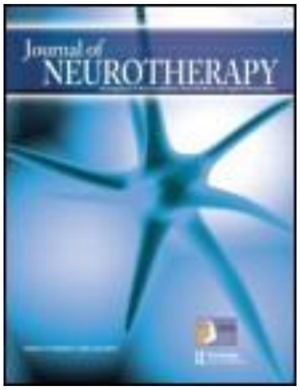

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Exploring Hemispheric Differences in Infrared Brain Emissions

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Exploring Hemispheric Differences in Infrared Brain Emissions

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SUMMARY. *Background*. Carmen (Toomim & Carmen, 1999) has shown that training to increase frontal lobe infrared emissions with neurofeedback techniques inhibits migraine pain, but nothing is known about the psychological correlates of the infrared signal. We assess if reading out loud would increase activation in the left hemisphere in comparison to the right. We also assessed test/retest reliability by repeating measures a week later.

Methods. Measurements of infrared activity, while reading or not, were taken three times from the left, center, and right forehead of 24 persons who had signed Institutional Review Board approved consent forms. The order of reading and non-reading was varied systematically.

Results. Significant differences in activation favoring the right rather than the left hemisphere were found, but only in those who read first. Both order-of-reading groups significantly declined in overall activity during the second session. Five of six Pearson correlations measuring test/retest reliabilities in the reading-first group and two of six in the

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reading-second group attained statistical significance. Only measurements taken at the left forehead site were reliable across all four conditions, which represent the combination of two orders and two types of stimulation.

Conclusions. Test/retest correlations provide some support for the inference that the infrared measures reflect enduring traits, especially in the left hemisphere. Hemispheric difference data suggest that infrared emissions were sensitive to processes such as orientation, habituation and attention. There was no evidence of sensitivity to left hemisphere specialization for verbal processing.

KEYWORDS. Infrared, neurofeedback, orientation, habituation, neurotherapy, hemoencaphalography

BACKGROUND

The purpose of this research was to explore some of the psychological features of the infrared signal emitted from the forehead and underlying brain. Specifically, we investigated whether there are spontaneous lateral asymmetries and if those asymmetries are altered in favor of left activation while reading aloud (Springer & Deutsch, 1985). We asked this question well aware that the frontal regions from which the signal emanated are not known to be selectively involved with speech and language. No prior research with the specific parameters of the measuring device we used existed to guide us. However, our interest in the properties of the emitted infrared signal emerged as a result of equipment and methods devised by Jeffrey Carmen (Toomim & Carmen, 1999) to treat migraine headaches and other conditions. He trained patients to raise the infrared signal from the center of the forehead and found surprising efficacy in ameliorating migraine pain. This procedure is termed Infrared Brain Emission Neurofeedback (IRBEN) within this manuscript. (Note: Carmen and others call this procedure "passive infrared hemoencephalography" [pIR HEG] on the assumption that it measures blood flow. It is termed "passive" because it just registers what emerges from the brain and contrasts with another biofeedback procedure called hemoencephalography [HEG], pioneered by Toomim [Toomim & Carmen, 1999], which involves a spectrographic analysis of light reflected from the brain that originates from a light source directed toward the forehead or scalp, a procedure which is not "passive." Our term, IRBEN, makes no assumptions and is operationally descriptive.)

Infrared emissions are waves of electromagnetic radiation whose length is considerably longer than that of light and are invisible to the human eye. Infrared emissions are generated from any object that has a temperature above absolute zero. In biological tissue, including the brain, the emissions reflect the level of metabolic activity which, in turn, is responsive to oxygen levels, neurotransmitter levels, blood flow, and other variables. Although the procedures for using infrared emissions to study brain and behavior are not well established, research has been done with multi-pixel infrared cameras with a wide field of view. Swerdlow and Dieter (1986a, 1986b, 1987, & 1991), for example, found abnormally low infrared emissions in regions of the forehead and face in migraineurs, which differentiated them from tension headache patients. Shevelev (1992, 1998), reviewing his own work and that of others, found a high correlation between localization of infrared output and localization of conditioned neural responses. He pointed out the advantages of infrared technology over other brain imaging procedures such as EEG, MRI, and CAT and PET scans which include freedom from artifact even when measuring activity in the frontal lobes, non-invasiveness, and low cost.

