Rudolf Arnold, EMU Ensemble, Musisches Zentrum, University of Ulm, Ulm, Germany, e-mail: rudolf.arnold@freefm.de

Figure 1: Music-controlled vibrator.

Figure 2: Feedback of sexual arousal using sonification.

Figure 3: PLAY ME for a single user.

the use of nonspeech audio to convey information and to perceive data relations [3,4].

In a single-user environment, the person plays her/his own synthesizer to provide genital stimulation and receives

feedback in the form of musical strains controlled by the biosensors as illustrated in Figure 3.

When two systems are brought together, PLAY ME can be used for the exchange of sexual stimulation and musical feedback between partners in long-distance relationships. This is shown in Figure 4. It is the main purpose of PLAY ME.

2 Background

2.1 Sexual arousal and orgasms

Orgasms are profound sensations surrounded by love, ecstasy, myths and taboos, accompanied by psychological and physiological changes. In literature, art, dance and music they are predominantly depicted as a holistic experience.

This concept was radically deconstructed by Masters and Johnson. In their famous book, *Human Sexual Response* [5], they reduced the sexual response cycle to corporeality and physiological changes. Their four-stage model of sexual response has been the most popular finding and has thus been cited in many publications about human sexuality.

Nowadays several methods are made use of for orgasm research. Most frequently, research measure the pulse amplitude, heart rate, skin conductance, blood pressure and breath rate and record them for a gender-neutral quantification of corporal effects during sexual arousal. Examples for cardiac rates can be found in Masters and Johnson [5, p. 35 Figure 3-2, p. 132 Figure 9-1 and p. 175 Figure 11-1]. Nevertheless, an accurate identification of an orgasm is impossible with only these parameters. Fortunately, however, orgasms can be detected by a clear-cut pattern: irrespective of gender, orgasms coincide with rhythmic contractions of the pelvic muscles which cannot be seen at any other time. In a clinical context, an orgasm is defined as the “sudden discharge of accumulated sexual tension during the sexual response cycle, resulting in rhythmic contractions in the pelvic region” [6]. The easiest and gender-neutral way to capture these tensions and contractions involve the use of anal probes [7].

2.2 Music and emotions

Even diagrams of the most impressive orgasms do not provoke any feelings. Showing them is not suitable for igniting passion in long-distance relationships.

The relations and interactions between music and emotions and between composers, musicians and listeners

Figure 4: The use of PLAY ME in long-distance relationships.

have been discussed and pondered by music philosophers, neuroscientists and other academics for a long time. An extended debate can be found in a paper by Michael Huppertz [8]. He notes: “It will be demonstrated which qualities make emotions musical and which make music emotional. Emotions and music may interact as scenarios and ‘scenic objects’.” Finally: What about the reality of musical emotions?” If sexual interactions between lovers can be seen as “scenarios,” there is an interaction between emotions and music provided by PLAY ME. Another “review of the current state of investigating music evoked emotions” is presented in a paper by Hans-Eckardt Schaefer [9].

2.3 Music-controlled vibrators

The idea to control vibrators by music was realized more than 10 years ago by a commercial sex toy called *OhMiBod*[®]. It was introduced as an *iPod*[®] vibrator and directly connected to an audio cable. *OhMiBod* was licensed under U.S. Patent No. 6368268, which expired in August 2018. Now there are improved wireless versions with apps available on the market produced by the companies *OhMiBod* [10] and *KIIRO*[®] [11]. Most of those

so-called mp3 vibrators are made for women, but there are also a few ones for men [12].

3 Construction

The major component of PLAY ME is a small pneumatic anal probe intended to measure the tension and contractions of the anal sphincter during genital sexual arousal and orgasm. It was invented by the author to enhance the experiments of sex researcher Nicole Prause, PhD. The final shape of the head was developed in cooperation with her and the base was designed according to her specifications. To make the pressure changes audible, the probe is connected to a pressure transducer which is connected to the analog input of an Arduino[®]-compatible board. This board is connected to a computer running Processing [13] and SuperCollider [14].

These programs were written by the author using free available libraries. The pulse sensor and the sensor for skin resistance employed within the system are available from online merchants.

Although many music-controlled vibrators are available, the author built a simple Arduino-based system to control the vibrators meant to be integrated into the

bodysuit in a flexible way. The usual vibrators on the market are too big, smaller ones are used in PLAY ME. Furthermore, the idea was to be able to adapt the position of the vibrators in the bodysuit to the preferences of the wearer and also to control all of them at once as well as each one individually.

