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# Analysis of the temperature effect on the P300 component by the left and right-hand movement

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***Abstract:****Event-Related potentials(ERPs) are one of the important methods of monitoring human brain response. ERPs are also a strong indicator of severe brain injuries of different levels. P300 is the most studied component of ERP. By analyzing this P300 component, lots of human mental disorder related problems can be identified and solved. This component is very much affected by the environment, artifact, and other distractions. So, it is very important to know the effect of these distortions on the P300 component. In this study, we explored the effect of temperature on the P300 component amplitude and latency. Our analysis suggests that there is a strong effect of temperature on the ERP components and we found larger amplitude for both amplitude and latency value for the peak of the P300 component. In the field of neuroscience research, these findings may contribute strongly to the real-world situation.*

***Background****: The components of Event-Related potentials are very much used in the clinical research of brain potential. The components are very important to measure a variety of psychological disorders. Such components are, P300, N100, N400,etc. In this study, the P300 component will be studied to investigate the effect of temperature in the brain signal by left and right-hand movements.*

***Materials and Methods****: To elicit the property of the P300 component, the oddball paradigm is very useful and in this study, the visual oddball paradigm will be applied. The dataset used here is publicly available on the ERP CORE web site of Dr. Steve Luck. Subject brain response will be used in 4 conditions. Left and right-hand response in cool and dry condition. Left and right-hand response in warm and humid conditions. The peak amplitude and latency of P300 component will be measured offline by the use of EEGLAB.*

***Results****: From the analysis of ERP response, the P300 component's amplitude and latency were compared in cool and warm temperatures. The analysis showed that both amplitude and latency values were larger in hot and humid conditions.*

***Key Word****:Event RelatedPotential (ERP),P300, visual stimuli, oddballparadigm.*

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## I. Introduction

Electroencephalography (EEG) can track and measure the activities of the brain signal and the time-locked activity of the EEG signal is known as Event-Related Potential (ERP). It can be simulated by a wide variation of sensual activities produced by the human brain. ERPs have a significant role in clinical research [1] and a good application to a variety of psychiatric and neurological disorders. ERP research isa non-invasive method of studying with good temporal resolutions. In human clinical research, ERP has various components for study and P300 is the most studied component for human brain study [2,3]. P300 is a component of recognition when the brain responds to a series of stimuli that include a common (or frequent) stimulus and an uncommon (infrequent) stimulus and it gives a large peak of approximately 250 ms to 600 ms[4]. In this study, we will investigate the temperature effect of human brain response by measuring right and left-hand movements.

In an EEG study, P300 is normally measured by the auditory or visual oddball paradigm. In the oddball paradigm, a sequence of repetitive stimuli is interrupted by a deviant stimulus and the P300 peak for oddball stimuli is larger than the regular or common stimuli [5]. In this study, we have used publicly available data (https://erpinfo.org/impedance) where subject responses for both the visual stimuli. This kind of paradigm is known as a passive paradigm. Subject see letters (80%) and digits (20%) and response either left or right hand using a push button. The analysis has four steps. Left and right-hand response in cool and dry temperature and then warm and humid temperature. For all the experimental setup, we measured peak amplitude and latency of P300 components. Our analysis showed that, for warm and humid conditions, the amplitude and latency values were larger than cool and dry conditions. So, we can conclude that this kind of human brain signal study may have a great influence on clinical research.

In [6], Anokhin studied the visual P300 component for the analysis of smoker's brain signals and he found that there is reduced P300 amplitude for smokers comparing to non-smoker. In [7], Alomari proposed an automated computer platform for EEG classification, and the visual stimuli were associated with the left and right-hand movements using a hybrid system.

This paper is structured as follows: methodology is described in Section 2; performance analysis is presented in Section 3; conclusions and future work are finally given in Section 4.

## II. Methods

**Dataset and Participants:** The EEG dataset used in this research are publicly available on Dr. Steve Luck's ERP INFO page (https://erpinfo.org/impedance). Seventeen subjects were tested for this study and their age ranges are 18 to 30. Five subjects were excluded from the dataset because of artifacts of more than 25% in the typical cool and dry testing conditions. So, finally, the dataset was obtained from 12 healthy subjects and there are 96 EEG recordings and 768 EEG data for 8 electrode positions on the scalp as indicated in Figure 1. Each subject was tested 4 times.

