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HEMIFACIAL SKIN TEMPERATURE CHANGES RELATED TO DECEPTION: BLOOD FLOW OR THERMAL CAPACITANCE?

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Abstract: The relationship between facial skin surface temperature and deception was examined using thermal image data collected during credibility assessment interviews of 21 U. S. Army basic trainees, some of whom had previously engaged in a mock theft. Facial regions of interest included the right hemiface, and three sub-regions overlying the periorbital, carotid, and cheek areas. Successive presentations of interview questions resulted in significant mean hemifacial temperature increases during the first block of testing, followed by temperature decreases throughout the remainder of the question sequence. The only facial temperature region of interest that was significantly related to deception was the cheek sub-region, which has a large soft tissue mass. These results suggest thatthe ability of the cheek region to store thermal energy after it is heated by the blood (thermal capacitance) contributes to the pattern of facial temperature changes seen during a credibility assessment interview.

Keywords: Thermal image analysis, Deception, Blood flow, Thermal capacitance.

INTRODUCTION

In 2001, researchers conducted a pilot study using non-invasive IR thermography to examine whether measures derived from thermal images were related to deceptive responses during a polygraph test[1]. Specifically, these researchers tested for deception-related thermal reactivity in a region around the eyesof study participants who had previously engaged in a mock-crime involving a simulated theft and assault. They reported that three-quarters (6 of 8) of the deceptive individuals were correctly identified as guilty and 90% (11 of 12) of the non-deceptive individuals were correctly categorized as innocent. They interpreted these significant results as being due to temperature increases resulting from regional periorbital blood flow changes during deception, and speculated that the “instantaneous” warming around the eyes was likely a component of fight/flight/freeze response mediated by the sympathetic nervous system [2]. However, other researchers who subsequently conducted a large-scale study attempting to relate deceptive responding to periorbital temperature changes failed to replicate these earlier findings [3]. At the present time, we do not have a satisfactory explanation for these conflicting results.

Many studies have shown that thermal images, which can provide a two-dimensional map of human skin surface temperature at well-defined times, can provide information about physiological processes in humans [4-12]. However, if the periorbital temperature changes reported by Pavlidis et al. [1] are part of an ANS-mediated response that accompanies deception, then psychophysiological mechanisms capable of generating this temperature response must exist [1]. It is known that, in human vasculature, as in that of other mammals, the responses of Adrenoreceptors to circulating adrenaline play a crucial role in the regulation of vascular tone [13]. Sympathomimetic agonists other than adrenaline can also provide vasoconstriction to the facial arteries, possibly resulting in phasic changes in blood flow due to the increased pressure [14]. Since blood flow in arteries is from areas closer to the core of the body, this would have the effect of heating the facial tissue that it perfuse through. However, the extent to which the facial skin temperature changes recorded by a thermal camera are a direct result of this process is not yet known. Other physiological mechanisms related to blood flow that could lead to an increase in facial temperature include the nitric oxide-mediated vasodilator response that results from rapid increases in blood pressure, and β2-receptor mediated vasodilation in response to increases in circulating epinephrine [15-17].

In addition to blood flow, which transfers thermal energy to the surrounding vascular tissues by convection, thermal capacitance is also a factor in the human body and is responsible for the slower temperature increases that can be measured at the skin surface [18]. The term "thermal capacitance" as it is used here refers to the ability of a mass of tissue to store thermal energy after it is heated by blood acting as a thermal energy source. The larger the surrounding tissue mass, the longer the time constant required for the blood to heat the tissue[19]. Theoretically, with sufficient time, the temperature of the tissue mass will converge to the temperature of the thermal reservoir (blood supply). One of our goals in conducting the research reported here was to investigate the extent to which thermal capacitance, inferred based upon the amount of soft tissue surrounding specific regions of the face and neck, contributes to skin surface temperature changes overlying those areas in deceptive and non-deceptive individuals.

Pavlidis et al. [1] collected their thermal data under conditions that simulated the credibility assessment procedures used by polygraph examiners [1]. Their procedures included the use of federally certified examiners to administer the tests, as well as the use of a Comparison Question Test (CQT) format, which is commonly used in the field[20-22]. In the present study, we chose to partially replicate these procedures, even though the CQT has been criticized for its lack of standardization [23]. This was done in order to facilitate direct comparison with the earlier, widely cited work, and also because it has been shown that a properly administered CQT can consistently discriminate deceptive and

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non-deceptive individuals at better than chance levels using either directed-lie or probable-lie comparison questions [24-26].