In contrast to an infrared camera which may generate an image of a whole head and the environment in which it exists, or even a landscape, Carmen devised an infrared sensor that operates more like an EEG electrode, registering a field of view measuring 32 millimeters. This size was selected in pilot studies using criteria of meaningfulness (non-randomness) to the participant during neurofeedback and independence from surface temperature measures taken from the forehead. The infrared signals are converted into temperature equivalents, which are then shown on a numeric, light emitting diode (LED) display in degrees Fahrenheit to the nearest one-hundredth of a degree. With Carmen's equipment, infrared intensity measures are in the 60's for office cabinets and generally between 89 and 94 when measured on the forehead.

In this special issue Carmen (2004) discusses the possible mechanisms involved when infrared emissions in the frontal lobes are increased via neurofeedback training. He has speculated that the procedure increases the inhibitory autoregulatory functions of the frontal lobes. Such a theory would be consistent with the rapid response found in many subjects. By contrast, he has also suggested that the training procedure is equivalent to exercise (Toomim & Carmen, 1999). Such an account would be consistent with a relatively slow and gradual improvement over time. Few data are available presently to support either hypothesis.

Currently very little is known about the characteristics of IRBE. In the present study we sought to learn whether a person reading out loud would show more intense infrared emissions on the left side rather than the right compared to measurements taken during a relaxed, eyes-closed, non-reading condition. A second goal was to estimate the reliability of measurement of the emitted signal over time. Participants were alternately assigned to two groups. Group A was instructed to read out loud while their emissions were measured and then were asked to close their eyes and relax while further measurements were taken. The reverse order was administered to Group B. Both groups returned a week later and were tested with the same procedure in the same order as before.

The following questions were posed to provide a framework for study: (a) Would emissions on the left exceed those on the right while reading out loud? (b) Would emissions on the left while reading out loud exceed left-sided, eyes-closed emissions? and (c) Would identical measures be positively and significantly correlated over a week's time?

METHODS

Participants

The participants were recruited through Emory University's psychology department's Human Subjects Pool. The sample consisted of 24 undergraduate students, 4 males and 20 females. Participants were enrolled in one of two introductory psychology courses at Emory University and received credit for participation. Participants signed up for two sessions, one week apart at the same time of day.

Materials

The instrument designed by Carmen consists of two parts. One is the infrared sensor, which is situated in a box with an opening in front of the sensor. The box can be mounted on the forehead by means of velcro straps and the sensor is positioned at a constant distance from the skin.

The same distance is maintained if the velcro is folded back and the box is held against the skin. The other part of the instrument is a metal case with a processor whose input is conveyed by wire from the infrared sensor. The sensor's output controls a numeric LED display. Readings are in degrees Fahrenheit to the nearest one-hundredth of a degree. The material read during the reading condition was the first section of the first chapter of *Tom Sawyer*, written by Mark Twain.

Procedure

Once seated comfortably, participants were given copies of the Institutional Review Board (IRB) approved consent form, one to read and sign, and another to keep. They were then shown the apparatus and taught how to hold the sensing device against their forehead with two hands. Participants were instructed to use two hands to minimize possible differential lateral activation stemming from the use of one hand. Half the participants (Group A) first read out loud and then were asked to close their eyes, relax, and clear their mind. The order of conditions was reversed for the rest of the participants (Group B).

