Squeeze, Rock, and Roll; Can Tangible Interaction with Affective Products Support Stress Reduction?

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ABSTRACT
Affective computing focuses on the interpretation of users emotions via physiological and behavioral inputs. Irrelevant gestures with a pen were found to increase when users were given a mentally demanding task. Accordingly, an embedded tangible interface was developed which afforded and measured a rolling behavior, and guided the user towards reaching a balanced state of movement. During informal evaluations users acknowledged how the device could contribute to stress reduction. Conclusion, tangible interfaces appear to offer a non-obtrusive means towards interpreting and reducing stress in the office work context.

Author Keywords
Tangible interaction, affective computing, stressful behavior, haptic feedback, stress reduction

ACM Classification Keywords
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INTRODUCTION
Stress can be described as a feeling of anxiety and physical tension occurring when demands placed on someone exceed their abilities to cope [7]. This presents a great problem in today's society, in particular in office environments. Although new technologies have been introduced to facilitate well-being of office workers, these technologies have not contributed to reducing stress of office workers [1]. Research towards reducing stress due to work pace in the work environment is therefore actively pursued in Western countries [8]. However, a problem with current solutions towards enhancing well-being in the office is that they focus mainly on the physical aspects [11], such as repetitive strain injury (RSI) prevention. These solutions often cause frustrations because they do not have any contextual knowledge of users concerning their mental, spiritual, or emotional well-being. Therefore new solutions for stress prevention should be explored that focus on these aspects, to increase well-being of office workers, thereby likely increasing productivity, and reducing sickness absence.

Affective computing
Towards improving the interpretation of people's emotional state, in the last decade research has been conducted on affective computing investigating how computers could recognize, communicate, or deliberately influence affect in a way that is natural and comfortable to the user [9]. With computers becoming more aware of people's affect they should be able to understand them better and support them in their work towards preventing stress. Affect can be detected through various types of sensors measuring physiology or users' motoric actions such as facial expressions [6] or interactions with keyboards and mice [10]. However, most applications in this field focus on computing as a desktop activity.

As any product nowadays can be equipped with computing power, we should also start exploring how sensing affect could be implemented in everyday products, as there is an apparent link between expression of emotion and product interaction such as clicking with a pen when nervous. Additionally, it has been shown that the predictive power from physiological signals or facial recognition is often not very accurate [12]. Combining different methods will considerably improve the power to accurately predict different affective states. Continuously, the objects could also provide appropriate feedback to support in reducing stress.

AFFECTIVE INTERACTION
It is very common to see people fidget with a pen or pointer during a presentation, but object manipulations as indicators of affect are still a very little explored subject. Some studies did focus on the hands as modality for expressing affect such as the alarm clock by Wensveen et al. [14] and eMoto by Fagerberg et al. [4]. In Wensveen et al.'s experiment users could express how they felt by moving twelve sliders to set their wake up time. Various aspects of the interaction with the sliders, such as speed, order, and patterns, were

explored as to how one could interpret affective states from them. In eMoto users would add affective information to their mobile phone text messages by shaking and squeezing the stylus. In the first example the way of expression was embedded in the interaction needed to control the alarm clock, and defined by the user. In the second example the movements were not essential for fulfilling the task of writing a message, however the movements were designed and not naturally expressed by the user. Designed gestures could be relevant if people purposely want to express their emotions, such as when sending e-mail or a text message. However, when considering stress or frustration in an office environment it is more difficult that people overtly express how they feel, because they will be very engaged in the task they are performing, and could be less willing to show their distress to others. Thus, when exploring modalities for detecting stress we believe the sensors should be unobtrusively integrated in the interaction with products of everyday use, such as in the alarm clock example, so that users can express natural behavior, while preserving their privacy.

Detecting stressful behavior

Several categories of behavior when manipulating objects have been identified when comparing stressful conditions to boring or neutral conditions. In a study by Kenner [5] higher frequencies of object manipulations were observed during the resting period after a stressful situation as compared to a pre-stress resting period. On the other hand in a study by Woods and Miltenberger [16] a higher frequency of movements was found during boring conditions as compared to stressful situations. These studies were limited in that respect that they did not mention whether a subject was holding objects continuously during the experimental conditions, nor was there any differentiation made in the types of manipulative hand movements during stress. If sensors will be implemented in a product to detect stressful behavior, the types of manipulations that are considered as stressful have to be defined first.

