THERMOGRAPHIC EVALUATION FOR THE DIVERSE STAGE OF ANXIETY ON FACE TEMPERATURE AT FRONTAL AND TEMPORAL USING THERMAL IMAGING

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Abstract

Purpose: Thermal imaging is a technology that is able to capture images quickly and provide results with high resolution so that it is able to provide accurate results about the temperature picture. The purpose of this study was to examine if there were differences in anxiety conditions at facial temperatures measured using thermal imaging.

Methodology: Eighty-one participants were taking the pre-clinical exams was chosen as the inclusion criteria and were divided into four categories of anxiety range (not anxious, mild anxiety, moderate anxiety, and severe anxiety) based on their score measured that using the General Anxiety Disorder (GAD-7) as the instrument. The participants were measured their face temperature using thermal imaging on the upper forehead (frontal) and left-right forehead (temporal). Data was analyzed to show the characteristic of anxiety level on the frontal and temporal temperature. There were difference anxiety conditions (no anxious, mildly anxious, moderate anxious and severe anxious) to thermal imaging face temperatures in the frontal and temporal.

Main findings: The results showed that more increased the temporal and frontal of face temperature, more severe the anxiety. There is a significant negative relationship between face temperature and anxiety level ($p < 0.05$).

Implications: These findings showed that anxiety can be fast screening with a thermal imaging image. Further research is needed to determine the specificity and sensitivity of thermal imaging as an anxiety detection tool with a short time and without invasive action as one of the technological advances.

Novelty: There are no studies that discussed the correlation between anxiety with face temperature using thermal imaging.

Keywords: Thermal imaging, anxiety, face temperature, a general anxiety disorder.

INTRODUCTION

Individuals in the world at this time are very susceptible to stress that can interfere with their activities, so we need quick efforts that can be used as self-defense. Today there are many ways to detect anxiety but still require in-depth checks such as interviews and the use of instruments that are filled out by individuals. When an individual experiences anxiety, their perception will be limited so that the individual will answer according to what he is capable at that time. This can certainly be biased when individuals are unable to distinguish right from wrong. Hence needs another way more fast and accurate in assessing individual anxiety as an initial step of prevention so that anxiety doesn't get worse.

Anxiety is self-defense that arises as one of the psychological responses. But anxiety that is not overcome can interfere with psychological well-being which ultimately makes individual mental health not optimal ([Sulistiowati et al., 2019](#)). Neurotransmitters associated with the anxiety process are norepinephrine, serotonin, and gamma-aminobutyric ([Stuart, 2005](#)). The work system of norepinephrine is connecting the fight and flight response which will then work with other structures in the brain such as the amygdala, hippocampus and cerebral cortex that have the functions of thinking, interpreting and planning something ([Barbosa Pereira et al., 2017](#); [Hong & Hong, 2015](#)).

Someone who is experiencing stress will arise feeling alert so that the levels of adrenaline have increased which affects the increased blood flow. Redistribution of blood flow to superficial veins results in sudden changes in skin temperature ([AbdelrahmannVelloso, Dingler, Schmidt, & Vetere, 2017](#); [Ioannou, Gallese, & Merla, 2014](#); [Singh, Kumar, & Arora, 2018](#)). Some ways to determine a person was in a state of stress can be done in several ways to measure vital signs including frequency of breathing, pulse and blood pressure ([Chudecka&Lubkowska, 2016](#)). Thermal imaging is one method that uses the detection of infrared radiation of objects by increasing the visibility of objects in dark situations and then changing these conditions into the form of color degradation images ([Llyod, 2013](#); [Warmenlink et al., 2011](#)).

Thermal imaging functions to detect heat or temperature on an object using a collection of infrared radiation ([Arora et al., 2008](#); [Kosonogov et al., 2017](#)). The work process of a thermal imaging tool that is fast in giving a picture of the temperature distribution can certainly be used in providing an image when individuals experience anxiety ([Hong et al., 2009](#); [Pavlidis, Levinem, & Baukol, 2000](#)). This fast and measurable procedure can certainly have an impact on health applications that impact on the early intervention that can be given to individuals who experience anxiety. Electro-thermal imaging provides a picture of temperature in cancerous tissues where use with electro heat imaging has a smaller risk than IR imaging ([Carlak, Gencer, & Besikci, 2016](#); [Jensen, McKess, & Chen, 2014](#)).

That is why researchers want to know how the image of the face measured temperature distribution in the frontal (forehead above) and temporal (forehead) in the respective levels of anxiety. The purpose of this study was 1). To determine the distribution of anxiety levels in the frontal face temperature; 2). To determine the distribution of anxiety levels in the temporal part of the face temperature; 3). Comparing frontal and temporal facial temperature distributions at each anxiety level.

