# The Role of the Repetition Suppression Effect in User Disregard of Security Warnings: An fMRI Study

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Warning messages are one of the last lines of defense in computer security, and are fundamental to users' security interactions with technology (Figure 1). Unfortunately, experimental research has consistently shown that security warnings are largely ineffective (Wu et al. 2006). A key contributor to pervasive user disregard of security warnings is *habituation*, the diminishing of attention due to frequent exposure to a warning. (Kalsher and Williams 2006). Furthermore, the habituation process can be accelerated if no negative consequence is experienced when a warning is ignored (Vredenburgh and Zackowitz 2006). Although previous security literature has examined habituation of security warnings, it has done so indirectly, by observing the influence of habituation on security behavior, rather than measuring habituation itself.

This study seeks to contribute by using neuroscience to open the "black box" of the brain to observe habituation as it occurs. Specifically, we point to the repetition suppression (RS) effect, the reduction of neural responses to stimuli that are viewed repeatedly, a phenomenon directly antecedent to the process of habituation. By investigating how repetition suppression occurs in the brain, we can make a more precise approach to designing security warnings that are resistant to, or possibly can even reverse the effects of habituation. For example, *polymorphic* warnings, or warnings that repeatedly change their appearance, are expected to reduce the effects of habitation (Brustoloni and Villamarín-Salomón 2007). We propose a series of three laboratory experiments using functional magnetic resonance imaging (fMRI) to observe brain data and improve user interaction with security warnings.

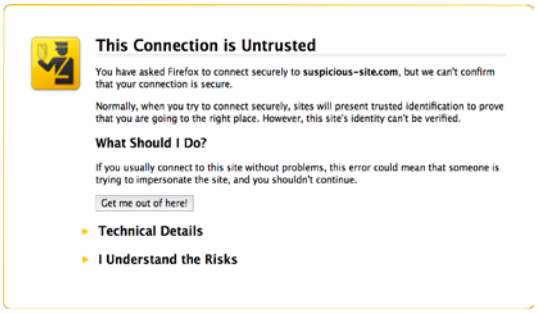


**Figure 1: SSL Security Warning**

A method of choice in decision neuroscience is fMRI because of its superior ability to identify areas of the brain that are activated during decision making and other behavioral tasks (Dimoka et al. 2012).

We propose three fMRI experiments to examine a variety of research questions on how the RS effect is exhibited in the brain, how it changes over time, and how it affects security warning disregard behavior.

- Experiment 1: fMRI with Static Images of Warnings
  - H1: The BOLD response will decrease in regions sensitive to repetition during the course of the experiment.
- Experiment 2: fMRI with Static Images of Polymorphic Warnings
  - H2: Polymorphic security warnings will exhibit lower levels of RS than static security warnings.
- Experiment 3: Longitudinal fMRI with Static Images of Warnings
  - H3: BOLD responses will continue to decrease in the ventral visual processing stream and medial temporal lobe regions but will increase in the basal ganglia with long-term repeated exposure to security warnings.

By studying the onset of RS in the brain, this study has the potential to more precisely remediate the problem of habituation to security warnings. The ultimate promise of applying neuroscience to behavioral information security is to use insights from the study of the brain to design effective user interfaces that can help users make informed decisions (Riedl et al. 2010). In this study, we propose to use our fMRI experiments to guide the design and testing of polymorphic warnings. Additionally, we anticipate that our findings will demonstrate the usefulness of applying neuroscience to the domain of behavioral information security.

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