

# Talis - A Design Study for a Wearable Device to Assist People with Depression

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One of the major diseases affecting the global population, depression has a strong emotional impact on its sufferers. In this design study, "Talis" is presented as a wearable device which uses emotion recognition as an interface between patient and machine to support psychotherapeutic treatment. We combine two therapy methods, "Cognitive Behavioral Therapy" and "Well-Being Therapy", with interactive methods thought to increase their practical application potential. In this study, we draw on the results obtained in the area of "affective computing" for the use of emotions in empathic devices. The positive and negative phases experienced by the patient are identified through speech recognition and used for direct communication and later evaluation. After considering the design possibilities and suitable hardware, the future realization of such technology appears feasible. In order to design the wearable, user studies and technical experiments were carried out. The results of these suggest that the device could be beneficial for the treatment of patients with depression.

## I. INTRODUCTION

"Depressive disorders are one of the most common forms of psychiatric disorders," and are one of the major issues affecting the population worldwide [1]. Those affected often live in a world of negative moods and thoughts. Sleep disturbance, loss of appetite, reduced ability to concentrate, and low libido are further symptoms which cause intense emotional distress, and which may even lead to suicidal thoughts or suicide attempts [1]. Depression is treated medically and / or psychotherapeutically using various therapeutic approaches such as cognitive behavioral therapy (CBT), depth psychology or interpersonal psychotherapy (IPT). People with depression find it difficult to recognise positive experiences as such, and to remember them [2]. They also tend to perceive problems as extremely threatening [3]. In the treatment of mild depression, cognitive behavioral therapy and well-being therapy methods such as: "Schatzkiste [4]" (translated: treasure chest), "Glückstagebuch [5]" (translated: fortune diary) and the "Gefühls- und Gedankenprotokoll" [4] (translated: minutes from memory) are used. What all these methods have in common is that they facilitate the recollection of positive qualities, abilities and moments in the patients life. These positive recollections re-enter the consciousness of the sufferer, who is then able to reflect upon them. One of the challenges of these treatment options is the required commitment on the part of the patient to collect and/or note down the Schtze and positive moments.

In addition to this, the idea of transferring the object or feeling of happiness to the positively connoted memory can prove difficult for the person concerned in negative situations [4]. Daily writing, collecting or reflecting also requires a change in the habits of the person concerned as well as a degree of conscientiousness. This is particularly difficult because a lack of motivation is a common symptom of depression. For those affected, it is often also difficult to remember moments objectively. An automatic recognition and recording of both relevant positive and negative moments would therefore be helpful. This, however, poses the questions: how can technology be used to allow these moments to be detected and how can this technology be integrated into the daily lives of those affected?

Current research shows that emotion recognition technology already functions well for many facial expressions. In order to be able to further analyze emotions effectively, a speech / auditory analysis is especially suitable. We assume that the overwhelming number of verbally expressed emotions in everyday life are genuine and are thus suitable for the recognition of the corresponding emotional state. Because of the way smartphones are used, it is not possible for them to conduct a continuous speech analysis; therefore in this study, we will present a concept for a wearable device worn around the neck to analyze the users emotional state. The name "Talis" derives from the word "Talisman", which means a "small object" or a "charm thought to have magical powers and to bring good luck" [12]. It is intended to help the person concerned remember positive things and strengthen his or her emotional wellbeing. A wearable that you are physically aware of has the advantage of being able to accompany the user in everyday life. Through this design concept, hurdles presented by the above-described therapy methods may be overcome. Within the user-centred design concept, a design vocabulary appropriate for the needs of the patient has been developed in order for the system to interact with the patient. More details including use cases in which the device is used, and its uses in therapy are described in chapter III-A. In section III-B, we describe our approach to the design process, which has led to an emotion user interface. In chapter IV, we describe how positive and negative emotions are identified and how the wearable interacts with the user. We provide information about how this data can be used within therapy. In chapter V, our considerations about how to realize this technology using hardware and software provide an idea of technical feasibility.