Anatomically, the carotid artery supplies the orbital branch, the inner facial branch, and the mesenteric artery [27-29]. The posterior superior alveolar branch and the inferior orbital artery branch off of the mesenteric artery and the inner facial branch to supply the periorbital region [30]. The mesenteric, maxillary, pterygoid, and buccal arteries supply the cheek region of the face, and are supplied by the inferior temporal branch of the external carotid artery. The buccinators muscle, the levator angular oris, the masseter, the zygomaticus muscles, and the medial and lateral pterygoid muscles comprise the cheek region. The cheek region also contains the buccal fat pad, which is a roughly triangular shaped region of adipose tissue [31]. We selected our facial regions of interest based on these considerations, and hypothesized that an anatomical area with higher thermal capacitance (i. e. , the cheek region) would provide a better indication of deception than areas directly overlying the carotid or its subsidiaries, due to the cheek's increased thermal responsivity during repeated phasic sympathetic responses.

METHODS

Participants

Twenty-four United States Army basic trainees stationed at Fort Jackson, South Carolina volunteered to participate in this study. Data from three of these participants were not analyzed due to experimenter error. Nine of the remaining participants were assigned to the Non-deceptive group (2 females, 7 males, M_{age} = 20. 6 years, age range: 18 to 26 years) and 12 were assigned to the Deceptive group (1 female, 11 males, M_{age}= 19. 2 years, age range: 18 to 25 years).

Materials

A handheld device, referred to as the Preliminary Credibility Assessment Screening System (PCASS), was used to collect electrodermal and vasomotor activity data[1]. A FLIR Photon™160 x 128 FPA camera core long wave infrared (LWIR; Spectral Band = 7. 5 to 13. 5 µm) micro-bolometer (Sensitivity = 85 mkdT at f/1. 6) fitted at the factory with a 19mm lens (FOV = 36°x 27°)was used to monitor skin surface temperature. The camera's 14 bit uncompressed digital video output was streamed to aDell Precision PWS490 Dual Quad Core 2. 66 GHz computer. A Santa Barbara Infrared, Inc. 2000 series blackbody and controller were used to perform all temperature calibrations. Participant instructions were presented in a room that included a chair, a desk, a cassette tape player, a pen, two pieces of chalk, and a black sheet of white 8. 5 x 11 inch paper. An overhead map of the mock crime area was also in the room.

MOCK CRIME PROCEDURES

General Procedure

The mock crime procedures used in this study were similar to those used in a scenario that was developed by researchers at the University of Utah [32]. First, pairs of participants who had given written consent to be enrolled in the study were told to open an envelope that was taped to a door at the end of a long hallway. Written information inside the envelope directed each pair of participants to open the door, press "play" on the tape recorder inside the room, and listen to pre-recorded instructions describing their mission. The tape-recorded instructions informed participants that if they were found to be truthful, they would be allowed to complete the process without consequence. Participants were also told that if they were found deceptive, they would have to stand before their drill sergeant, their unit, and the NCCA staff and give a speech on the importance of Army values, such as honesty, integrity, and loyalty. This punishment was not actually administered to participants. After completing their mission, participants were instructed to return to the(same) room, after which they were individually escorted to a testing suiteand met by a federally certified polygraph examiner who was blind to the participant's (Deceptive / Non-deceptive) group membership.

Deceptive Group Procedure

The tape-recorded instructions directed deceptive participants that they had 15 minutes to steal a "classified" piece of equipment from inside a shipping container in a nearby building, stash the container, and hide the classified equipment in the woods so that it could be picked up at a later time. Deceptive participants were also instructed to prepare an alibi, and to each take one piece of chalk with them and keep the chalk hidden on their person, ostensibly to be used later to make a mark that would be used as a signal that the equipment was ready for pickup. Deceptive participants were provided with a cover story that matched the actual activities of non-deceptive participants, and instructed to try to appear truthful during the "lie detector" testing. After deceptive participants completed the mock crime and were returning to the building, they were stopped by a staff member and asked what they were doing. The staff member accepted their answers, and then told them that they needed to return to the building.

Non-deceptive Group Procedure

Non-deceptive participants were instructed via tape recorder to leave the contact room and go to a bench under a covered area behind the building and remain at the break area for approximately 10 minutes, at which time they were instructed to return to the room. The recorded instructions for participants in the Non-deceptive group did not provide any details of the theft or indication that a crime had been committed. Non-deceptive participants who were returning from the bench were stopped by a staff member, asked what they were doing, and told that they needed to return to the building.

Data Collection Procedures

Prior to the participant's arrival, two-point temperature calibrations were performed, using the thermal camera to image the surface of the blackbody after the absolute blackbody temperature was set and thermally equilibrated to 28.00°C and then to 40.00°C. These calibrations were used to convert the camera's 14 bit raw digital video image data to radiometric

[1]Participants in this study were a subset of 107 U.S. Army basic trainees (40 females, 67 males, M_{age} = 22.1 years, age range: 18 to 42 years) stationed at Fort Jackson who had volunteered to test the effectiveness of the PCASS device. Detailed results based on the PCASS data will be reported in a separate manuscript.

