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LETTER TO THE EDITOR

Utility of infrared thermography when monitoring autonomic activity

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Dear Editor,

We have read with interest the study of Huggins and Rakobowchuk (2018), in which the authors concluded that infrared thermography (IRT) is not useful to estimate sympathetic nervous activity (SNA) in humans. The authors supported their conclusions with the absence of significant skin temperature (T_{Sk}) changes during sympathetic activation and the lack of significant physiological association between T_{Sk} and heart rate, pulse transit time and mean arterial pressure. However, we would like to highlight some important aspects that may question the validity of such conclusions, namely the site of temperature measurement and the methodological quality of temperature measurements.

Several research papers have assessed the role of IRT in SNA research. Contrary to the author's claim that convincing evidence supporting the use of IRT as an effective measure of autonomic activity in humans is absent, several studies provide evidence of the opposite (e.g. Kistler et al. 1998; Panasiti et al. 2018). The review by Ioannou et al. (2014) explores the observed changes in T_{Sk} of several regions of interest (ROI) when facing sympathetic activation in different contexts.

The temperature of the human body must be understood in a two-compartment logic, the regulated core representing the inner organs, and the peripheral shell, which comprises all superficial tissues and organs such as muscle subcutaneous fat and the skin. The skin vasculature is under the control of the autonomic nervous system and is a potent effector in the temperature regulation system through modification of heat exchange by regulation of skin perfusion. The lacrimal caruncle is adjacent to the inner canthus of the eye, which is supplied by the internal carotid artery and is an indicator of core temperature, rather than shell temperature. In fact, the International Organization for Standardization has issued the standard ISO/TR 13154:2017 specifically addressing the use of IRT in febrile temperature screening assessing the temperature of the inner canthus. When monitoring autonomic activity, analyzing the tip of the nose or the fingers would be preferable choices, with eventual stronger association with other parameters.

Ignoring the fact that the site of T_{Sk} assessment might have not been the most appropriate, some methodological issues related to image acquisition and analyses must be discussed. As the authors recognized, standardized protocols must be implemented, which is not possible with the information provided in the article. A consensus statement was published (Moreira et al. 2017) aiming to standardize the collection and analysis of T_{Sk} data collected with IRT. Important information regarding ambient temperature, relative humidity, acclimation period duration (before data collection and between trials) was not reported and, considering the thermogram provided as example, it is possible to note that the camera was not perpendicular to the ROI, leading to measurement errors. Since the face was the area of interest, it should occupy as much pixels as possible of the total area of the image (Fig. 1). Another important issue is the fact that T_{Sk} was assessed using a single image pixel which, considering the distance between the camera and the participant, is hard to place in the same spot for all participants and can

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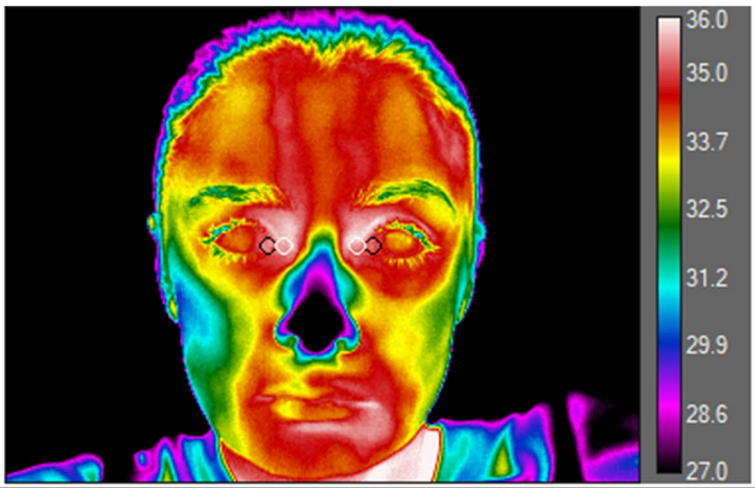

Statistic [units]	Right	Left	Right (2)	Left (2)
Mean [°C]	35.2	35.0	35.5	35.4
Std. Dev. [°C]	0.1	0.1	0.1	0.2
Center [°C]	(132.0, 120.0) 35.3	(185.0, 120.0) 35.2	(140.0, 120.0) 35.5	(177.0, 120.0) 35.4
Maximum [°C]	(133, 118) 35.4	(184, 121) 35.2	(143, 119) 35.7	(178, 117) 35.8
Minimum [°C]	(134, 122) 34.9	(187, 118) 34.7	(141, 122) 35.3	(179, 122) 34.9
Number of Pixels	37	37	37	37
Single Pixel Area [cm²]	N/A	N/A	N/A	N/A
Area [cm²]	N/A	N/A	N/A	N/A
Length [cm]	N/A	N/A	N/A	N/A
u Emissivity	0.98	0.98	0.98	0.98

Fig. 1 Thermographic image of the face with four ROI and corresponding temperature data

provide large temperature differences if an adjacent pixel is selected, especially when movement correction algorithms were not implemented. An area of pixels should always be selected, increasing the representativeness of the measured values and decreasing the error when small changes in positioning occur. Please consider Fig. 1 as an example.

There are four ROI represented in the image, two in the right side and two in the left side. Since the image was captured close to the participant, framing the face within the upper and lower limit of the image, it is possible to use ROI with 37 pixels each. For each region, the software used in the analysis (FLIR ResearchIR Max, version 4.30.0.69) provides information regarding the maximum, minimum, mean and centre (of the region) temperature and, it is easy to calculate the difference between the maximum and the minimum temperature values, which are 0.5 °C, 0.5 °C, 0.4 °C and 0.9 °C for "Right", "Left", "Right(2)" and "Left(2)", respectively. It is easy to understand that using a single pixel in T_{Sk} assessment is not advised since the method is more prone to error. Moreover, a close-up image has more temperature information, which is illustrated by the temperature differences between the two ROI on each side. Finally, the authors state that the mean temperature was taken every 10 s of the lacrimal caruncle region, which is not accurate since the authors used a point (1 pixel) estimate of T_{Sk}; therefore, there is no mean temperature, just a single temperature value.

Considering all the identified issues, caution is recommended when considering the reported findings.

Author contributions AS and KA conceived and wrote the manuscript.

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