**Experimental procedure:** There were black letters and digits, presented on a video monitor. The subject was sitting on a chair and viewed the monitor from 70 cm distances. The ISI (Inter stimulus interval) was 200 ms, followed by a blank interval of 1100-1500 ms. Letters and digits were presented randomly and there were 80% letters (frequent stimuli) and 20% digits (oddball stimuli). Whenever a subject sees any stimuli on the monitor, he had to press a button with this finger. He used the index finger to press the button for one category of stimulus and the middle finger from the other category of the stimulus either using the left hand or right hand. In every block of stimuli, there were 160 trials and each subject tested for 4 times. In total, there were 128 target stimuli (oddball stimuli) and 512 frequent or standard stimuli. There is a full description of the overall methods of the experiment can be found in [8].

1. Press button by Left hand in cool and dry condition.
2. Press button by Right hand in cool and dry condition.
3. Press button by Left hand in warm and humid condition.
4. Press button by Right hand in warm and humid condition.

The EEG was recorded in an Eckel C-15A sound-attenuated room with fans and a building ventilation system for cool and dry conditions. On the other hand, there were space heaters and humidifiers for warm and humid conditions. The temperature for the cool and dry conditions was between 19.5$^{o}$C and 23$^{o}$C (67 $^{o}$F – 73 $^{o}$F ). Also, the temperature for the warm and humid conditions was between 26$^{o}$C and 29.5$^{o}$C (79 $^{o}$F – 85 $^{o}$F ). The EEG was recorded by using a Biosemi Active Two EEG recording system (Biosemi B.V., Amsterdam, and The Netherlands). The humidity level was fixed and it was 11.5 g/m$^{3}$. The electrodes were mounted in an elastic cap using a subset of the International 10/20 System sites (F3, C3, P3, P9, F4, C4,P4, P10), as depicted in Figure 1.

**Filters and Artifact Rejections:** The EEG were filtered between 0.3-30 Hz and the sampling frequency was 1024 Hz. Also, a 60Hz notch filter was applied. Epochs were extracted from -1000 to 2000 ms.For removing eye blinks and horizontal eye-movements, ICA was run by using the "RUNICA" routine on EEGLAB [9]. Trials containing artifacts, defined as voltages exceeding 150mV, were marked for rejection and were excluded from all analyses. From these averaged waveforms, we measured P3 peak amplitude and latency between 250 and 650 ms at the P3 or P4 electrode site. All simulations were conducted in Matlab (TheMathworks, Inc., Natick, MA) using the EEGLAB Toolbox and custom routines[10].

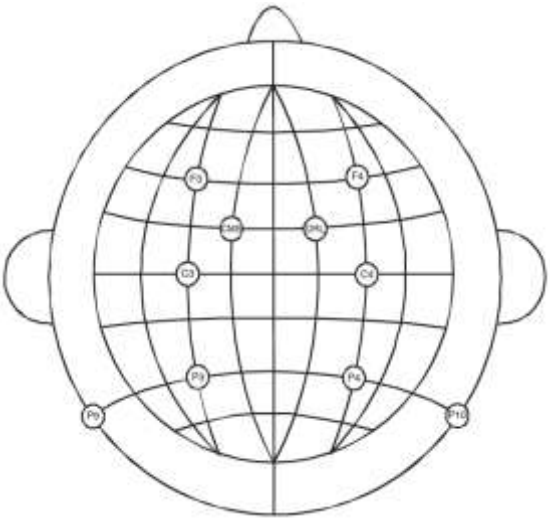

Figure 1: Electrodes position on the scalp.

## III. Performance Analysis

The peak amplitude and latency of the P300 component were analyzed offline. When the oddball paradigm was tested in cool and dry conditions, we measured the peak amplitude and latency of the P300 component when the subject pressed the button both for left and right hand. In Table 1 and 2, they are marked as cold_left and cold_right. Similarly, when the subject pressed a button and warm and humid conditions, the recorded data are hot_left and hot_right. We analyzed the epoch for electrode position P3. Peak latency for all 4 experimental conditions are summarized in Table 1 and peak amplitudes are summarized in Table 2.

From Table 1, it is shown that among the 12 subjects, 9 subjects had increased latency from cool to hot temperature for both hand responses. Subject 3 and 9, showed an inverse trend. On the other hand, for subject 10, there were no latency changes in any condition. Similarly, from Table 2, subject 2 and 9, showed decreased amplitude from cool to warm temperature, and subject 11 had no change in amplitude in any condition. Otherwise, there is an increment of peak amplitudes of P300 components. Figures 3 and 4 show the temperature effect on the left and right hand.