The diagram in Figure 5 shows a connection scheme of the basic components which the PLAY ME prototype consists of. The upper left part depicts the electronics used for digitalization of the biosignals (Sections 3.2 and 4) captured by the probes and electrodes integrated in midsection which represents the bodysuit (Section 3.3). The bodysuit contains vibrators driven by the electronics shown in the lower part (Section 3.1). The right-half describes the connections of the devices used for sonification (Section 5).

3.1 Music-controlled vibrators

Employing an Arduino compatible microcontroller and commonly available electronics makes this do-it-yourself construction very cheap and simple. Only a transistor, a diode, a resistor and some wires are necessary besides the microcontroller. A more secure and versatile version uses the so-called motor shield.

For the PLAY ME prototype, an iPad® Air 2 and the App Garage Band® as shown in Figure 6 are used to play the music which controls the vibrators. The iPad® is connected to an analog input of a Teensy® 3.2 using a small adapter as shown in Figure 7.

The analog-to-audio adapter is connected to an analog input of the Teensy® board. As depicted in Figure 8, the board operates the motor drivers DRV8838, which drive the vibrators shown in Figure 9.

3.2 Biosensors

Electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG) and galvanic skin response (GSR) are commonly used to collect data from a human body during a sexual response cycle. Changes in breath, temperature, blood pressure or blood oxygen level can also be gauged by a number of instruments. Anal probes in addition measure the tensions and contractions of pelvic muscles during sexual arousal and orgasm.

For practical reasons, the number of sensors in PLAY ME needs to be as small as possible. At the same time, their signals have to be significant enough for the evaluation of genital arousal. And they have to be suitable for easy sonification.

Only three sensors meet these demands: pulse amplitude, GSR and pelvic muscle tension. In the case of sonification for PLAY ME, GSR is not mandatory.

3.2.1 Pulse amplitude

Pulse amplitude and pulse rate can be measured by a simple optical sensor using green light. In most cases, it will be attached to the index finger or the ear lobe. Within the maker community *pulse sensor amped* shown in Figure 10 is the most frequently used sensor. A comprehensive introduction with exemplary programs can be found in *theorycircuit.com* [15].

3.2.2 Electrodermal activity – GSR

“EDA is a sensitive psycho-physiological index of changes in autonomic sympathetic arousal that are integrated with emotional and cognitive states” [16]. Electrodermal activity (EDA) is measured by skin conductivity that changes due to the activity of sweat glands. As sweating is a reaction of the sympathetic nervous system, higher arousal, including sexual arousal, leads to more sweat gland activities and thus to an increased conductivity of the skin. An alternative term used to describe these phenomena is GSR. An introduction and a download link to a free guide about GSR can be found in the homepage of Imotions Company [17].

An easy-to-handle device to measure EDA is the Grove-GSR Sensor by Seeed Studio as shown in Figure 11 [18]. Unfortunately, the device measures the skin resistance R and not the skin conductivity S , but S can be calculated by $S = 1/R$.

3.2.3 Sensors for pelvic muscle tension

There are different ways to register the pelvic muscle contractions. In some cases, the force-sensitive resistors (FSRs) were integrated into the vibrators to measure the contractions in the vagina. An example is the *Neurodildo* mentioned above [2]. A commercial available vibrator for women is the *Lioness vibrator* [19]. Besides the vibratory functions, it uses FSRs to capture vaginal contractions. It also uses an accelerometer, gyroscopes and a temperature sensor. These values can be recorded and evaluated with an app. Due to the dimensions, both seem to be deductible only vaginally. Their construction suggests that the orientation of the device within the vagina and

Figure 5: Connection scheme of basic components.

body movements might have an influence on the measurements. Furthermore, FSRs have a threshold value for force.

Anal probes are used in sex research because they are gender neutral. A second reason is the stronger power of anal contractions compared to vaginal contractions [20].

Figure 6: iPad® Air 2 with app Garage Band.

Figure 9: Bullet vibrators.

Figure 7: Audio-to-analog adapter.

Figure 10: Pulse sensor amped.

Figure 8: Teensy® board with motor drivers and connectors.

Figure 11: Grove-GSR sensor.

Figure 12: EMG of internal anal sphincter.

Some probes contain microphones, some use photoplethysmography and others have integrated FSRs.

Most people take to EMG since many probes are available and are prescribed for the treatment of incontinence. Two probes [21,22], a shield [23] and a breakout board [24] for Arduino were tested with good results.

