In current healthcare research, pain logs are an important means to measure the impact of medication and to detect pain patterns. However, the entry of textual pain data may be negatively reinforcing, due to its character of direct confrontation with one's pain, potentially leading to a higher pain awareness. This paper introduces valeo, a new form of a tactile pain log, which is based on a vibrotactile, pressure- and tilt-sensitive device. Future iterations will also include body part recognition. By squeezing it close to one's own body, the subjective intensity of a local pain is manifested in the device. Via a shove gesture, it is then transmitted to a docking station. Advantageously, the pain data is covert and conceptually alienated from the patient's body, which may support a possible relief. A proof-of-concept prototype and a user study indicate that our concept is perceived as convenient and reduces negative conditioning.

To assess the needs of the patient and the curative status, systematical measurements of pain quality are considered helpful, but are rarely conducted or are incomplete [3]. The use of pain logs instead is, due to possible negative conditioning, mostly not considered as an alternative, meaning that such logs not only take data, but also repel to the psyche [4]. Furthermore, especially elderly people are trying to avoid such encroaching methods due to a potential loss of independence [5]. Pain emerges not only from physical states, but also from mental variables, which could be a trustworthy doctor, the belief in a cure, or even distractions [6].

A pain log addressing these factors through the concept of alienation (extraction, manifestation and releasing of pain), gesture-activated and supported by a physical simulation of the pain, materialized in the valeo device, could cause positive psychological effects, like the soothing of pain. To avoid negative conditioning, it should be considered to prevent intense thoughts about one's pain level. We approached this by using pressure input for intuitive expression and 'grasp'-activation of the extraction gesture, which showed to be a good metaphor for participants of our initial study, in which we analyzed different input/output methods and their combinations. Furthermore, we decided to hide all logged data on the device to prevent the user to see a possible worsening.

To successfully implement a positive effect on pain perception, our background research indicates three factors which had to be addressed: the knowing about a trustworthy aid through the documentation, the diversion from the inner pain and, for avoiding nuisance, the simplicity in the interaction itself (see Related Work).
Prototype and Interaction
The proposed device (Fig. 2) has a minimalistic outward appearance, consisting of two pressure-sensitive stripes at two sides of the 12 x 8 x 4.5 cm big, oval-shaped, hand-held device and a miniature camera at its bottom. For providing a pliant gripping surface of the stripe, we used 2mm thin silicon layer and for better grip in general, the plastic case has a light rough coating. On the inside, a 9V battery is mounted on top of an Arduino [18] board, which is connected to an accelerometer, the two pressure sensors and four vibration motors. In future research, the body part recognition through the camera could be achieved in combination with the soon to be released 3DV Systems DeepC™ [14] chipset, but for our prototype, we focused on the haptic quality of the interaction.

Positive effects and the dispersal of negative conditioning through the interaction was achieved as follows: If users of the valeo device feel pain, they hold the device above the aching spot and exert pressure on valeo’s squeezable sides equal the perceived pain. To log the intensity and location, the level has to be hold for few seconds. With this gesture, the pain is extracted and captured inside the device, which can be felt by four circle-like arranged vibration motors inside, each for one direction. On the technical side, we simulate a virtual pain object which size is determined by the expressed pain intensity. It can be moved in the device through tilting. Depending on the object's size, a corresponding amount of motors are activated, as the object crosses a threshold proximity to one or more of the device's edges. The intensity of the vibration is controlled through the object's inertia. The pain is now represented in a tangible manner and should feel diverted from the body. To receive a relieving effect, a shove gesture away from the body initiates a haptic animation of the released pain. The pain object is then caught by the docking station, where it is visualized through a short flash, followed by a fading light. The docking station adds a timestamp and saves the data into the log. The data could then be send to the patient’s physician, providing the basis for analysis and the planning of medical treatment. The quick assessment of subjective pain data may also enable researchers to find pain patterns, which may help to prognosticate diseases earlier and manage the right medication.