In the experiments described in chapter V-A, we determine the suitability of emotion recognition algorithms as well as energy requirements. The scientific contributions are: (1) elicitation requirements for Talis - a wearable that supports therapeutic measures for people affected by depression (2) user-centered design process to create the physical design, as well as the interaction model for Talis (3) discussion of potential hardware and processing methods.

## II. RELATED WORK

Emotions are not linked to culture or origin, but are felt and expressed in the same way by all human beings [6]. Emotional expression is, for instance, the primary means of communication for infants who cannot speak, but who express their needs through their emotions [7]. Emotions arise through cognitive assessments and are influenced by ones personal goals and the likelihood of an outcome in a particular situation. Emotions are expressed through facial expression, gesture, body language and vocal intonation. The processing of emotions takes place in the subconscious and influences actions, perception, memory, and neural stimulation. Although humans have very little influence over their emotions, we have been conditioned to subconsciously associate people and objects with positive and negative emotions [2]. R. W. Picard describes emotions as important factors that have a measurable impact on a person's health [8]. She also gives examples of cases in which emotions detected by wearables have been used to draw conclusions about the general health of the user. Similar to our concept, the mobile app ARYA[9] gives users the opportunity to track their emotional state and share it with their therapists. But in contrast to our contribution, has the tracking to be done manually, which might be hard for some patients. Recognition of expressions using sensory data is a research focus, as minimally invasive systems with low energy requirements find more and more applications [10][11]. Ongoing research in the development of flexible batteries suggests that, in the near future, designers will have broader range of forms to choose from and that flexible cable shaped type neckwear will be achievable [12]. Recent works such as those by Puiatti et al. [13] and the ICT4Depression Project [14] show that a combination of smartphone data analysis (microphone, SMS / email) and sensors installed in the wearables (acceleration sensors, Galvanic Skin Response [GSR], and Blood Volume Pulse [BVP] ) are well suited to classify the social behavior, interaction, and mental state of patients. In the practical treatment of depression there is, in particular, the need to develop supporting methods which can help relieve the therapist. This has led to the development of innovative systems which connect via the internet on a meta data level in order to support treatment [15]. Works based on heart rate variability (HRV), GSR or BVP [16] [17], showed more promising results in the recognition of emotions. In order to detect depression, a test group of patients and non-depressed people were tested in sequence; they were recorded and analyzed in an Audio / Visual Emotion Challenge [18]. The results showed that depression can be detected in audio data with an F1 score of between .462 and .682 In comparison, humans demonstrate an accuracy of only 63% [19].

## III. TALIS DESIGN STUDY

### A. Approach

In order to create the concept that was leading us to 'Talis', we followed a classic user-centered design process. We made a literature review about the disease and common therapy methods. We conducted interviews with patients and therapists analyzing their needs and requirements. In order to understand the target group we used the 'persona' method and created fictional characters to represent potential users. We have derived mental models from the acquired knowledge about communicating interaction with the device. In a workshop, shape drafts were created cooperatively to precise the psychological models. The 'user story' method was used to analyze if the developed service fits into the living environment of the target group.

### B. Use-Case

The target group for the wearable presented in this study are those suffering from depressive moods and those with mild and moderate depression. As those affected with severe depression often find themselves in a precarious position, it is necessary in these cases to use other treatment approaches. "Talis" is designed to assist those affected by depression in everyday life and help them to recognize and remember the positive aspects of life. To make this possible, three cognitive behavioral therapy and well-being therapy methods have been combined. The concept presented here encompasses these methods and implements them in a new way using modern technology. The device is designed to be used by the patient and the treatment provider to accompany therapy. In contrast to traditional methods, "Talis" eliminates the need for the patient to engage in collecting Schtze or recording positive moments. With this device, positive moments are detected automatically and recorded as audio. Therefore, the effort exerted by writing a diary and/or collecting Schtze is no longer required. The collected data can be used to create a mood image for the period of use, which provides the therapist with a visual representation of the emotional progression (see Figure 6) of the user. Depressive phases may be linked to the patient's personal situation and can be analyzed during a therapy session. Together, the patient and therapist can work on how to avoid or prevent the factors or situations responsible for these negative phases. However, access to this data should be restricted to therapy sessions since reflecting upon these phases without the help of a therapist could lead to a worsening of the condition [1].

