Abstract

Autonomous systems, organizations, and interpersonal interactions are rapidly becoming more complex in a contemporary society. Trust plays a crucial role in assisting the cognitive complexity and increased uncertainty in complex systems. The previous studies focus on brain regions using fMRI and efMRI, which engage with stimuli related to trust and mistrust. This research measures and analyzes brainwaves in situations involving trust and mistrust to understand the cognitive process by using an electroencephalogram (EEG). For recording brainwaves on trust and mistrust situation, this experiment uses a word elicitation study from a previous research containing words related to trust and mistrust that were ranked by survey participants. Participants’ brainwaves are recorded in real time as they are watching the selected words which evoke trust and mistrust situation. The 10-20 system of electrode placement is used for recording brainwaves and power spectrum analysis is used for brainwaves analysis. The result is that specific brainwaves can be affected by a trust or mistrust situation. A goal of this research is to identify brainwaves in trust and mistrust situations and to analyze a relationship between the brainwaves and human behaviors.

Keywords
EEG, Trust, Mistrust, Brainwaves. Spectrum Analysis.

1. Introduction

Autonomous systems, organizations, and interpersonal interactions are rapidly becoming more complex in contemporary society. In these complex situations, the role of trust between humans and humans, humans and machines, and in general becomes important. A stable and well-structured environment that emphasizes order and procedure does not highly depend on trust [1]. However, complex automation systems increase unstable and uncertain situations in workplaces, and eventually the increased uncertainty will increase cognitive complexity [2]. Trust plays a crucial role in assisting the cognitive complexity and increased uncertainty in sophisticated autonomous systems. Trust can be a decision aid in dynamic and uncertain situations when it is impossible to fully comprehend the intricate automation system and when it is required to have flexible behavior for unexpected situations that procedures cannot help [2]. The degree of trust can influence system performance [3], because it affects the degree of acceptance and reliance on automation [4] and operator’s strategies regarding the use of automation [5]. In order to better predict performance, it is necessary to measure situations of trust and mistrust.
There are only a few studies measuring trust using brain signals. There are previous studies investigating the correlation between the degree of trust and human facial appearance using event-related functional magnetic resonance imaging (fMRI) [6], and examining interpersonal trust in online to detect different brain regions depending on conditional and unconditional trust using hyperfunctional magnetic resonance imaging (fMRI) [7]. Another study defined a relationship between brain areas and psychological processes using functional magnetic resonance imaging (fMRI) and proved a correlation of trust and mistrust with different brain areas [8]. The previous studies focused on brain regions using fMRI and eMRE, which engage with stimuli related to trust and distrust, but they did not investigate trust and mistrust with cognitive processes. This research measures and analyzes human brainwaves in situations involving trust and mistrust to understand the cognitive process by using an electroencephalogram (EEG). An EEG can monitor, record, and measure the electrical activity of the brain in real time, making it an effective tool for researching brain functions and activities that engage with situations of trust and mistrust. For this research, the 10-20 system of electrode placement is used for recording brainwaves, and power spectrum analysis is used for brainwave analysis.

2. Method

2.1 Participants

This research recruited 4 subjects who were over 18 years old without any cognitive or psychological problems. All were either undergraduate or graduate students and participated voluntarily. Two were male and two were female. The subjects participated under the same conditions in an isolated place with guided instructions.

2.2 Framework for Experimentation

For recording human brainwaves in situations of trust and mistrust, this experiment uses a word elicitation study from a previous study containing words related to trust and mistrust that were ranked by survey participants [9,10]. This research extracts only the first through fifteenth ranked words related to trust and mistrust from the previous research. The subject is expected to think about situations of trust and mistrust evoked by the selected words. The subject is fitted with a cap of electrodes and seated in front of a computer screen.

Before starting the experimentation, the instruction on the screen is presented for 10 seconds. Each word is presented for 7 seconds, which is enough time to read the word and understand the meaning of the word. Each slideshow is presented for 3 minutes and 30 seconds, which is enough time to evoke a situation of trust or mistrust. An experiment comprises of two sessions: 1) trust words and 2) mistrust words.

When the subject watches the first slideshow, which consists of the 30 random stimuli of the selected 15 words related to trust, the brainwaves are recorded. The subject takes a break for 1 minute to avoid fatigue and stress. When he or she watches the second word slideshow, which consists of the 30 random stimuli of the selected 15 words related to mistrust, the brainwaves are recorded.

2.3 EEG Recording and analysis

The EEG data are recorded using the g.HIamp (256 multichannel amplifier), g. GAMMAsys (active electrode system with g. GAMMAcap) and g. Recorder (brain signal recording software) by g. tec medical engineering company. According to the international 10-20 system of electrode placement, the 20 electrodes (Fp1, Fp2, Fpz, F7, F3, Fz, F4, F8, T7, C3, Cz, C4, T8, P7, P3, Pz, P4, T6, O1, O2) are recorded and measured (see figure1). The 10-20 system is based on the relationship between the location of an electrode and the underlying area of the cerebral
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cortex. The letters F, T, C, P, and O represent the frontal, temporal, central, parietal, and occipital lobes. Even numbers refer to the right hemisphere, and odd numbers refer to the left hemisphere. The subject’s head is fitted with a cap of electrodes (e.g., GAMMAcap) and the selected 20 electrodes are filled with abrasive electrolyte gel using a syringe. For the setting to record the brainwaves, the sampling frequency is set as 256 Hz, high frequency filter as 50 Hz and low frequency filter as -50 Hz.