Orgasmic contractions can be clearly identified by an EMG of the internal anal sphincter showing sharp regular signal peaks as shown in Figure 12. But increasing the muscle tensions does not appear to deliver increasing signal voltage. It might show up as higher frequencies of the signal. This can be seen between 450 and 480 s in Figure 12. This signal behavior makes an easy evaluation of muscle tensions difficult. Another drawback is that condoms hinder the functioning, so good sanitizing is essential when the probe is used more than once.

In 1979, *Joseph Bohlen and James Held* developed “An anal pressure probe for monitoring vascular and muscular events during sexual response” [7]. In their illustrated paper, the construction of the probe is described carefully. However, it appears to be complicated to build it with simple skills. That might be the reason why it was not used very often in other labs.

Nicole Prause, PhD, a sex researcher from LA, thus wanted to find a better version of this pneumatic anal probe. It should be cheap, easy to build, easy to handle and reliable. She looked for someone who was familiar with *Arduinos*, sensors, 3D printing and able to construct a pneumatic anal probe.

In January 2018, a 3D-printed probe as shown in Figure 13 was developed by the author using freeware *Autodesk 123D Design*. The shaft provides mechanical counterpressure and a secure placement for the tube. The 4 cm length of the shaft is based on the probe design of Bohlen and Held [7]. A downloadable standard triangulation/tesselation language file for 3D printing of the shaft and a short description can be found on Thingiverse [25].

We employed a silicone tubing of 1 mm × 3 mm and a differential pressure sensor to measure pressure changes. In order to maximize the contact area of the probe within the anal canal, the tube is coiled around the probe. Secure threading is provided by three small holes. The shape of the head allows easy insertion and extraction. After passing the anal canal, it will be placed in the rectum without discomfort and prevents expelling even when the

Figure 13: 3D model of anal probe.

sphincter muscles contract very strongly. The assembled probe is shown in Figure 14.

The silicone tubing is attached to the upper inlet of an MPXV7002DP differential pressure sensor [26]. It is mounted to a breakout board shown in Figure 15 and connected to an analog input of an Arduino.

Figure 14: 3D printed anal probe with coiled silicone tube.

Figure 15: Differential pressure sensor MPXV7002DP on a breakout board.

3.3 Bodysuit

The bodysuit depicted in Figure 16 is custom-made with two layers of stretch fabric. On top of the bottom layer, a second slightly smaller layer is sewn using parallel double seams, whereas the outer edge is left open. The distance between the

Figure 16: Bodysuit front pattern with pink bullet vibrators.

Figure 17: Insertion of a pink bullet vibrator.

two double seams corresponds with the diameter of the bullet vibrators, which is 16.4 mm.

Due to the use of the stretch fabric, the bullet vibrators can be inserted into different hoses between the double seams as shown in Figure 17. They can be shifted according to the wearers' needs but will stay in place.

This solution was chosen, since it is not possible to locate the exact position of the wearer's erogenous zones in advance. The vibrators can be removed for washing without any problems. The number of bullet vibrators is variable and limited only by power supply and the type and number of motor drivers. Over this arrangement, any clothes can be used, whereas tight clothing like a catsuit as shown in Figure 18 or a swimsuit provide the best skin contact.

4 Sensor signal evaluation

Sensor signals were evaluated using a Teensy 3.2 board connected to a computer by way of a USB connection. As shown in Figure 19, the differential pressure sensor was connected to the analog input A0, the pulse sensor to A1 and the skin resistance sensor to A2.

The analog signals were converted and sampled with 13 Bit ADC running at 250 Hz. The serial transmission rate was 57,600 Baud. The computer was equipped with Microsoft Windows® 7. The digital values were recorded with Real Term: Serial Capture Program 3.0.1.43 [27].

Figure 19: Teensy 3.2 board with analog inputs.

Figure 18: PVC catsuit worn over vibrator bodysuit.

Figure 20: Pressure of internal anal sphincter and GSR normalized.

Data were then imported to Microsoft Excel® 2013. Skin conductivity S was calculated from skin resistance R by $S = 1/R$. The anal pressure sensor was covered with a condom and inserted into the anal channel. The pulse sensor was attached to the left index finger. The sensor for skin resistance was attached to the left middle and ring finger. The biosignals were captured during a full sexual response cycle induced by genital stimulation with a Europe Magic Wand Vibrator running at the lowest speed (40 Hz). The readings were normalized to the maximum value recorded during the sexual response cycle and then plotted. The respective diagram is shown in Figure 20.