USER STUDY
We conducted a qualitative evaluation in which we talked about the participants’ experience with pain and gave them the valeo device (omitting the docking station) to go through a complete use case (pressing, feeling, and shoving), assessing their feelings during the test and their comments regarding the expected real-world usefulness of the interaction.

Users and Tasks
Six patients of the Pain Center Berlin [16], aged between 32 - 55 years (4w, 2m, Ø 44.3yrs.), participated in the study. They experienced pain in various forms for 0.75 - 30 years (Ø 10.1 yrs.), four of them had experiences with analog pain logging; one kept a digital pain log in Excel. Each of the five reported that they wrote the log in the evening, having sometimes problems to estimate the pain level with a 10-point scale and therefore copied similar old entries. Furthermore, all of them stated that they did not feel comfortable using the log: For three of them, it was, as they stated, a ‘necessary evil’, two experienced negative effects due to their awareness of bad or even worsening bodily states – one of the users was even forced to abort the logging. Given these circumstances, users however appreciated ‘to be in the hands of a professional physician’, which gave them a ‘safe and comfortable’ feeling. They also liked the fact that their illness, while not physically measurable, was taken seriously and treated adequately.

In the study, the patients had to use the valeo device, including the squeezing, feeling and shoving away from the body. During and after the 10 minute long test the participants were asked to express their impressions. Finally, we assessed the perceived real-world usefulness in a semi-structured interview.

Results
Initially, our participants were reluctant to the thought that the device could be operated by squeezing, but they quickly moved on to explore it in an experimental way. The first part of the interaction (squeezing) was the most difficult for the users due to a restriction of our prototype: Instead of complete pressure sensitive sides, sensors were just on the upper areas, which is why it was hardly possible for the users to correctly initialize the virtual pain object. After a experimentation phase for this step, users proceeded to the next part.

The first reaction to the pain object was about the vibration itself – four users perceived it very pleasurable, one said it was ‘ alright’, one participant did not feel comfortable with it. Besides the vibrations, one of the patients reported that he could also hear a change of sound. The illusion of something moving inside the device however was successfully recognized by five people, two interpreted the movement to be 'like a ball’.

The shove gesture worked for all users in the first attempt, but there was some confusion about where the object went. A short reminder that the data would now be sent to the docking station was quickly understood, but some kind of visual feedback would have been, reportedly, appreciated. In the end, it was mentioned that the whole mental model of extracting the pain, feeling it in a materialized manner, and releasing it then was 'simply and reasonably typed' by the proposed gestures: Everybody felt capable of using valeo.

User Statements
All users would favor a smaller sized device, although two of the participants conceived it as ‘perfectly sized’, with their parents in

Figure 2. The valeo device, including the Arduino board, two pressure sensors, four vibration motors, an accelerometer and a battery.
mind, however, they argued likewise. Furthermore, users stated that instead of the 2mm thin silicon layers, something more pliable might provide better physical feedback of the squeezable areas. The combination of valeo with a mobile phone was requested twice: Users argued that 'everyone has a phone with such features nowadays'.

Two participants reported a pain relieving effect. One patient reported 'less pain in the back for a short time'; while touching her elbow, another participant stated: 'I could still feel it a bit in the depth, but apart from that it feels much better'. Another woman was previously diagnosed psychosomatic (mentally caused) pain. She commented that, given the nature of her circumstances, even if a positive psychological effect would not occur, the device still would be a lot more practical than her pain log book.

The comments of the participants indicated that the most appreciated features were
- the covert collection of pain data; not influencing the estimation of one's pain level, being only visible when (separately from the logging process) accessing it through a computer for analysis,
- the setting of the pain level through pressure; requiring no abstract quantification (e.g. deciding between 6 or 7 on a 10-point scale), and
- the speed of the interaction; leading to a direct use in place of posterior writing.

Furthermore, the tracking of pain moving within the body was noted to be potentially helpful, but might require, as one user stated, improvements in the pointing accuracy of the device. The possibility to record spoken details was remarked twice, but rejected by an other participant in favor to speed and simplicity.

