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The mental and subjective skin: Emotion, empathy, feelings and thermography

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ABSTRACT

We applied thermography to investigate the cognitive neuropsychology of emotions, using it as a somatic marker of subjective experience during emotional tasks. We obtained results that showed significant correlations between changes in facial temperature and mental set. The main result was the change in the temperature of the nose, which tended to decrease with negative valence stimuli but to increase with positive emotions and arousal patterns. However, temperature change was identified not only in the nose, but also in the forehead, the oro-facial area, the cheeks and in the face taken as a whole. Nevertheless, thermic facial changes, mostly nasal temperature changes, correlated positively with participants' empathy scores and their performance. We found that temperature changes in the face may reveal maps of bodily sensations associated with different emotions and feelings like love.

1. Introduction

Back in 1890, William James wrote, "Brain-activity seems accompanied by a local disengagement of heat (...). He [Dr. S. Lombard in 1867] noted the changes in delicate thermometers and electric piles placed against the scalp in human beings, and found that any intellectual effort, such as computing, composing, reciting poetry silently or aloud, and specially that emotional excitement such as an anger fit, caused a general rise of temperature" (pp. 99–100). Since then, thermography as a technique has increasingly been employed in the field of psychology in order to study psychological processes.

One of the advantages of thermography is the reduction in noise often collected in physiological measurements (Agnew & Wise, 2008). It is rather simple to differentiate between physiological measurements of various parts of the subject's body like the nose, the forehead or the cheeks, obtaining a reasonably low level of data contamination (Or & Duffy, 2007). However, initial thermographic research concentrated on mental workload. Studies by Genno et al. (1997) used it to measure mental workload in relation to the evaluation of fatigue. They conducted experiments in which the temperature of the skin

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was shown to have a great potential as a physiological measure, because when using a thermographic camera no physical contact with the subject is needed. The autonomic nervous system's response to stress causes a change in the temperature of the skin, which the experimenters measure in the nose, a part of the body that, despite experiencing little movement, can undergo variations in temperature under stressful conditions. Their results reveal a decrease in nasal temperature during stressful situations due to vasoconstriction, which leads to a reduction of blood flow to the peripheral capillaries of the nose, causing the decrease in temperature (Genno et al., 1997; Veltman & Vos, 2005). However, the temperature of the forehead is one of the most stable temperatures in the body (Stoll, 1964), so Genno et al. (1997) used it as a reference area. Veltman and Vos (2005) remind us that the change in nasal temperature is the important measurement, and not the absolute value of the temperature (considering that mental workload may not be the only factor that affects nose temperature). Their methodology is to use thermographic cameras and determine which Region of Interest (ROI) should be studied. This paradigm confirmed the equivalency of the temperatures of the forehead and the nose in rest condition and the change in temperature of the nose in all of the conditions in which mental workload was manipulated (Or & Duffy, 2007).

Few studies apply thermography to the study of emotions. Pavlidis, Eberhardt, and Levine (2002) have used infrared cameras to measure participants' facial temperatures, based on the idea that facial temperature changes in various regions of the face correlate with emotional experience. In particular, they have studied the emotions of deceit and anxiety and found evidence that facial temperature changes can indeed predict both. However, the results of thermographic studies are sometimes inconclusive. Briese and Cabanac (1991) found that stress levels correlate with increased blood flow in the frontal vessels of the forehead. Tanaka, Ide, and Nagashima (1999) and Nagumo, Zenju, Nozawa, Ide, and Tanaka (2002) obtained correlations between arousal level and nasal skin temperature. Zenju, Nozawa, Tanaka, and Ide (2004) and Zenju, Nagumo, Nozawa, Tanaka, and Ide (2002) found that nasal skin temperature rises when shifting to pleasant mental states and fall when shifting to unpleasant mental states. Similarly, Nakayama, Goto, Kuraoka, and Nakamura (2005) and Kuraoka and Nakamura (2011) obtained decreased nasal temperature in negative emotional states, but Nakanishi and Imai-Matsumura (2008) observed facial skin temperature decrements also during joyful expressions in the nose. Robinson et al. (2012) found that warming of the brow, near the corrugator muscle, and the cheek, near the zygomatic major muscle, are related to less positive feelings but that warming in the eye area, near the orbicularis oculi, is related to positive self-sentiments. The correlations between facial thermal changes and other brain or physiological measures are clearly significant during experimental tasks but also for ecological tasks such as driving, as has been demonstrated by Sheba, Elara, Lerín, Martínez-García, and Torres-Córdoba (2012). Poppendieck, Ruff, Fernández, and Hoffman (2009), Jarlier et al. (2011), and Jenkins, Brown, and Rutterford (2009) employed EEG, EMG, GSR, and heart rate, in their works to demonstrate these correlations. Dimberg, Andréasson, and Thunberg (2011) argued that emotional empathy is linked to facial reaction to the facial expressions of others. In other words, people with high empathy are more facially reactive when exposed to pictures of angry and happy facial expressions. Facial EMG was measured in the corrugator and the zygomatic muscles, derived from the above-cited research which examines the warming of the brow and cheek with regard to facial thermal changes. However, researchers such as Khan, Ward, and Ingleby (2006) and Khan, Ward, and Ingleby (2009) have opened new lines of research in this area: the relationship between thermographic changes and feelings. Their experiments show variations in the intensity of the temperature in subjects that express positive and negative affective states, particularly in states of happiness and sadness.

In short, thermography can be considered a biometric measurement of human emotions, but arousal, valence, Ekman (1970) basic emotional states, stress, empathy or feelings, including complex emotions such as love or happiness, are not differentiated in previous research. The characteristics of the populations employed (adults, infants, elderly or animals), the ecological or laboratory context and the different tests and stimuli employed yield contradictory results, such as the thermal increments or decrements associated with empathy or positive emotions.

The main goal of the present study is to ascertain whether facial thermograms can be used as a valid and reliable somatic indicator of emotional parameters. Specifically, we want to determine if there is a relation between changes in temperature of the face and valence, arousal, empathy and subjective feelings. The principal aim of our research is to validate the use of thermography as an effective experimental paradigm to study emotions and to discover the somatic indicators of subjective feelings.

We approach these questions via three experiments: 1. The thermal effect of valence (positive and negative) and arousal (high or low) of IAPS images; 2. The thermal effect of empathy; 3. The thermal imprint of subjective experiences felt in the body and face, following Nummenmaa, Glerean, Hari, and Hietanen (2014): the case of love.

2. Experiment 1. The thermal effect of valence (positive and negative) and arousal (high or low) of IAPS images

According to the emotions theory developed by Lang (1995) see also (Lang, Bradley, & Cuthbert, 2005; Vila et al., 2001), valence and arousal are the key factors in this field. In Experiment 1.a we study whether the positive or negative valence of the IAPS images produces different thermal changes in the face. Previous studies suggest that positive images increase facial temperature while negative images lower it. In Experiment 1.b we focus on the thermal effect of high arousal, hypothesizing that the temperature of the nose and/or forehead correlates with the level of arousal.