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temperature values. The thermal camera was mounted on the edge of the examiner's desk, directly below and in front of the participant, at an angle of approximately 45° to both the horizontal and vertical components of the sagittal plane, so that the camera's FPA was orthonormal to the participant's right hemiface (Figure 1, top).

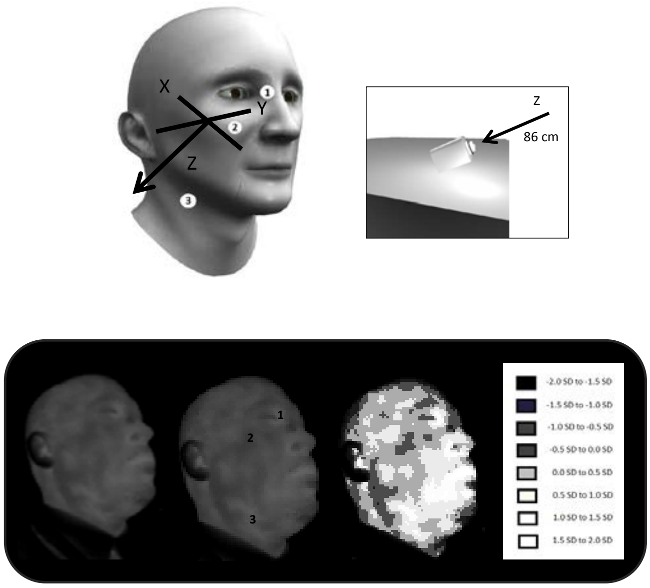

Figure 1. Thermal data collection procedures during the credibility assessment test (top). Thermal energy radiating from the XY plane of the participant's right hemiface (top, left), traveled through Z, and struck the focal plane of the thermal camera (top, right) positioned orthonormal to the hemiface. Raw 14-bit integer data from the camera were converted to a series of 8-bit grayscale images (bottom, left). After masking temperature regions outside the range of human skin surface temperature, periorbital (region 1), cheek (region 2), and carotid (region 3) ROIs, each containing 12 pixels of thermal data, were manually extracted from a subset of the images (top, left and bottom, center). A normalized temperature map of the same thermal facial data (bottom, right) shows the distribution of light (hot) and dark (cool) isotherms across the face of one of the experimenters (DAP).

When the participant entered the examination suite, they were seated in a Lafayette adjustable arm polygraph chair and testing began with a highly structured pretest interview consisting of a review of the instrumentation, the case facts, the participant's alibi, and the test questions. The test questions were always reviewed in the same order, beginning with the crime-relevant questions, and then the comparison questions, and finally the crime-irrelevant questions (Table 1). At the conclusion of the pretest, the PCASS sensors were attached to the participant's palm and middle finger using conductance gel and a plastic clip. The participant was asked to remain still, and then the test questions were verbally presented by the examiner. Successive questions were presented at30 second intervals[2]. Digital video data from the Photon were collected continuously during the question presentations, and stored for offline analysis as 14 bit grayscale images in the Tagged Tiff file format, using a 10 Hz sampling rate. Although there were a total of nine comparison questions on the test (as is standard field practice), in order to create a balanced experimental design we did not include the last comparison question in our data analysis. This created one trial block consisting of 4 comparison questions, 4 crime-relevant questions, and 4 crime-irrelevant questions, and a second trial block consisting of 4 comparison questions and 4 crime-relevant questions. The first crime-relevant question, "Regarding that stolen electronic device, do you intend to answer truthfully?" was asked only once during the testing and was therefore also excluded from our analyses.

[2]As a part of the PCASS investigation, some of the participants (n = 53) were instructed to answer the questions verbally with a "yes" or "no", and others (n = 54) were instructed to nod or turn their heads slightly to indicate a yes or no response. All thermal data were collected from participants who answered verbally.

Table 1: Questions Asked during the Collection of Thermal Image Data.

Question	Category
Regarding that stolen electronic device, do you intend to answer truthfully?	Crime-Relevant
Did you steal that electronic device?	Crime-Relevant
Did you help anyone steal that electronic device?	Crime-Relevant
Did you ever say something derogatory about another person behind their back?	Comparison
Did you ever do anything that made a close friend mad at you?	Comparison
Did you ever say anything in anger that you later regretted?	Comparison
Did you ever lie to a close friend?	Comparison
Did you ever lose your temper?	Comparison
Did you ever lie to make yourself look important?	Comparison
Are you now sitting down?	Crime-Irrelevant
Are the lights on in this room?	Crime-Irrelevant
Are you now in South Carolina?	Crime-Irrelevant

Note. Although all of the crime-relevant questions were asked during the test, the examiner was free to select two of the three crime-irrelevant questions and three of the six comparison questions from the list above when constructing the test questions. The test always began with a crime-irrelevant question. The first crime-relevant question listed above was asked only once, immediately following the first crime-irrelevant question. Each of the remaining two crime-relevant questions was asked four times (crime-relevant question n = 8). Each of the three comparison questions was asked three times (comparison question n = 9). Each of the two crime-irrelevant questions was asked two times (crime-irrelevant question n = 4). Except in the case of a mis-answered question or physiological response artifact, no two questions from the same category were ever asked successively during the test.

