SKIN TEMPERATURE (SKT)

: A psychophysiological measure used as an indicator of certain affective states such as stress or tension

The skin is the largest organ of the human body and generally acts as a protective barrier for the body. Due to its magnitude, skin temperature varies depending on which surface is measured (Karthikeyan, Murugappan, & Yaacob, 2012). The fluctuations in skin temperature can be influenced by factors such as skin blood flow, core temperature and environmental temperature (Ammer & Formenti, 2016). Other factors, such as muscle tone and evaporation, can also affect skin temperature. With these influences considered, skin temperature can add very interesting insight to research if approached properly. Skin temperature is particularly useful for sharing information from the sympathetic nervous system (SNS) to explain a participant's affective states.

The transfer of heat from deep tissue to the surface indicates the skin temperature, measured via infrared thermopile, thermistors, thermoelectric effects or optical means (Kamišalić, Fister, Turkanović, & Karakatič, 2018). Most commonly, a thermistor sensor is placed on a peripheral body extension (such as a finger). The set-up is relatively fast compared to other psychophysiological measures. Once the participant is informed of the appropriate information regarding psychophysiological data collection and feels comfortable proceeding (in addition to signing a consent form), the technician will request the participant's nondominant hand to place the thermistor on the fingertip. The probe includes a surface temperature component encased in polyurethane which conforms to the individual's finger. Furthermore, the probe is secured to the index finger via a Velcro strap. The technician ensures the sensor is secured properly without feeling uncomfortable. As with any psychophysiological measure, an acclimation period and a baseline reading will occur prior to any experimental exposures.

Figure 1

An example of Biopac Systems, Inc. (2020) fingers or toes thermistor (left), as well as the placement for measuring index fingertip temperature (right).

A thermistor is a resistor that provides variable resistance based on temperature. The thermistor can be either a Negative Temperature Coefficient (NTC), where the resistance decreases with increasing temperature, or a Positive Temperature Coefficient (PTC), where the resistance increases with a higher temperature. On a computer, the voltage signals will be converted to degrees for analysis. Collecting biofeedback responses continuously over time can give an understanding of the experience from start to finish. Skin temperature outputs are reviewed via one second means, and then the value is compared to the baseline measurement to show reactivity. The biofeedback is influenced by sympathetic effects, since an increase in blood flow to a particular area results in an increase in skin temperature.

Skin temperature is a useful tool to gain autonomic insights into challenging populations, such as infants or children. Soussignan, Schaal, Marlier, and Jiang (1997) recorded skin temperature changes on infants' wrists to review responses to different odors while awake or asleep. The measure was simple to incorporate and gave telling insights into behavioral state responses. The fluctuations in skin temperature contribute to a larger story, thus helping to explore the overall participant experience without being invasive.

(Not...) Getting Under Someone's Skin

So, when you have increased blood flow to any region of the body, skin temperature increases. Why is that? Imagine one day you are on a hike and suddenly you come face to face with a bear. Ahh! The experience of fight or flight takes place due to the SNS. Blood flows away from your peripheral systems, such as your fingers and ears, and goes to large muscle groups to help you get away. Hormones, such as epinephrine (aka adrenaline), enter the blood stream, tightening blood vessels. The SNS activation in your body results in the central internal areas becoming warm, while hands and feet become colder. With this understanding, stress and peripheral skin temperature have an inverse relationship- when one goes up, the other goes down. Therefore, the negative correlation of skin temperature and stress shows that an increase in skin temperature indicates a decrease in stress levels. Stress, relaxation and emotion can be explored through this simple measure because of its relationship to the autonomic nervous system.

SNS Activation → Blood Vessels Tighten → Less Bloof Flow → Lower SKT

Core vs Skin Temperature

Three layers make up the skin: the epidermis, the dermis, and the hypodermis. Skin temperature is measured from the outermost surface, the epidermis, while the core temperature is determined deep within the body. The core temperature maintains internal organs, such as the heart and the brain, while peripheral measurements are gathered through skin temperature. Skin temperature responses are much more variable than core temperature; however, they are not mutually exclusive. Core temperature can influence an individual's skin temperature (Karthikeyan, Murugappan, & Yaacob, 2012). Additionally, both skin temperature and core temperature modulate sweat production. Skin temperature is often preferred over core temperature when doing consumer research due to factors such as invasiveness.

It's Right at Your Fingertips!

Let's take a closer look at why skin temperature is a great measure for SNS activity. Within your fingertips, the skin has small blood vessels called arterioles that lead to capillaries (an exchanger for body necessities such as gases, nutrients, etc.). The arterioles only tighten up when the SNS is activated to decrease blood flow, thus giving a clean measure of the SNS (Sheng & Zhu, 2018). The magnitude of changes in skin temperature are low and slow, varying typically only by ~1 degree Fahrenheit. A change in skin temperature due to an emotional event or psychological change typically demonstrates itself within 15 seconds (Gruber, 2013). The delay in biofeedback can make it difficult to determine the cause of skin temperature fluctuations, which is why it is crucial to minimize variability and create a strong baseline. The research design must account for outside influences which may impact the responses. Adjusting the design to minimize artifact (aka unwanted noise which clouds the data) will help isolate the stimuli and build confidence in what factors are causing changes.