Pelvic muscle tension measured by internal anal sphincter pressure increased up to the onset of orgasm at 498 s. There were 16 regular contractions until the end of the orgasm at about 524 s. The increase in the intervals

is in full accordance with the results of Bohlen and Held [7]. GSR decreases continuously from 496 s until the end of the recording at 565 s. This shows that an orgasm leads to a significant relaxation. All in all, 33 recordings were made under different conditions, showing similar results as depicted above. As shown in Figure 21, even two multiple orgasms could be found, even though the test person was male.

5 Sonification

In short, sonification is defined as “data-dependent generation of sound, if the transformation is systematic, objective and reproducible, so it can be used as scientific method” [28,29].

Figure 21: Pelvic muscle tension during two male multiple orgasms.

Figure 22: Mapping of pelvic muscle tension to pitch.

Figure 23: Processing and SuperCollider programs for sonification.

The prototype version of PLAY ME uses sensors for pelvic muscle tension, pulse amplitude and GSR. The sensors are connected to analog inputs of a Teensy 3.2 and their data converted to digital values with a 13-Bit resolution. The data for sonification are mapped in a simple way. As illustrated in Figure 22, higher values lead to higher pitches of tones.

Because the sound needs to be agreeable and should always be harmonic, a pentatonic scale is used for all three

signals. For technical reasons, the serial output of the Teensy 3.2 is connected to a computer via USB. This computer runs with a Processing [13] program which controls a software synthesizer run by in SuperCollider [14]. Figure 23 shows a screenshot. The audio output of the computer is connected to a mixer.

Hermann [29] listed four sonification criteria:

1. The sound reflects properties and relations of the input data.

2. The transformation is completely systematic. This means that there is a precise definition of how interactions and data cause the sound to change.
3. The sonification is reproducible: given the same data and identical interactions and triggers, the resulting sound has to be structurally identical.
4. The system can intentionally be used with different data and also be used in repetition with the same data.

The present method of converting the sensor signals into sound fulfills all four criteria:

1. The pitch of sound is directly related to the pressure captured by the anal probe and the pressure sensor.
2. The range of data delivered by the probe is matched to the index of an array containing frequencies of a pentatonic scale leading to higher tones when pressure increases.
3. The same pressure values always lead to the same pitch.
4. The system can be used by different persons, resulting in different melodies but within the same range of notes defined by the frequencies in the array.

The time-frequency spectrum of anal sphincter tension sonification during three short masturbation episodes is depicted in Figure 24.

Higher level of anal sphincter tension equals higher frequency, and more brightness indicates a higher amplitude. The spikes indicate pelvic muscle tension, i.e., sexual arousal. Note that the spike level stays very high between 112 and 122 s, creating a steady high pitch induced by very high arousal. This equals the so-called plateau phase described by Masters and Johnson [5, p. 5 Figures 1-1 and 1-2]. At 122 s, the orgasm starts which can be seen by a fast decrease in the spike level. The recording was made using a prototype arrangement shown in Figure 25. Genital stimulation was provided by a Europe Magic Wand Vibrator running at the lowest speed (40 Hz).

Figure 24: Time–frequency spectrum during three short masturbation episodes.

Figure 25: Prototype arrangement for sonification of arousal.

6 Concept of PLAY ME and user scenarios

The main concept of PLAY ME is the combination of music-controlled vibrators and the sonification of biosignals during sexual arousal together. PLAY ME can be used alone, together with another person playing the synthesizer, or by two persons in a long-distance relationship using two PLAY ME devices over the Internet for passionate erotic interaction.

6.1 Single user

The easiest scenario to use PLAY ME is that the person wearing the vibrators and sensors also plays music as

Figure 26: Single user scenario.

shown in Figure 26. The aim is not only amusement but also to let the partner hear what kind of music one prefers and to find out what reactions can be provoked.

6.2 Performance

In performances, the synthesizer can be played by a second person. It might be replaced by sound generators controlled by sensors like gyroscopes, color and more. Figure 27 shows a PLAY ME scheme for two dance performers.

A similar arrangement was indeed used for an experimental music performance. In this event, the mixer was connected to a big audio system. The musician playing the synthesizers wore a stethoscope microphone to also make his own arousal audible by heartbeats. Figure 24 in Section 3.3 shows the author and performer in a bodysuit worn during the event.