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Data Reduction

Each participant's thermal digital video file was converted to a time series of 16 bit grayscale Tiff images, resulting in approximately 10 frames per second of video. The Tiff images were then converted to 8 bit grayscale bitmap images, including only the intensity values corresponding to temperatures between the low (28. 00˚ C) and high (40. 00˚C) temperatures obtained from the calibration files[3]. A National Instruments head tracking algorithm was then used to track and extract a rectangular region of interest (ROI) within each successive frame. The ROI always included the participant's hemiface, as seen in Figure 1, bottom. The mean and SD of the pixel intensity values within each of these ROIs was calculated, and then the average and SD of the hemifacial temperature responses to each interview question were determined by averaging across successive frames recorded during each of the questions.

Three smaller regions of interest, including the hottest (brightest) skin surface areas overlying the periorbital region between the bridge of the nose and corner of the eyeand the carotid artery were manually selectedfrom within the larger (hemiface) ROIs using a mouse. The cheek ROI was selected in a similar manner, except that the coldest (darkest) region of the cheek was chosen (Figure 1, bottom, center). Each of these three ROIs was circular in shape and contained 12 pixels of thermal data (Figure 1, top left). A commercially available software package (National Instruments Vision Assistant, version 2010) was used when selecting these ROIs. Because we were interested in tonic changes in these areas, specific frames were selected from within the time series of hemifacial images for inclusion in the data analyses of these three regions. A total of six frames per participant were included in the analysis of these smaller regions. These frames were comprised of the onset of the participant's responses to the first and last crime-irrelevant questions, the first and last crime-relevant questions, and the first and last comparison questions.

Separate Group (Deceptive/Non-deceptive) X Question Block (Comparison Block 1/Crime-Relevant Block 1/Crime Irrelevant Block 1/Comparison Block 2/Crime-Relevant Block 2) X Repetition of Stimuli within a Question Category (1/2/3/4) ANOVAs were conducted on the mean of the hemifacial temperature responses and the mean SD of the hemifacial temperature responses during each test question. Tonic changes in the periorbital, carotid, and cheek regions were also evaluated using Group X Region (Periorbital/Carotid/Cheek) X Question Number (First/Last) XQuestion Category (Crime-Irrelevant/Crime-Relevant/Comparison) mixed factor ANOVAs conducted on the mean and SD of the ROI temperatures. Greenhouse-Geisser corrections were applied where appropriate to correct for violations of the sphericity assumption. In reporting the significance levels for the ANOVAs, the uncorrected degrees of freedom are given along with the epsilon (ε) values used to adjust the significance levels. Eta-squared (η^2), a measure of effect size, is reported. A statistical significance criterion of . 05 was used for all statistical tests.

RESULTS

Background Temperature

Because we were concerned with participants' tonic skin temperature changes in this study, which could have been affected by changes in the ambient temperature of the testing room during the course of each interview, we recorded the mean pixel intensity of a rectangular ROI selected from the wall directly behind each participant at the start and again at the end of each interview. The results of a Time (Interview Start/Interview End) X Deceptive/Non-deceptive Group mean wall temperature ANOVA failed to show any main effects, $F(1, 19) = 1.13$, $\eta^2 = .06$, n. s. , or interactions, $F(1, 19) = 0.19$, $\eta^2 = .01$, n. s. , involving deceptive status. There was, however, a significant main effect of Time, $F(1, 19) = 20.15$, $\eta^2 = .52$, $p < .001$. This finding suggests that there may have been a thermal radiation increase throughout the course of each interview resulting from the additional person in the room during testing, or possibly a time of day effect, as testing was always started in the morning when it was cooler and continued throughout the day.