METHODOLOGY

Study design and participants

Students from Udayana University, Bali were recruited into this cross-sectional study with purposive sampling. A total of 81 participants were chosen because they were taking the pre-clinical exam as the inclusion criteria. All participants were explained about the aims of this study, and informed consent, they will sign consent forms before the test started and continued with the shooting temperature using thermal imaging face temperatures in the upper forehead (frontal) and forehead (temporal).

Instruments

This study was using GAD-7 to measure the anxiety level of the participants. GAD-7 has been validated with a large sample in a primary care setting by [Spitzer, Kroenke, B.W. Williams, & Lowe \(2006\)](#) that useful in assessing the symptoms and monitoring the anxiety ([Jordan, Shedden-Mora, & Lowe, 2017](#)). GAD-7 represented a level of anxiety with seven items with a Likert scale from zero to three. The total score ranged from 0 to 21 and cut-off scores for mild, moderate and severe anxiety symptoms were 5, 10 and 15 respectively ([Spitzer et al., 2006](#)). FLIR SC5000 thermal imaging was used to take pictures of participants' face temperatures.

Procedures

The measurement procedure is carried out in the morning 30 minutes before the test. The room temperature throughout the study was 24°C. After participants completed the questionnaire, they were then asked to sit with their heads held high and avoid head movements during shooting using thermal imaging on the forehead/ frontal and left and right foreheads/ temporal. The distance between thermal imaging and the portion of the image taken is about 10 cm and the length of time using thermal imaging is about 2-3 minutes for each participant.

Data analysis

Variables of the study consist of anxiety conditions as dependent variables; face temperature in the upper forehead as a frontal side and left/right forehead as a temporal side to independent variables. Data was analyzed to show the characteristic of anxiety level on the frontal and temporal temperature. Data analysis was used ANOVA, to examine difference anxiety conditions (no anxious, mildly anxious, mild anxious and severe anxious) to thermal imaging face temperatures in the frontal and temporal. ANOVA can be used to find differences between more than two groups. The results obtained then recorded and statistically analyzed using SPSS version 20.

RESULTS

The average temperature at the forehead/frontal was 37.36°C with a minimum and maximum temperature at 35°C and 39.20°C respectively. The data were normally distributed ($p > 0.05$). While the average temperature at the sidehead/ temporal was 37.41°C with a minimum and maximum temperature at 35.30°C and 39°C respectively. The data were normally distributed ($p > 0.05$) (Table 1). The temperatures were widely distributed at 36°C-38°C in the frontal, whereas in the temporal, the temperatures are widely spread at 36°C-37°C (Graph 1).

Table 1: Distribution of average temperature on the frontal and temporal (n = 81)

Variable	Mean	Median	SD	Min-Max	p
Frontal temperature	37.36	37.40	0.88	35.00-39.20	0.671
Temporal temperature	37.41	37.50	0.72	35.30-39.00	0.151

Figure 1: Image of the face temperature of participants in the temporal (a, c) and the temperature of the face in the frontal (b) captured using thermal imaging.

Figure 2: Temporal and Frontal Facial Temperatures of participants when the conditions are not anxious

Figure 3: Temporal and frontal face temperature of the participants on mild anxious conditions

Figure 4: Temporal and frontal facial temperatures of the participants on moderate anxious conditions

Figure 5: Temporal and frontal facial temperatures of the participants on severe anxiety condition

Graph 1: Temperature distribution in the frontal and temporal sections based on modulus/ most of the data ($n=81$)

A total of 15 participants didn't experience anxiety, 49 participants had mild anxiety, 14 participants were anxious and 3 participants experienced severe anxiety through temperature measurements in the frontal face ($P < 0.05$). In addition, this study also found about 15 participants not anxious, 49 participants had mild anxiety, 14 participants were anxious moderate and 3 participants had severe anxiety through face temporal temperature measurements ($P < 0.05$) (Graph 2). The ANOVA test showed that the frontal and temporal face temperature has a significant relationship to the level of anxiety ($P < 0.05$) (Table 2).

Table 2: Difference of temporal and frontal of temperature face with the level of anxiety

	Variable	F	p-value	Outcomes
Anxious conditions (no anxious, mild, moderate, and severe anxious)	Frontal temperature	11.985	0.000	α^{++}
	Temporal temperature	8.888	0.000	α^{++}

Data analysis was used as a one-way ANOVA to examine difference anxiety conditions (no anxious, mildly anxious, moderate anxious and severe anxious) to thermal imaging face temperatures in the frontal and temporal.

