Tokens of Interaction: Psycho-physiological Signals, A Potential Source of Evidence of Digital Incidents

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ABSTRACT

As part of a computing network, the human factor is a key component with high cognitive responsiveness to their environment. Cognitive responsiveness manifests as psycho-physiological signal change. With the proliferation of devices that measure and record psycho-physiological signal devices in user space, an opportunity arises to harness human cognitive functioning for potential cybersecurity applications. This research investigates how the electrical signals generated from the functioning of the body, respond to human interaction with digital Incidents. If we can find that response-related signal changes are consistently notable, and we can locate these response-related changes within recorded signal with an accuracy that is greater than chance, then we can claim that psycho-physiological signals contain markers of digital incidents. Applications of these markers include: triangulation of other evidence in digital investigation, input to cybersafety management tools for regulating immersive digital experiences for locked-in individuals.

KEYWORDS

Human Factor, Human-Computer Interaction Artifacts, Psycho-physiological Tokens of Interaction, Digital Evidence, Digital Incidents, Digital Events, Psycho-physiological Signals, Signal Changes, Cognition, Cognitive Responsiveness, Cybersecurity Applications

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1 INTRODUCTION

Digital devices play an increasingly central role in the society, and one that often includes handling or witnessing of material that relates to cybersecurity threats. The device user on the other hand is characterized by high cognitive and emotional responsiveness to their environment. This responsiveness manifests as psycho-physiological change[7], even when no physical reaction is observable[1]. Hence, a digital record of the state of body and mind of the human factor, can to one degree or another reflect the state of other components in a given network while the person is a part of it.

This work investigates the extent to which such record of psycho-physiological signals, can reflect the cognitive responses to human interaction with digital events and incidents occurring at the same time.

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2 PROBLEM STATEMENT

Psycho-physiological signal data could provide a source of evidence of digital incidents but has remained largely unexplored in this regard.

3 RESEARCH OBJECTIVES

This work investigates what neurological and physiological signal data can reveal in the context of digital activity, when one is:

- Interacting with digital material that typically predicts, causes, or indicates a security breach or raises chances of one.
- Carrying out an illegitimate task.

4 GUIDING INSIGHTS

Cognition drives the human functioning that is called for in the digital user workspace.

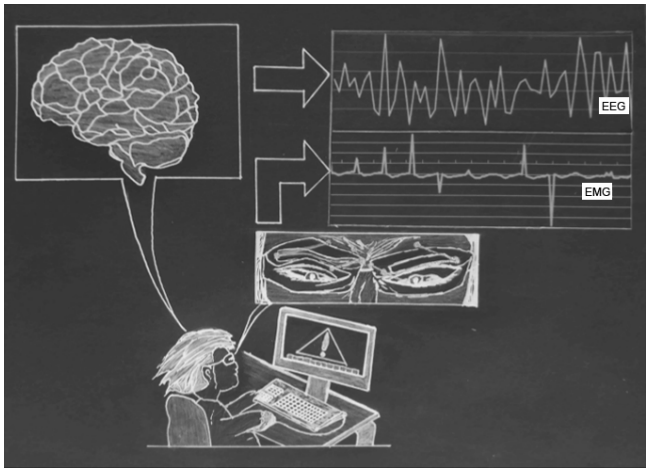

Figure 1: Perception and thought are core elements of the digital experience

During a digital task, conscious cognition [3] — also known as system 2 cognition [4] — is mainly dedicated to the task. On the other hand, automatic (system 1) [3, 4] cognition is divided amongst various aspects including the digital task, the features of various material in the digital space as well as appraisal of the general environment. Such appraisal may include fetching or forming various heuristics and making of various judgements. These cognitive events constitute the functioning necessary to complete digital tasks.

In turn, cognitive functioning creates psycho-physiological signals as artifacts[2, 7]. Such signals include: Electroencephalograms (EEG), Electromyograms(EMG), Electrocardiograms(ECG) and Electrodermograms(EDR). These signals have known structural forms and follow predictable change patterns [6].

Various cognitive influences on psycho-physiological signal have been studied and documented. For example, some signals have been found to change in response to changes in cognitive experiences such as change in level of mental workload[8], shift in attentive focus, and experience of emotional affect such as disgust[2, 5]. These signal changes are known to capture even subtle and transient cognitive reactions[1].

These signals being measurable and recordable, present an opportunity to study psycho-physiological change in the context of digital interaction.

5 RESEARCH APPROACH & ASSUMPTIONS

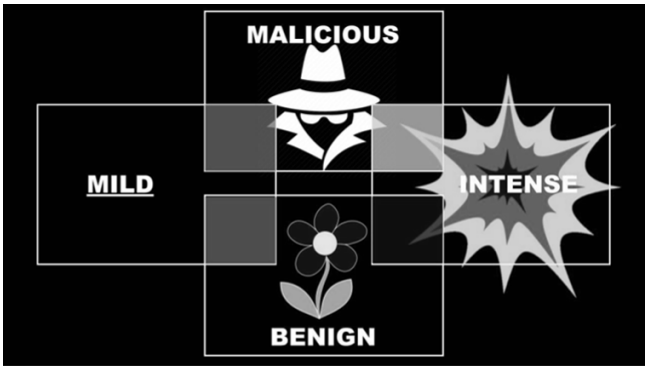

Figure 2: Context dictates what is a security event. Intensity of event is relative to user perception.

5.1 Research Approach

This study takes a non-blind followed by blind study methodology, and utilizes relevant signal analysis methods including event related potential analysis and wavelet transformation.

In the non-blind phase we match signal changes to event timings using a separately tracked record of event stimuli display timings. In the blind phase, event timings are initially unknown to primary researcher, but held by another researcher. We attempt to identify event timings via signal analysis and then verify against the actual timings.

Figure 3: Security-relatedness is a wide spectrum.

If we can retrieve event timings from signal with accuracy greater than chance, then we can make the claim that psycho-physiological signals contain markers of digital events and incidents.

5.2 Assumptions

We assume that response-evoking properties [2, 5, 8] e.g. salience and aversiveness, are inherent in cybersecurity events.

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