The supplementary sound sample **PLAY_ME_Transition.mp3** sonifies first the performer's pulse. Second, we hear a synthesizer pad, played by the involved female partner, steering the vibrators in the performer's suit. Third, the harp-like chimes (Arpeggio) are an expression of the

performer's reaction to this input. They sonify his sexual arousal.

6.3 Two persons in a long-distance relationship

The most viable application of PLAY ME is the exchange of emotions and passion by music in long-distance relationships. In this case, two sets are necessary. Figure 28 shows a simplified scheme.

7 Results

7.1 Music-controlled vibrators

The components shown in Section 3.1, Figures 7 and 8, worked without problems. When the audio amplitude increased, the strength of the vibrations also increased. Since the current circuits of the microcontroller board and the motors were separated, it was possible to run different 3 V vibration motors without side effects. Whenever the audio amplitude was not strong enough,

Figure 27: Dance performance using one PLAY ME arrangement.

the motors did not run or only made noise without noticeable vibrations.

7.2 Biosensors

7.2.1 Finger pulse amplitude

From an electronic point of view, the pulse sensor amped shown in Section 3.2.1, Figure 10, worked without problems. But sometimes a proper and durable placement on an index finger was difficult and caused artifacts during sonification, especially when the sensor lost finger contact. Because very low signal amplitudes were matched to a frequency of only 8.18 Hz (MIDI note # 0), a signal loss was not disturbing. Figure 29 shows a pulse amplitude diagram recorded during masturbation and orgasm. The gray area marks the period where the anal orgasmic contractions occurred.

The decrease in amplitude is a known phenomenon and is described as a *vasoconstrictive response* [30]. A detailed view in Figure 30 shows the good quality of the signal.

7.2.2 GSR

The electronics of the Grove-GSR-Sensor shown in Section 3.2.1, Figure 11, worked without problems. The electrodes did not lose contact with the fingers but minor changes in placement caused perceptible results. When the electrodes got in contact with each other, the resistance R inadvertently dropped to nearly $0\ \Omega$ and conductivity $S = 1/R$ rose above limits. To avoid problems during sonification, a threshold for R needs to be defined in the program running on the microcontroller board, as shown in Figure 19. Figure 31 shows a GSR diagram recorded during masturbation until orgasm. The gray area marks the period when the anal orgasmic contractions occurred, as seen in Section 7.2.1. The continuous decrease is typical for relaxation [31].

7.2.3 Anal pressure probe

The 3D printing took 2 h. Assembling the silicone tube was accomplished within 5 min. To evaluate wearing comfort, the anal probe was covered with a condom and

Figure 28: PLAY ME in a two-user scenario.

Figure 29: Pulse amplitude recorded during masturbation and orgasm.

inserted into the anal canal until the head of the probe reached the lower part of the rectum. Due to the upper shape of the head, insertion was easy and painless. Since the inferior rectum is wider than the anal canal, the probe head

caused no discomfort. The probe could not be expelled even by strong contractions of the anal sphincter. This property is not only important for PLAY ME but also for a reliable evaluation of orgasms during human sexual response cycles.

Figure 30: Detailed view of pulse amplitude.

Figure 31: GSR recorded during masturbation and orgasm.

The probe was worn several times for up to 4 h, including standing, reclining and sitting, walking and dancing. None of these activities caused any pain, nor did they damage the condom. No injuries could be found by a proctologist after the 4-h test. Due to the lower shape of the head, extraction was easy and painless.

The functionality and reliability of the anal pressure probe were tested during several masturbation situations. Stimulation was provided by different vibrators, manually or by the so-called “pillow humping” (coital movements using a pillow between the thighs). In each case, changes

in pelvic muscle tension and orgasmic contractions of the sphincter could be captured with good signal quality.

Figure 32 shows a pressure diagram recorded during masturbation until orgasm. The gray area marks the period when the anal orgasmic contractions occurred, as seen in Sections 7.2.1 and 7.2.2.

Movement artifacts are a big problem in psychophysiological experiments. To evaluate them, the probe was worn during masturbation with a strong vibrator while dancing lively to “*Cleopatra*” by David Vendetta [32]. Figure 33 shows that movement artifacts are small and have no significant influence

Figure 32: Anal sphincter tension recorded during masturbation and orgasm.

Figure 33: Anal sphincter tension recorded during masturbation and orgasm while dancing.

on the signal quality of anal pressure recording during stimulation and orgasm. And even in this unusual situation, the anal probe stayed in place and did not get expelled.