DISCUSSION

Average temperatures in parts of both the frontal and temporal were 37°C , with the minimum temperature was 35°C and the maximum temperature was 39°C . This indicates that both the temporal and frontal could almost provide the same image for the measurement of face temperature. Higher the face temperature, so more severe anxiety experienced by the individual. The study shows that more a person feels stressed, so it will increase the adrenaline which affects the blood flow and the temperature on the surface of the skin will change due to increased metabolic processes. Other research explains that facial thermal detection is also carried out to find out consistently periorbital heating associated with increased blood flow around the eyes (Pavlidis et al., 2000).

Graph 2: Distribution of steam plot graph and the average level of participant's anxiety based on face temperature at the temporal and frontal (n = 81)

Alertness, anxiety, and fear are very likely to occur due to the work of the sympathetic/adrenergic nervous system. The increase of temperature in the carotid veins is the result of an increase in blood flow that occurs because of stress. The results are shown by research from [Pavlidis et al., \(2000\)](#) when given a subcutaneous injection of adrenaline make vasoconstriction and if it measured using thermal imaging the outer edge of the skin produces was more heat.

The heat balance in the body was regulated by the largest thermoregulatory organ in cutaneous tissue ([Matos et al., 2015](#)). While the vasoconstriction that occurs in blood vessels decreases the blood flow to the skin tissue and internal organs, a hyperemia reaction will occur that causes an increase in blood volume in the internal organs. The increased blood volume would stimulate arterial baroreceptors in the aortic arch and carotid sinus on replacing the activity of regulating heart rate by the sympathetic nerve in becoming parasympathetic nerve activity. That process makes the blood would return to the periphery. Vasodilatation occurs when there was a change in capillary permeability due to the reflex regulation of heart rate and blood pressure ([Matos et al., 2015](#)). It can be concluded that thermal imaging is able to provide the monitor skin temperature.

The section of pale measured using thermal imaging indicates constricting blood flow. [Kosonogov et al., \(2017\)](#) states that the face would become paler which means it indicates an emotional feeling. This means that statistically, facial temperature measurements at both the frontal and temporal parts are equally capable of providing significant results in detecting anxiety. Temperature detection in thermal imaging uses a bolometer type on detection material, which can measure the strength of electromagnetic radiation based on the heat of the material with temperature-dependent electrical resistance. Microbolometer's type of material used as a detector on a thermal camera without a cooler which is commonly called an uncooled microbolometer. Microbolometer can be placed on the camera to detect heat radiation (infrared) on objects with a wavelength of 7.5-14 μm ([Willardson Weber, Skatrud, & Kruse, 1997](#)). The detection of object heat uses the Uncooled vanadium-oxide (Vox) microbolometer sensor technology where the temperature will fluctuate according to the incident flux response. Changes in temperature will cause a proportional change in each microbolometer's resistance ([Jensen et al., 2014](#); [Llyod, 2013](#)).

Figures 2, 3, 4 and 5 show the heat produced by the object in the face image of the temporal and frontal parts forming color degradation on the face with a certain temperature degree. This shows a temporal and frontal face temperature degradation from a temperature of 36°C to 39.1°C which is categorized in the level of anxiety, mild anxiety, moderate anxiety, and severe anxiety. The color degradation method based on the temperature scale through thermal imaging is able to provide information quickly in the form of images of the distribution of face temperature based on the condition of the thermoregulator that occurs on the face due to the level of stress experienced by someone.

Consequently, the images were produced by thermal imaging on facial objects display the results of different temperature distributions at different levels of anxiety, both male and female objects with a scale model of color degradation in each heat image where the heat image of this part of the face has similarity with anxiety level measurement instruments. Thermal

imaging is also used to detect the grade of a burn. In burns, heat transfer occurs due to lack of protective epithelium and high hydration of the tissues so that the risk of damage to blood vessels is higher which can result in heat moving into deeper tissues. This thermal imaging can detect how the temperature in existing tissue so that it can be detected early (Hardwicke, Thomson, Bamford, & Moiemmen, 2013; Renkielska, Nowakowski, Kaczmarek, & Ruminski, 2006). In addition, thermal imaging is also believed to be able to provide convenience for the determination of further therapeutic prognosis in the field of medicine (Kaczmarek & Nowakowski, 2016). Therefore it is only natural that thermal imaging is one of the technologies that can be used in health applications.

CONCLUSION

Thermal imaging can be used in detecting anxiety levels as one of the early detecting anxiety on individuals in a short time. The higher of the facial temperatures at the temporal and frontal, the level of anxiety was increasingly severe.

LIMITATION AND STUDY FORWARD

This study only uses students who will have examinations. This is based on the number of students that have shown anxiety symptoms when they get an exam. For future research, it can use more varied criteria and a greater number of participants so that it can provide a common figure for the effectiveness of using thermal imaging to detect anxiety. Nurses as part of the health care provider can provide early intervention in preventing anxiety from becoming worse by using thermal imaging as a detection device.

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AUTHOR'S CONTRIBUTION

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