Right Hemifacial Temperature Changes

The hemifacial mean temperature ANOVA showed a main effect of repetition of stimuli within a question category, $F(3, 51) = 5.68$, $\eta^2 = .25$, $p < .01$, $\varepsilon = .61$, and a Repetition X Question Block interaction, $F(12, 204) = 6.21$, $\eta^2 = .27$, $p < .001$. This significant interaction appeared to be due to increases in hemifacial temperature during the first block of stimuli

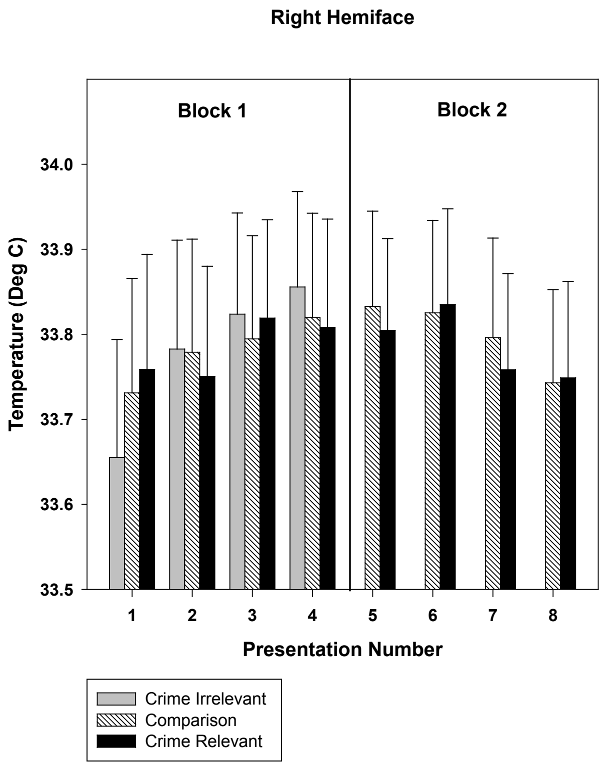

Figure 2. Mean (± SEM) hemifacial temperatures during successive presentations of crime irrelevant, comparison, and crime relevant questions.

[3]Linearity of the thermal image pixel intensity increase corresponding to a given temperature increase was verified by increasing the blackbody temperature at 1.00˚ C intervals starting at 28.00˚ C and ending at 40.00˚ C. Digital thermal video data was obtained by imaging the blackbody at each of the temperatures, and then the blackbody temperatures were correlated with the integer values corresponding to the pixel intensities.

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within each category, followed by a decrease in hemifacial temperature to comparison and crime-relevant questions during the second block. Crime-irrelevant questions, which were only asked four times during each test and never near the end of the question sequence, showed only an increase in temperature with successive presentations (Figure 2). There were no significant main effects or interactions involving the Deceptive/ Non-deceptive Group variable in this analysis on hemiface temperature, suggesting that there is no obvious relationship between right hemiface temperature change and deception. The hemifacial SD temperature ANOVA failed to reveal any significant main effects or interactions between right hemifacial temperature variability, as measured by the SD, and either question category or repetitions of questions within a category.

Periorbital, Carotid, and Cheek Temperature Changes

Unlike the analyses involving the right hemifacial ROI discussed above, both the mean and SD temperature ANOVAs conducted on smaller regions contained within the right hemiface showed significant effects of Group. Specifically, the omnibus mean temperature ANOVA showed a significant Region X Deceptive/ Non-deceptive Group interaction, $F(2, 36) = 5.34$, $\eta^2 = .23$, $p < .05$, $\varepsilon = .68$, which was the result of higher mean cheek ROI temperatures for deceptive individuals, and similar mean carotid and periorbital ROI temperatures for individuals in both the Deceptive and Non-deceptive groups (Figure 3, top). The SD temperature analysis revealed significant main effects of Region, $F(2, 36) = 47.63$, $\eta^2 = .73$, $p < .001$, $\varepsilon = .77$, and Group, $F(1, 18) = 5.07$, $\eta^2 = .22$, $p < .05$. The significant main effect of region was due to larger skin surface temperature SDs in the area overlying the periorbital region than either the cheek or carotid areas. The significant group effect was due to smaller temperature SDs for deceptive participants (Figure 3, bottom).