### C. Design Process

The Interaction Design Kit by Enes Ünal [20] was used to create product personality. In this case, archetypes from the Heros Journey by Joseph Campbell [21] , which represent the personality, were chosen. The archetypes of the Caregiver, the Magician, and the primary archetype, the Lover, were chosen for their stereotypical properties. When these are combined, an image of positivity, sympathy, appreciation, understanding, genuine interest, security and trust based on the principles

of conversation described by Carl Rogers [22] emerges. The Magician is mainly reflected in the impressive functionality of "Talis"; the distinction between positive and negative moments and their immersive reproduction and interpretation. The cautious and thoughtful Caregiver is particularly important as those who are affected by depression are a very vulnerable target group, and should be protected from harm. The characteristics of the Caregiver are also present in the gentle introduction to "Talis" and in the general communication style between object and man. The needs and moods of the user are always central to the concept. "Talis" is never defeatist or negative, but always compassionate and positive. In this way it provides reassurance and does not overwhelm the user. Both the Lover and the Caregiver can be seen in the tone of communication and interactivity used in the device. Through the sensory-aesthetic design, the Lover invites the user to touch and utilise "Talis". He provides the user with unconditional love, rewards success and is empathic in negative moments. The haptic properties of the wearable are intended to encourage touching and feeling and, at the same time, provide emotional support. Because "Talis" should remind the user of happy times and should be a symbol of hope, it is important that its shape and its materials reflect these values. The two emotional poles, joy (the Lover) and trust (the Caregiver) play a particularly important role in the products design

#### 1) *Look and Feel*

Round and symmetrical shapes, derived from the archetypes, have been selected as these give the impression of clarity and reliability. Together with the traditional materials, they are particularly good at providing a feeling of trust. Objects that radiate joy do not have any particular shape in common, instead emotions can be stimulated using light materials and colors. To achieve this design, shape (see Figure 1) and material moodboards (see Figure 2) were developed and sketches were made. Various basic shapes, such as the cone, the sphere and the cylinder, were mooted on the shape moodboard. Further inspiration came from shells and speakers, whose open forms give the impression that sounds and noises can be heard. The first drawings, which were later moulded three-dimensionally in plasticine, also focused on these basic forms and inspirations. The material moodboard was dominated by wood on one side and bright glass, resin and porcelain on the other. Together they create an object that unites the properties of the two materials.

Due to their illness, those in the target group demonstrate particular characteristics and conditions which were analyzed in an expert interview with psychotherapists. Owing to the lack of motivation among the target group and possible social stigma, the following design requirements were identified (1) The device must be unobtrusive (2) Easy to carry (3) Intuitively usable.

#### 2) *Design Workshop*

In order to draw more precise conclusions about the psychological models, shapes and materials that provide the basis for "Talis", a workshop was carried out in which shape drafts were created cooperatively. Five people who were not involved in the conceptualisation of Talis were asked to come up with some ideas for shapes and materials. They were asked to

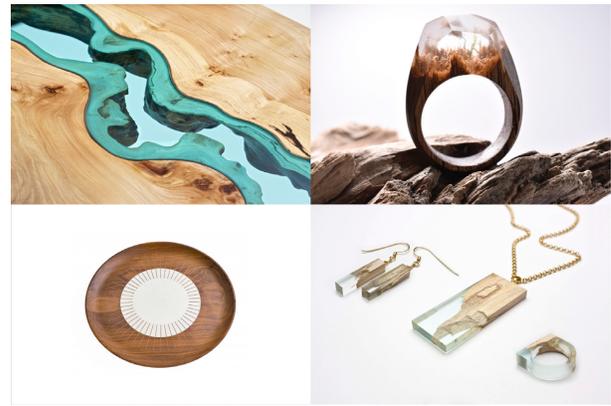


Fig. 1 – Shape Moodboard, Sources: [23][24][25][26].



