Auditory Noise Can Facilitate Body’s Peripheral Temperature Switchovers

Eduardo Lugo, Faubert Lab, School of Optometry, Universite de Montreal, Quebec, Canada
Rafael Doti, Faubert Lab, School of Optometry, Universite de Montreal, Quebec, Canada
Jocelyn Faubert, Faubert Lab, School of Optometry, University of Montreal, Quebec, Canada

ABSTRACT

Home is the context of an ambient-intelligence environment. Nonetheless, one can downsize the environment. For example, the human body as an environment, and by reading all possible bio-signals, this article can create control loops where many of these bio-signals can be used as sensory inputs to make humans aware of their current perceptual-cognitive state. In this article, the authors present an example where the peripheral temperature is used as a marker to know when a human switchover from a stress state to a calm state happens. The switchovers are controlled by the sympathetic and parasympathetic nervous system. The authors showed that finger temperature can be modulated by an effective auditory noise, and in four of the six tested subjects, 70 dBSPL was the optimal noise. These results open the possibility of making personalized, adaptive and anticipatory devices capable of modulating the switchover from a stress state to a calm state.

KEYWORDS


INTRODUCTION

Imagine a person returning home after a long journey and he is exhausted. It opens the door and after many devices already installed in its house, have interacted with it that it is not even aware of them. From the surveillance cameras, automatic alarms and door locks. Once inside, automatically, the person can communicate with its family or friends and know about their whereabouts thanks to a GPS interface. Its smart kitchen is suggesting what to cook for dinner and ready to order a take-out if the menu does not please anyone. Meantime its health bracelet is saying that its stress level is high and immediately suggests it begins a biofeedback therapy or meditation exercises along with yoga.

This history can continue forever like that, and it could represent our lives shortly, and it reflects how an electronic environment responds, or it is sensitive to human presence with the sole idea of helping people in their many activities and tasks. The way to implement this, it is not straightforward because it needs to be done as natural as possible. The technical field related to the relationship between this electronic ambiance and humans is known as ambient computing or intelligence. The ambient computing paradigm builds upon, among other things, human-centric computer interaction design that it is characterized by technologies and systems (Epstein, 1998). These systems and devices are embedded (many networked devices integrated within the environment). They could recognize a person and their current circumstances (situational context). They are personalized devices (tailor
your needs). They are adaptive (change depending on your response) and finally they can have an anticipatory response (they know what you want before you are conscious of your need).

Usually, as in our previous example, home is the typical context of an ambient intelligence environment, but it can also be enlarged to offices, public spaces, schools or hospitals. Nonetheless, one can downsize the environment as well. For instance, take a human body as the environment, and by reading all possible bio-signals, we can create control loops. That is, many of these bio-signals can be used as sensory inputs to make humans aware of their current physiological or cognitive state. Take back the health bracelet example, where from heart rate, skin conductance, and peripheral temperature can be measured. The amplitude, slope, and variation of these signals represent dynamic transitions among different nervous systems whereby perception and cognition may be affected. A concrete example is a peripheral temperature; whose amplitude usually decreases when anxiety or stress is present. On the contrary when the peripheral temperature increases humans tend to relax. From the ambient intelligence point of view, we can ask how we can use this information to create a personalized, adaptive and anticipatory protocol and a device capable of modulating the transition from a stress state to a calm state.

The peripheral temperature is controlled by the autonomic nervous system (ANS). The ANS is classified into sympathetic (SNS) and parasympathetic nervous system (PNS). They both primarily control the subconscious activity of the body. The SNS’s primary function is to excite the fight-or-flight reflex and the PNS is thought to trigger the rest-and-digest reflex.

One beautiful example of how both subsystems act upon a physiological reaction is the cardiovascular reflex to modulate stress. This reflex has mystified sports professionals for decades (Makivic, Djordjević, & Willis, 2013). Essential alterations are carried out unfailingly to the cardiovascular system to satisfy distinct requirements of the heart and muscular fibers (Makivic, Djordjević, & Willis, 2013; Fagard, 1992; Vatner, & Pagani, 1976). One example of these alterations is the ANS regulation, which happens as a feedback agent to quick modifications in “blood pressure and heart rate.” The exploit of electrocardiography (ECG) methods open up a test window for the estimation of ANS activity. For example, evaluating the risk of a person with blood sugar disease and nerve disease and heart-related problems, the usage of heart rate variability (HRV) is known (Makivic, Djordjević, & Willis, 2013; Khandoker, Jelinek, & Palaniswami, 2009; Tereshchenko, 2012). Other tangible uses of HRV is supervising sports training. Makivic et al. (Makivic, Djordjević, & Willis, 2013) compiled a review on the usage of HRV to assess sports performance. HRV can be used to observe the status of the nervous system whereas commanding the heart. Essential by defining variations of sequential time lapses known as R-R episodes (Camm et al., 1996; Quintana, Heathers, & Kemp, 2012; Vanderlei, Silva, Pastre, Azvedo, & Godoy, 2008). Sympathetic activity increases the heart rate, thus its contraction, and conduction velocity, whereas the inverse is registered if the parasympathetic system is activated. The parasympathetic reactions intercede across muscarinic receptors whereas sympathetic actions are exchanged by alpha and beta adrenoreceptors.

HRV may be scrutinized using frequency-domain approaches (Fourier methods). Such approaches provide distinct parameters connected by means of parasympathetic action (high frequency/HF) or sympathetic action (low frequency/LF). In an HRV research testing cyclists, before and after a series of 20 minutes of exercise at different workloads, the results exposed a sympathetic prevalence (suggested by a rise in the LF/HF proportion) throughout comparatively not so much intensive workout and parasympathetic prevalence (denoted by a reduction of the LF/HF proportion) through comparatively to a greater degree of intensity workout (Hottenrott, Hoos, & Esperer, 2006). The cyclists’ HRV power spectra were contrastive prior to afterward the workloads. Roughly speaking, spectral shapes were similar to a bimodal frequency distribution, The LF and HF crests varied their amplitude as the workload changed. These results clearly indicated that changeovers among SNS and PNS occurred, and they are driven by the workout task itself.

In addition, in the past few years, it has been underscored the relationship between HRV and selective attention under cognitive load. G. Park et al. scrutinized the correlation between cardiac vagal
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