In addition to the findings involving significant between-group

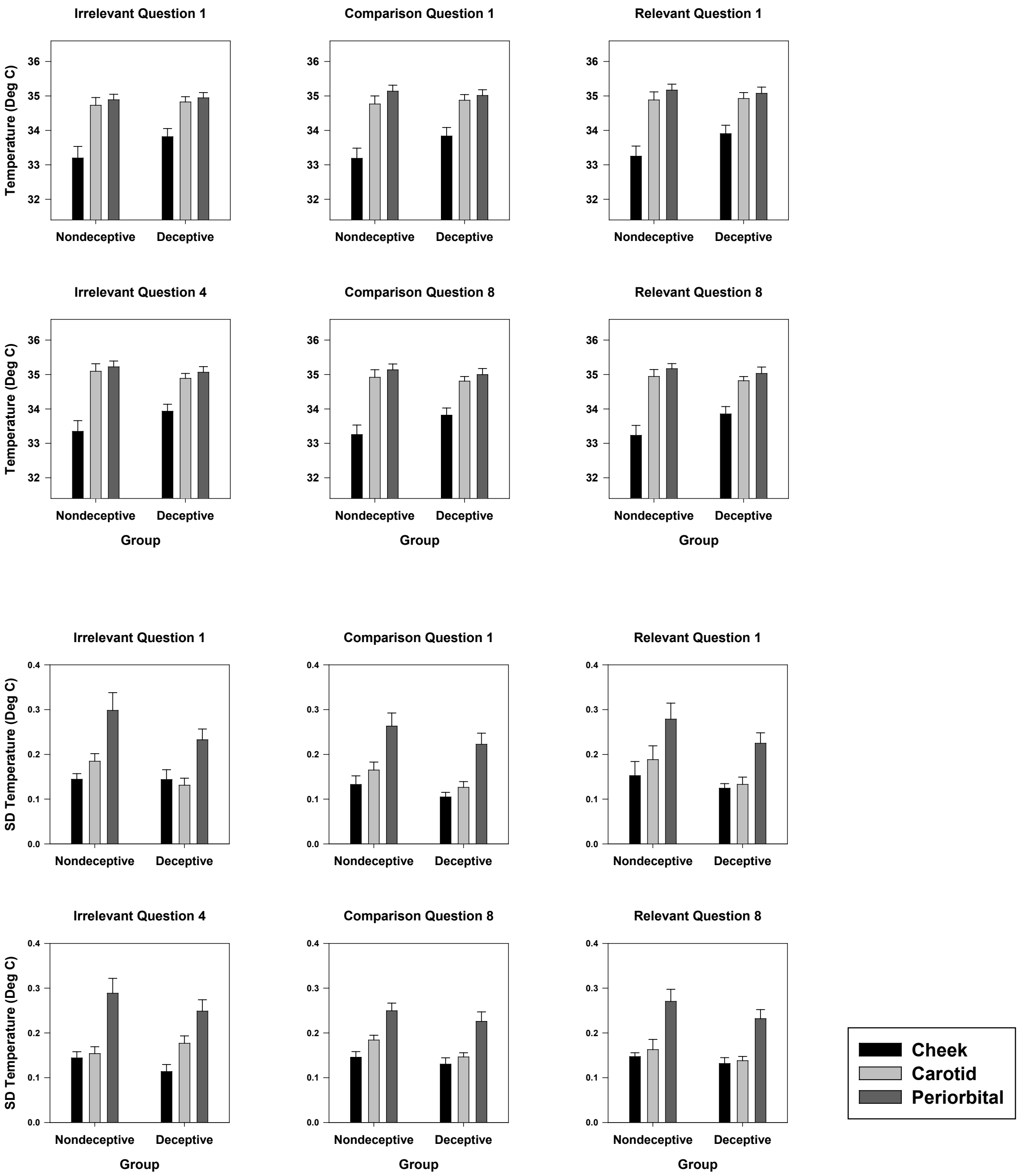

Figure 3. Mean (± SEM) cheek, carotid, and periorbital ROI temperatures (top) and ROI temperature SDs (bottom) in nondeceptive and deceptive participants.

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effects, the mean temperature ANOVA on periorbital, carotid, and cheek regions also showed a significant main effect of Region, F(2, 36) = 102. 95,η^2 = . 85, p < . 001,ε = . 68, which was due to significantly lower mean temperatures in the cheek region, relative to either the carotid or periorbital areas(Figure 4). Additionally, the Question Number by Question Category interaction reached significance in this analysis, F(2, 36) = 4. 80, η^2 = . 21, p < . 05, ε= . 95. Figure 5 shows that this was due to relatively stable mean temperature responses to crime relevant and comparison questions as the test progressed, combined with a significant increase in the mean ROI temperature responses to crime irrelevant questions.

Classification Accuracy

The significant between-group effects seen in the group analyses above suggest that better than chance accuracies at detecting deception in the individual case might be possible using a combination of DVs derived from the thermal measures. To test this assumption, and because this type of statistical test could serve as a useful starting point in the development of an effective credibility assessment algorithm based on thermal image analysis, we used a binary logistic regression procedure to predict the deceptive status of our study participants. We used deception/non-deception as a dichotomous dependent variable, and mean and SD facial ROI temperatures (collapsing