Fig. 2 – Material Moodboard, Sources: [27][28][29][30][31][32].

incorporate various requirements into their designs. Starting with a ball of plasticine, they were asked to produce a design in four steps. At the beginning, they were given a ball of plasticine which they were told to mould into a shape that could be spoken into. Then they were asked to alter the shape so that it could be worn around the neck comfortably. Next, they were asked to create a shape that would provide emotional support to the wearer. The results of this workshop decisively influenced the design in terms of shape, size and material and also confirmed the above-mentioned interaction models.

The final design consists of a chain and a pendant which, when combined, look like a necklace. It therefore does not have a completely new form-language and does not appear particularly unusual or strange. It does not give away its purpose and function to others and therefore protects the privacy of the wearer. In addition to this, it is easy to carry as it is worn around the neck of the user. The user can also combine it with other jewellery or accessories when they get dressed in the morning, and then continue to be accompanied by "Talis" for the whole day. Thus, the device becomes a sensory, recognisable symbol of happy memories; the users own abilities; and positive thoughts for the future.



Fig. 3 – Design Prototype.

#### IV. INTERACTION MODEL

The functional model for interaction with "Talis" is that it listens to and records sound. It can be compared with talking into a tin can telephone or listening to a large shell. The well shape, provided by the opening of the shell or by the hollow of the can, is communicated in the design of the device. The pendant is a speaker which, through its hollowed out form and funnel shape, implies a similarity to the above-mentioned objects.

##### A. Haptic Interaction

"Talis" initiates haptic communication with the user in three cases.

- 1) To prompt the user to listen to a recording The request for the user to listen to an audio recording occurs when a negative mood has been detected over a long period of time. The vibration pattern must be clearly noticeable even a phase of listlessness. A pattern with a strong rise and a gentle decay after the climax was therefore chosen. It repeat three times. (See Figure 3-a).
- 2) Battery low To indicate that the battery level is low, a vibration pattern is used. To fit mental model of a low energy level, the vibration pattern starts at half Intensity and decreases slowly and slowly decreases (see Figure 3-b). The reminder is provided more frequently the lower the energy reserve gets.

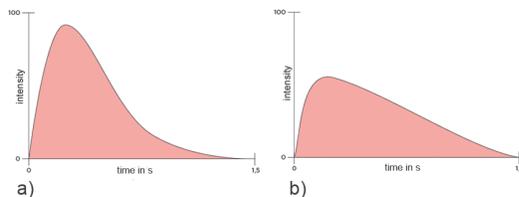


Fig. 4 – Vibration Pattern used in Haptic Interaction.

##### B. Acoustic Interaction

Acoustic recordings can be of one's own voice but also other peoples voices. These voices, together with ambient noises,

create a unique atmosphere intended to remind the user of the positive mood of the moment. Such an atmosphere could, for example, be a relaxed evening with friends cooking together, a trip to the seaside with family or another special event.

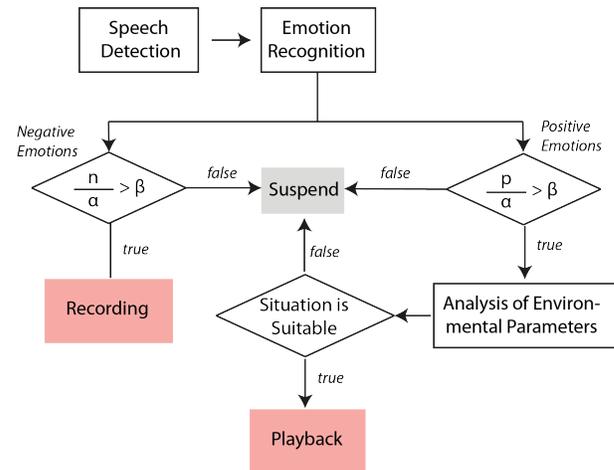


Fig. 5 – Interaction Flow Diagram of Acoustic Interaction

- 1) Automatic Recording - If the number of speech samples classified positive ( $p$ ) over a period of time ( $\alpha$ ) are above a threshold value ( $\beta$ ), the wearable starts recording. A minimum time gap ( $a$ ) between any previous recording reduces the number of unusable recordings (see Figure 5)).
- 2) Automatic Playback - The emotion-recognition-algorithm analyzes samples with a length of a few seconds. In order for the wearable to auto-play a positive recording, the number of samples classified as "negative" ( $n$ ) have to exceed a threshold value ( $\beta$ ) over a certain period of time ( $\alpha$ ). Tests have shown that this reduces the amount of falsely interpreted moments to prevent the device from auto-playing too often. Before automatic playback, an analysis of the surroundings of the user is carried out to check whether the moment is suitable for playback, which is then announced by a vibration (see Figure 5).