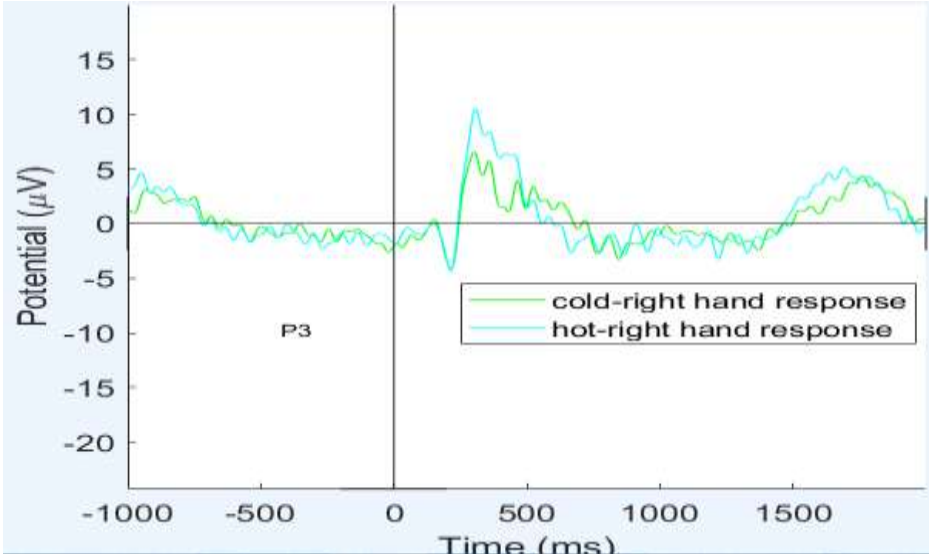


**Figure 3:** ERP comparison for the right-hand response of subject-6 in cool and hot temperature. In the y-axis, there is amplitude in micro-volt.

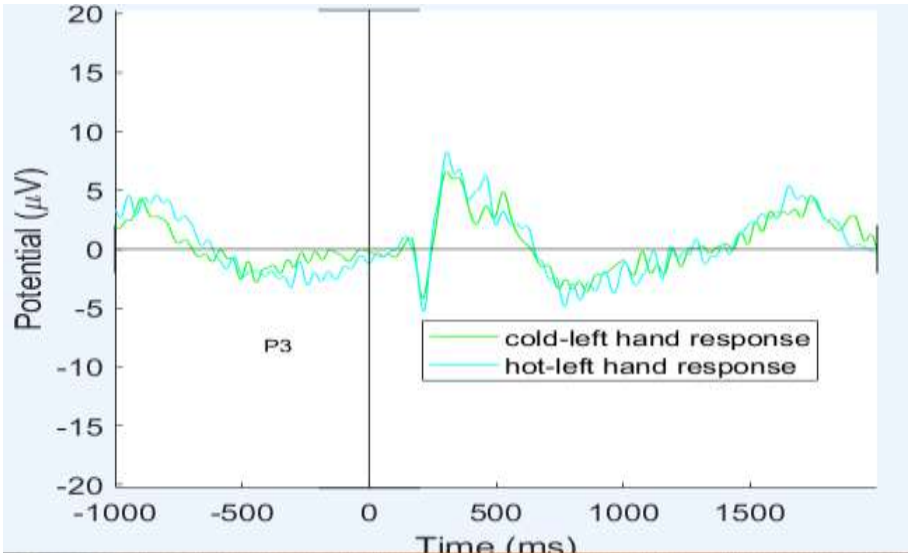


**Figure 4:** ERP comparison for the left-hand response of subject-6 in cool and hot temperature. In the y-axis, there is amplitude in micro-volt.

We compared the temperature effect on both hand performance. From Figures 5 and 6, it is found that on average, both peak amplitude and latency are increased from cool temperature to hot temperature. The analysis is the same for both left and right-hand responses.