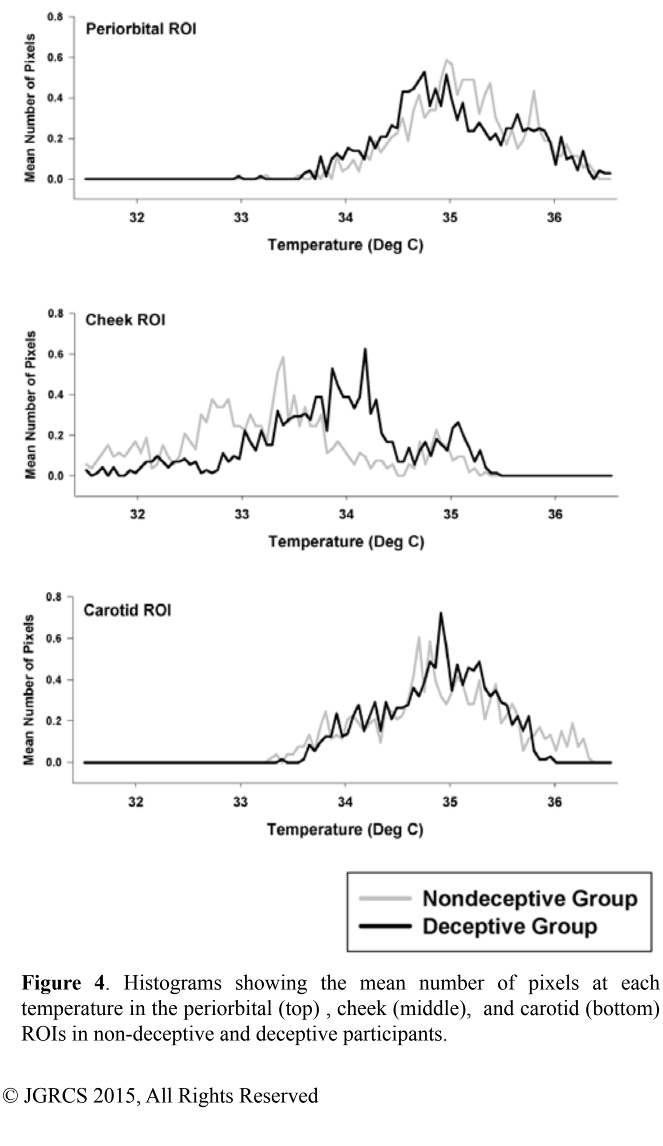

Figure 4. Histograms showing the mean number of pixels at each temperature in the periorbital (top) , cheek (middle), and carotid (bottom) ROIs in non-deceptive and deceptive participants.

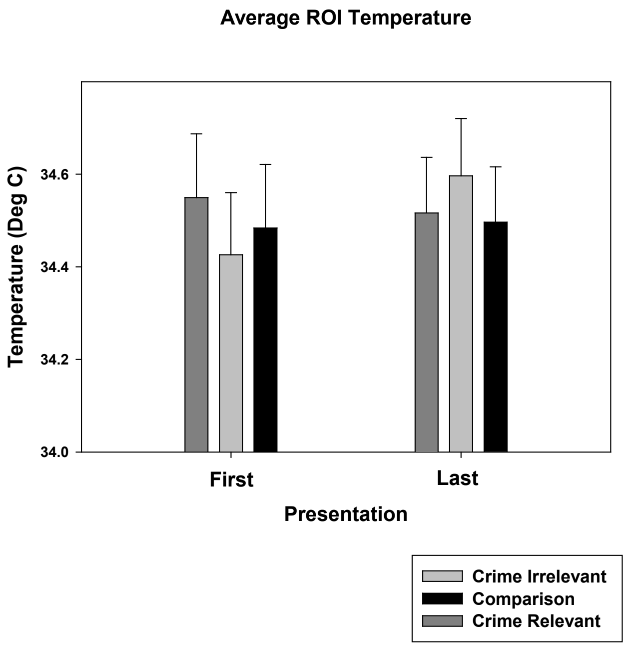

Figure 5. Mean (± SEM) temperature of the three(cheek, carotid, periorbital) hemifacial ROIs during the first and last presentations of crime irrelevant, comparison, and crime relevant questions.

across Question Number and Question Category) as the six covariates. The three (Carotid, Cheek, Periorbital) mean ROI temperature predictors were entered simultaneously as a single block of variables; the three (Carotid, Cheek, Periorbital) SD ROI temperature predictors were entered simultaneously in a second block, and blocks 1 and 2 were entered into the analysis sequentially. Classifications were made using a case inclusion cutoff probability of p = . 5, which forced a classification of each case.

Overall, the correct classification rate was 76. 2% after the first (mean temperature) block of predictors was entered into the model, and the addition of these three predictors significantly improved the model's classification ability,χ^2(3, N = 21) = 12. 36, p < . 01, NagelkerkeR^2 = . 60. After the second (SD temperature) block, the classification accuracy increased to 85. 7%, but this improvement was not statistically significant, χ^2(3, N = 21) = 6. 86, p = . 08. However, there was a good model fit on the basis of the six predictors, χ^2(6, N = 21) = 19. 22, p < . 005, NagelkerkeR^2 = . 81. Sensitivity (True Positives / (True Positives + False Negatives)) of the six predictor model was . 83. Specificity (True Negatives / (True Negatives + False Positives)) of the six predictor model was (8/8+1) = . 89. One individual predictor, mean cheek ROI temperature,made a significant contribution to the model as a stand-alone measure, (p < . 05).