Dependence of the complexity and the handwriting, is more or less difficult. If logs should also be saved, they require post-hoc digitalization. To make documentation and analysis easier for both, systems like the mobile pain documentation system AC-STB [7] aim at making documentation easier. They are mostly based on simple digital questionnaires on different devices e.g. the mobile phone of the patient, capable to send the collected data to a server. Although this is highly practical, such systems face most of the issues (e.g. negative conditioning) as their analog counterparts. We also discovered a trend to micro-blog (e.g. through services like Twitter) the current pain, visible to friends, physicians and the rest of the world [8], which raises questions about privacy. The integration of medical software into already used communication systems as the aforementioned seems to be promising, but does, again, not solve the risks of negative conditioning.

**Pain Relieving Applications and Practices**
Evoking placebo effects is of great scientific interest. Placebos can be effective if the patient is not aware of it being a placebo [23]. The factor of perceived officiality in medical treatment goes further: Medicine works reportedly better in combination with a trustworthy, emotionally more engaged physician, compared to a less engaged physician [9]. Another method is relaxation in which the biological states are viewed from an outside perspective. With the addition of biofeedback to the treatment it became possible to gather awareness of such states and train their control [10]. Work in the area of mobile applications is conducted with the Painfree iPhone App, letting users choose a pain location in the software interface and presenting pertinent relaxation practices [11]. It can be concluded that in order to be able to be relieved, pain needs to be understood – even if the understanding is based on a false mental model.

**Simulation of Mass**
Currently, the integration of mass is researched by a actual integration and movement of itself, as seen in Weight-Shifting Mobiles [20] or the GyroCube project [12]. In contrast, a simulation of mass on a basis of vibrotactile feedback is an interesting topic since the rise of virtual reality. This haptic feedback is mostly used to provide a sense of virtual contact, improve the situational awareness, compensate for shortcomings of current technology or increase the overall realism [19]. For achieving more realism, haptic rendering has to occur, as the link between a simulation software engine and a haptic device [21]. In the Shoogle [13] project, a pulse-width-modulation-based vibration motor is used to render hitpoints of virtual embedded objects, agitated by shaking the mobile phone. As Williamson et al. argued, auditory feedback supports the illusion of an object within the device, if only one vibration motor is used. Even though circular movements with two vibration motors seem to be beneficial due to the 'Sensory Salutation' illusion [22], it appears difficult to realize a controlled two-dimensional movement. Therefore, the use of 6 actuators like in Sahami's work [23] appears more promising: 'findings indicate that the corners of the handheld device provide the most effective places for mounting vibration actuators', which could support accuracy rates up to 82% to recognize a circular movement. In Linjama's research [24], a virtual ball on a mobile device was also simulated through vibrotactile actuation – however, it can be moved only by directional tapping.
CONCLUSION AND OUTLOOK
We have introduced a new form of digital haptic pain logging. All participants of our study assessed valeo as simple to use and convenient. Some also reported positive effects on their pain suffering. In conclusion, we reduced negative conditioning, which is a worthwhile activity in pain logging. Technically, pressure input and size might need to be customized for certain target groups, a transmission feedback should be added.

In future iterations of this initial work, we will address technical issues and conduct a more extensive study on pressure and its relation to expression of pain. In addition, it may be worthwhile to combine valeo with a mobile phone. Ideally, valeo will offer physicians a digital haptic pain logging device that even contributes to the patient's recovery.

ACKNOWLEDGEMENTS
We would like to thank the Stephanus-Seniorenzentrum Müggelspree [17] for participating in our initial study and Dr. med. Jan-Peter Jansen [15] of the Pain Center Berlin [16] for his great insight into pain general and pain logs in specific, as well as for the participants of the final user tests. In addition, we would like to thank Brendan Howell, Johannes Landstorfer and Josefine Zeipelt for their writing advice as well as Fabian Hemmert for his writing advice and research support.

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