The user also has the option to activate an audio recording on Talis himself by holding Talis to his mouth and speaking into the opening. In this case, recording mode is started remotely and confirmed by a vibration.

- 1) Manual Recording - These recordings can consist of diary-like speech messages to oneself; insights gleaned from therapy; music; and/or other happy, positive messages. The user can, for example, ask family members and friends to record loving messages, record his favorite songs; or the soundscape of his favorite place.
- 2) Recording of an Intro - Before a recording is auto-played at a negative moment, a short intro voice message is first played to the user. It is intended to prevent the positive message having too much of a contrary effect on the current mood / situation of the user. In order to ensure the user is able to benefit from the positive message at that time, the intro creates a bridge between the two

opposite emotional worlds. The intro is recorded with the help of the therapist in the first therapy session with "Talis" and is spoken by either the user or the therapist. The voice recording is transferred to the wearable via the Bluetooth interface.

### C. Data Analytics

Data transmitted by the Talis wearable consist of the detected emotions, the positive audio recordings that have been played back, as well as the progression over the period of use. Using this data, a mood image, as shown in Figure 6, consisting of the detected emotions, evaluated on a scale from purely negative to purely positive over a period  $x$ , can be generated. Patient and therapist can analyze individual days or even longer periods in detail. Positive audio recordings can be displayed separately and further details can also be retrieved.

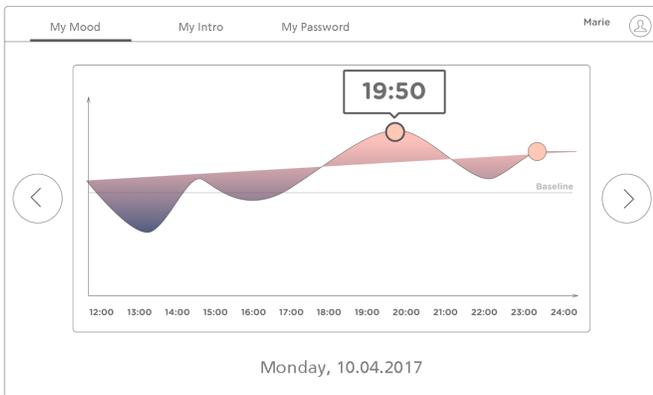


Fig. 6 – Emotional Trend Visualisation for one Day.

By selecting a positive memory (depicted in the image as a circle), additional information can be displayed. Selecting detailed view allows the recording of this particular memory to be played back.

## V. SYSTEM CONSIDERATIONS

In order to check the computer capacity and applicability of the emotion detection, an algorithm for emotion detection was selected and implemented. With the help of a test group, the performance of this algorithm was tested. When creating the hardware, consideration was made as to which parts would be required and whether these could be feasibly used in terms of both performance and size.

### A. Software Pipeline & Experiments

The Emo-voice [33] framework was chosen for a proof of this concept. It classifies emotions based on frequency, volume and the relationship between tone and noise (HNR) in speech. The detection is performed in real time, but requires the ongoing audio signal to be segmented. Sampling takes place in speech-containing audio samples in 200ms stages. For this purpose, speech segments with a maximum length of two to three seconds were selected. Emovoice was trained using both existing labelled databases as well as own voice

data. In our tests, the "Velten mood induction technique" [19] was used. This method requires users to read a number of emotional sentences aloud, in order to help them reach the desired emotional state. The sentences are chosen to move within a quadrant: positive-active, positive-passive, negative-active, and negative-passive. Training consisted of the following classifications: joy, satisfaction, anger and frustration, and an SVM classifier was used. Preliminary results in this non-representative evaluation show that emotion detection also works in an informal environment. In order to check the level of computer performance required to carry out the preliminary classification, memory capacity requirements and CPU utilization were measured. The results show that about 8 MB of RAM is required and an Intel Core i7 / 3632QM CPU with 2,20 GHz uses 2.4% of its capacity. A32-bit quad-core ARM Cortex-A7 MP2 wearable would therefore be adequate in terms of performance. The energy usage of these CPU is between 35mW and 150mW at full capacity.