Nine readings of infrared levels (three each from the left, center, and right of the forehead) were taken for each of the conditions, a total of 18 measurements. The experimenter, standing behind the chair in which the participant was seated, positioned the participant's hands holding the infrared sensor over each of the three sites: the middle of the forehead over the bridge of the nose, and over the center of the left and right eye. The order of the trials was semi-randomized and the same for all participants such that no site was measured twice in immediate succession. Only the examiner could see the LED display. After positioning the sensor, the examiner waited three seconds before recording the data. Holding the sensor while reading was a somewhat awkward experience to which all participants adjusted quickly. Elevating the arms to hold the sensor was tiring for some subjects and they were instructed to indicate when they needed a rest break. They were then allowed to rest until they were ready to resume the procedure. In most subjects, readings were relatively stable three seconds after positioning the sensor. When they were unstable, the examiner selected just the number that was displayed after a lag of three seconds. During the second session, infrared emissions were measured following the same procedure and order as in the first session.

RESULTS

Questions About Lateral Differences

Mean emission levels are presented in Table 1. Data bearing on the first question, that emissions on the left would exceed those on the right during reading, can be found by comparing mean left and right scores in the two columns of data obtained while reading. There are four possible comparisons and in three of the four, the answer is negative: the emissions from the left side are lower than those on the right. In the instance where left emissions exceed the right, left emissions are less than those from the center. Data bearing on the second question, which emissions on the left while reading would exceed emissions on the left while not reading, can be found in the rows presenting left-sided emissions. Again, there are four possible comparisons and again, in three of the four, the findings are negative.

Questions About Test-Retest Reliability

Table 2 shows the correlations between the first and second sessions for groups A and B. For Group A, correlations were significant at all sites except for emissions on the right while reading. For Group B, significant correlations occurred only on the left. We have no explanation for the different patterns observed but do believe that the sheer number of significant measures allows some confidence that we were measuring some enduring aspect of the emitted signal.

TABLE 1. Mean Emissions

	Group A (Reading First)				Group B (Reading Second)			
	Reading		Non-reading		Reading		Non-reading	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Day 1								
Left	91.568	2.53	92.015	1.69	91.987	1.80	92.176	1.51
Center	91.842	2.24	92.098	1.24	92.072	1.44	92.130	1.22
Right	92.173	2.30	92.482	1.42	91.748	1.74	92.129	1.38
Day 2								
Left	90.057	3.46	90.852	1.62	91.162	2.00	90.744	3.04
Center	90.085	1.89	90.722	1.46	91.697	0.99	91.317	0.91
Right	91.191	1.99	91.577	1.62	91.424	2.14	91.308	1.63

TABLE 2. Day 1-Day 2 Test-Retest Reliability (Pearson correlations, n = 12)

		Group A	Group B
While reading	Left	.91**	.69*
	Center	.71*	−.03
	Right	.35	.32
While non-reading	Left	.67*	.72**
	Center	.59*	.17
	Right	.82**	.50

*p < .05
**p < .01

Post-Hoc Analyses

Given the exploratory nature of this study, failure to verify our ad-hoc questions led us to consider what the data might suggest. First, we noted that the patterns for reading first (Group A) vs. reading second (Group B) were different with right emissions exceeding left in each comparison in the former case and comparable findings on Day 2 for the latter, but the reverse for Day 1. We also noted that emission levels declined overall on Day 2 as compared to Day 1. The combination of relative right-sided activation upon an initial novel challenge and attenuation with familiarity suggested to us that the infrared signal may be linked to mechanisms of orientation and habituation and therefore to attentional systems. The merits of these post-hoc conjectures would be enhanced if any of the patterns observed could be shown to be statistically reliable.

Accordingly, a three (Laterality-left, center, and right) × two (Reading-reading vs. non-reading) × two (Day 1 vs. Day 2) within subjects analysis of variance (ANOVA) was conducted separately for Groups A and B to determine whether any of the differences noted were unlikely to be attributable to chance. Significant findings were found for two main effects: Day, $F(1, 11) = 14.90$, $p = .003$, thus indicating that the decline in emissions across days was statistically reliable, and Laterality, $F(2, 22) = 5.00$, $p = .016$. Post-hoc tests with Bonferroni correction indicated that the significant laterality differences were between the higher emissions found on the right and the smaller ones in the center and left, irrespective of whether participants were reading or not. Left and center emissions were not significantly different.