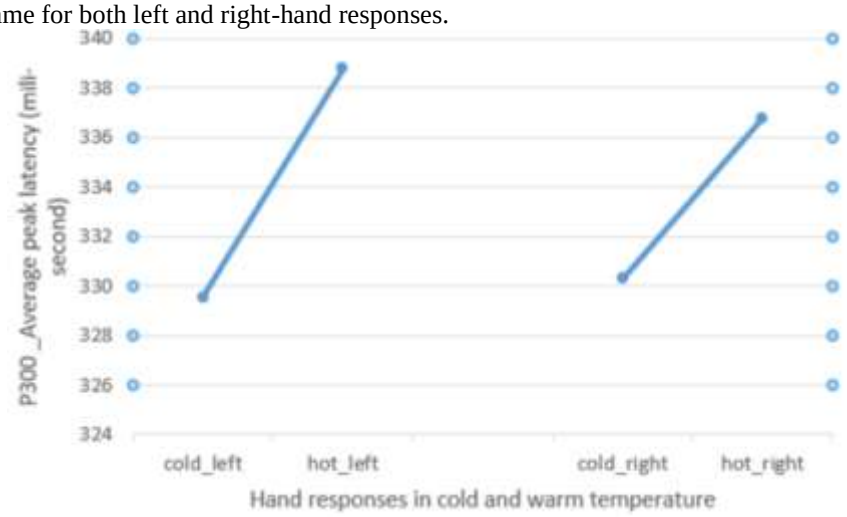


**Figure 5:** Comparison of P300 peak latency in average for left and right-hand response in cool and hot temperature.

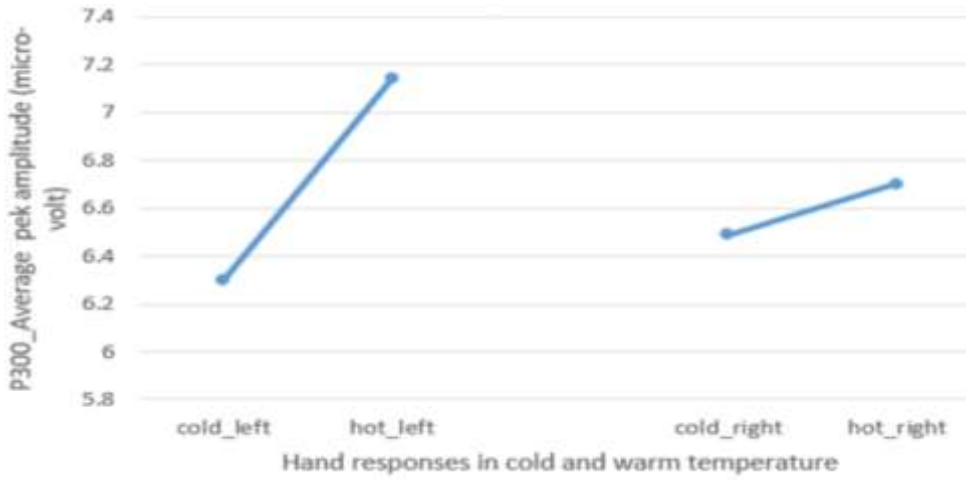

**Figure 6:** Comparison of P300 peak amplitude in average for left and right-hand response in cool and hot temperature.

**Table no 1:** The P300 peak latency in millisecond ( ms) for all the 12 subjects in both cool and warm/hot temperature for both left and right-hand response

| Subject | cold_left | cold_right | hot_left | hot_right |
|---|---|---|---|---|
| S1 | 269.5 | 244 | 315 | 303 |
| S2 | 354.5 | 354.5 | 343.8 | 351.6 |
| S3 | 368.2 | 362.3 | 370.1 | 365.2 |
| S4 | 316.4 | 320.3 | 328.1 | 322.3 |
| S5 | 339.8 | 338.9 | 381.8 | 393.6 |
| S6 | 303.7 | 358.4 | 305.4 | 306.6 |
| S7 | 328.1 | 325.2 | 328.1 | 332 |
| S8 | 325.9 | 332 | 349.6 | 347.7 |
| S9 | 389.6 | 375 | 381.8 | 329.1 |
| S10 | 293.9 | 293.9 | 293.9 | 295.9 |
| S11 | 359.4 | 356.4 | 356.4 | 361.3 |
| S12 | 305.7 | 302.7 | 311.5 | 333 |
| Average | 329.5583 | 330.3 | 338.7917 | 336.775 |

** cold_left: Left hand response in cold temperature.
cold_right: Right hand response in cold temperature
hot_left: Left hand response in hot/warm temperature
hot-right: Right hand response in hot/warm temperature