Making Connections

Skin temperature is utilized to explore product or consumer research, frequently with the integration of other physiological and behavioral measures like GSR, HR and facial coding. It is frequently cited as a contributing measure for connected sensory stimuli, such as different odors, to emotional responses. He, Boesveldt, De Graaf and De Wijk, (2014) utilized several psychophysiological measures (GSR, HR, skin temperature and facial coding) to report on responses of pleasant or unpleasant food odors. Although the study was relatively simple, it lacked a strong indication for a measure of liking. De Wijk (2012) conducted a similar study looking into young adult and children's responses to different foods. Here, heart rate and skin temperature were unaffected by immediate exposures but claimed skin temperature increased when participants were exposed to liked foods compared to disliked foods. This contradicts Danner et al. (2014) which reported disliked foods resulted in an increase in skin temperature. Overall, the emotional responses of consumer behavior for skin temperature in terms of liking are unclear at this point; however, if utilized properly, the measure can provide information into the *overall* autonomic experience.

In an attempt to dive deeper into how to categorize skin temperature responses within emotion, Kreibig (2010) reviewed several biofeedback responses of emotion under the cardiovascular measure of skin temperature. The majority of studies suggest the decrease in skin temperature is associated with emotions such as anger, anxiety, fear and sadness, and an increase in skin temperature implies positive emotions such as happiness. The experimental paradigms of emotion varied among the studies included in the review, with the utilization of methods of emotional induction such as film clips, images and the Velten Mood Induction Procedure (VMIP). While these methodologies help give foundational exploratory research into the impact of emotion on skin temperature, the results are imperfect given its focus solely on direction rather than magnitude. Skin temperature oscillates frequently as a function of thermoregulation, making it challenging to connect parallels of *specific* emotions to skin temperature.

The exploration of any specific emotion through biofeedback is a very challenging (maybe impossible) task without the compliment of psychophysiological measures such as facial EMG, implicit testing or traditional tools like surveys or interviews. The story skin temperature

contributes to is especially valuable when integrated with multiple sources of data (such as traditional, psychological or other biofeedback measures) for a holistic view of an experience. Using skin temperature to report on levels of physiological stress can add valuable context regarding the overall experience. Creating a strong network of data collection catered to the research question will promote a better design, as well as actionable findings.

IF YOU ARE INTERESTED IN LEARNING MORE ABOUT SKIN TEMPERATURE,
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REFERENCES

Ammer, K., & Formenti, D. (2016). Does the type of skin temperature distribution matter?.

Biopac Systems, Inc. (2020). Fast Response Thermistor, TP: TSD202A, TSD202B, TSD202C, TSD202D, TSD202E, TSD202F: Research: BIOPAC. Retrieved July 17, 2020, from https://www.biopac.com/product/thermistor-transducers/

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, 64, 81-90.

de Wijk, R. A., Kooijman, V., Verhoeven, R. H., Holthuysen, N. T., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference*, 26, 196-203.

Gruber, June. [YaleCourses]. (2013, May 30). *Human Emotion 7.2: Psychophysiology II (Cardiovascular System)* [Video file]. Retrieved from https://www.youtube.com/watch?v=yzpxppWaNK0.

He, W., Boesveldt, S., de Graaf, C., & de Wijk, R. (2014). Dynamics of autonomic nervous system responses and facial expressions to odors. *Frontiers in Psychology*, *5*, 110–. https://doi.org/10.3389/fpsyg.2014.00110

REFERENCES

Kamišalić, A., Fister, I., Turkanović, M., & Karakatič, S. (2018). Sensors and functionalities of non-invasive wrist-wearable devices: A review. *Sensors*, *18*(6), 1714.

Karthikeyan, P., Murugappan, M., & Yaacob, S. (2012). Descriptive analysis of skin temperature variability of sympathetic nervous system activity in stress. *Journal of Physical Therapy Science*, 24(12), 1341-1344.

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological psychology*, 84(3), 394-421.

Sheng, Y., & Zhu, L. (2018). The crosstalk between autonomic nervous system and blood vessels. International journal of physiology, pathophysiology and pharmacology, 10(1), 17.

Soussignan, R., Schaal, B., Marlier, L., & Jiang, T. (1997). Facial and Autonomic Responses to Biological and Artificial Olfactory Stimuli in Human Neonates: Re-Examining Early Hedonic Discrimination of Odors. *Physiology & Behavior*, 62(4), *745–758*. https://doi.org/10.1016/S0031-9384(97)00187-X