7.3 Bodysuit

The anal probe was covered with a condom and inserted before putting on the bodysuit. The bodysuit was comfort-

able and it was easy to place four vibrators over erogenous zones. Two were fitted over the breasts and the others over the genital area. A skintight PVC catsuit was worn over the bodysuit. The vibrator cables and the hose of the anal probe were led through zippers in the crotch area and connected to a small box containing the motor drivers, the pressure sensor, microcontroller boards and the power supply. The box was attached to a belt around the waist. This clothing was worn for up to 4 h without any

discomfort for testing and for three experimental music performances.

7.4 Sonification

During different tests and performances, the sonification process was stable and reproducible. During performance, the audio cable between the mixer and the notebook was not directly connected to the audio output of the computer but to the output of a professional USB-audio interface to ensure good sound quality. Since all biosignals were mapped to pentatonic scales, they always created harmonies. It proved possible to also use a second notebook and a Wi-Fi access point to distribute signals between more than two musicians and to enhance musical expression by feature extraction and improving sound complexity.

8 Discussion

There are alternatives to the anal probe construction shown here, but none has so far used the tube itself for measuring pelvic muscle tension. Bohlen and Held invented an anal pressure probe for sex research in 1979 [7]. It worked well and the results were the same as shown here. The anal probe has a diameter of 20 mm, a 35 mm long active area and a 30 mm diameter and

25.5 mm long head. Insertion and wear of a Bohlen's probe 3D-printed dummy proved not nearly as painless compared to the PLAY ME probe and it got occasionally expelled by strong contractions in self-test. Then there are commercial pressure probes employed for continence care [33]. In this case, the anal sensor has a diameter of 15–19 mm, a 30 mm long active area and a 30 mm diameter flange. The overall length is 80 mm and the sensor has a medical grade silicone rubber sheath. The size of this probe is similar to the probe presented here. It should be possible to connect the 120 cm tube with the pressure sensor of PLAY ME using an adapter and the results will likely be comparable. However, 3D printing and inserting a dummy with its shape and dimensions showed that it can be expelled voluntarily. Thus, using it for PLAY ME was considered to be problematic.

As described in Section 7.2.1, it is difficult to attach the pulse sensor to a convenient location, as it easily loses finger contact whenever the test person moves or the pulse amplitude grows too weak. Furthermore, the cable of the finger pulse sensor can interfere with playing music and masturbation. As an alternative, the pulse sensor can be clipped to an ear but that may be unpleasant. Using ECG with textile electrodes integrated into the bodysuit might solve these problems [34]. As the pulse or heartbeat signals provide rhythm, which is an essential feature of music, it is not recommended to omit them.

Positioning the electrodes for recording GSR is not as difficult as the finger pulse sensor, but the wires between

Figure 34: GSR recorded on toes and fingers during masturbation and orgasm.

Figure 35: Planned practical solution of PLAY ME.

the fingers and the microcontroller board are distracting and impede certain masturbation practices. As an alternative, the electrodes can be placed on the toes with similar results as shown in Figure 34.

It is difficult to associate GSR with sexual arousal at a given moment. In the event of emotional stress, it has a latency between 1 and 5 s and a duration of between 10 and 20 s and the tonus has a response time of up to several minutes [35]. The only outstanding change that the GSR shows is the strictly monotone decrease in skin conductance after orgasm when sexual stimulation ceases, as described in Section 7.2.2. Thus, the GSR sensor might be considered dispensable, as it accounts for an insignificant loss of musical expression of sexual arousal.

Vibrator noise can be a problem when using PLAY ME if privacy is not safeguarded or in the quiet phases of a performance.

It has to be admitted that the prototype is not easy to handle at all. Besides the vibrators in the bodysuit, there also needs to be a small box with an Arduino-compatible microcontroller, a Bluetooth adapter for wireless connection and a battery. The pressure sensor, the pulse sensor and the skin resistance sensor will be connected to the case. Their data are sampled and transmitted to a control box that is responsible for the conversion of data into music. This box

should also contain a stand-alone synthesizer and an MIDI interface for a small keyboard. The audio signal here generates control signals, which are transmitted to the bodysuit wearer in order to drive the vibrators. There also needs to be a Bluetooth connection from the control box to the headphones. The parameters of the electronic components inside the box should be controlled by an app on a smartphone or a tablet. The app may replace the external synthesizer. It is planned to use the open-sound control (OSC) protocol [36] to exchange biosignal data and control data between the local and the remote user. The remote OSC messages are also used to control the local synthesizer. The sketched out solution is shown in Figure 35.