TABLE I – Engery Consumption and Hardware Size.

Name	Size	Min/Max (mW)	Remark
Processor	15 x 15 x 0,7 mm	35-150	ARM, 500Mhz
Microphone[34]	4 x 3x 1mm	0.02-1.76	55Hz - 12kHz
Speaker [35]	15 x 11 x 3.6mm	0-1000	0.3-20kHz, 73db
Gyroskope[36]	4 x 4 x 1mm	0-7.3	Sleep Mode
Bluetooth[37]	8,7 x 6,4 x 1.5mm	14.5-39.2	Bluetooth v4.2
Memory[38]	11 x 9 x 1mm	-	internal, 8 GB
Battery	3,5cm <sup>3</sup>	-	3,7V/400 mAh
Inductor[39]	28 x 15 x 0.7mm	-	-
Vibration	12mm $\varnothing$ x 1	150-420	-

Modern electronic devices, such as smartphones and smart watches, illustrate how hardware can be installed in space-saving manner. A requirements of this device is therefore that the components are integrated on a circuit board in a space-saving manner. We calculated that the device should be capable of functioning for 12 hours, 2 of which it should be able to record and analyze speech. When the energy consumption of the necessary sensors, actuators and the processor is added, the device requires about 1.5W of power. A battery with about 3.7V/400mA therefore appears to be sufficient.

### B. Hardware Considerations

Microphones that are commonly installed in smartphones (see Table I) are suitable for this device in terms of audio quality and energy efficiency. Since the wearable is not worn right next to the mouth, the microphone needs to be pointed in the direction of the mouth using the curvature of the housing. Data transmission between Talis and its accessories, takes place via Bluetooth LE. Memory chips can be built into the circuit board to provide data storage. We assume that 8 GB is sufficient for the software and audio data. For the wireless charging of the battery, a receiver coil is required which must be demodulated from the battery. If all the above-mentioned technologies are implemented, the product size is 1.21cm<sup>3</sup> without the battery, circuit boards and other connectors. Taking the required space for an iPhone 6 battery as an example, we assume that we will need another 3.5cm<sup>3</sup> for a 400mA

rechargeable battery. This space could be saved in future product development by, for example, attaching it to the outside of the necklace.

## VI. CONCLUSION

With "Talis", we have presented a design-study for a wearable emotional user interface which supports those who suffer from depressive moods or mild to medium depression in their therapy. The study combines methods from cognitive behavioral therapy and well-being therapy with new technologies that allow for a better application of existing therapy methods. Within the framework of a user-centered design process, a device that uses emotion recognition as an interface between humans and machines was developed. During this process, we examined the usability of emotion recognition technology, and drew on 'emotional user interface' methods. These methods were used in the conceptualization of the interactive model in so far as they provide the opportunity for direct communication with the user and later evaluation of the audio recordings. Considerations made regarding the possible future realization of this device using suitable hardware provide an idea of the technical feasibility. Workshops, user studies and technical experiments were conducted within the design process; the results of which can be expected to benefit the treatment of patients. Up to now, the device presented in this study has only been created as a prototype testing the form and materials. Some technical requirements have also been tested for their feasibility but the product still has to be tested on users to prove that the technology described can be used in everyday life. Psychotherapists who supervised this study also expressed an interest in discussing negative moments with their patients. This could help patients experiencing a stable phase in their disorder to remember how they coped in a negative phase. It is often difficult for patients in a positive phase to remember negative phases as they really were. For this reason, they find it difficult to fully understand why they still need their medication and therapy. However, as this is usually only the case for those with severe depression, the recording of negative moments has not been integrated into this design study.

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