DISCUSSION

Attempts to effectively discriminate deceptive from non-deceptive individuals using thermal image analysis have not been entirely successful despite some promising early results[1,2,33]. These initial studies focused on phasic temperature responses to specific types of questions using a methodology that is similarly employed in traditional polygraph testing. With some exceptions, this work has tended to be data-

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driven, with researchers looking for "hot spots" or other similar signs of deception, based on the idea that physiological arousal causes rapid increases in blood flow to the face, resulting in temperature increases in some facial regions[34]. Our results suggest thatthere is a relationship between thermal capacitance and facial temperature responsivity during a credibility assessment test. Our data also suggest that for this reason the cheek, not the region surrounding the eyes, was most sensitive to the tonic facial temperature changes that did occur during the course of the interview[13,35].

Although successive presentations of interview questions did result in significant mean hemifacial temperature increases during the first half of the test, followed by temperature decreases throughout the remainder of the question sequence, these changes across the entire hemiface were not specific to either the type of question that was asked or the individual's deceptive status. In fact, the only facial temperature ROI that was significantly related to (Non-deceptive/Deceptive) group assignment was the cheek "cold spot" sub-region, rather than either of the two high temperature sub-regions overlying the carotid andperiorbital areas. These findings can be attributed to the fact that both the carotid and periorbital regions have a large arterial blood supply with little soft tissue surrounding them. Because of this, the soft tissue surrounding these regions will be of similar temperature to the blood supply, which is acting as the thermal source. In contrast, the cheek region has soft tissue in addition to the buccinators muscle, the levator angular oris, the masseter, the zygomaticus muscles, and the medial and lateral pterygoid muscles. The cheek region is supplied by the inferior branch of the external carotid artery that branches into the masseteric, maxillary, pterygoid, and buccal arteries. The mass transfer of blood to this region is less than the mass transfer to the carotid or periorbital ROIs, and the thermal supply is therefore also less.

At resting when the cephalic blood supply is less, the cheek region will converge to the temperature of the surrounding environment. During ANS activation resulting from repeated presentations of the interview questions, resultant increased blood supply to the facial arteries will result in increased blood flow within the cheek region, which will increase its temperature as it starts to converge towards the temperature of the blood supply. This will not only increase the mean skin surface temperature in the cheek ROI, but also significantly *decrease* the SD temperature of the cheek ROI pixels, because as it heats up, thermal conduction will cause the skin to become more isothermic. Both of these effects are shown in Figures 3 and 4. Interestingly, the SD temperatures of the carotid and periorbital ROIs also decreased more for individuals in the deceptive group, resulting in a significant main effect of group in the SD ANOVA, and suggesting that measures of ROI variability may be a more sensitive indicator of deception than ROI mean temperature, especially when warmer areas of the face are selected to be the regions of interest.

This study adds to the growing literature showing that thermal image analysis might eventually be used as an effective credibility assessment tool. Using logistic regression, we were able to build a model that accurately categorized deceptive and non-deceptive individuals. However, this finding should not be considered conclusive because the sample size was small and the model has not yet been cross-validated. Similar to Pavlidiset al. [1]we chose to collect our thermal data using a polygraph test format [1]. Our findings suggest that this format was probably sub-optimal because the short-duration interview did not lend itself to the tonic physiological changes evidenced during the testing. We also did not directly investigate phasic temperature responses in this study. It remains possible that the rapid-onset periorbital temperature response first reported by Pavlidiset al. [1] does occur and is of some psychophysiological significance[1]. More research will be necessary to determine the best credibility assessment test formats to employ when skin surface temperature, recorded using thermal image analysis, is the dependent measure.

In conclusion, the results of this study suggest that thermal capacitance contributes to the pattern of hemifacial temperature changes seen during a credibility assessment interview. Support for this conclusion includes the finding that the mean temperature responses of deceptive participants were higher than those of non-deceptive participants in the cheek region, which has relatively high thermal mass, but not in (periorbital or carotid) regions of lower thermal mass. Also, the temperature variability within the cheek, periorbital, and carotid ROIs was less for deceptive participants at multiple points throughout the interview, suggesting that as the skin temperature increases within these regions it also becomes more isothermic. The mean temperature of the entire right hemiface did show an increase during the first half of the interview, which was followed by a decrease throughout the remainder of the test, but did not show any effects of (deceptive/non-deceptive) group. Taken together, the results support the conclusion that thermal image analysis can be used as a credibility assessment tool. Future studies investigating alternate, more standardized credibility assessment test formats that may be better suited to the tonic skin surface temperature responses seen here are needed, as are more basic research investigations of the relationship between these facial skin surface temperature responses and other, better understood measures of ANS activity.

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