9 Conclusion

The aim of this article was to present a system that allows partners in a long-distance relationship to perceive each others' sexual arousal and to provide stimulations of erogenous zones by the creation and exchange of music. This seems to be much more interesting, thrilling and respectful as using a remote-control application to directly stimulate a distant partner sexually. A prototype of PLAY ME was constructed that fulfilled the main specifications:

first, capturing pulse, GSR and pelvic muscle tension signals and transforming them into agreeable music that makes sexual arousal audible and thus shareable; second, control genital vibrators by music created by the involved persons; and third, exchange OSC signals between partners to receive and control music as a medium to express passion and sexual arousal.

To develop a commercial product, a few enhancements need to be accomplished:

- Covering the probe used for PLAY ME with a thin medical grade silicone rubber sheath.
- Padding the bodysuit to reduce vibration noises.
- Replacing the bullet vibrators by quieter ones.
- Replacing the sonification equipment by a stand-alone solution integrating all components.
- Autocalibration of the pressure sensor to get a reproducible range of tones.
- Options to change scales, timbre, loudness, harmonies and other musical parameters.
- Ability of feature extraction to enrich musical expression by adding modulation and harmonies.

Furthermore, PLAY ME or parts of it can be used in medical therapy, psychotherapy and sex research.

The probe and sonification devices can also be used in continence care. Most elder people have problems with their eyesight, so reading the gauges may be difficult or even impossible. In this case, sonification can help them to register the strength of pelvic muscle contractions during continence training in the way of biofeedback. The sonification parts of PLAY ME can be made user-friendly, for example, by creating a stand-alone system and adding rotary knobs to change the scale and loudness. A speaker can be included or an earphone connector to ensure privacy during training.

Music therapy is a common method for treating psychic problems such as depression or anxiety disorder. In sex therapy, PLAY ME can be used to (re)gain self-confidence and awareness by listening to one's own body signals and/or to the music generated by sexual stimulation of the partner. This may be coined as *partnered sonification of sexual arousal* and can be an option during special therapies such as *orgasmic meditation*.

Originally, the anal probe was invented to enhance sex research in order to obtain a precise identification of orgasm onset and duration. This is beneficial when EEG or functional magnetic resonance imaging (fMRI) is used to distinguish patterns and images of orgasms from other states of arousal. As the probe and the tube do not contain any metal, there are no problems when used with an fMRI.

References

- [1] L. R. Emery, "5 sex toys that could improve your long distance relationship," *Cosmopolitan Magazine*, June 7, 2017, <https://www.cosmopolitan.com/uk/love-sex/sex/g9988579/long-distance-relationship-sex-toys/> [last accessed 2019-09-14].
- [2] L. Gomes and R. Wu, "Neurodildo: a mind-controlled sex toy with e-stim feedback for people with disabilities," *Love and Sex with Robots, 3rd International Conference*, Springer International Publishing, 2018, pp. 65–82, https://doi.org/10.1007/978-3-319-76369-9_6.
- [3] *Auditory Display: Sonification, Audification, and Auditory Interfaces*, G. Kramer, Ed., Santa Fe Institute Studies in the Sciences of Complexity, Proceedings, Addison-Wesley, Reading, MA, 1994, vol. XVIII, ISBN 978-0-201-62603-2.
- [4] T. Hermann, A. Hunt and J. G. Neuhoff, *The Sonification Handbook*, Logos Publishing House, Berlin, 2011, ISBN 978-3-8325-2819-5, <https://sonification.de/handbook/> [last accessed 2019-09-14].
- [5] W. Masters and V. E. Johnson, *Human Sexual Response*, 1996, Current Printing in January, 2010 by Ishi Press, New York, Tokyo, ISBN 978-0-923891-21-3.
- [6] Wikipedia, <https://en.wikipedia.org/wiki/Orgasm> [last accessed 2019-09-15].
- [7] J. G. Bohlen and J. P. Held, "An anal probe for monitoring vascular and muscular events during sexual response," *Psychophysiology*, vol. 16, no. 3, pp. 318–323, 1979.
- [8] M. Huppertz, *Musik und Gefühl/Music and Emotion, Musik und Ästhetik*, 7. Jahrgang, Heft 26, Klett-Cotta Stuttgart, German Language, April 2003. Abstract: https://www.musikundaesthetik.de/article/mu_2003_26_0005-0041_0005_01 [last accessed 2019-09-15].
- [9] H.-E. Schaefer, "Music-evoked emotions – current studies," *Front. Neurosci.*, vol. 11, p. 600, 2017, <https://doi.org/10.3389/fnins.2017.00600>.
- [10] <http://www.ohmibod.com/> [last accessed 2019-09-16].
- [11] <https://www.kiiroo.com/> [last accessed 2019-09-16].
- [12] <https://de.lovense.com/sex-toy-blog/sex-toys-that-can-sync-with-music> [last accessed 2020-02-02].
- [13] <https://processing.org/download/> [last accessed 2019-09-20].
- [14] <https://supercollider.github.io/download> [last accessed 2019-09-20].
- [15] <http://www.theorycircuit.com/pulse-sensor-arduino/> [last accessed 2019-09-16].
- [16] H. D. Critchley, "Review: electrodermal responses: what happens in the brain," *Neuroscientist*, vol. 8, no. 2, pp. 132–142, 2002, <https://doi.org/10.1177/107385840200800209>.
- [17] <https://imotions.com/blog/gsr/> [last accessed 2019-09-16].
- [18] http://wiki.seeedstudio.com/Grove-GSR_Sensor/ [last accessed 2019-09-16].
- [19] <https://lioness.io/pages/how-it-works> [last accessed 2019-09-17].
- [20] J. G. Bohlen, J. P. Held, M. O. Sanderson and A. Ahlgren, "The female orgasm: pelvic contractions," *Arch. Sex. Behav.*, vol. 11, no. 5, pp. 367–386, 1982.

