As mobile technology begins to dominate computing, understanding how their use impacts security becomes increasingly important. Fortunately, this challenge is also an opportunity: the rich set of sensors with which most mobile devices are equipped provide a rich contextual dataset, one that should enable mobile user behavior to be modeled well enough to predict when users are likely to act insecurely, and provide cognitively grounded explanations of those behaviors. We will evaluate this hypothesis with a series of experiments designed first to confirm that mobile sensor data can reliably predict user stress, and that users experiencing such stress are more likely to act insecurely.

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15. SUBJECT TERMS

Security, user behavior, mobile

16. SECURITY CLASSIFICATION OF:

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17. LIMITATION OF ABSTRACT

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Modeling and Sensing Risky User Behavior on Mobile Devices

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Categories and Subject Descriptors
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D.2.8 [Software Engineering]: Metrics—complexity measures, performance measures

Keywords
Security, user behavior, mobile

1. INTRODUCTION
Mobile devices are everywhere today. But it is not just their size that makes them ubiquitous, it is their usefulness: they help us reach our destinations, talk to each other, buy things, and answer our questions. But this pervasive utility also makes them an important security risk: one malicious app could easily tell others where we have been, who we have spoken to, what we buy, and even what we are thinking about. How can we help users manage this risk? Rather than scolding or restricting mobile users, we plan to use behaviorally grounded techniques to encourage secure behavior. But a necessary first step to apply such techniques is understanding their cognitive state. Fortunately, a great deal of the utility that mobile devices provide is enabled by their ability to sense context. Our working hypothesis is we can use the contextual awareness provided by mobiles to predict when users are acting insecurely, and to offer cognitively grounded explanations of these actions. In this research we are testing this hypothesis. Our work has two major components: lab study and field study. In the lab study, we seek to verify whether users will act insecurely when under controlled conditions known to cause stress (stressors). In the field study, we seek first to verify whether mobile sensors can reliably detect such stressors outside of the lab, and therefore predict user stress in the real world. Second, we seek to confirm that user stress is reliably related to insecure mobile user behavior. Our focus in this abstract is our field study.

2. A BRIEF REVIEW OF LAB STUDY
In our lab study, we asked users to find the safest mobile app from among a set of three. While doing so, users experienced no stressors, heard loud noise, had to multi-task, or were under time pressure. As signals of app safety, users could examine star ratings and reviews. Other signals such as permissions and number of installs did not vary. In current results, participants reported significantly less stress in the no stressor condition than in all stressor conditions, indicating that we successfully manipulated stress in our study. Stressors did not significantly alter user ability to choose safe apps, though a strong trend in this direction was present. We are following up these results in pursuit of this trend.

3. PROPOSED FIELD STUDY
The first phase of our field study will examine whether or not we can reliably detect stress using mobile sensors. The second will test whether or not the stress we detect is reliably related to insecure mobile behavior.

3.1 Stressors
Real world stressors often combine several individual lab stressors. We plan to examine three in our field study:

- Noise: Evans et al. demonstrated that chronic noise elevates psychophysical stress. Evidence that
noise can function as a stressor [1,2] includes elevated psychophysiological activation, greater psychosomatic symptoms of anxiety and nervousness, and deficits in motivation indicative of helplessness. In our field study we will use the microphones in mobile devices to detect noise.

- Multitasking: Jeong et al. [4] and Strayer and Johnston [5] show that when people switch rapidly between two or more tasks, their performance on both tasks suffers. We will detect phone-centric multitasking in our field study by sensing when people are already using their phones to perform a task. We will then ask them to perform an experimental task with a security risk, effectively asking study participants to multi-task.

- Mode of transportation: Traveling is a complex activity that often involves noise, multitasking (e.g., driving and talking), and time pressure (e.g., go when the light changes). Novaco [6] found that traffic congestion is a source of stress, likely because it increases all of these stressors. We will detect mode of transport using the Android mobile operating system’s location API.

3.2 Hypotheses

The hypotheses for our field study are: 1) mobile sensing can be used to predict of when users are more likely to act insecurely, 2) mobile sensing can also predict user stress, providing potential explanations of insecure actions, and 3) stress and insecure mobile user behaviors will have a significant relationship, providing evidence that stress-based explanations have merit.

3.3 Experiment Plan

To collect and react to sensor data from mobile phones, we are using AWARE (http://www.awareframework.com/home/), a recently developed Android mobile context instrumentation framework. Our experimental apparatus will take the form of an AWARE “add-on”, which is then loaded onto participant phones as an app to measure noise, multitasking, and transportation mode. The AWARE framework can then monitor the mobile user’s context, and when appropriate, ask the user to describe how much stress they feel, or to perform a potentially risky act. The first phase of this study will focus on the relationship between sensed stressors and users’ cognitive state. We plan to recruit 100 participants who will install this app and then use their mobile phone normally for a few weeks. When AWARE detects that a certain combination of stressors exists, it will ask users, using a popup dialog on their phone, to indicate how much stress they feel on a 1-5 Likert scale. It will also ask users to indicate the degree to which each stressor contributed to the stress they experienced. This will occur no more than two to three times during the day. We will examine all eight possible stressor combinations (Table 1 from no stress to all three stressors present). However, because this is a field rather than a lab study, we fully expect to have unbalanced results, requiring the use of matching techniques for analysis of results. The second phase of this study will be quite similar, but focus on sensed stressors and insecure behavior. A similar number of participants will install our experimental AWARE app. When a certain combination of stressors exist, we will ask users to perform a potentially risky action, such as installing an app. Likely participants will have to pick the safe app from several apps, much like our lab study. We expect that combinations of stressors that caused more stress in the first phase of our field study will cause more insecure behavior in this second phase.

4. CONCLUSION

Should our field study succeed, we believe it will be the first to experimentally examine the security of mobile user behavior outside of the lab, to demonstrate that mobile sensors can be used to reliably predict the likelihood of insecure mobile behavior, and to show a relationship between the user’s cognitive state and security behavior. We would then follow up our work with cognitively based interventions that exploit our timely knowledge of the user’s cognitive state.

5. ACKNOWLEDGMENTS

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6. REFERENCES