DISCUSSION

We set out to explore some of the psychological correlates of the infrared signals emitted from the frontal lobes. Picking a well known (Goldberg & Costa, 1981; Springer & Deutsch, 1985) characteristic of hemispheric activation, we asked whether this signal would be radiated from the left hemisphere with greater intensity if the person were reading out loud. If the apparatus had three sensors and three readouts, we could have been more assured that we were measuring hemispheric differences reliably. With only one sensor and readout, we had to estimate simultaneous levels at three sites by means of sequential readings. We had no idea of how many trials would be required to obtain a reliable estimate and arbitrarily decided to do three measures at each site, a number of trials that appeared to be minimal.

Consequently, we are pleased that the methods used yielded results that provide a basis for further, more definitive research. These initial findings are that the signal does not reflect activation of some verbal-reading mechanism. Rather, the available evidence (i.e., right greater than left when significant hemispheric differences appeared and less overall reactivity on day 2) is consistent with the interpretation that the psychological mechanisms related to the infrared signal have to do with orientation, habituation, and more generally, attention. Relative activation of the right hemisphere in the presence of novelty was put forward by Goldberg and Costa (1981) as a general principle of hemispheric differentiation.

It should be noted that the entire measurement procedure lasted less than five minutes. It is possible that the present findings would show a different pattern if measurement durations were long enough to assure habituation to the novel aspects of the procedure. Further research will be necessary to determine if some different pattern of relationships will emerge with time and familiarity or whether the brain will show less differentiation under those circumstances. It is possible that the brain may show one pattern of function during an early phase of experience and a different one at a later phase. That there was no pattern of significant hemispheric differences when non-reading preceded reading (Group B) hints at the possibility that the response mechanism being measured by the infrared emission is very sensitive to changes in the sequence of stimulation.

Finally, the high levels of reliability found in intersession correlations suggest that the signal does reflect enduring traits or characteristics. Noteworthy features of the results were that all measurements on the left were significantly reliable while order of activity had a differential effect with reading-first yielding five of six reliable correlations while reading-second yielded only two.

REFERENCES

Carmen, J. A. (2004). Passive infrared hemoencephalography: Four years and 100 migraines. *Journal of Neurotherapy, 8* (3), 23-51.

Goldberg, E., & Costa, L. (1981). Hemisphere differences in the acquisition and use of descriptive systems. *Brain and Language, 14,* 144-173.

Shevelev, I. A. (1992). Temperature topography of the brain cortex: Thermoencephaloscopy. *Brain Topography, 5* (2), 77-85.

Shevelev, I. A. (1998). Functional imaging of the brain by infrared radiation (thermoencephaloscopy). *Progress in Neurobiology, 56,* 269-305.

Springer, S. P., & Deutsch, G. (1985). *Left brain right brain* (Rev. ed.). New York: W.H. Freeman & Company.

Swerdlow, B., & Dieter, J. N. (1986a). The persistent migraine "Cold Patch" and the fixed facial thermogram. *Thermology, 2,* 47-52.

Swerdlow, B., & Dieter, J. N. (1986b). The validity of the vascular "Cold Patch" in the diagnosis of chronic headache. *Headache, 26,* 22-26.

Swerdlow, B., & Dieter, J. N. (1987). The thermographically observed effects of hyperoxia on vascular headache patients and non-headache individuals. *Headache, 27,* 533-539.

Swerdlow, B., & Dieter, J. N. (1991). The value of medical thermography for the diagnosis of chronic headache. *Headache Quarterly, Current Treatment and Research, 2,* 96-104.

Toomim, H., & Carmen, J. A. (1999). Hemoencephalography (HEG). *Biofeedback, 27,* 10-14.