- [21] <http://www.neenpelvichealth.com/products/anuform-r/> [last accessed 2019-09-17].
- [22] <https://www.amazon.de/Sonde-Inkontinenzbehandlung-Anschlu%C3%9F-Reizstromger%C3%A4te-PR-12/dp/B003TOE2U8> [last accessed 2019-09-17].
- [23] <https://www.olimex.com/Products/Duino/Shields/SHIELD-EKG-EMG/open-source-hardware> [last accessed 2019-09-17].
- [24] <https://www.sparkfun.com/products/12650> [last accessed 2019-09-17].
- [25] <https://www.thingiverse.com/thing:3543727> [last accessed 2019-09-18].
- [26] <https://www.nxp.com/docs/en/data-sheet/MPXV7002.pdf> [last accessed 2019-09-18].
- [27] <https://realterm.sourceforge.io/> [last accessed 2019-09-18].
- [28] <https://sonification.de/son/definition/> [last accessed 2019-09-20].
- [29] T. Hermann, "Taxonomy and definitions for sonification and auditory display," *Proceedings of the 14th International Conference on Auditory Display*, Paris, France, 2008.
- [30] A. A. Alian, M. A. M. Ghobashy, W. Ouda, R. G. Stout, D. G. Silverman and K. H. Shelley, "different responses of ear and finger pulse oximeter wave form to cold pressor test," *Anesth. Analg.*, vol. 92, no. 6, pp. 1483–1486, 2001.
- [31] M. V. Villarejo, B. G. Zapirain and A. M. Zorilla, "A stress sensor based on galvanic skin response (GSR) controlled by ZigBee," *Sensors*, vol. 12, no. 5, pp. 6075–6101, 2012, DOI: 10.3390/s120506075.
- [32] <https://www.youtube.com/watch?v=n7HKVb117sM>, [last accessed 2020-02-19].
- [33] <https://www.win-health.com/anal-sensor-vaginal-sensor.html> [last accessed 2020-02-19].
- [34] G. Acar, O. Ozturk, A. J. Golvarpar, T. A. Elboshra, K. Böhringer and M. K. Yapici, "Wearable and flexible textile electrodes for biopotential signal monitoring: a review," *Electronics*, vol. 8, p. 479, 2019, <https://www.mdpi.com/2079-9292/8/5/479/pdf> [last accessed 2020-02-19].
- [35] <https://www.tobiipro.com/learn-and-support/learn/GSR-essentials/response-time-of-gsr-changes/> [last accessed 2020-02-19].
- [36] A. Freed and A. Schmeder, "Features and future of open sound control version 1.1 for NIME 2009," *Proceedings of the International Conference on New Interfaces for Musical Expression*, Pittsburgh, Pennsylvania, USA, 2009, pp. 116–120, <https://www.nime.org/>.