Except for the alarm-clock study [14] and studies on affect expressed through interaction with a mouse or keyboard [e.g. 10], no other studies were found that investigated how one could detect affect through natural (non-desktop computer related) object manipulations. If objects would have embedded computational power and could interpret these movements, they could serve as a promising input for an affective computing system.

Squeeze, rock, and roll

In a previous study in which subjects were observed during a mentally stressful condition [2], reciprocal synergies, as specified by Elliott and Connolly [3], appeared to be the most frequently observed object manipulations movements when using a pen in a stressful situation as compared to a non-stressful situation. According to Elliott and Connoly's classification reciprocal synergies include, twiddle, rock, radial roll, index roll, and full roll (see for examples figure 1). Although in our study no difference was found in the types of movements during stressful and non-stressful conditions, significant differences were found in the frequency of the movements and the amount of movements in relation to the relevant movements, i.e. subjects would fiddle more with the pen before starting to write when they felt stressed.

When studying reciprocal movements one can observe, that all movements imply either rocking or rolling an object between the fingers. Therefore we have chosen to focus on rock and roll as object interactions. Furthermore we believe that squeeze should also be included, as an interaction that could tell about the level of stress (see figure 1 for an illustration of the selected movements). Although in our initial experiment squeeze was only scored when the pen was clicked, this being a simple synergy, the pressure exerted on the pen was impossible to observe in video analysis. Previous studies have already shown that squeezing an object, such as a mouse, could provide valuable information about stress [10]. Furthermore, commercial products already exist that use a pressure sensor to determine whether the object, in this case a pen [http://www.tensorpen.com], is pressed too hard. We therefore also included squeeze as a stressful behavior to be measured.

STRESS REDUCTION

Coping is the person's cognitive and behavioral effort to manage (reduce, minimize, master, or tolerate) stress. The principal goal of coping is that if people become aware of

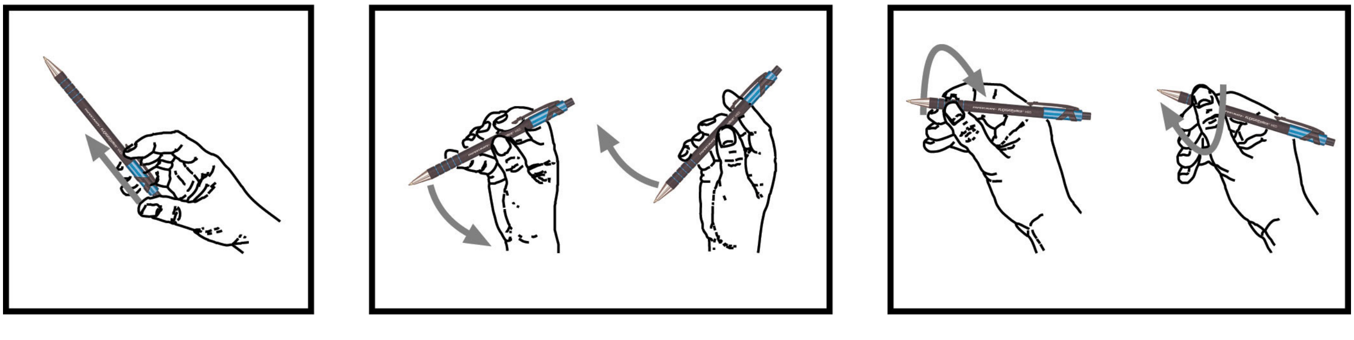

Figure 1. Manipulative hand movements, from left to right: squeeze, rock, and twiddle (a type of roll).

being stressed, it could help them avoid or at least minimize the bodily responses [13]. Solutions towards coping should create awareness on stress and support in changing negative behavior and emotion towards creating a more productive and positive experience.