![Figure 1: International 10-20 system for electrode placement](image)

3. EEG Analysis

For analyzing human brainwaves, there are linear spectral measurements, nonlinear measurements of complexity, and interdependency measurements [11]. As one of the linear spectral measurements, the power spectrum measurement is a common method to quantify EEG data to present the distribution of signal power by frequency [12].

To identify specific brainwaves in situations of trust and mistrust, the recorded raw EEG data are analyzed by the power spectrum through the EMSE Suite Data Editor by Cortech Solutions. In the power spectrum analysis, an FFT (Fast Fourier Transform) is performed on defined data intervals and the results are squared and then averaged. The units are Volts$^2$. The entire time series file from the whole experimental time is selected and analyzed by the power spectrum. The power spectrum data is displayed in units of Volts$^2$(V$^2$). The axis and legend scaling is shown in units of uV$^2$(uV$^2$). EMSE uses the mathematical convention in which uV$^2$ is an equivalent representation of (uV)$^2$. See equation (1) below.

$$1.0 \text{ uV}^2 = 1.0 \text{ (uV)}^2 = 1.0e^{0.12V^2}$$

(1)

4. Result

In this research, the subjects’ brainwaves are recorded as they respond to the selected word related to trust and mistrust by the 10-20 system of electrode placement (22 channel) with a total time of 210 seconds for each session. They are then analyzed by power spectrum analysis. The brainwaves of the 4 subjects are normal, without any extreme brain activity, so the average of all collected brainwaves is used for analysis.

This research focuses on identifying specific brainwaves and cognitive processes related to situations of trust and mistrust. Using power spectrum analysis, the recorded brainwaves are categorized by their frequencies: alpha (8-13 Hz), beta (13-30 Hz), and gamma (30-60 Hz). The beta waves are divided into low beta (13-15 Hz, which is called as SMR), mid beta (15-20 Hz) and high beta (20-30 Hz) for more detailed analysis [13,14].
Using the power spectrum, the power of alpha waves is averaged from 8 Hz to 13 Hz. In alpha waves, the average of trust is 4.23 uV² and the average of mistrust is 1.90 uV², so the difference is 2.33 uV² (see Figure 2). The power of beta is averaged from 13 Hz to 30 Hz. The average of trust is 4.28 uV² and the average of mistrust is 2.61 uV², so the difference is 1.67 uV² (see Figure 3). The power of gamma is averaged from 30 Hz to 60 Hz. The average of trust is 2.89 uV² and the average of mistrust is 3.19 uV², so the difference is -0.3 uV², indicating that mistrust is higher than trust (see Figure 4). Therefore, alpha and beta waves are stronger in trust situations and gamma waves are stronger in situations of mistrust.

Situations of trust and mistrust are compared by low, mid, and high beta waves, which are related to cognitive processes. The power of low beta is averaged from 13 Hz to 15 Hz. The average of trust is 4.62 uV² and the average of mistrust is 2.10 uV², so the difference is 2.52 uV². The power of mid beta is averaged from 15 Hz to 20 Hz. The average of trust is 4.39 uV² and the average of mistrust is 2.54 uV², so the difference is 1.85 uV². The power of high beta is averaged from 20 Hz to 30 Hz. The average of trust is 2.82 uV² and the average of mistrust is 2.88 uV², so the difference is -0.06 uV², indicating that the mistrust is higher than the trust (see Figure 5). Therefore, low and mid beta waves are stronger in situations of trust and high beta waves are stronger in situations of mistrust. The difference between the averages of trust and mistrust decreases from low beta (2.52 uV²) to high beta (-0.06 uV²).
5. Conclusion

Based on the power spectrum analysis, situations of trust and mistrust are compared by $\alpha$, $\beta$, and $\gamma$ waves. While alpha and beta waves are stronger in situations of trust, gamma waves are stronger in situations of mistrust (see Figure 2-4). Alpha waves are related to a calm state without any stress or tension [15], and gamma waves are related to complicated cognitive processes with significant stress and anxiety, so trust situations can help to calm down any mental activity, but situations of mistrust can interrupt mental activity because of increased stress and anxiety.

This research focuses on the beta waves because they are detected in the normal waking state of consciousness related to cognitive tasks [16]. Beta waves can affect cognitive tasks such as attention, problem solving, judgment, and decision-making [17]. In sustained attention tasks, SMR affects perceptual sensitivity and lowers omission errors and mid beta waves (beta 1) reduces reaction times [16,18]. Beta waves can be a guideline to measure cognitive process [19]. High beta waves are associated with intensity, anxiety and hypervigilance [17].

Overall, all beta waves are more powerful in situations of trust than situations of mistrust. On a closer view, in trust situations, the power of beta waves decreases from low beta to high beta. In contrast, in situations of mistrust, the
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The power of beta waves increases from low beta to high beta. Therefore, trust situations can aid sustained attention and problem solving, which are related to low beta and mid beta waves, but situations of mistrust can disturb the focused mental activities exposed by intensity and anxiety, which are related to high beta waves.

6. Discussion

According to this research, trust can assist in effective decision-making by increasing concentration and performance, but mistrust can interrupt effective decision-making by increasing stress and anxiety. Even though there were limited samples of brainwaves, this research presents the difference between trust and mistrust. Further research with more samples of brainwaves will aid in the further analysis of the differences between trust and low and mid beta waves and mistrust and high beta waves to define how trust can affect performance and decision-making.

References

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