Lessons for Labeling from Risk Communication

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Abstract

Labeling for software and Internet of Things devices (including the software embedded within them) will better meet the goals of the Executive Order on Improving the Nation's Cybersecurity [17] if the design and implementation integrates previous results on risk communication and warnings. Here we provide a partial summary of previous research in online risk communication that could inform the design of effective, usable, and helpful labels. We also identify a handful of classic works on warnings to provide a potentially useful foundation for exploring the wealth of findings which might be helpful in designing labels for software and the devices in which is it embedded.

Introduction

Decision-making in the face of privacy and security risks can be considered holistic risk communication [16]. The harms resulting from exposure to the risks are stochastic, and vary based on the vulnerability of the exposed. The results of the same security flaw or privacy lapse may range from simply annoyance to severe loss. Risk communication offers guidance for the creation of labels where the vulnerability to exposure and ability to mitigate can vary widely. Labels that are grounded in risk communication offer the potential to impinge the risk perception of those who interact with them.

There is the potential of a virtuous circle in security and privacy if effective labels support changes in risk perception and decision-making. Such changes in decision-making would reflect changes in habits of use and expectation. Since habits of use, perceived risk, and dimensions of the underlying risk predict cautionary behavior, a change in use that results from clear risk communication has the potential to impinge future choices and behaviors [24].

Background and Recommendations

Loss of privacy and loss of security are risks. As a result, the development of labels should be informed by risk communication and warning science. In this submission, we identify previous work leveraging risk communication in security and privacy to support this core recommendation. Based on this foundation we make three central observations, and close with recommendations.

Timing matters. Warnings are provided before risk exposure, to enable risk avoidance and harm minimization. In the case of IoT and software, this means that labeling information should be provided during purchase, before installation or use. The importance of providing labels before exposure has been reified in studies on privacy permissions manifests on mobile devices. Prior research has found that the iOS vetting and run-time warnings were less effective than Android's community ratings and permissions manifest mechanism [10, 20]. Previous work with apps found that when permissions were included in the app description page instead of being presented after people chose to install an app, people chose apps that had fewer permissions [18, 15]; later work found stronger evidence in IoT selections [14]. There is also evidence that people are desensitized toward repeated run-time dialogs that are widely used on mobile, stationary, and embedded devices [1, 25]. Multiple research investigations with a range of methods has found that people may view these warning dialogs as yet another interruption rather than meaningful alerts, and simply click through them [23, 29, 9, 5, 8].

Multi-layer warning systems can empower a wide range of stakeholders. The same software and devices may be used in homes with only non-expert consumers, or in workplaces with dedicated technical staff. Labels designed for the average consumer will exclude the most vulnerable half of the population by definition. Here warning science offers a solution: when there is a highly variable audience, effective warnings are those designed for the low-end extreme to include the entire population [28]. As a result, multi-layer labels can be designed as warning systems to serve both the expert and the non-expert.

Simple interaction are needed to inform those with the least expertise. These may be augmented with audio, first of course to ensure accessibility. Secondly, a combination of visual indicators to support informed decision-making with an audio to increase risk awareness can create an effective labeling and warning system [26, 28, 21].

Yet simple icons and audio indicators can fail to serve the needs of experts. These also may not perfectly align in customizable systems. For example, there may be products which offer far greater functionality yet require expertise to enable these functions. Such products could be more safe in the default configuration yet more risky when used fully enabled. A multi-layer warning system could communicate information about both situations. Concerns about non-expert consumers may be mitigated with secure configurations, with the hope that the less expert may either not change the default or seek information. In terms of the first, the power of defaults in security is substantial. In terms of the second, when a product is perceived to be complex then the less expert users have long been found to be more likely to read instructions [19].

Align with the mental models of less expert users. Repeated experiments and evaluations on the mental models of computer security risks illustrates that expertise has an impact. More expertise corresponds to perceptions of risks as ubiquitous, with mental models that correspond to consistent awareness and severe results (e.g., health, grievous bodily harm). Those with less expertise more frequently choose mental models that correspond to less severe risks (i.e., nuisance crimes) or risks when the victim has no ability to mitigate (i.e., war) [2, 6, 7].

Even among those with less expertise, different mental models can correspond with different behaviors in terms of risk avoidance and effective mitigation [27]. Thus, selecting a model that is both salient and aligned with safe behavior holds the most promise. Such an approach has been evaluated in the context of of web browsing, where simple icons based on mental models has been found to improve online safety by changing risk behavior [4, 7].

Expertise also influences security perceptions, so that the less expert may engage in more risk-seeking behaviors. For example, Gallagher et al. showed that expertise level is a strong determinant of usage patterns in Tor [11]. Stanton et al. discussed the correlation between users' technological expertise and their security awareness [?]. Both found that expertise corresponded with more risk avoidance. Less expert consumers have the greatest need for guidance.

Flawed risk communication can result in perverse results. Security is not immune to the phenomena of risk compensation, where increases in safety technology do not result in decreased harm due to increases in risk-seeking behaviors. This phenomena was apparent in a study on privacy behaviors in social networks, where increasing knowledge about privacy without risk communication lowered risk perceptions [13]. This has also been seen in the mobile context, with a comparison of risk communication in Android. Interactions that focused on improving the permissions interface through simplified text, explanations with more text, and icons using eyes found that those in the group with just the icon accepted fewer high-privacy and high-security apps, while rejecting more relatively safe ones [3]. Evaluating the effect of labels on long-term behaviors requires evaluation of how these influence individual risk thermostats [22].

There are many explanations for the lack of adoption of technologies to enhance security and privacy: lack of concern, lack of usability of tools, or lack of knowledge about risk. An empirical evaluation of the three explanations found that lack of knowledge or risks was the driving factors for over-exposure [12]. Labels that are designed to embed effective risk communication may better enable consumers to engage in informed self-protection.

Recommendations

Security and privacy labels are risk communication. Thus, the design of labels should be informed by design of warnings, and include multiple levels of communication. Labels should be available for evaluation and comparison before any risk is encountered, ideally at the time of purchase or selection, to be effective. Different label designs embed distinct conceptual models, and selection of these should be informed by mental models. Labels that simply list information may not be adequate, and may even create perverse effects. It is worth evaluating a modular approach which enables evaluating an entire product, platform, or device or a only a specific desired service. Any label must be evaluated with an awareness of the potential influences of biases in human decision-making in the face of uncertainty.

In summary, we argue for multi-level as well as single-level warning systems that are presented at the time a purchase or download decision is made. User-centered design that embeds mental models can serve this goal. We strongly encourage that any design be subject to evaluation based on its impact on risk perception. Finally, we argue for public campaigns grounded in risk communication with a focus on severity of consequences of loss of digital privacy, security, and safety concurrent with the development and diffusion of labels.

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