Given that it is important to create awareness at the apparent moment stress occurs, the interface should provide immediate feedback. According to Wensveen et al's frogger framework [15], feedback should also match in location, direction, modality, dynamics, and expression, As we intend to detect stress by the way an object is manipulated, the feedback on the stressful behavior should be at the spot where the interaction takes place, i.e. where the hand touches the object. This is in contrast to applications that interpret physiology or facial expressions. Subjects cannot always directly relate the system's interpretation to their actual emotional state. If a product interpreting stress from stressful behavior should convey awareness, it has to be conducted through tactile stimuli to the hand, and in a similar vein as the expressed behavior. Additionally, feedback on stress has to be very personal, as people probably do not want others to be aware of the fact that they are stressed.

Vision

Our vision on how to reduce stress through tangible interaction with everyday products focuses on how the product can detect stress from apparently irrelevant movements (not immediately related to the task at hand), such as rocking, rolling, and squeezing behaviors. Once the product detects stress-related behavior it responds through tactile feedback to make the user aware of his or her way of manipulating the object. It continuously tries to modify the users behavior by guiding them towards making a relaxed behavior.

IMPLEMENTATION

To illustrate our vision on stress reduction through tactile feedback we introduce a prototype that was developed during the TU Delft Industrial Design Engineering, master's course of Interactive Technology Design. Students started the project by exploring different types of stressful movements that could be made with a pen. Based on the previously mentioned study [2] movements that involved rocking, rolling, and squeezing were selected and different interfaces were developed that afforded one of these behaviors. An interface had to sense different qualities of the movement, such as frequency and duration. It needed to detect a baseline measure for these values, where subjects could express their normal or relaxed way of behaving with the product. It also had to analyze whether a movement would differ from the baseline, and has to be considered as stressful; provide tactile feedback in order to create awareness; and finally provide feedforward to support the user in adapting his or her behavior.

Wigo

One of the prototypes that were developed is Wigo (see Figure 2), named after the wiggling movement that it is based on. While holding Wigo in one hand, the button can be rolled from side to side by the thumb, i.e. wiggled, the movement that is used for stress detection. The Wigo device can detect frequency, speed, distance, and duration of the movement. Before starting to detect behavior as defined by our initial experiment, i.e. rolling, a relaxed movement needs to be made, after which the button on top has to be pushed inwards to set the baseline movement detection levels.

Figure 2. The Wigo prototype.

Feedback

During use, the interface compares the current movement to the predefined relaxed-baseline movement settings along the previously mentioned variables. If the interface computational system detects that the movement becomes stressful, for example when the movements become rapid and short it will provide feedback. The feedback consists of increasing the friction on the rotation, which is directly noticed by the user as it becomes increasingly difficult to rotate the Wigo button. Users are thus forced to slow down, at which point the friction gradually reduces, thus providing feedforward until they are back to a more relaxed movement. Considering the frogger framework the movement thus coincides in time, as the interface provides immediate feedback when the movement changes; as well as in location, direction, modality, dynamics, and expression, as the friction increases on the button while the user is rotating it.

Evaluation

The prototype was presented to various users in informal presentations and a small pilot study was conducted in which subjects were asked to relax by wiggling Wigo's button after a mentally stressful condition. During the pilot experiment dynamic-tactile feedback was provided when the movements became too rapid and short during one condition. In the second condition, Wigo did not provide any dynamic-tactile feedback. Unfortunately no subjective stress reduction was found in the pilot study, which can be attributed to several reasons such as the small sample size, and the fact that various participants did not notice the haptic feedback provided by the prototype. However, in the discussions conducted after the experiment and during the informal presentations, where participants did appreciate haptic feedback, people acknowledged that it supported them in making a relaxed movement, as long as it would be subtler than in the current situation. Furthermore they considered playing with an object a relaxing experience, despite the ergonomically uncomfortable size of the object.

FUTURE RESEARCH

The current implementation in Wigo should be considered as a prototype that was only meant to explore how people would experience the envisioned feedback. Feeling the feedback appeared to be worth more than a thousand words in explaining our vision. Future research will focus on refining the level of feedback. Furthermore, we will continue exploring how tactile feedback can also be provided on the squeezing and rocking movements. Finally, all three interactions with appropriate tactile feedback will be embedded in different especially designed everyday products. Research will be conducted on whether product-embedded affective interactions could support in creating awareness on stressful behavior and perhaps support users in feeling relaxed. Hopefully this will provide more insight in how to make expressive interaction affective.

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