**Table no 2:** The P300 peak amplitude in microvolt for all the 12 subjects in both cool and warm/hot temperature for both left and right-hand response

| Subject | cold_left | cold_right | hot_left | hot_right |
|---|---|---|---|---|
| S1 | 2.5 | 3.5 | 4.74 | 4.008 |
| S2 | 3.68 | 5.8 | 5.32 | 5.12 |
| S3 | 10.15 | 9.013 | 8.925 | 7.73 |
| S4 | 8.85 | 8.55 | 10.83 | 8.78 |
| S5 | 4.15 | 6.23 | 7.73 | 5.16 |
| S6 | 6.55 | 5.74 | 8.24 | 10.48 |
| S7 | 4.99 | 5.23 | 5.7 | 5.75 |
| S8 | 6.26 | 6.79 | 5.56 | 5.327 |
| S9 | 7.56 | 5.79 | 8.27 | 7.99 |
| S10 | 12.22 | 12.69 | 11.79 | 12.85 |
| S11 | 2.039 | 2.083 | 1.605 | 1.709 |
| S12 | 6.67 | 6.58 | 6.96 | 5.5 |
| Average | 6.301583 | 6.499667 | 7.139167 | 6.700333 |

** cold_left: Left hand response in cold temperature.
cold_right: Right hand response in cold temperature
hot_left: Left hand response in hot/warm temperature
hot-right: Right hand response in hot/warm temperature

## IV. Conclusion

The goal of this study was to investigate the effect of temperature in both left and right-hand responses. We have investigated the responses by the visual oddball paradigm. We compared the P300 peak amplitude and latency for all 4 experimental setups. From the analysis, it is found that there is a change of amplitude and latency values in cool and hot temperature response. More specifically, on average, both the amplitude and latency of the P300 component showed an increased value in hot temperature comparing with cool temperature response. Although, more data is required to show the specific conclusion of the results.

This study is concerned with how different temperatures may influence the P300 component in the visual oddball paradigm experiment. The outcome of this experiment may contribute to ERP research in the real world. But more data is required to decide a good conclusion.

More research can be implemented in the future by adding audio-visual task difficulties with various types of distractions. We are also thinking to do an ERP study in a virtual environment with external distortion or/and audio visual effects.

## References

[1]. Polich, John P300 Clinical Utility and Control of Variability, Journal of Clinical Neurophysiology: January 1998 - Volume 15 - Issue 1 - p 14-33

[2]. Valeriani, Davide, et al, "BrainComputer Interfaces for HumanAugmentation", Brain sciences vol. 9,2 22. 24 Jan. 2019,doi:10.3390/brainsci9020022
[3]. Krisst, Lara, and Steven J. Luck,"The P3b ERP component as a functionof visibility, accuracy, decision, and confidence", Journal of Vision 19.10(2019): 246c-246c.[b] Anokhin, A., Vedeniapin, A., Sirevaag, E. *et al.* The P300 brain potential is reduced in smokers.*Psychopharmacology* 149, 409–413 (2000). https://doi.org/10.1007/s002130000387
[4]. Polich, J,0,"Updating P300: an integrative theory of P3a and P3b", Clin.Neurophysiol. 118, 2128–2148. DOI: 10.1016/j.clinph.2007.04.019
[5]. Rafia Akhter, KehindeLawal, Md. Tanvir Rahman and Shamim Ahmed Mazumder, "Classification of Common and Uncommon Tones by P300 Feature Extraction and Identification of Accurate P300 Wave by Machine Learning Algorithms" International Journal of Advanced Computer Science and Applications(IJACSA), 11(10), 2020. http://dx.doi.org/10.14569/IJACSA.2020.0111080
[6]. Anokhin, A., Vedeniapin, A., Sirevaag, E. *et al.* The P300 brain potential is reduced in smokers.*Psychopharmacology* **149,** 409–413 (2000). https://doi.org/10.1007/s002130000387
[7]. Mohammad H. Alomari, AyaSamaha, and Khaled AlKamha, " EEGSignals using Advanced Feature Extraction and Machine Learning",International Journal of Advanced Computer Science and Applications,Vol. 4, No. 6, 2013.
[8]. Kappenman, Emily S., and Steven J. Luck. "The effects of electrode impedance on data quality and statistical significance in ERP recordings." *Psychophysiology* 47.5 (2010): 888-904.
[9]. Balbir Singh, Hiroaki Wagatsuma, "A Removal of Eye Movementand Blink Artifacts from EEG Data Using Morphological ComponentAnalysis", Computational and Mathematical Methods in Medicine, vol.2017, 17 pages, 2017. https://doi.org/10.1155/2017/1861645
[10]. Gajos, Anna, and Grzegorz M. W´ojcik. "Independent component analysisof EEG data for EGI system". Bio-Algorithms and Med-Systems12.2 (2016): 67-72. https://doi.org/10.1515/bams-2016-0004 Web.

ArifulHaque Siddique, et. al. "Analysis of the temperature effect on the P300 component by the left and right-hand movement."*IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE),* 16(1), (2020): pp. 45-49.